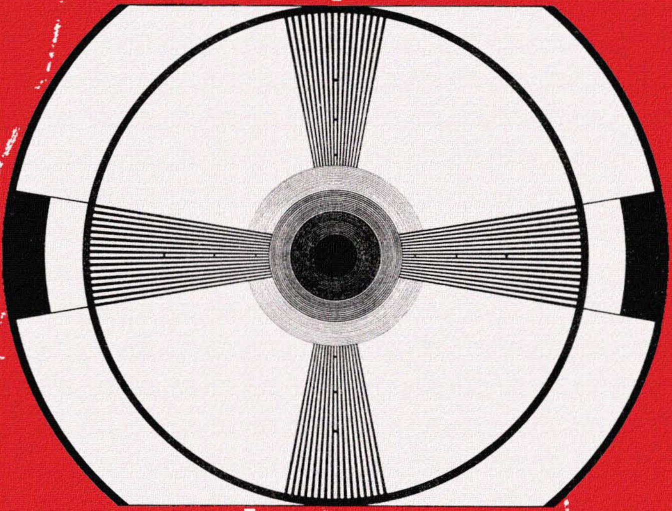
TV

SERVICING



PRACTICAL INFORMATION ON

- **TV TROUBLE SHOOTING**
- **TV TUNER ALIGNMENT**
- **TV CIRCUIT ANALYSIS**

RCA

RADIO CORPORATION of AMERICA

TUBE DEPARTMENT

HARRISON, N. J.

TV SERVICING

—A compilation of articles on TV servicing written by two of RCA's experts in the fields of TV servicing and test equipment—John R. Meagher, Television Specialist, and Art Liebscher, RCA Test Equipment Specialist.

"TV Servicing" has been prepared to take care of numerous requests for copies of the articles by Mr. Meagher which appeared in "RCA Service News" under the general titles of "Television Service" and "Television Antennas and Transmission Lines". His recent articles on "Horizontal Pulling" and a previously unpublished article on "Audible Hum and Buzz" have also been included to increase the usefulness of this publication.

A new article, "Television Tuner Alignment," by Art Liebscher is a thorough, practical guide to tuner alignment. It will be particularly welcomed by those servicemen who have shied away from this phase of TV servicing—the article disproves the popular misconception that television tuners are complicated devices.

CONTENTS

Page

Television Service (by John R. Meagher)

Parts I-IV—Using the Test Pattern 1
Part V —How RF-IF Alignment Affects Picture Quality 9
Part VI —Troubles in Horizontal Deflection and High-Voltage Circuits 11
Part VII —Vertical Deflection Troubles 13
Part VIII —Vertical Oscillator Troubles 15
Part IX —Blanking and Synchronizing Signals 17
Part X —More on Horizontal-Deflection Troubles 20
Part XI —Automatic-Gain-Control Troubles 22
Part XII —Visible Symptoms of Hum Trouble 23
Part XIII—Microphonic Troubles 25

Audible Hum and Buzz (by John R. Meagher) 28

Horizontal Pulling (by John R. Meagher) 32

Television Tuner Alignment (by Art Liebscher) 37

Television Antennas and Transmission Lines (by John R. Meagher) 41

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TELEVISION SERVICE

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PART I

USING THE TEST PATTERN

When something goes wrong in a television receiver, it generally shows up as a definite symptom in the picture. In no other type of electronic equipment are the troubles and symptoms so clearly displayed before our eyes.

If we learn to recognize these visible symptoms, we can quickly localize the trouble to a particular portion of the set. Even the complete absence of picture and raster tells us to suspect certain definite parts.

For those who hope to become expert in television service, it will pay to study, observe, and learn how to analyze symptoms in the television picture.

There are several text books that cover television principles, the action of television circuits, and the effects of some interference conditions, but there is practically no information that correlates specific troubles with the visible symptoms.

So in this series of articles, we will concentrate on diagnosing and localizing troubles by analyzing their effects on the picture.

However, in order to build a foundation for subsequent articles, it is logical and necessary to start with a discussion on how to interpret and use the television test pattern. This includes much practical service information.

Typical test patterns

There is no standard test pattern in general use. The nearest thing to a standard is the RCA "Indian head" monoscope, which is used by a number of TV stations. RMA has proposed a standard "resolution chart", but for various reasons it has not been adopted by TV stations for air use.

Many TV stations have designed their own test patterns, which, although differing in appearance, are all intended to facilitate adjustments and checks in both the transmitting equipment and in the receivers.

Two typical test patterns, the NBC, and the RCA Indian head, are shown in figures 1 and 2. The various elements are named in figure 1, and these names will be referred to in the following discussion.

Size and linearity

The controls for width, horizontal drive, and horizontal linearity, and the controls for height and vertical linearity should be adjusted so that:

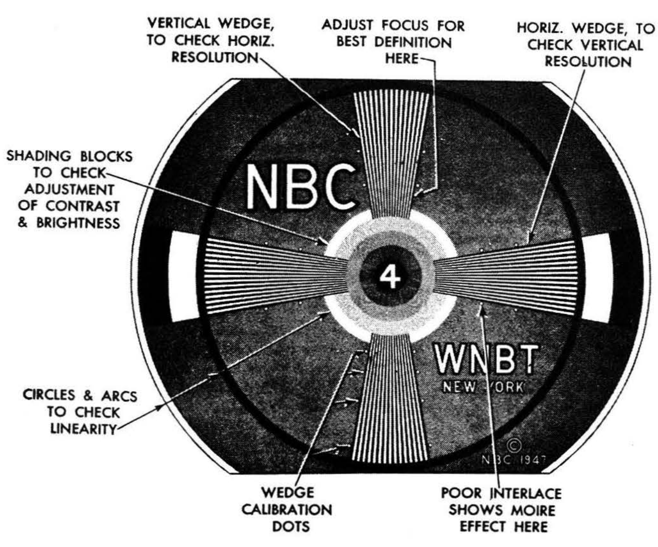


Figure 1. The NBC Television Test Pattern.

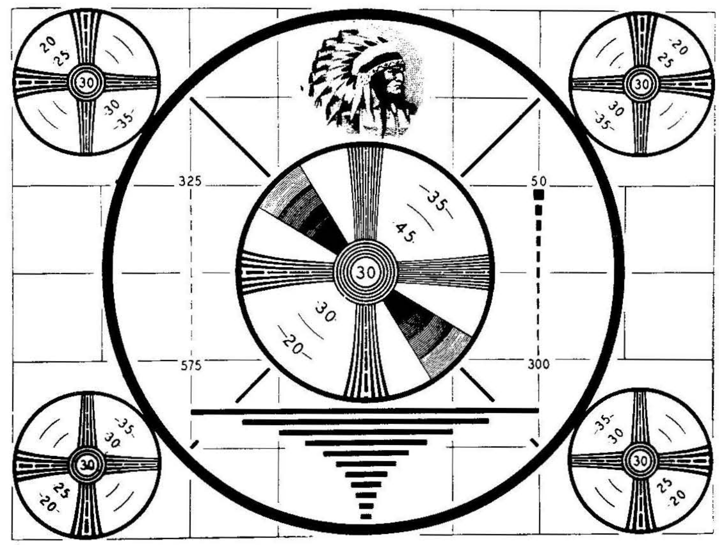


Figure 2. The RCA Indian Head Test Pattern.

1. The circles in the test pattern are as round as possible, and
2. The test pattern is slightly larger than the mask appearing in front of the kinescope.

If linearity is not correct, the circles will be flattened or egg-shaped.

In judging *vertical* linearity, it helps if you lay your head on your shoulder and look sideways at the picture. This makes vertical nonlinearity more apparent.

Many TV owners are extremely fussy about having the circles exactly round. Some of them check the circles by holding a small plate in front of the screen, and others measure the wedges to see if they are equal lengths. In some TV areas, this makes life extremely difficult for the television technicians, because it is an unfortunate fact that some stations do not transmit good linearity. Also, the linearity may be different from one camera to another. In one particular city, if the receiver is adjusted so the test-pattern circle is round on the first station, the second station will be egg-shaped vertically, and the third station will be egg-shaped horizontally.

In the latter case, it is sometimes necessary for the technician to adjust the receiver for the best compromise linearity on all stations in the area. But it is preferable to select the station that is most likely to have correct linearity, and adjust the receiver on this station, because in time the other stations will correct their nonlinearity.

Frequently, it is necessary to install and adjust TV receivers at night or when there are regular programs, but no test patterns on the air. In such cases, it is possible to use a "bar generator" which produces a number of vertical and horizontal bars on the picture. These bars are "synced" by the sync. pulses so that the bars remain stationary on the picture. The set is then adjusted for equal spacing between the bars.

A very useful hint for checking and adjusting vertical linearity when there are only programs and no test patterns on the air, is to turn the vertical-hold control so the picture keeps rolling slowly from top to bottom. If the vertical linearity is good, the black vertical-blanking bar will remain the same thickness in all positions from the top to the bottom. This is shown in Figure 3. There is no similar easy way to check horizontal linearity.

In a few test patterns, all circles are intentionally omitted: regularly spaced horizontal and vertical lines are used to check and adjust linearity, as shown in Figure 4. This design of test pattern is the answer to the technician's prayers, because it avoids the trouble of the fussy customer who insists that the circles be exactly round, yet it provides a satisfactory means for adjusting linearity within reasonable limits.

Of course nothing that has been stated here should be used as an alibi to excuse poor linearity that is

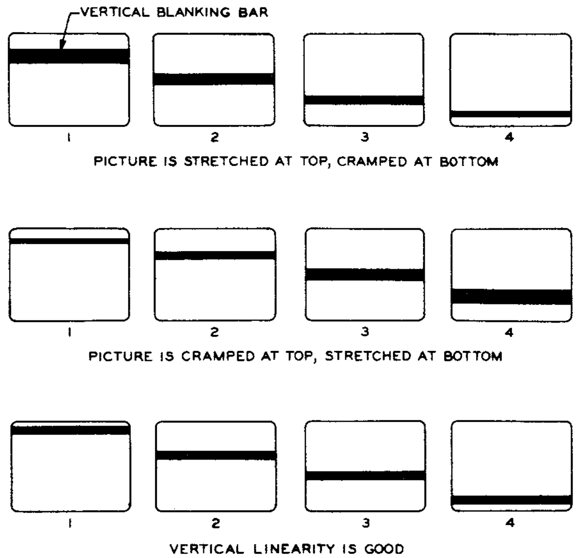


Figure 3. Checking Vertical Linearity with Vertical Blocking Bar.

caused by incorrect adjustment of the receiver, or by failure or change in value of components, in the deflection circuits of the receiver. The question of whether the station or the receiver is at fault can be determined by experience with a number of different receivers, or by the use of a bar generator.

Most TV set owners complain if the picture does not completely fill the mask, but they do not complain if a small portion of the picture is hidden behind the mask.

It would seem reasonable to make the picture exactly the same size as the mask, but this is impractical for several reasons:

1. There is considerable variation in the horizontal and vertical blanking time on different stations, and on different sync. generators in the same stations. Actually there may be as much as ¼-inch difference in height or width on a 10-inch set when the station changes from one sync. generator to another, or from a local to a relay program.
2. The line voltage at the receiver may change. This changes the deflection voltages and high-voltages, both of which affect the picture size. (For this reason also, a TV set that is adjusted in the service shop for correct size may be found to have a smaller or larger picture on the owner's power supply.)
3. There may be some drift in the picture size or centering during the first hour of operation.

For these and other reasons, experience has taught that it is a practical necessity to make the picture extend slightly beyond the mask.

The test pattern should be designed with this in mind. For example, if the pattern has small circles or other information too close to the corners, it may cause unnecessary headaches for the technician, because when the picture is made larger than the mask, the designs in the corner may be partly hidden. Some TV owners want to know why.

Centering

The two arcs of circles in the NBC pattern, Figure 1, are an aid in adjusting horizontal centering. The main black circle is used in adjusting vertical centering.

Focus

The television signal controls the intensity of the electron beam in the kinescope. This beam produces a fluorescent spot of light on the inner face of the kinescope. It is this spot that "paints" the picture.

For good definition or resolution, or ability to make very small details evident and distinct in the picture, the spot must be small and round. It should be small enough so that the horizontal line structure can be seen distinctly, and it should be round in order to get the best definition from top to bottom and from left to right.

If the spot is slightly elliptical or oval shaped, instead of round, it may be rotated by adjusting the focus control, as described below.

The vertical and horizontal wedges are used in adjusting focus; they provide a check on the shape of the kinescope spot, as follows:

Closely examine the separate lines toward the narrow end of the vertical wedge, and adjust the focus control so these lines are in best focus, or sharpest.

Then look at the lines toward the narrow end of the horizontal wedge, and see if a slight readjustment of focus improves the focus on these lines.

If best focus on both the vertical and horizontal wedges is obtained at the same setting of the focus control, it may be assumed that the spot is round.

If the setting for best focus is slightly different for the two wedges, it indicates that the spot is oval. In this case it is generally *preferable to adjust the control for best focus on the vertical wedge.*

In most test patterns, the narrow ends of the wedges are intentionally placed near the center of the test pattern. By focusing here, it ensures that the picture will be in best focus at the center, which is desirable.

Some test patterns, such as Figure 1, provide additional wedges in the corners to show whether the focus is good on the sides and top and bottom, compared with the center.

If focus is not reasonably uniform over the entire picture, it may indicate need for repositioning of the ion-trap magnet, or the focusing coil and focusing control.

If the test pattern does not have wedges in the corners, the horizontal scanning lines can be observed to check focus over the entire screen.

When focus must be adjusted on a program, without the help of a test pattern, it is generally satisfactory to adjust for the finest scanning lines near the center of the picture.

In projection receivers, there is the usual electrical focus control for the kinescope, and the mechanical focusing adjustments for the optical system. To prevent confusion, and to get the best possible pictures, it is important to adjust the electrical focus first while looking at the kinescope, or at the reflection of the kinescope in the spherical mirror. The optical system should not be touched until the test pattern as seen on the kinescope is sharp and clear.

If the test pattern has crossed lines in the corners and in the center of each side, and in the center of the top and bottom, they are very helpful in adjusting the reflective optical systems that are used in some projection receivers.

Contrast and brightness

Almost all test patterns include some form of shading blocks to assist in correctly adjusting contrast and brightness.

The shading blocks have at least five shades, black, dark grey, medium grey, light grey, and white. The contrast and brightness should be adjusted so that each shade is distinguishable. With contrast too high, the darker greys become black, and with contrast too low, the lighter greys become washed out.

If brightness and contrast are set too high, the definition will suffer, owing to "blooming" of the kinescope spot. When the spot is too bright, it grows larger, and best definition depends on a small spot.

Instead of shading blocks, some test patterns have a section of light grey background with white lettering, and a section of darker grey background with black lettering. This serves the same purpose on the shading blocks, and is more foolproof, because few persons are aware of the significance of the shading blocks.

Many test patterns are designed with a grey background to secure an average modulation of 50%. This reduces the need for readjusting brightness and contrast when the station switches from the test pattern to an average program. It is a desirable feature (except when photographing a pattern).

Interlacing

The horizontal wedges show lack of interlacing by a moire pattern, or wavy effect, toward the narrow end of the horizontal wedges. A moire pattern is somewhat similar to the effect that is seen when looking through two pieces of window screening, or at a piece of satin.

The appearance of poor interlacing can usually be duplicated by turning the vertical-hold control slowly until the picture is just beginning to move down. At this point the moire effect will be seen on the horizontal wedges. Also the horizontal scanning lines, instead of interlacing, will lay over each other, or "pair". This pairing can be observed by the increased dark space between the horizontal scanning lines, particularly near the top of the picture.

Lack of correct interlace also produces a jagged or saw-tooth effect ondiagonal lines and on the circles. The Indian-head test pattern has diagonal lines for this reason.

Some test patterns have closely-spaced concentric circles which show the moire effect if interlacing is poor.

On some TV stations, all receivers may show evidence of poor interlace on the horizontal wedges. In this case there is no need to worry about the receivers. It is likely that there will be no evidence of poor interlacing when the station switches to a program. In looking at a test pattern on a kinescope, there may be an optical illusion of vertical jitters. By looking at a small part of the scanning lines through a ¼-inch hole in a piece of thin cardboard held against the face of the kinescope, it is possible to determine whether the jitter is an optical effect, or real.

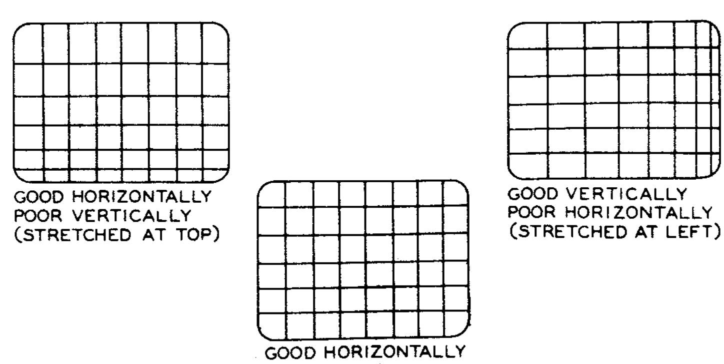


Figure 4. Horizontal and Vertical Lines instead of circles for Linearity Check.

PART II

Low-frequency phase shift

The general subject of phase shift in relation to the diagnosis and repair of TV receivers will be covered in a subsequent article. At present we will give a brief outline of the trouble, and describe some of the symptoms as seen on the test pattern and in the picture.

Any horizontal line in the test pattern may be regarded as representing a half-cycle of a relatively low-frequency square wave. For example on a 10-inch receiver, a half-cycle of one-megacycle is approximately 1/16-inch long, and a half-cycle of 100 kc is 3/4-inch long. See Figure 5.

A square wave is composed of a fundamental and numerous harmonics of different amplitudes. For good reproduction all of these components must be amplified equally and have the same time delay in passing through the receiver. Otherwise, the signal arriving at the kinescope will be a distorted square wave: It may have a dip before or behind (leading and trailing reversal), it may trail off very gradually instead of sharply.

This trailing-off makes a long smear after horizontal lines. Incidentally, this accounts for "X-ray" effect, where a long horizontal molding or shelf can be "seen" right through a person standing in front of it.

The effect of low-frequency phase shift is more evident in the picture if the horizontal lines are fairly thick. The thick horizontal lines in the Indian-head test pattern are used to show and to check this effect, by the intensity, polarity, and duration of the trailing smear. However, most horizontal lines, such as in the horizontal wedge, and horizontal portions of lettering, will show the effect.

Open peaking coils and coupling capacitors in the video amplifier can cause phase shift and smear, but it may also be due to transmission troubles. This can be determined by checking a second receiver; if both receivers show smearing, it is most likely due to the station.

Resolution or definition

Now we come to the final and possibly the most important application of the test pattern, its use in determining vertical and horizontal resolution.

The words "resolution" and "definition" are commonly used interchangeably in rating the capability of the receiver to resolve, or define, or make clear, small details in the picture or test pattern.

In a general sense, if a picture is sharp and clear, and shows small details we say that it has good resolution, or high resolution. If the picture is soft and blurred, and small details are indistinct, we say that it has poor resolution, or low resolution.

Owing to the manner in which a television picture is "drawn", the definition from top to bottom is generally different from the definition sideways. With present TV standards the definition from top to bottom is somewhat better than from left to right.

Consequently, in television we must distinguish between vertical and horizontal resolution, and accordingly we will treat each one separately.

Vertical resolution

The vertical resolution, (the resolution from top to bottom of the picture) is expressed in the number of *horizontal* lines that can be resolved. Therefore, we use the horizontal wedges in the test pattern to determine vertical resolution.

Vertical resolution depends primarily on the size of the kinescope spot. It does not depend on the high-frequency response or bandwidth of the receiver.

There are approximately 490 usable horizontal scanning lines (525 minus 7% for vertical blanking). If the kinescope spot can be focused to a small enough size so that it can trace these 490 lines without overlapping, the maximum vertical resolution in 490 lines: actually, the effective resolution is considerably less than this and can be determined from the horizontal wedges.

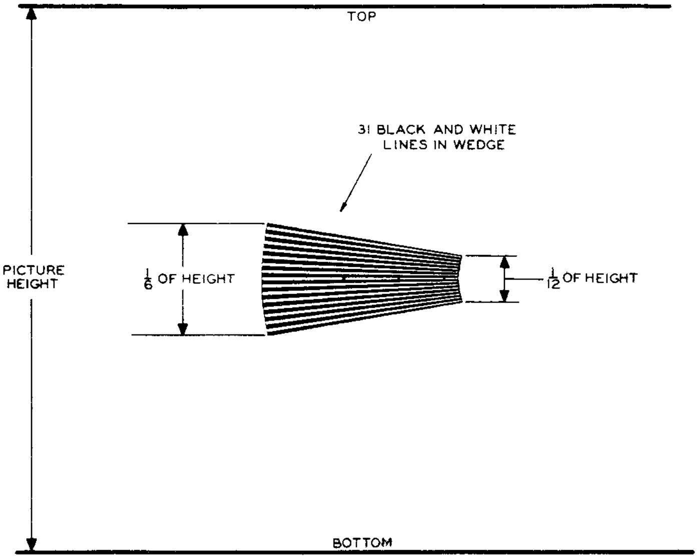


Figure 6. Horizontal wedge of pattern, showing relation to overall picture size.

Figure 6 will help in explaining the calibration and use of the horizontal wedges in a test pattern. There are 31 alternate black and white lines in this particular wedge. The left-hand edge of the wedge is 1/6th of the picture height. Considering only the left-hand edge of the wedge, we could fit 6 x 31 or 186 lines in the space between the top and bottom of the picture.

Considering only the right-hand edge of this same wedge, which is 1/12th of the picture height, we could fit 12 x 31 or 372 lines in the space between the top and bottom of the picture.

Therefore the left-hand edge of the wedge represents 186 lines, and the right-hand edge represents 372 lines.

Assume that when a test pattern with the wedge dimensions shown in Figure 6 is reproduced on a particular TV receiver, the separate lines in the wedge become blurred or indistinct at a point where the wedge is 1/10th of the picture height. This is equivalent to 10 x 31 or 310 lines. So in this example we can state that the maximum vertical resolution is approximately 310 lines.

It should be noted that it is not customary to refer to frequency in regard to the horizontal wedges, or in regard to vertical resolution. However, as a point of interest, if the center line in the horizontal wedge extends for about 1/4th of the complete time for one horizontal scanning line, it is equivalent to 1/2 cycle of a 30-kc square-wave signal. The scanning lines cross the other lines in the horizontal wedge at various angles, equivalent to a maximum frequency of roughly one megacycle. *The intensity or blackness of the horizontal wedge, compared to the vertical wedge, is therefore dependent on the low-frequency response of the receiver.* If the low-frequency response is poor, the horizontal wedge may be grey when the vertical wedge is black.

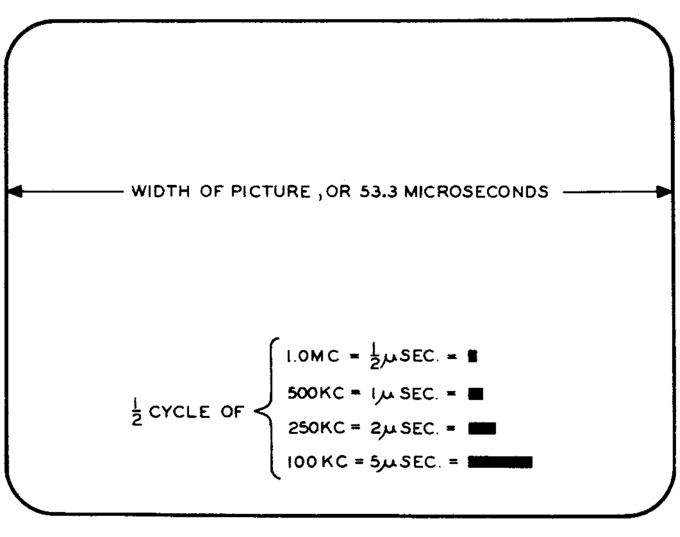


Figure 5. Relation of horizontal lines by a frequency vs. time comparison.

Horizontal resolution

The vertical wedges are used to determine *horizontal* resolution.

Horizontal resolution depends on the high-frequency response or bandwidth of the receiver, and also on the size of the kinescope spot.

Horizontal resolution is expressed in two ways:—

1. Horizontal resolution in "number of lines" is based on the number of distinct black and white dots that can be produced by the kinescope beam in three-quarters of the usable length of a horizontal scanning line.

This length (3/4 of width) is selected because it equals the height of the picture and therefore gives a basis of direct comparison between horizontal and vertical resolution.

In Figure 7, "L" equals three-quarters of the active or usable picture width.

In this example, the wedge has 31 alternate black and white lines. The top end of the wedge is 1/6 of L. Therefore the equivalent number of lines at the top is 6 x 31 or 186. The bottom of the wedge is 1/12th of L, so the equivalent number of lines is 12 x 31 or 372.

If this pattern is reproduced on a TV receiver, the separate lines in the vertical wedge might become blurred at the point where the wedge is 1/10th of the L. In this case, the maximum horizontal resolution is 10 x 31 or 310 lines.

2. The horizontal resolution may be expressed in frequency. This is very desirable in service work, because it indicates the effective bandwidth of the receiver.

The explanation involves some simple arithmetic:

The horizontal scanning frequency is 15,750 cycles per-second. One complete horizontal line takes 1/15,750 seconds, or approximately 63.5 microseconds, (millionths of a second). The horizontal blanking time is 10.2 microseconds so the time for the usable portion of one horizontal scanning line is 63.5 minus 10.2, or 53.3 microseconds.

The spot therefore requires 53.3 microseconds to travel from the left

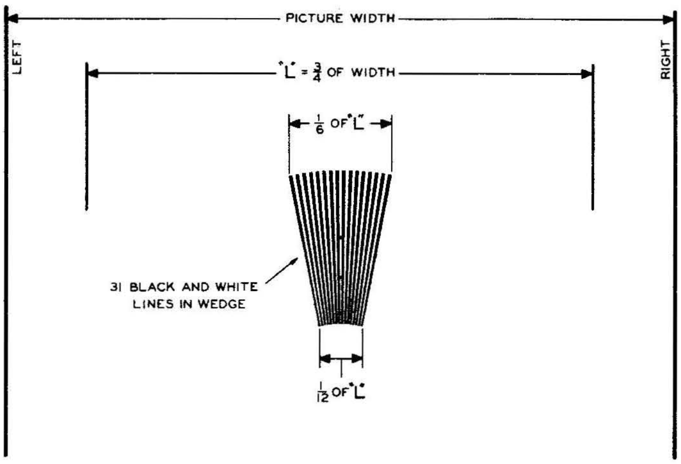


Figure 7. Vertical wedge of pattern showing relation to overall picture size.

to the right edge of the picture, but in speaking of resolution, we are interested in three-quarters of the width, which is traveled in ¾ x 53.3, or 40 microseconds.

A video signal of one megacycle (Mc) produces one cycle in one microsecond. Each cycle has a negative half-cycle and a positive half-cycle, which when applied to the kinescope, produce a black dot and a white dot. Each cycle therefore produces two dots which we will consider as "lines".

In 40 microseconds, a one-megacycle signal produces 40 cycles, or 80 lines: 2 megacycles, 160 lines; 3 megacycles, 240 lines; 4 megacycles, 320 lines.

Horizontal resolution expressed in lines may be converted to frequency, by dividing the number of lines by 80. For example, if the maximum horizontal resolution of a set is 325 lines, the equivalent frequency or bandwidth is 325/80 or 4.06 Mc. Conversely the horizontal resolution of a receiver expressed in frequency may be converted to equivalent lines, by multiplying the frequency (in megacycles) by 80. For example, if the maximum horizontal resolution of a receiver is 3 megacycles, the equivalent number of lines is 3 x 80, or 240 lines.

In the accompanying table, "Vertical Wedge Data", we have listed in columns 1 and 2 the corresponding lines and frequency for horizontal resolution.

Here are two examples in the application of this table:—

1. On a particular TV receiver, the vertical wedge becomes blurred beyond 250 lines. What is the equivalent frequency, or bandwidth?
   Using column 1 and 2, we find that 250 lines is equivalent to approximately 3 Mc.
2. A receiver has a bandpass of 4 Mc. How many lines should it resolve on the vertical wedge? Using column 2 and 1, we find that 4 Mc is equivalent to 320 lines.

Wedge calibration

On some test patterns, the equivalent number of lines is indicated by numbers at a few points on each wedge. It is a general practice to omit the last zero; so "20" means 200, etc.

In some test patterns, the wedges are not numbered but are marked by dots or other means at major steps. For convenience, in Figure 8, we have shown the equivalent number of lines at each dot and at each end of the wedges for this NBC pattern.

In cases where the pattern does not indicate the number of lines, the information can usually be obtained from the TV station.

The equivalent number of lines at any point on either the horizontal or vertical wedges may be computed:

Multiply the number of black and white lines in the wedge, by the ratio of picture height to the width of the wedge, at the desired point on the wedge.

Even under the best conditions this is only an approximation, owing to inaccuracy in measuring the width of the wedge on the kinescope, and errors due to non-linearity.

The receiver must first be adjusted for the best possible linearity. with the test pattern just filling the mask, with a mask of the correct size and 3 x 4 proportions, and with contrast and focus set correctly.

Single lines for horizontal resolution

The single resolution lines in the Indian-head test pattern represent the width of a single line ranging from 50 to 575 lines.

Consider the thick line marked 50: It would take 50 alternate black and white lines of this width to stretch across three-quarters of the full width of the picture.

It would take 575 alternate black and white lines of the width shown, for the single line marked 575, to fill three-quarters of the full width of the picture.

These single lines are intended to show "ringing", or damped oscillation at certain frequencies.

For example, assume that the video amplifier response rises at 3 megacycles and is then cut sharply. It will tend to ring at 3 Mc, when a signal containing this frequency is fed into the amplifier. The single line corresponding to 3 Mc or 240 lines, would provide the signal, and the resulting ringing or damped oscillation would be visible as several echoes of diminishing intensity following this and possibly adjacent lines.

The same ringing should be evident at the right of the vertical wedge at a point along the wedge corresponding to 240 lines, or 3 Mc. However it is better to observe and analyze the ringing on a single vertical line.

Effect of regeneration on the vertical wedge

If there is tendency toward regeneration at some particular frequency in the picture-if amplifier, it may be evidenced by fine dark lines streaking horizontally across the vertical wedges at a point corresponding to this frequency.

For example, if the if amplifier is regenerative at a frequency 3 Mc removed from the picture if carrier frequency, the effect will be seen at a section along the wedge equivalent to 3 Mc, or 240 lines.

Regeneration depends on the gain of the if amplifier. Therefore it may be evident on a weak signal where the gain is high, and not evident on a strong signal where the gain is low.

When there is evidence of regeneration, the alignment, bypassing, and lead dress of the picture-if amplifier should be checked in an effort to reduce or eliminate the regeneration.

Practical rating of horizontal resolution

In most test patterns, the wedges are not marked by numbers to indicate the equivalent number of lines along the wedge.

However, in television service work it is satisfactory to rate the horizontal resolution on the simple basis of "how far down" it is possible to distinguish the separate lines in the vertical wedge.

For instance, using the test pattern of the highest-definition station in the area, all receivers of a certain model may, when correctly aligned, resolve the lines in the vertical wedge "all the way down" to the narrow end of the wedge.

If a particular receiver of the same model does not give equally good resolution, it may need alignment, or other work.

On a cheaper model of receiver, with less bandwidth but with the same size picture tube, the vertical wedge in the same test pattern may be clear "down to within ½-inch" of the narrow end of the wedge.

This practical method of rating has already become rather widespread, but it is hoped that with increased knowledge of the subject, and possibly the standardization of wedge limits and markings, it will become common to note the horizontal resolution in frequency, and the vertical resolution in "lines". In fact, for TV receiver servicing it would be possible to omit the horizontal wedges and depend on the scanning lines structure as a check of vertical resolution.

Precautions in checking horizontal resolution

In using the vertical wedges on a test pattern to estimate the maximum horizontal resolution of a TV receiver, the following points must be remembered and considered:

1. The size and shape of the kinescope spot has a definite bearing on the apparent resolution, as pointed out in the section on focus.
2. Contrast and brightness must be set correctly, and not high enough to make the spot "bloom".
3. Reflections (echoes, ghosts) can reduce the apparent resolution of the receiver if they fall within the wedge.
4. "Snow" on a weak signal will reduce the definition. On a very weak signal, the entire vertical wedge may be blurred and indistinct; on a strong signal the same set may show excellent resolution.
5. A few TV stations use experi, mental or temporary equipment-producing signals of low definition.

Figure 8. The NBC Test Pattern, showing the equivalent frequency and number of lines at the major points on the wedges.

PART III

A high percentage of television service calls, possibly 80%, are due to troubles that can be located and corrected without requiring a great amount of technical knowledge, providing the technician has been adequately informed of the common troubles and their symptoms and remedies in the particular model of TV receiver.

The other 20% of service jobs require capable and resourceful technicians with thorough understanding of basic television principles and considerable practical experience. Serious technicians realize this fact and are continually striving for clearer understanding of basic principles.

In this series of articles, we will cover many essential television principles in the process of showing how to diagnose troubles. Two essential principles are included in the present article.

We recommend that readers purchase a copy of the author's booklet "Television Trouble-Shooting and Alignment" which has recently been published by the RCA Service Co., Inc., Camden, N. J. This booklet shows how to localize troubles, describes the requirements for TV alignment equipment, and gives illustrated step-by-step alignment instructions for two popular makes of TV receivers. (40 pages, 49 illustrations, price $1.00).

To check the over-all (rf, if, video) frequency and phase response of a television receiver, we would ordinarily need three pieces of laboratory equipment—

1. A square-wave video signal generator.
2. A high-frequency oscillator, amplitude modulated by the video generator.
3. A wide-band cathode-ray oscilloscope.

When a test pattern is available, however, the over-all frequency and phase response of the television set can be checked quickly and conveniently by observation and analysis of the test pattern on the kinescope.

1. The wedges in the test pattern take the place of the square-wave video signal generator.
2. The TV station provides the rf signal, which is amplitude-modulated by the square-wave video signals of the wedges.
3. The kinescope takes the place of the wide-band oscilloscope.

Figure 1 shows both of these setups. The test pattern and the kinescope provide a very convenient and useful testing system for everyday TV service. But we must furnish the initiative, the persistence, and the time to learn how to use them.

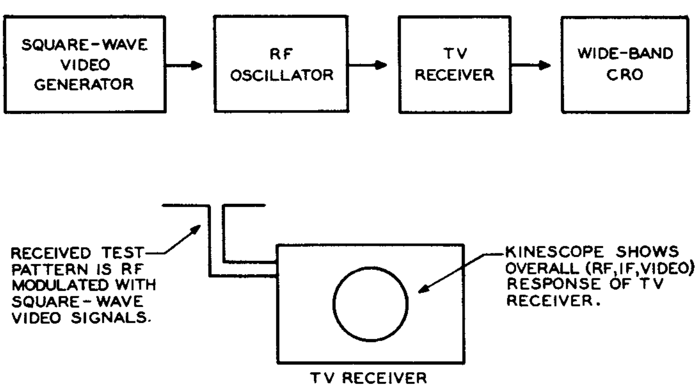


Figure 1. Comparison of two methods of checking TV response.

Wedges are Video Signals

It is important to understand that the wedges in the transmitted test patterns are much more than a collection of black and white lines. They actually represent video signals ranging from about 30,000 to 4,000,000 cycles-per-second.

These video signals are generated in the camera tube and are used to amplitude-modulate the station's carrier. The transmitted video signals are square-wave at the lower frequencies, and esssentially sine-wave at the higher frequencies.

The following simple analogy may help in understanding how the wedges are utilized at the transmitter in producing this wide range of video signals: When a boy runs a stick across a picket fence, he generates a noise, or an audible signal. The frequency of the signal depends on the speed of the stick and the number of pickets in a given distance.

Suppose the boy had a V-shaped trellis with 5 pickets, as shown in Figure 2. As he draws the stick across the pickets, the *motion* at the tip of the stick resembles a series of square waves. If the stick is drawn across at the top in one second, it traces 5 square waves in one second, or a frequency of 5 cycles-per-second.

If the stick is drawn *at the same speed* across the bottom of the trellis, which is half the width of the top, it traces 5 square waves in ½ second. This is a rate of 10 cycles-per-second, double the previous frequency.

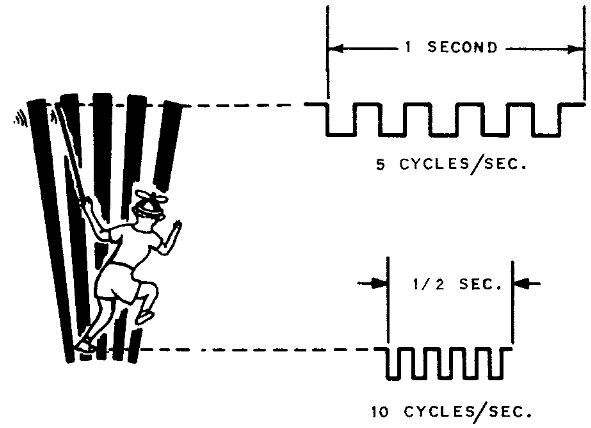


Figure 2. Analogy to vertical wedge in test pattern.

In an analogous manner, as shown in Figure 3, the camera tube at the TV transmitter produces an electrical square-wave signal as the electron beam in the camera tube is drawn across the image of the vertical wedge. But in this case the frequency is very high because the beam crosses the wedge in a few millionths of a second.

In this particular example, there are 10 black and 10 white lines in the wedge, equivalent to 10 cycles. (For simplicity, there is assumed to be a white line at the right-hand side of the wedge.)

At the top of the wedge, the beam crosses the 10 cycles in 5 millionths of a second, or 5 microseconds: In one microsecond, the beam crosses 2 cycles. This is equivalent to a rate of 2 million cycles-per-second, or 2 Mc.

At the bottom of the wedge, which in this example is half the width of the top, the beam crosses the 10 cycles in ½ the time, or in 2.5 microseconds: In one microsecond, the beam crosses 4 cycles. This is equivalent to a rate of 4 million cycles in one second, or 4 Mc.

When the beam scans across other points along the wedge, the generated frequency is between 2 and 4 Mc.

The horizontal wedge can be analyzed in the same manner, but for our purpose it is sufficient to know that in test patterns where the center line of the horizontal wedge is about ¼ the length of a horizontal scanning line, it represents a half-cycle of a 30-kc square wave. In the RCA Indian-head pattern the horizontal lines (at bottom center) represent half-cycles of square-wave signals ranging from about 19 kc. to 0.6 Mc.

Signal-Wave Form vs Brightness

Electrical signals are changes in voltage during a period of time. Such signals are shown in books and on the screens of cathode-ray oscilloscopes as "waveshapes" or "waveforms".

In radio, if we want to see the wave-form of audio-frequency signals, we must use an oscilloscope.

In television we have a tremendous advantage because, *without* using an oscilloscope, we actually see each of the thousands of video signals that form the complete test pattern or picture. *We see these signals not as waveforms, but as changes in brightness along each scanning line on the kinescope:* We see signals that last for as little as one-tenth of one-millionth of a second; we see other signals that remain unchanged for as long as 53 millionths of a second.

To take advantage of this graphic display of the picture signals, we must understand the relation between the changes in brightness and the waveform of the signal that produces these changes: We must learn to look at any section of a

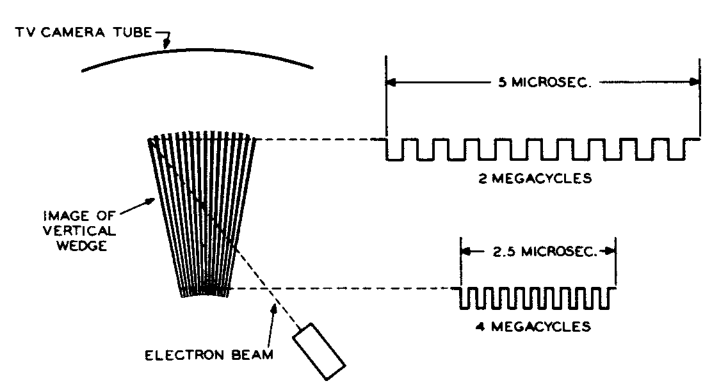


Figure 3. Vertical wedge is used in providing square-wave video signals of a wide frequency range.

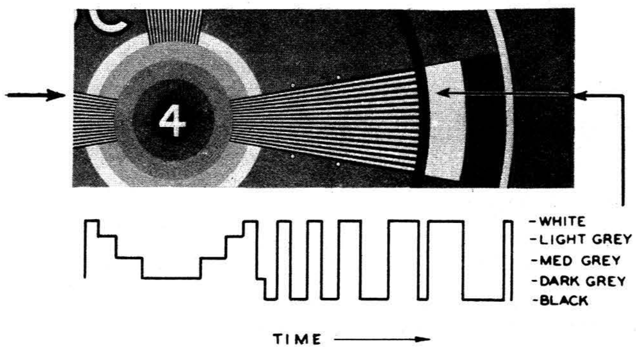


Figure 4. Waveform of signal voltage along one line of WNBT test pattern.

scanning line and immediately visualize how the signal voltage must be changing to produce the changes in brightness that we see along the particular scanning line.

The following paragraphs briefly cover this subject:

The intensity of the electron beam in the kinescope, and consequently the brightness of the spot, depends on the voltage at any instant between the grid and cathode of the kinescope.

If we connect an electronic voltmeter between the grid and cathode of the kinescope, and vary the grid voltage, by means of the brightness control, we can observe how the brightness of the spot or raster changes as the grid voltage is changed. An arbitrary example of this relation is listed below:

Kinescope grid voltage	Brightness of spot or raster
0 v	Bright (—white—)
—10 v	Light grey
—20 v	Medium grey
—30 v	Dark grey
—40 v	Black

(For simplicity, we are using a reference of zero volts for white.)

Assume that the receiver in this example is tuned to a TV station, and the brightness and contrast controls are correctly adjusted:

When the electron beam in the TV camera is scanning a white portion of the picture, the rf output of the transmitter is zero (for practical purposes). This results in zero signal voltage at the kinescope grid, which, as shown in the table above, is the condition that makes the spot bright, producing "white" on the kinescope.

When the camera is scanning a *black* portion of the picture, the rf voltage output of the transmitter is maximum (for picture signals). This produces maximum negative signal voltage at the kinescope grid, or —40 volts in the above example. This is the condition that extinguishes the spot, producing "black" on the kinescope.

When the camera is scanning a grey portion of the picture, the rf voltage output of the transmitter is some percentage of the black signal output. This produces the same percentage of the maximum negative signal voltage at the kinescope grid, and results in the same shade of grey on the kinescope.

We are not particularly interested in the actual values of signal voltage at the kinescope grid, because it is preferable to think in terms of percentage, or relative signal voltage, as listed below:

Spot Brightness	Relative Signal Voltage
Black	100%
Dark Grey	75%
Medium Grey	50%
Light Grey	25%
Bright (—white—)	0

(For simplicity in this discussion, we are omitting reference to the sync pulses, which are 33% higher in voltage than the black signal level.)

It should be pointed out that the "blackness" of black portions on the kinescope depends on how much direct or stray light from lamps and windows is illuminating the front of the kinescope. In a pitch-dark room, the black portions of the picture are quite black, but in a bright room, the black portions of the picture can not be darker than the front of the kinescope appears when the TV set is turned off. This may seem like an obvious fact, but it is frequently overlooked. In visualizing the waveform of the signal, it is desirable to have the kinescope screen reasonably well shaded so that the blacks will be black.

Figure 4 shows how the signal voltage changes along one scanning line in the NBC test pattern. We have shown the background of this pattern as a medium grey, but the printed illustration may appear as a lighter or darker grey.

Figure 5 shows how the signal voltage changes along one scanning line in the RCA Indian-head pattern.

For practice, we recommend that the reader sketch out the changes in signal voltage across other lines in those test patterns. There is no better way to become acquainted with this subject.

PART IV

In the first three articles of this series we explained the function and the application of television test patterns in analyzing the response of television receivers. These articles contain a large amount of practical information which to the best of our knowledge is not available elsewhere.

We have now paved the way for the second major section of this series: Starting in this article, and continuing for several issues, we will analyze the effects of actual troubles with the graphic aid of several hundred photographs that have been made by the author specifically for these articles. These photographs clearly show how the picture or test pattern is affected by various faults in different sections of a typical television receiver.

Portion of Patterns for Clarity

Test pattern photographs are frequently printed in such a small size that most of the details are lost. It is not practical to use a magnifying glass to enlarge the printed reproduction because the dot structure involved in the half-tone printing process spoils the enlargement. If the photographs are printed in large enough size to make the details visible, only a few can be shown on each page. To overcome these limitations, the author is showing only a small portion of photographs in cases where it is necessary to observe small details. In this way it is possible to include numerous photographs on each page and yet maintain a sufficient size so that the reader can observe the desired effects.

The reader is probably aware that printed reproductions are not as sharp or as clear as the original photographs, and that some of the finer effects are lost in the printing process.

Specially Designed Receiver

The receiver used in making these photographs was specially designed and constructed to facilitate the work, and will be described in a later issue.

The receiver employs essentially the same circuit as the standard RCA Model 630TS, 8TS30, etc. Readers who wish to brush up on the function and action of the circuits in this type receiver, as an aid in studying the photographs, should obtain the 630TS service notes. These are included in a booklet "RCA Television Service Data", Form TV-1003, available through RCA distributors at $1.50.

Video Troubles in This Issue

The photographs in this issue show how the TV picture is affected by certain troubles in the video amplifier. The circuit of the amplifier is shown in Fig. 1. The caption under each photograph states the nature of the trouble and describes the principal effects that are evident in the picture.

Inspection of the photographs will show that the troubles selected for this issue affect the picture "quality" and are generally accompanied by "smearing" that ranges from a slight to a severe condition.

It must be mentioned that some of the troubles pictured here can be duplicated in part by incorrect conditions of rf-if alignment. These troubles will be covered in a later article.

Other troubles in the video amplifier, such as open coupling capacitors, open plate, screen, or cathode circuits, dead tubes, etc., will result in complete absence of the picture, or a very faint picture.

A third class of trouble in the video amplifier is caused by incorrect bias, which may be due to off-value resistors, leakage in coupling capacitors, etc.

Any serious trouble in the video amplifier may produce symptoms of sync failure. However, even when the picture is completely out of sync and will not remain stationary, it is possible to judge the picture quality and to determine from this, and from the appearance of the sync pulses, whether the trouble is due to incorrect rf-if-video response, or to a defect in the sync circuits.

Other Troubles in Following Issues

Study of the effects pictured in this and the succeeding articles will help to pave a smooth path to our goal, which is the development of a comprehensive and logical troubleshooting procedure based on analysis of the picture.

In the following issues we will show photographs of the effects of troubles in the horizontal deflection, vertical deflection, rf-if, sync, and power-supply sections.

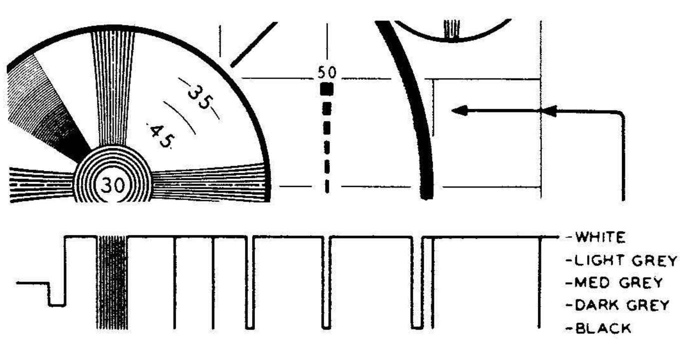


Figure 5. Waveform of signal voltage along one line in RCA test pattern.

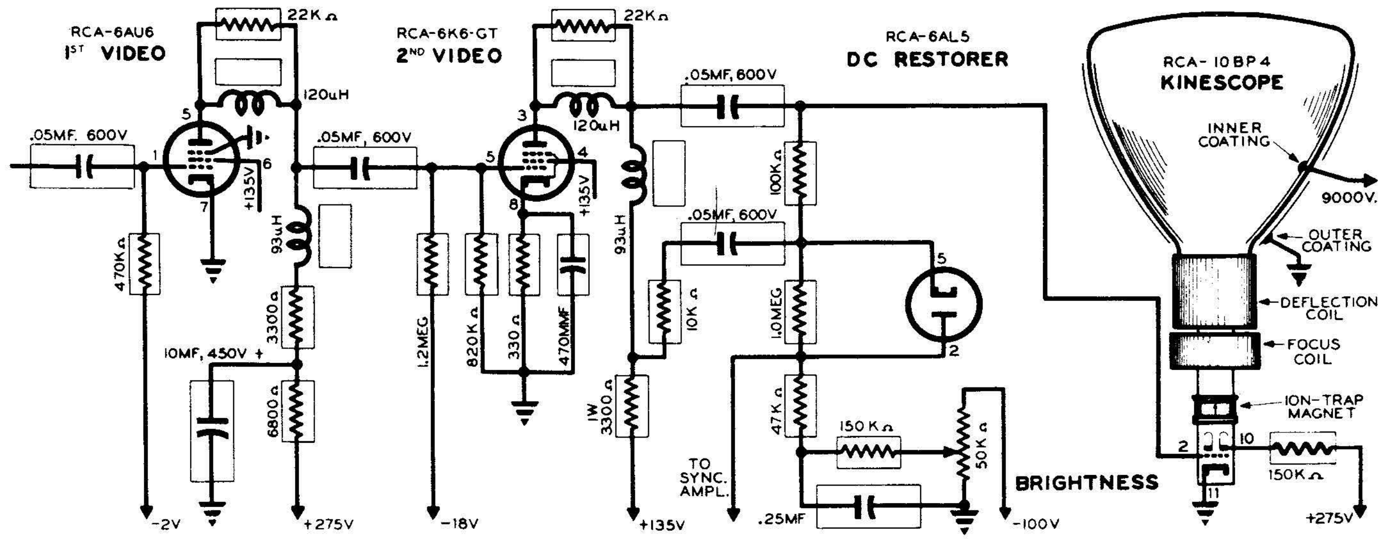


Fig. 1—Schematic of video amplifier as it appears in the special TV receiver used for these photographs. The illustrations in this article show how the picture quality is affected by various troubles in this circuit.

Fig. 2—This shows normal conditions. There is a slight trailing light-grey smear on the right-hand side of the lettering, and after the lines in horizontal wedge.

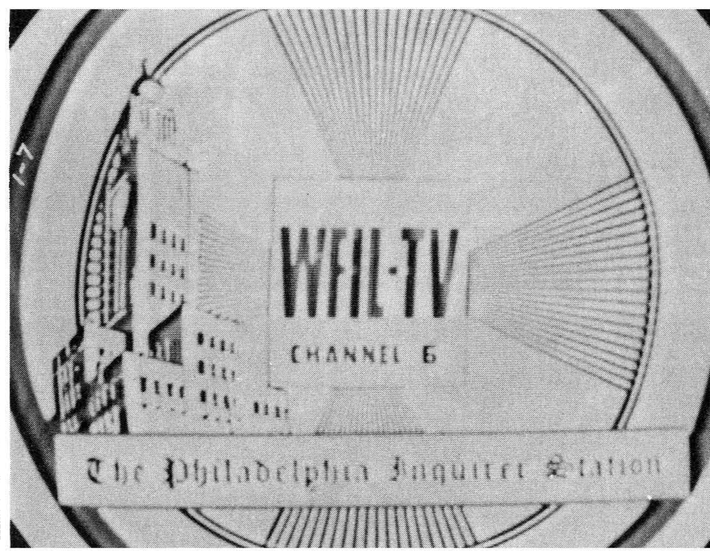


Fig. 3—Poor low-frequency response. 2nd-detector load resistor, not shown in schematic, dropped from 3900 to 100 ohms. Note trailing reversal, white after black, on right-hand side of lettering. Lettering and outer circle are not uniform black, as evident in cross-bar on letter T.

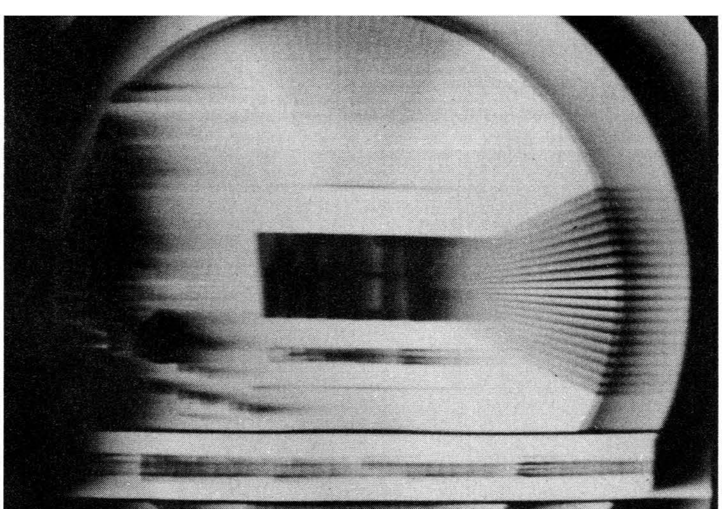


Fig. 4—Excessive low-frequency response and phase shift. 2nd-detector load resistor increased from 3900 to 100,000 ohms. Note smearing of lettering and horizontal wedge, and almost complete wiping out of vertical wedge.

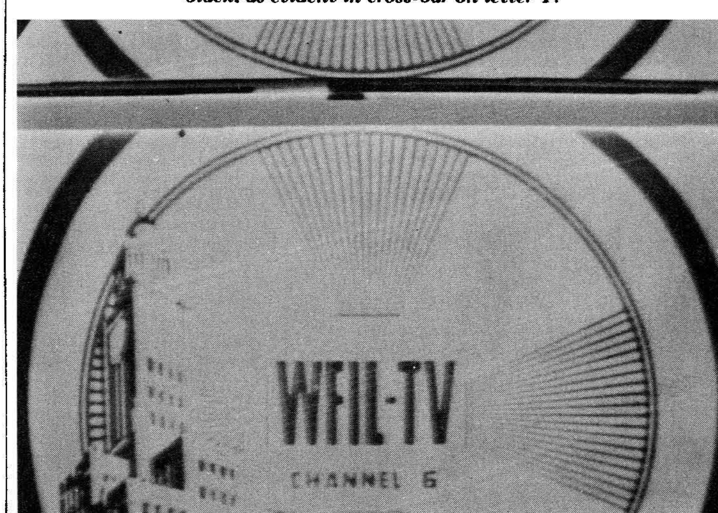


Fig. 5—Low-frequency phase shift. 1st-video grid resistor dropped from 470,000 to 3000 ohms. The contrast was turned down, brightness turned up, and vertical hold control adjusted to show vertical blanking and sync. Note trailing reversal after vertical sync, and after vertical blanking.

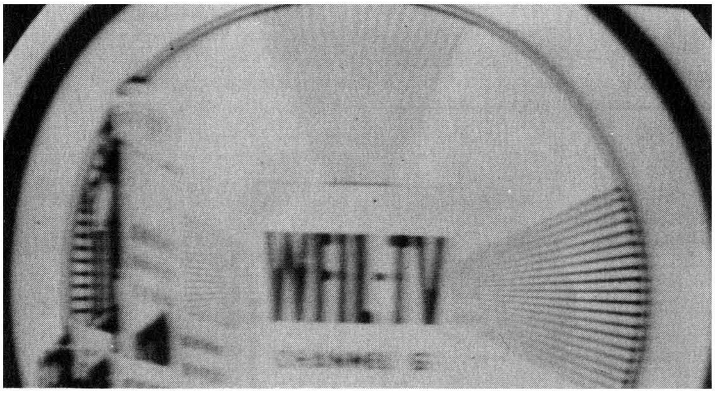


Fig.6—Poor high-frequency response. 1st-video plate filter capacitor (10 uf) open, effectively increasing plate load resistor from 3300 to 10,100 ohms (3300 plus 6800). General smearing of wedges except center lines in horizontal wedge.

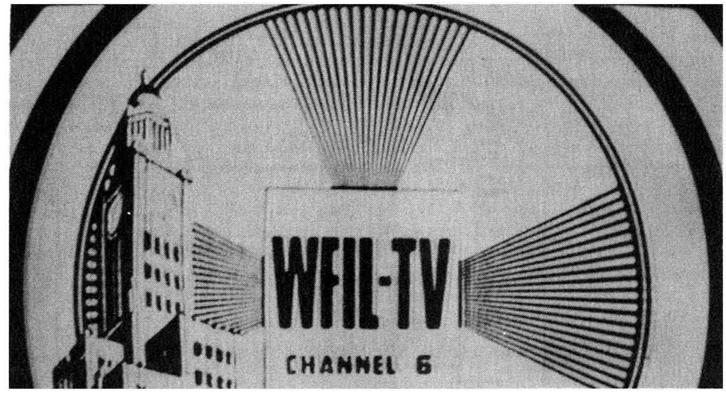


Fig. 7—Excessive high-frequency response. 1st- or 2nd-video plate load of 3300 ohms dropped to 1000 ohms. Reduces low-frequency response, exaggerating highs. Note trailing reversal, white followed by a fine dark line, after lettering.

Fig. 8—Excessive low-frequency response. 1st- or 2nd-video plate load of 3300 ohms increased to 10,000 ohms. Increases low-frequency response, decreases highs. General smearing of both wedges except center lines in horizontal wedge. Same general effect as shown in Figs. 4 and 6.

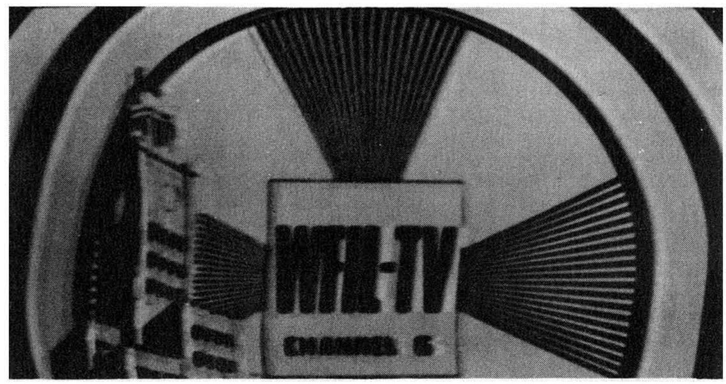


Fig. 9—Trailing reversal, white after black, produced by 2nd-video cathode resistor increasing from 330 ohms to 1500 ohms. Resulting incorrect bias makes it difficult to obtain suitable contrast.

Fig. 10—Hum in video, produced by heater-cathode leakage (700 ohms) in 2nd video stage. Hum voltage darkens some portions and lightens other portions of picture. Hum also gets into horizontal sync, distorting shape of picture.

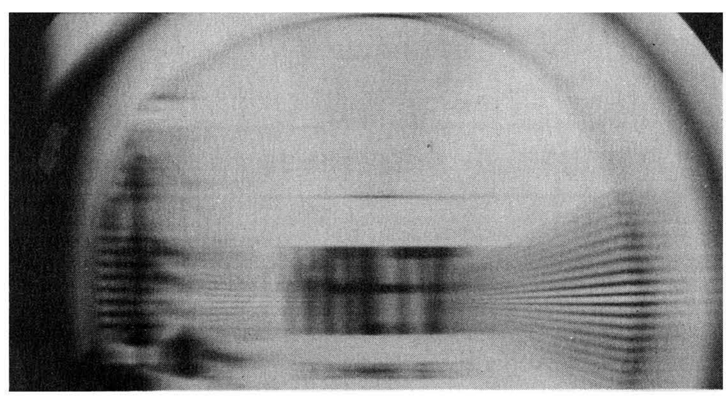


Fig. 11—Loss of highs, and low-frequency phase shift produced by open coupling capacitor (0.05 uf) to the kinescope grid. Note that vertical wedge is practically wiped out. Note smear after lettering and after horizontal wedge.

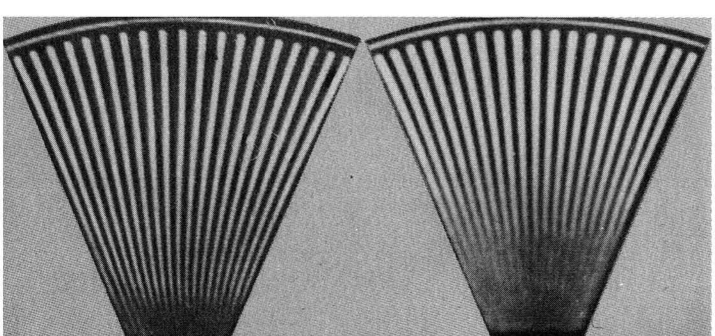


Fig. 12—Vertical wedge at left shows normal conditions in video amplifier. Wedge at right is with the 120-microhenry peaking coil in the 1st-video amplifier open. This condition reduces definition in the vertical wedge and makes the wedge and lettering fuzzy.

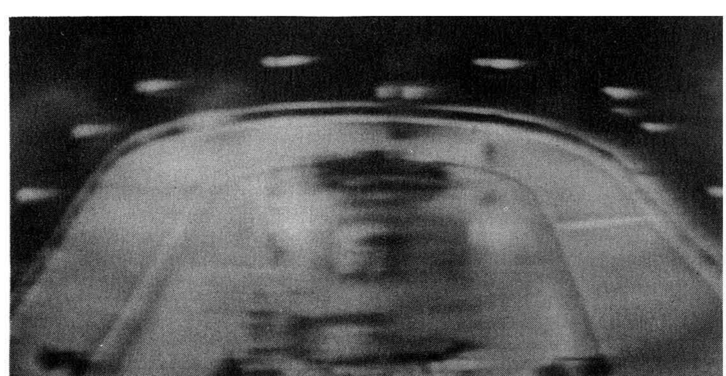


Fig. 13—Believe it or not, this is a roller-skating rink. The smearing is not caused by trouble in the receiver, but by unusually poor TV relay conditions. Moral. Don't tear the set apart until reception has been checked on other stations or on other receivers.

PART V

How RF-IF Alignment Affects Picture Quality

In the previous issue, through the aid of numerous photographs that were made by the author especially for this series of articles, we showed how the picture quality is affected by various troubles in the video amplifier of a typical television receiver. In this issue, continuing the series of photographs, we show how the picture quality is affected by incorrect rf-if alignment.

The poor picture quality shown in *Fig. 1.* was produced simply by detuning one adjustment in the picture-if amplifier: The adjacent-channel sound trap, normally 27.25 Mc in this particular receiver, was detuned to about 26 Mc. This reduced the gain of the amplifier near the picture-carrier frequency of 25.75 Mc, decreasing the amplitude of low-frequency modulation, and producing poor phase response.

Note in Fig. 1 that the longer horizontal lines, which represent low-frequency picture signals, are weak or grey, while the lines in the vertical wedges, which represent high-frequency signals, are stronger or blacker. Note that the outer circle, which should be a uniform black across any scanning line, is composed of seven different shades followed by a white trace (trailing reversal).

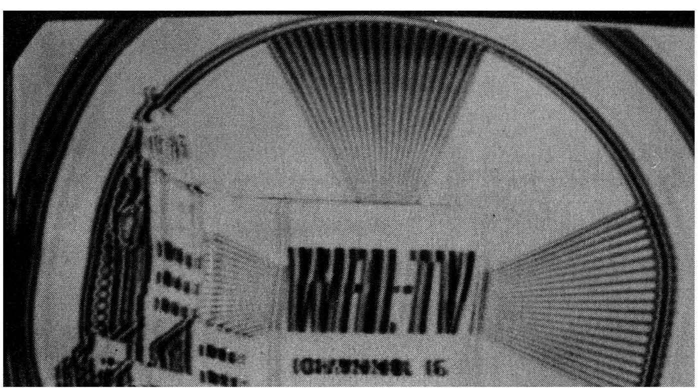


Fig. 1—Did you guess the trouble in this picture? It is poor rf-if alignment. Read text for details.

Because of the poor low-frequency response, the horizontal sync action is not good, as evidenced by sidewise distortion in the shape of the circle. This distortion will vary with different scenes, and with motion of persons or objects in the picture. The effect is caused by picture signals "getting into" the sync. If the trap were tuned still closer to the picture-if of 25.75 Mc, the low-frequency signals would be virtually eliminated, and it would be impossible to hold the picture in sync.

Without alignment equipment (sweep, calibrator, and CRO), a technician might fumble around for days before locating the reasons for the poor picture quality shown in Fig. 1. Remember that this picture is the result of only *one* misadjustment.

It should be understood that incorrect rf-if alignment can cause other troubles in addition to poor picture quality. Incorrect alignment can produce unstable sync, inadequate blanking of the return lines, excessive noise in the picture, regeneration, and interference.

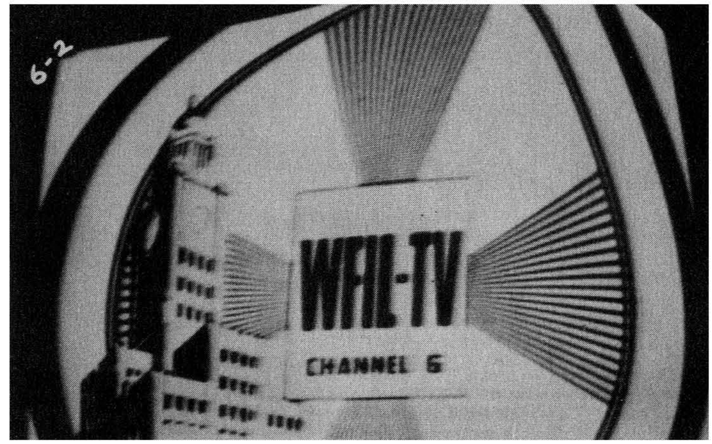
The numerous troubles that can originate in the rf, oscillator, converter, picture-if, second detector, and video amplifiers can be located quickly and easily with the aid of good alignment equipment.

Alignment equipment has particular interest for the writer, who has used a wide variety of such instruments during the last ten years, and has also designed several sweep-frequency generators and calibrators for special applications. The writer recommends the RCA WG-59A Sweep Generator and the RCA WR-39A Calibrator as being the most suitable and most accurate instruments on the market. The calibrator merits particular attention because it is the only TV service instrument available that provides the necessary crystal calibration at every quarter-megacycle point, not only in the if range, but throughout the rf range as well.

After studying the photographs in this article and in the previous one, it should become obvious to the reader why we devoted several of the early issues to an understanding of the wedges in the test pattern. Readers may find it helpful to review these early issues.

One major subject that is necessary for good understanding of how rf-if alignment effects the quality of the picture has not yet been covered. This subject is outlined in simplified form in the following paragraphs. It will be explained in detail in future articles.

TV picture signals are transmitted as amplitude-modulated waves. Low-frequency picture signals appear as two sidebands, one on each side of the carrier and relatively close to it. High-frequency signals appear as a single sideband, spaced relatively far from the carrier.



Try to determine the cause of this picture defect. The answer will appear in the next issue.

With normal rf-if alignment in a TV receiver, the carrier is placed at about 50% or half-way down the slope of the response curve. On high-frequency signals, where there is only one sideband, it falls on the flat-top of the response curve, so it is amplified 100%. On low-frequency signals, both sidebands are received: One is amplified less than 50%, and the other is amplified more than 50%. For example, for some particular low-frequency picture signal, one sideband is amplified 40%, while the other is amplified 60%. At some higher signal frequency the gain is 10% and 90%, etc. The two sidebands add together to provide approximately 100% amplification.

Consequently, with normal rf-if alignment, the amplification is the same for both low-freuqency and high-frequency picture signals. This type of response is generally desirable.

If the carrier is placed lower than 50%, the gain at low frequencies is reduced. If the carrier is placed higher than 50%, the gain at low frequencies is increased.

The principal picture components and the blanking and sync pulses, represent relatively low frequencies, but the sharp edges on these signals require good high-frequency response also.

In considering rf, the low-frequency picture signals are relatively close to the *rf* carrier. In considering if, the low-frequency picture signals are relatively close to the *if* carrier. The if carrier is usually at the high-frequency end of the if response band. The carrier frequency, rf or if, corresponds to zero frequency in the video amplifier.

Bandwidth is always measured from the carrier frequency to a point on the opposite slope; this point is usually taken as 50% down.

It must be remembered that incorrect alignment is not always the primary reason for poor rf-if response. Off-value damping resistors (across the tuned circuits), open plate, screen, and grid-return bypass capacitors, open coupling capacitors, off-value coupling components, and regeneration, all affect the rf-if response. Abnormal bias on one or more of the rf-if tubes may cause poor response. This condition in turn may be due to a leaky coupling capacitor, or to a defect in the automatic gain control circuits, etc. Excessive input signal from a nearby TV station may necessitate biasing off several if tubes which also affects the frequency response.

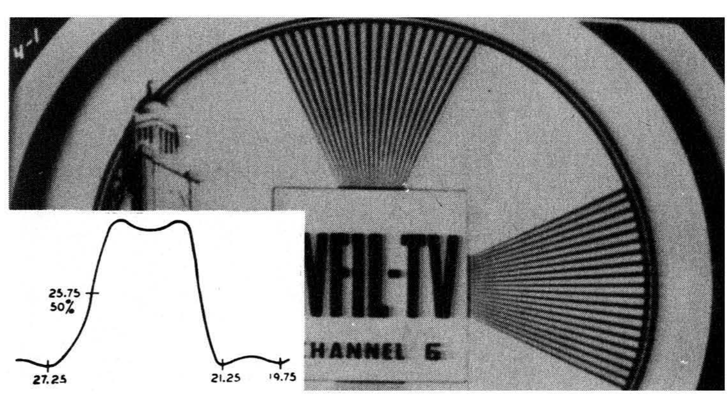


Fig. 2—Normal response with normal alignment, carrier at 50%

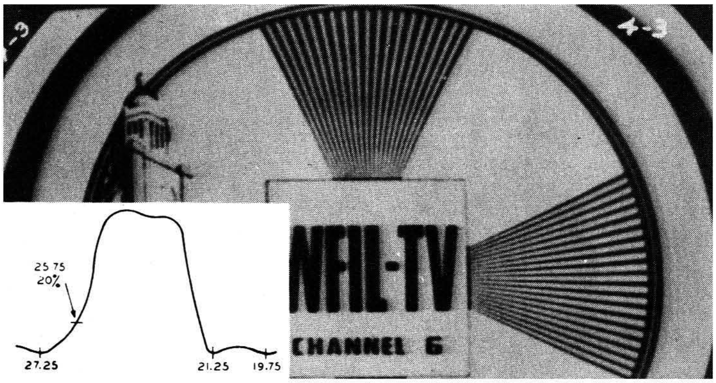


Fig. 3—Picture carrier at 20%. Good picture quality. Signal-noise ratio not as good as for alignment in Fig. 2.

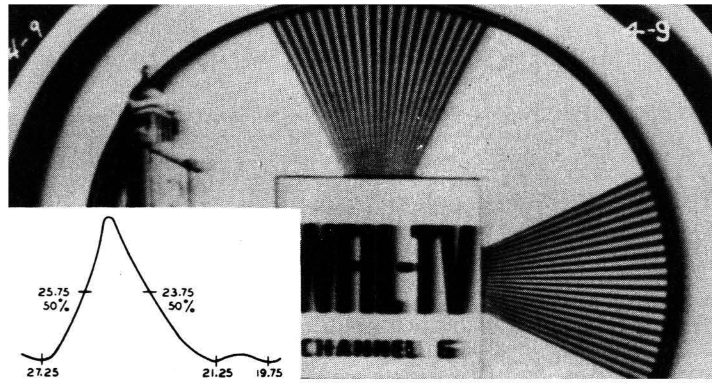


Fig. 7—Narrow bandwidth, single peak response, with carrier at 50%. Vertical wedge becomes lighter beyond 3 Mc, but is not cut off sharply as in Fig. 6. Good signal-noise ratio.

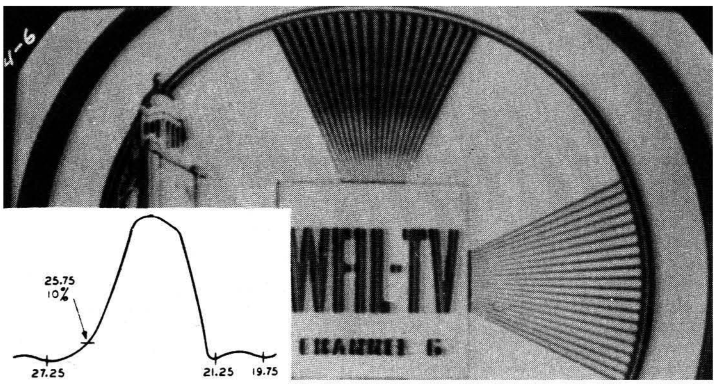


Fig. 4—Picture carrier at 10%. Poor low-frequency response, evidenced by the fact that horizontal wedge is lighter than vertical wedge. Poor sync, blanking, and signal-noise ratio.

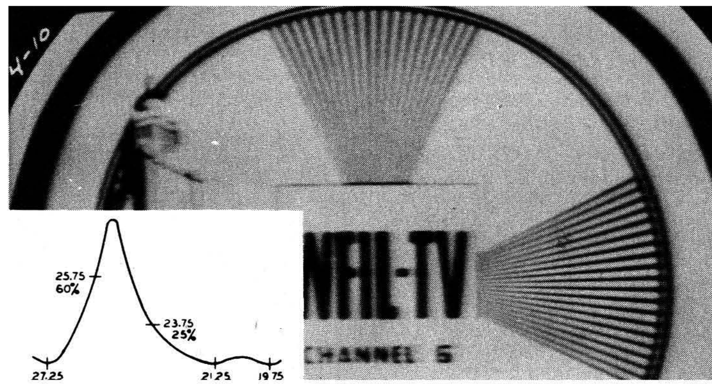


Fig. 8—Similar to Fig. 7, but vertical wedge is much weaker due to position of carrier, and narrower bandwidth.

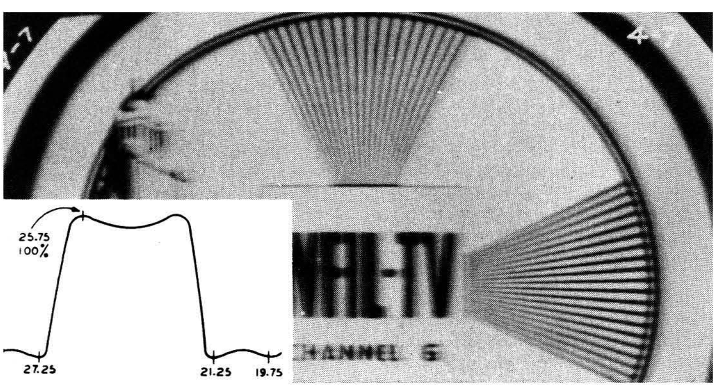


Fig. 5—Picture carrier at 100%. Excessive low-frequency response, evidenced by the fact that horizontal wedge is darker than vertical wedge. Considerable smear after lettering.

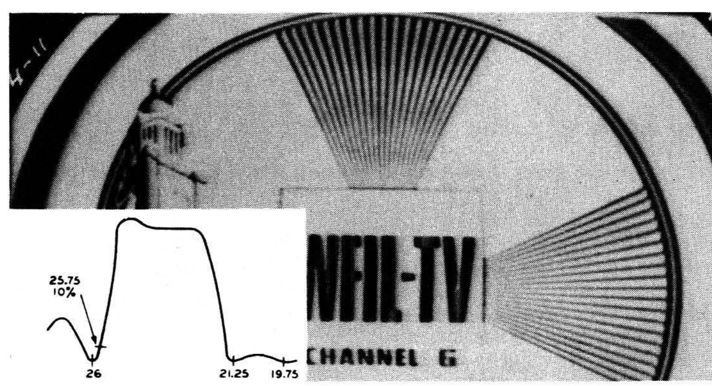


Fig. 9—Poor low-frequency response, evidenced by weak horizontal wedge. This was caused by tuning adjacent-channel sound trap close to picture carrier. Similar to Fig. 1.

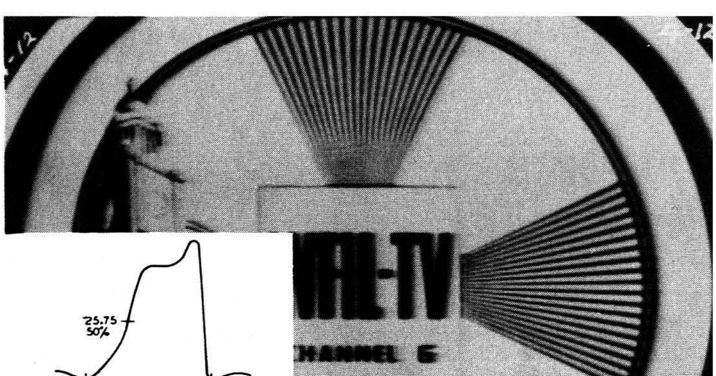


Fig. 6—Narrow bandwidth. Note that the lines in vertical wedge are cut off beyond about 3 Mc.

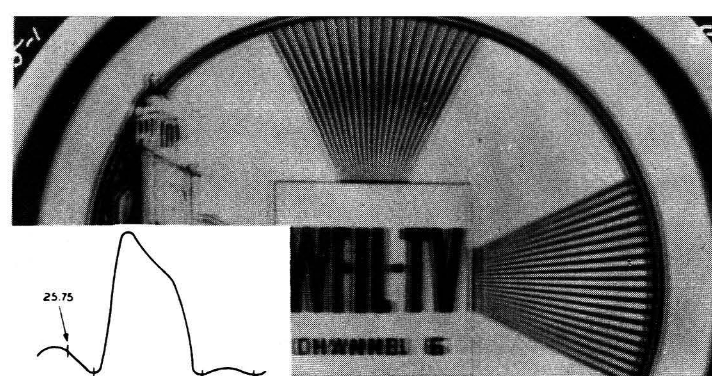


Fig. 10—Poor response in general, caused by tuning adjacent-channel sound trap lower than picture carrier. Note leading smear on left-hand side of lettering.

PART VI

Troubles in Horizontal-Deflection and High-Voltage Circuits

The essential factor in successful television trouble-shooting is the ability to analyze any particular trouble as it appears in the picture or on the raster, and from this mental analysis to localize the trouble to one particular section of the receiver. From then on, it is usually a fairly simple matter to check the tubes, voltages, and components in the suspected section and to find the exact cause of trouble. Of course, if the trouble is due to incorrect rf-if alignment, it is necessary to use a sweep generator, calibrator, and CRO to realign the receiver.

In general, troubles in any particular section of a TV receiver produce effects in the picture, raster, or sound, characteristic of that particular section. Troubles in different sections produce different effects. The best way to explain and classify these effects is by means of photographs. For this reason the author has made several hundred photographs of screen patterns showing specific troubles. These pictures were made using the RCA Television Dynamic Demonstrator to facilitate the work. The trouble and causes as described apply to this basic type of television receiver circuit and not necessarily to others.

For the best results, we recommend that you obtain and study the author's RCA Television PICT-O-GUIDE (announced in this issue of RADIO SERVICE NEWS). Each PICT-O-GUIDE photo is reproduced with exceptional clarity on a special photographic type of card. They are systematically indexed and cover subjects and troubles which, in the main, we have not discussed elsewhere—due to space limitations and the type of paper and printing used.

In the two previous RADIO SERVICE NEWS issues we showed in brief, how picture quality is affected by troubles in the video amplifier and by incorrect rf-if alignment.

In this issue we show, briefly, how troubles in the horizontal-deflection and high-voltage circuit affect the raster or test pattern.

This circuit, diagrammed in Fig. 1, is fed from the output of the horizontal oscillator. If the oscillator fails, there will be no input and, consequently, no high voltage. Without high voltage, there can be no raster or scanning lines visible on the kinescope.

In the absence of a raster, the first step is to check the high voltage by means of a VoltOhmyst* and high-voltage probe such as the WG-284 or WG-288. If there is no high voltage, check the developed grid bias on the horizontal oscillator to see whether the oscillator is working.

Characteristic symptoms of trouble in horizontal-deflection circuits include:

1. Bright vertical bars on the raster.
2. Fold-over at the left-or right-hand side of raster.
3. Poor horizontal linearity that cannot be corrected by adjustment of the horizontal linearity, width, and drive controls.

*Trade Mark Reg. U. S. Pat. Off.

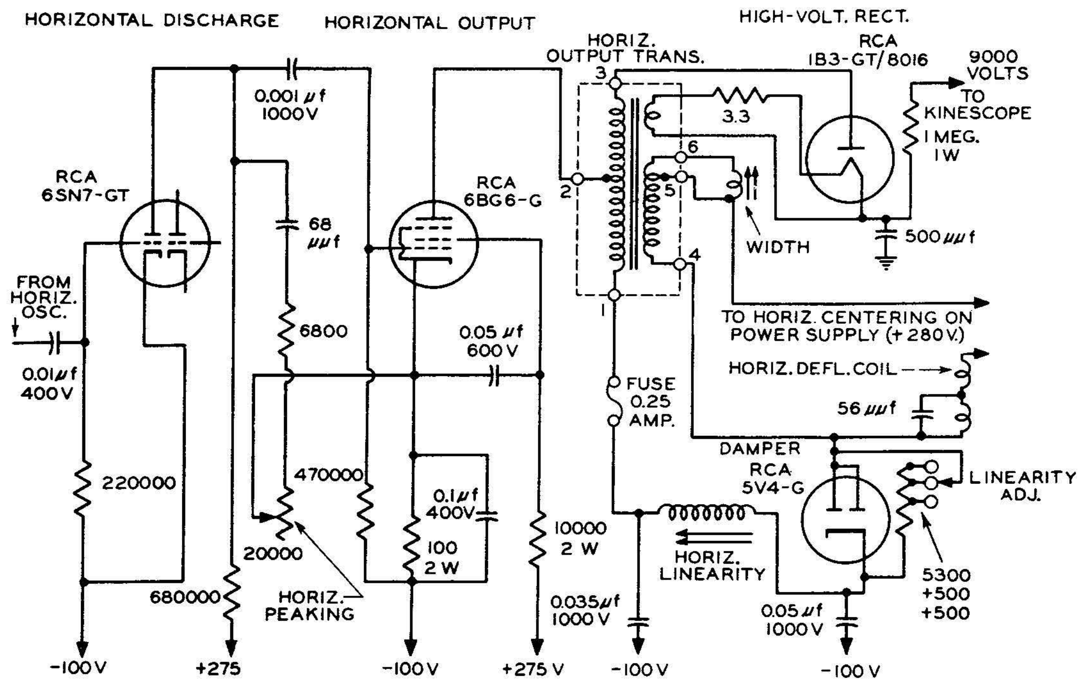


Fig. 1—Horizontal-deflection and high-voltage circuit used in producing the troubles shown in accompanying photographs. The input signal for this circuit is obtained from the horizontal oscillator which operates at 15,750 cycles per second.

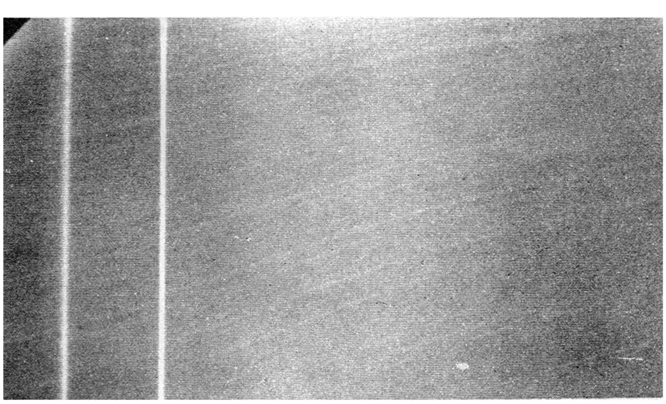


Fig. 2—Bright vertical lines at left-hand side of raster produced when the value of the plate resistor in the horizontal-discharge tube is changed from 680,000 to 200,000 ohms.

A PM speaker field near the top right-hand side of the flare of the kinescope pulled this picture out of shape. Reversing the magnet would squeeze the picture.

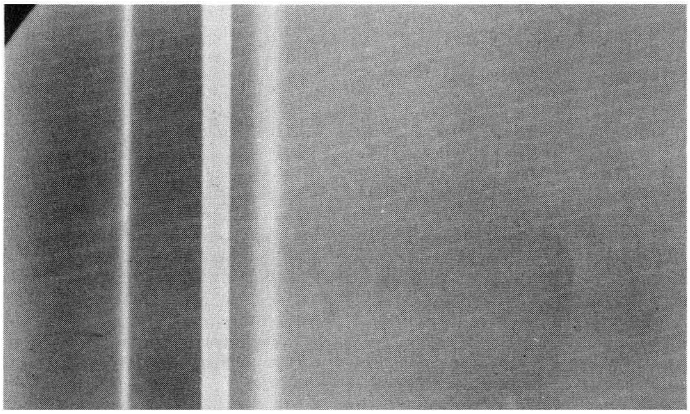


Fig. 3—Same general cause as Fig. 2, but produced by reduction of resistor value to 50,000 ohms.

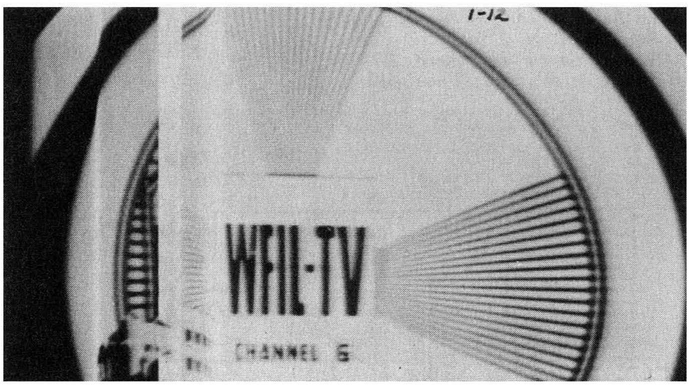


Fig. 4—Same trouble as Fig. 3, but with TV signal added to show effect on test pattern.

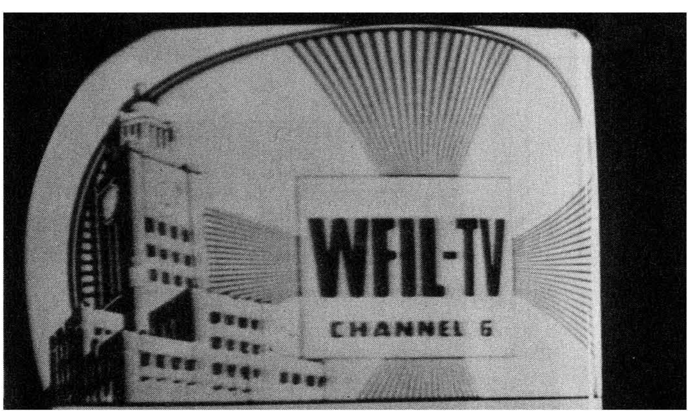


Fig. 5—Fold-over at right-hand side produced when the value of the grid resistor of the horizontal output tube is changed from 470,000 to 40,000 ohms.

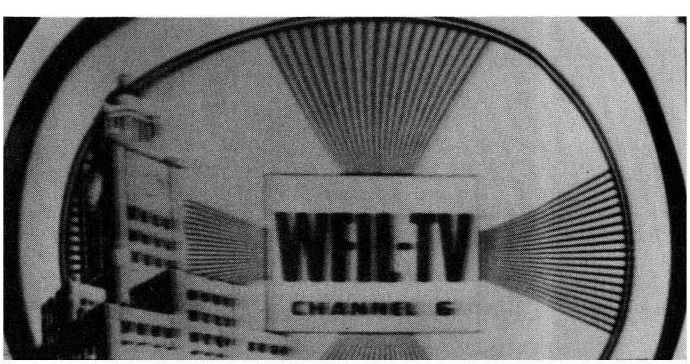


Fig. 6—Bright vertical line at right, and picture expanded at left produced when the 0.035-uf capacitor in plate return of horizontal output tube is opened; drive control set full clockwise.

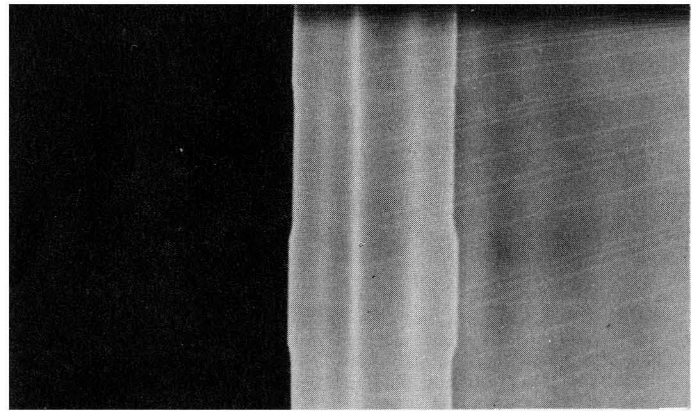


Fig. 7—Fold-over at left-hand side, produced by open 0.05-uf capacitor between cathode of horizontal damper tube and—100-volt bus

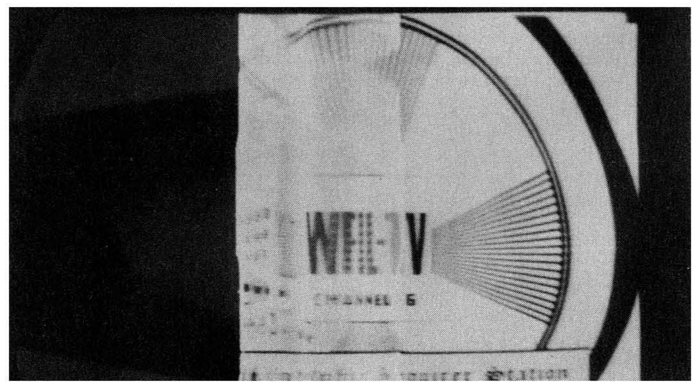


Fig. 8—Same trouble as Fig. 7, but with TV signal added to show effect on test pattern.

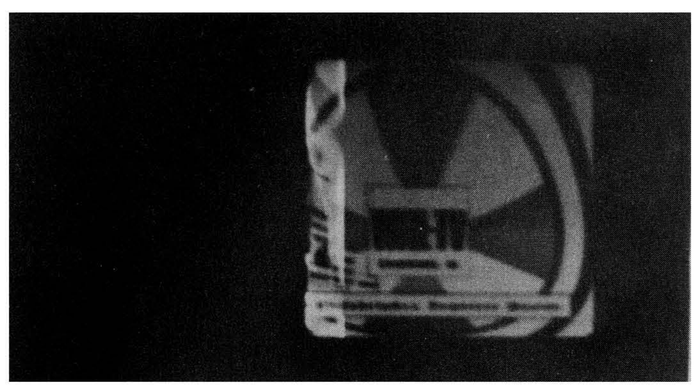


Fig. 9—Small dim picture with fold-over at left produced when damper tube is removed from socket. This photograph was taken in a dark room with high line voltage applied to receiver. Normally, failure of damper tube causes complete absence of raster or picture.

Fig. 10—Picture stretched at left produced by open resistor across damper tube

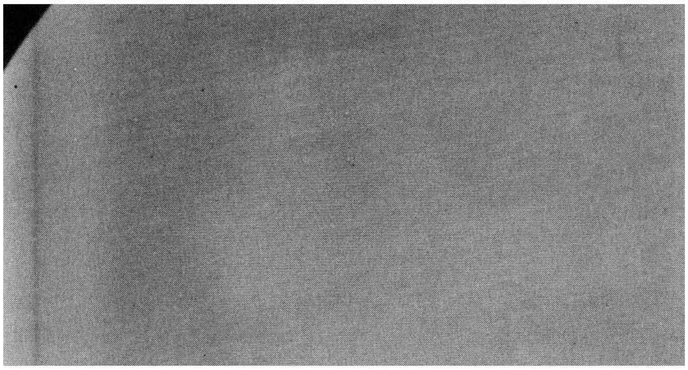


Fig. 11—Not all vertical lines are caused by trouble in the horizontal-deflection circuits. For example, the fine line at left—is caused by Barkhausen oscillation in the horizontal output tube. This interference is picked up in the input of the TV receiver. The effect is most evident on the higher channels when contrast control is turned up to maximum position.

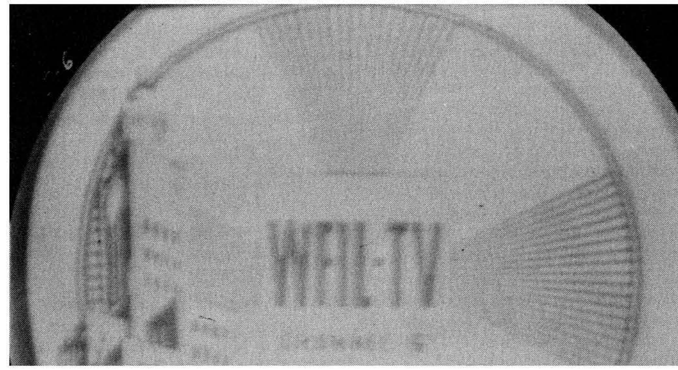


Fig. 12—Normal expansion in picture size when brightness control is turned up. Turning up the brightness increases the kinescope beam current so that the voltage drop across the 1-megohm high-voltage filter resistor is increased and the accelerating voltage decreased. As a result of the decreased accelerating voltage, the beam is more easily deflected and the picture becomes larger.

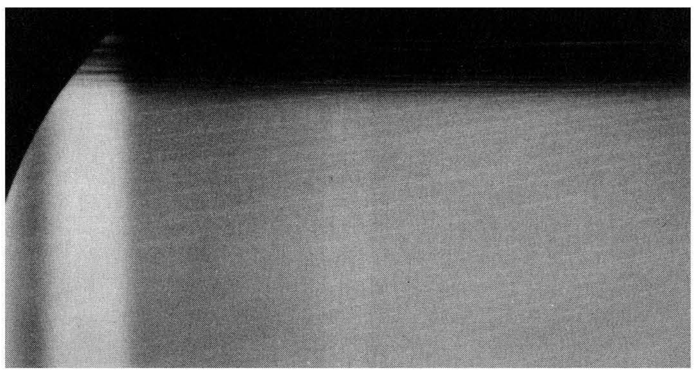


Fig. 13—Same trouble as Fig. 11, but greater intensity. This effect may be minimized by adjusting the horizontal drive control, checking lead dress and shielding, and, in extreme cases, by replacing the horizontal output tube.

PART VII

Vertical Deflection Troubles

It may be helpful at this time to review the guiding principle behind this series of articles. This principle was outlined in the first issue, from which we quote:

"When something goes wrong in a television receiver, it generally shows up as a definite symptom in the picture. On no other type of electronic equipment are the troubles and symptoms so clearly displayed before our eyes. *If we learn to recognize these visible symptoms, we can quickly localize the trouble to a particular portion of the set.* For those who hope to become expert in television service, it will pay to study, observe, and learn how to analyze symptoms in the television picture . . . in this series of articles we will concentrate on diagnosing and localizing troubles by analyzing their effects on the picture."

We began this series of articles by showing how the vertical and horizontal wedges, which are incorporated in virtually every variety of TV test pattern, can be used to determine the frequency and phase response of the receiver. We then showed, by means of actual photographs, how typical troubles in the video amplifier affect the picture, how incorrect rf-if alignment affects the picture, how troubles in horizontal deflection affect the picture, and now in this issue, how troubles in vertical deflection affect the picture.

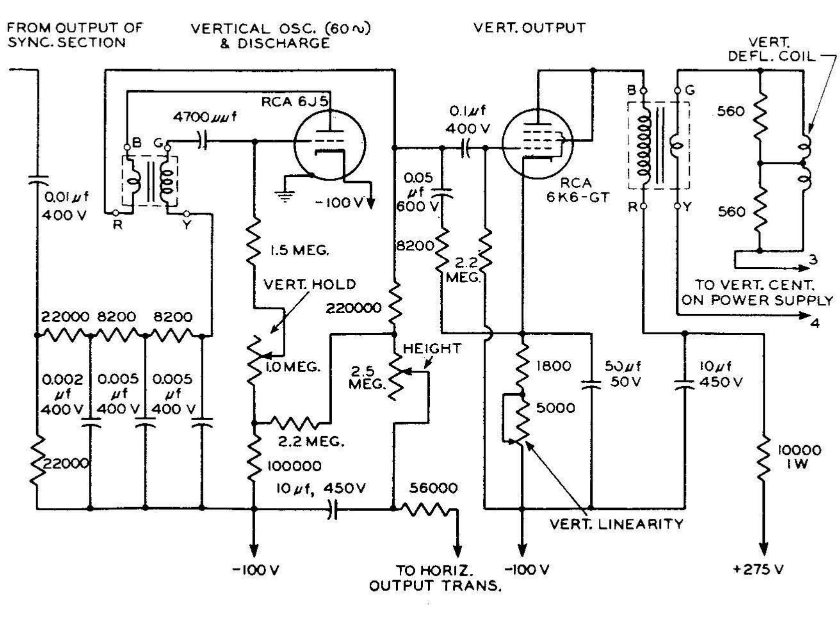


Fig. 1. Diagram of vertical oscillator and vertical-deflection section of a typical TV receiver.

We do not expect the reader to be able to look at a faulty picture and say, "That must be R192, or C287½". We will feel that we have accomplished our aim when the reader can look at the picture and decide definitely that the fault lies in one particular section of the receiver. Sectionalizing, or localizing of the trouble is 90% of the job, because any one section of a TV receiver is relatively simple, consisting of only a few tubes and a handful of components. Once the fault has been accurately localized to one particular section of the receiver, the rest of the job is relatively simple and straightforward. The tubes can be checked by substituting new ones. The components and circuit voltages can be checked with a VoltOhmyst.* The signal can be traced through the particular section with an oscilloscope, or "signal injection" may be used as outlined in this article.

The author has seen actual cases where much time was wasted by orienting the antenna and even installing new antennas in an effort to eliminate multiple pictures and "ghosts" that were due in one case to the horizontal oscillator being off frequency, and in several other cases, to incorrect rf-if alignment. These instances emphasize the need for accurate analysis and localization of troubles.

By reviewing the pictures that we have published thus far, the observant reader will note the following important facts as an aid in sectionalizing troubles:

1. Pronounced streaking or smearing is due to troubles in the video amplifier section.
2. Poor definition is generally due to incorrect alignment of the rf-if sections.
3. Foldover on the left- or right-hand sides of the raster, or bright vertical bars, are due to troubles in the horizontal deflection coils.
4. Foldover on the top or bottom is due to troubles in the vertical deflection section.
5. Keystoning on a direct-view electro-magnetically deflected kinescope is due to open or short circuits in the deflection coils.

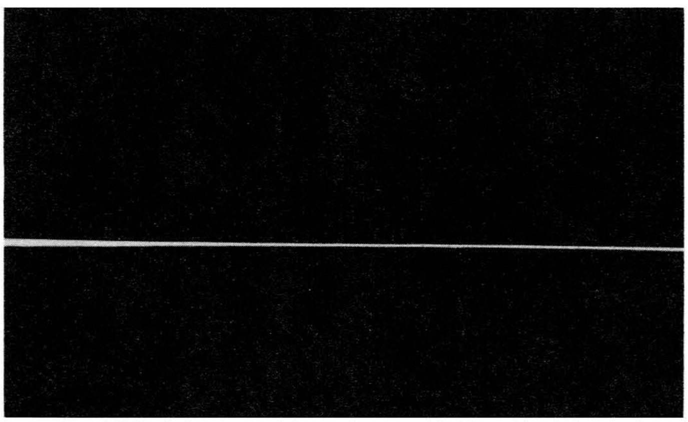


Fig. 2. Absence of vertical deflection. All of the horizontal scanning lines (approximately 500) are compressed into a single bright horizontal line. This photograph was made with a "dead" vertical output tube. The same effect is produced by failure of the vertical oscillator, by an open coupling capacitor between the vertical oscillator and the vertical output tubes, by an open winding in the vertical output transformer, or by an open circuit in both halves of the vertical deflection coil.

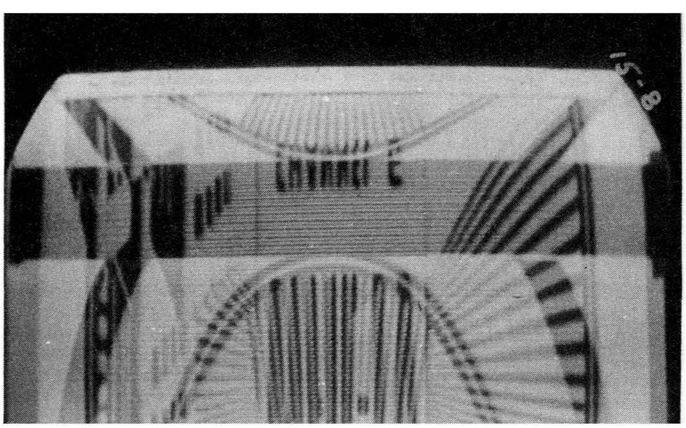


Fig. 3. When there is no vertical deflection, a quick check on the vertical output section can be made by introducing 60-cycle ac into the grid of the vertical output tube. When this picture was made the coupling capacitor between the vertical oscillator and the vertical output tubes was opened, and 60-cycle voltage was introduced into the grid of the output tube by placing a finger on the grid. The hum voltage picked up by the body is usually sufficient to produce some vertical deflection as shown above. Note in this picture that the test pattern appears to be wrapped around a cylinder, due to the sine-wave deflection. This simple check shows that the vertical output circuit, including the tube, output transformer, and vertical deflection coils, are in operating condition, thereby indicating that the trouble is ahead of the vertical output tube. As mentioned previously, the fault in this case was an open coupling capacitor between the vertical oscillator and output tubes. This system of "signal injection" to find troubles quickly in the vertical deflection circuit can be extended and improved by using a good audio oscillator, such as the RCA WA-54A to provide a 60-cycle sine-wave signal of adjustable amplitude. First feed the audio oscillator directly across the vertical deflection coils, then across the primary of the vertical output transformer, then into the grid circuit of the vertical output tube, and finally into the output circuit of the vertical oscillator. Absence of vertical deflection on the kinescope at any one of these test points will reveal the location of the trouble.

Fig. 4. When the raster or test pattern on a directly viewed kinescope has a trapezoidal or keystone shape, the trouble is usually due to a short circuit or open circuit in the deflection coils. In this photograph, one half of the vertical deflection coil is short circuited.

Fig. 5. Same effect as in Fig. 4, but the other half of the vertical deflection coil is shorted, causing keystoning in the opposite direction.

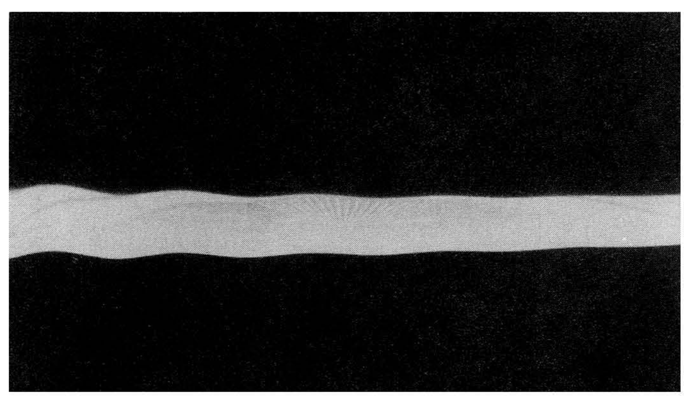


Fig. 6. Keystoning aue to an open circuit in one half of the vertical deflection coil.

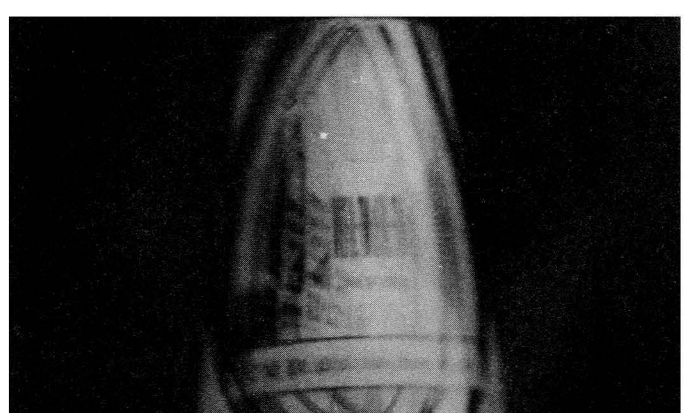


Fig. 7. Keystoning produced by a short circuit across one half of the horizontal deflection coils. This photograph is included in this issue so the reader may compare it with Figures 4, 5, and 6.

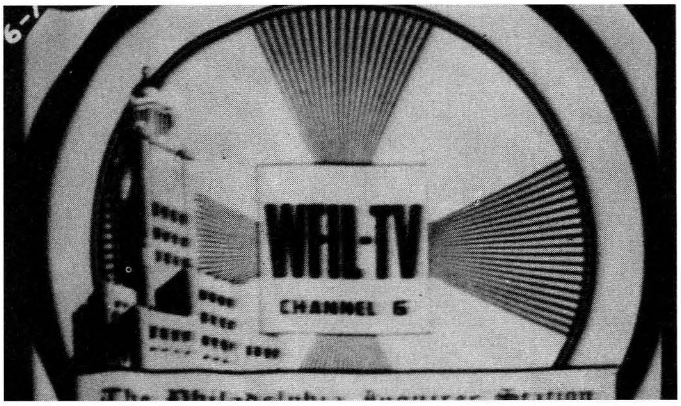


Fig. 8. Damped ripple (ripple of decreasing amplitude) on left half of each horizontal scanning line, produced by open resistors across both sections of the vertical deflecting coil. This damped oscillation occurs in the horizontal deflecting circuit and it is coupled into the vertical deflecting circuit. The resistors across the vertical deflection coils prevent the ripple from becoming evident.

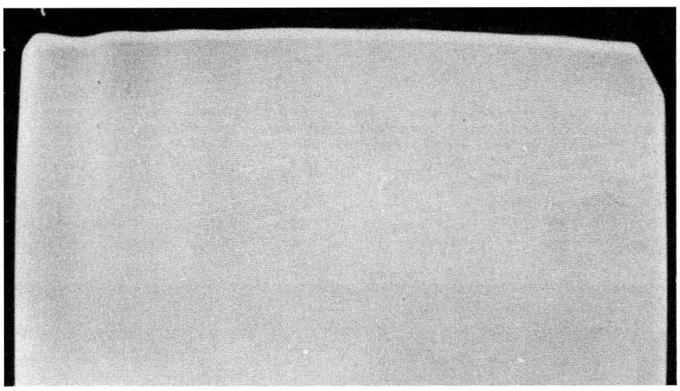


Fig. 9. In addition to the ripple shown in Fig. 7, faint dark vertical bars are produced on the left-hand side of the raster when both of the resistors across the vertical deflecting coils are opened. These bars show up more clearly on the raster alone in this photograph than on the test pattern of Fig. 8.

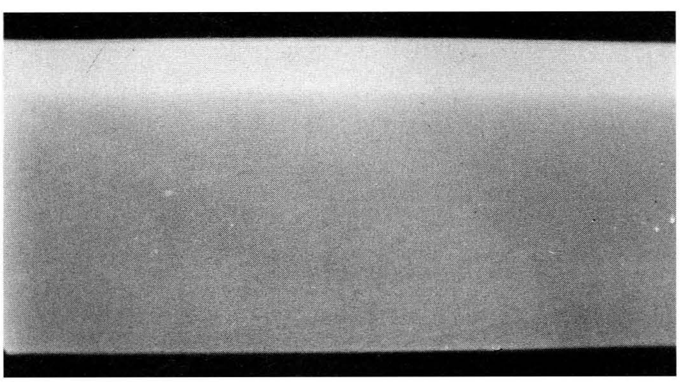


Fig. 10. Foldover or brightness at top of raster produced by heater-cathode leakage in the vertical output tube.

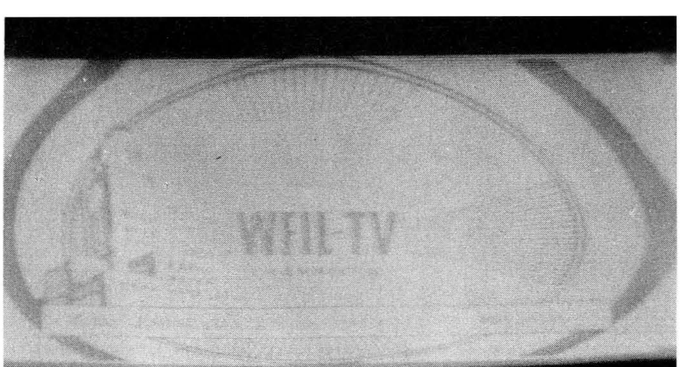


Fig. 11. Insufficient height and poor vertical linearity may be due to incorrect value of the vertical discharge capacitor (0.05 uf), or to open electrolytic capacitors in the cathode and plate circuits of the vertical output tube.

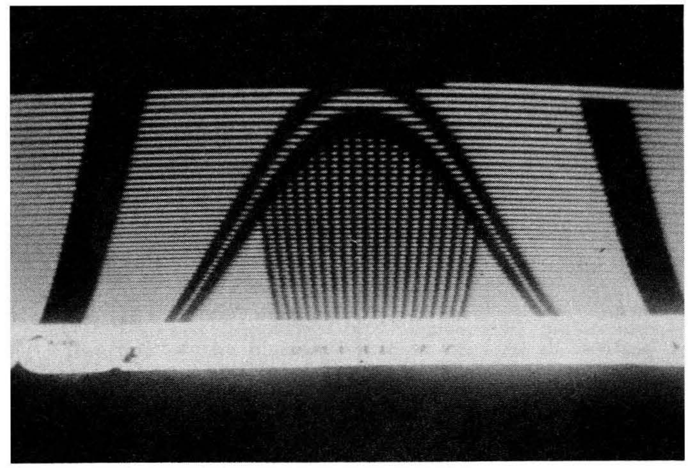


Fig. 12. Foldover at bottom produced by leakage across the coupling capacitor between the vertical oscillator and the vertical output tubes, or by a low value grid resistor in the vertical output tube.

When this photograph was made the vertical linearity control was adjusted to make the horizontal scanning line structure clearly evident. Note that each white horizontal scanning line becomes thinner to produce the effect of black on the inner circles and on the lines of the vertical wedge. It may also be observed in this photograph that there is some tendency toward "pairing" of the interlaced sets of lines. That is, the 2nd and 3rd lines are closer together than the 3rd and 4th, etc.

PART VIII

Vertical Oscillator Troubles

In a previous article dealing with vertical deflection troubles, it was pointed out that when the vertical oscillator fails to operate there is no vertical deflection. It was shown that this trouble is evidenced by a single bright horizontal line on the kinescope.

When the output of the vertical oscillator is weak it may be impossible to obtain sufficient height with good vertical linearity. The activity of the vertical oscillator can be checked quickly and easily by measuring, with an RCA Volt-Ohmyst*, the developed negative bias on the grid of the oscillator tube. The use of an electronic voltmeter such as the Volt-Ohmyst is necessary because it does not affect the operation of the oscillator circuit. In a circuit such as that given in Fig. 1, the developed bias can be measured between the grid of the oscillator tube and the junction of the vertical-hold control and the 2.2-megohm resistor.

A further trouble in the vertical oscillator is incorrect frequency. The impossibility, by careful adjustment of the vertical hold control, of getting one (and only one) complete picture from top to bottom, is a reasonably definite indication that the frequency, or blocking rate, of the vertical oscillator is either too high or too low. The correct frequency is 60 cycles per second.

Effects of various incorrect frequencies are shown in the accompanying photographs. In each of the cases pictured here, the vertical hold control was adjusted to obtain a stationary pattern. At other settings of the vertical hold control, the picture rolls up or down.

There is frequently confusion as to whether troubles such as those illustrated here are due to faulty sync, or to incorrect frequency of the vertical oscillator. A decision can be made quickly by "killing" the sync and "free-wheeling" the vertical oscillator, as follows:

1. Remove the sync input to the vertical oscillator. One way to do this is to open the coupling capacitor from the sync section. This capacitor, as shown in Fig. 1 at left side is 0.01 uf in value.
2. Slowly adjust the vertical hold control. If at some critical setting it is possible to obtain one (and only one) complete picture from top to bottom, and hold it almost stationary by careful adjustment of the control, it is a definite indication that the frequency of the vertical oscillator can be adjusted correctly. Naturally, the hold control in this case should not be too near the extreme end of its range because there may not be enough range of adjustment when sync is again applied.
3. If it is not possible to obtain one complete picture at any setting of the vertical hold control, it is a definite indication that the frequency of the vertical oscillator cannot be adjusted to the correct rate of 60 cycles per second. If the reader studies the accompanying photographs and explanations he should have no difficulty in recognizing and understanding the symptoms of incorrect vertical frequency.

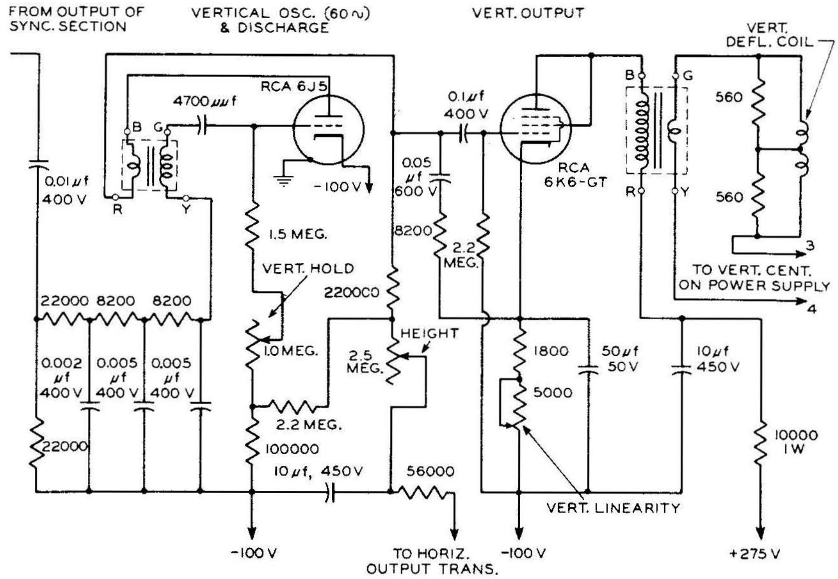


Fig. 1—Vertical oscillator and vertical deflection section of the television receiver used in producing the troubles shown in accompanying photographs. The frequency or blocking rate of the vertical oscillator is largely dependent on the RC time constant in the grid circuit. The value of resistance in the grid circuit is adjustable by means of the vertical hold control. The correct free-running blocking rate is slightly less than 60 cycles per second. Incoming vertical sync pulses serve to trigger the vertical oscillator, keeping it in step or in sync with the vertical deflection of the TV transmitter.

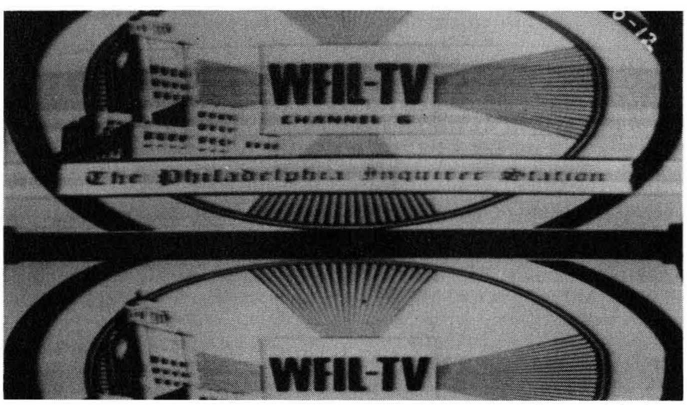


Fig. 2—The presence of two complete pictures indicates that the electron beam in the kinescope is being deflected from top to bottom in 1/30th second, or that the frequency or blocking rate of the vertical oscillator is 30 instead of 60 cycles per second. This condition was produced by increasing the value of the 1.5-megohm resistor in the oscillator grid circuit to 3 megohms, and by adjusting the vertical hold control to obtain a stationary picture. This effect is accompanied by flicker and lack of interlace.

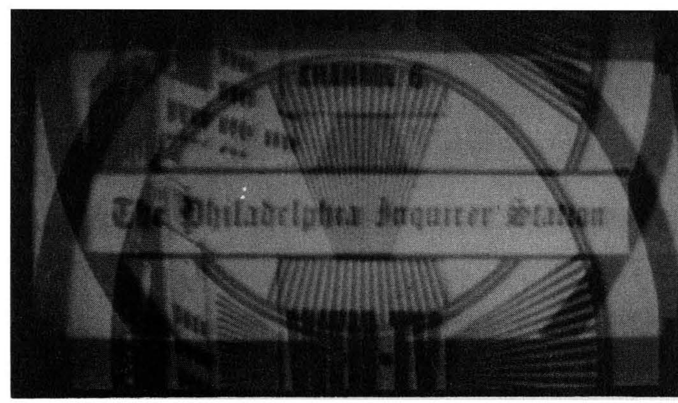


Fig. 4—The presence of two superimposed half-pictures indicates that the electron beam in the kinescope is being deflected from top to bottom in 1/120th second, or that the frequency or blocking rate of the vertical oscillator is 120 instead of 60 cycles per second. This condition was produced by a short circuit across the 1.5-megohm resistor in the oscillator grid circuit and by adjusting the hold control for a stationary picture.

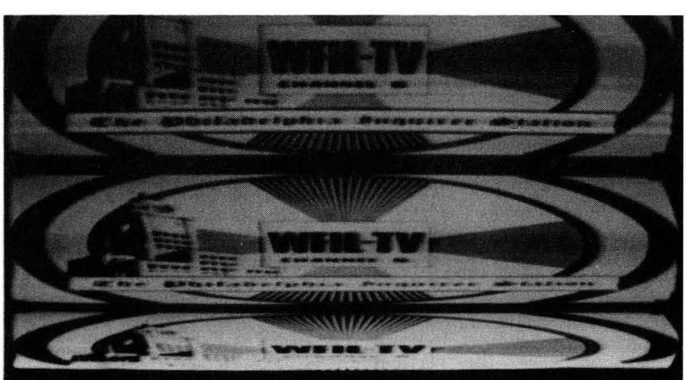


Fig. 3—The presence of three complete pictures indicates that the electron beam in the kinescope is being deflected from top to bottom in 1/20th second, or that the frequency or blocking rate of the vertical oscillator is 20 instead of 60 cycles per second. This condition was produced by increasing the value of the 1.5-megohm resistor in the oscillator grid circuit to approximately 6 megohms and by adjusting the vertical hold control to obtain a stationary picture. This effect is accompanied by flicker and lack of interlace.

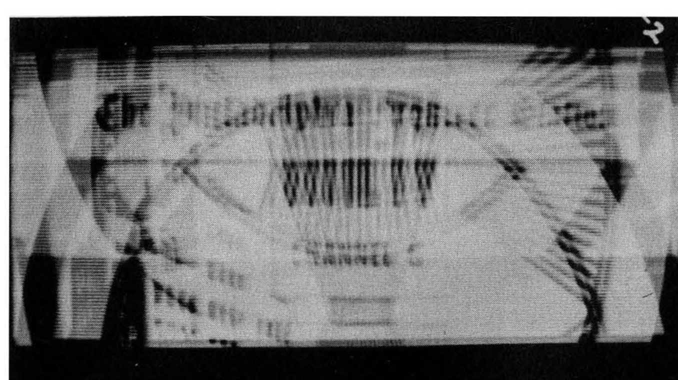


Fig. 5—Same trouble as in Fig. 4, but with the hold control readjusted for a different blocking rate. When the frequency of the vertical oscillator is either too high or too low, the effect that is seen on the kinescope varies with adjustment of the vertical hold control. Usually, the picture appears to rotate vertically except at one or more definite settings of the vertical hold control. Under some conditions of trouble, the picture cannot be held stationary at any setting of the hold control.

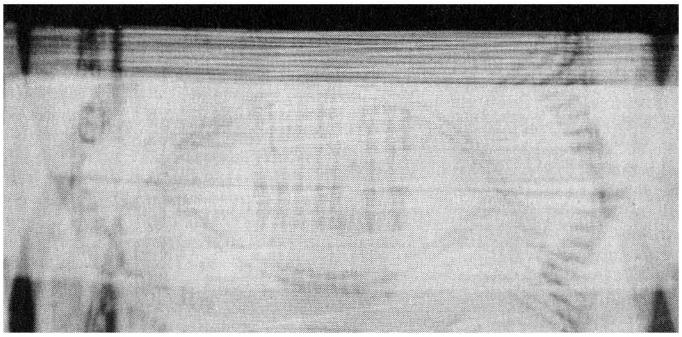


Fig. 6—Effect similar to Fig. 4 and 5, but produced by opening the 100,000-ohm resistor which is connected between the vertical hold control and the minus 100-volt bus. The effects shown in Fig. 4, 5, and 6 can be duplicated by leakage across the grid capacitor of the vertical oscillator, by a low-value grid capacitor, and by other troubles in the vertical oscillator circuit. Fortunately, the vertical oscillator and discharge circuit contains only a few components which can be checked quickly with a VoltOhmyst to locate the faulty unit.

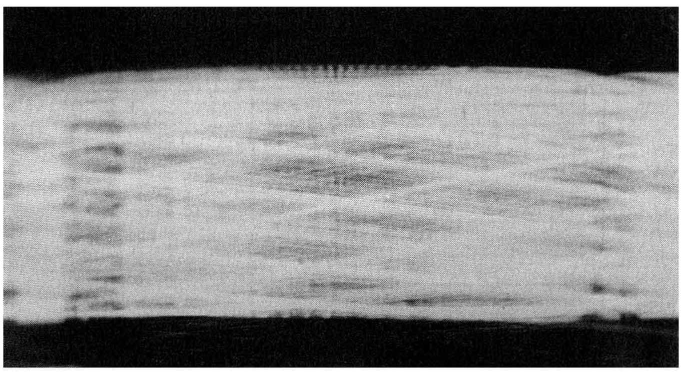


Fig. 7—The effect shown above was produced by opening either the 0.05-uf capacitor or the 8200-ohm series resistor in the plate circuit of the vertical oscillator and discharge tube. In normal operation, the saw-tooth voltage for the vertical output tube is generated across this capacitor. When the capacitor is open, the voltage on the plate of the discharge tube rises very rapidly instead of gradually. This rapid rise, and the normal rapid discharge, produces rapid vertical deflection of the electron beam in the kinescope, even if the blocking rate is correct. As a result, all of the scanning lines, which should be nearly horizontal, have a decided slope.

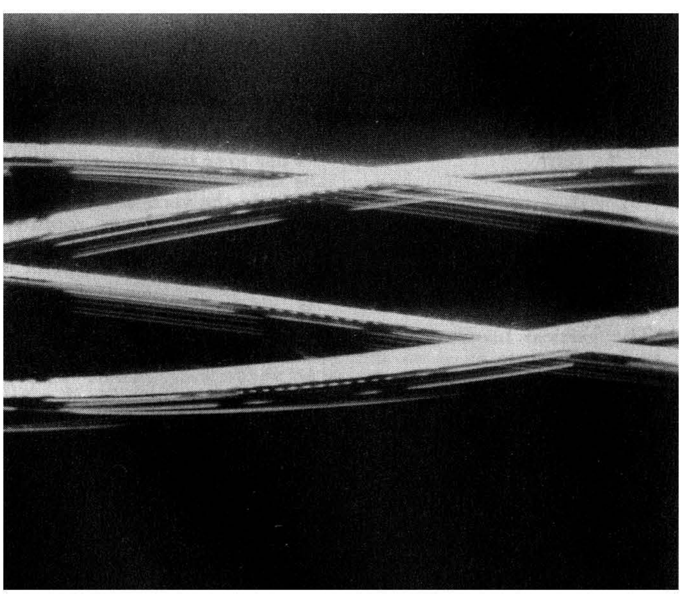


Fig. 8—Same trouble as in Fig. 7 but with a different setting of the vertical hold control. It is suggested that the reader duplicate the troubles shown in these photographs, and study the resulting symptoms displayed on the kinescope, particularly noting the wide variety of effects that are produced by adjusting the vertical hold control in each case. For classroom or other instructional purposes, the hold control and the 1.5-megohm series resistor may be replaced with a 10-megohm potentiometer to permit changing the vertical oscillator frequency over a wide range.

PART IX

Blanking and Synchronizing Signals

It is now generally recognized that the majority of troubles in television receivers can be localized to a particular section of the receiver by correctly interpreting the symptoms displayed in the picture on the kinescope. It is not equally well known that the blanking and synchronizing signals, which normally are not visible on the kinescope, but which can easily be brought into view, provide a positive means for localizing sync troubles and for checking incorrect blanking.

To take full advantage of the information that can be obtained from visual inspection of the blanking and synchronizing signals, it is necessary to have a reasonably good knowledge of the relative signal amplitudes and time elements involved. We are, therefore, devoting this issue to a brief study of the blanking and synchronizing signals.

Specially-Prepared Chart

To simplify the study of blanking and synchronizing signals, we have prepared a special chart, Fig. 2, in which the signals are drawn to scale and arranged in line-under-line sequence for ease in comparing with the same signals as they appear on the kinescope. Television students and instructors will find that this chart, together with the accompanying photographs, is much easier to understand and is, therefore, more effective than the conventional "synchronizing waveform" charts that have been used up to now.

The chart shows the waveform of signal voltage for each line of vertical blanking and sync in each of the two interlaced fields, which are identified as "A" and "B" for convenient reference. Waveforms for all-white and all-black picture lines are shown at the top of the chart; the actual waveform on each picture line depends on the televised scene.

As a further aid to the reader, we are including several unusual photographs (Fig. 5, 6, 10) that were made with a relatively high shutter speed of 1/100 second in order to show some of the lines in a single field. In 1/100 second, the electron beam in the kinescope traces about 160 of the full 525 lines.

In studying the chart in Fig. 2, the following points should be noted:—

1. *The Total number of horizontal scanning lines is 525.* There are approximately 490 picture lines and 35 lines of vertical blanking and sync. Half of these lines are in field A and half in field B. There is a permissible plus and minus tolerance in the number of lines of vertical blanking, with a similar tolerance in the number of picture lines to maintain the total at 525.

2. *The relative amplitude* of the signal voltage along each line is indicated by the figures 1.00, 0.75, and 0, adjacent to the top lines, corresponding to signal voltages of 100%, 75%, and zero. These figures are shown only on the top lines, but they apply to all lines.

Signal amplitudes higher than approximately 70% produce black. Signal amplitudes of approximately 15% or less produce white. Amplitudes between 15% and 70% produce various shades ranging from light grey to dark grey respectively. With correct adjustment of contrast and brightness, when the signal from the transmitter is greater than approximately 70% of its maximum voltage, the electron beam in the kinescope and the spot of light on the kinescope screen are blanked out. The spot, therefore, is blanked out for the duration of the blanking and sync signals.

3. Horizontal and vertical fly back occur during the respective blanking intervals. The beam is deflected rapidly from right to left during a portion of the horizontal blanking time. The beam is moved rapidly from bottom to top during a portion of the vertical blanking time.

4. *The duration* of the horizontal scanning lines and of the blanking and sync signals can be determined from the microsecond scale shown at the bottom of each field:—

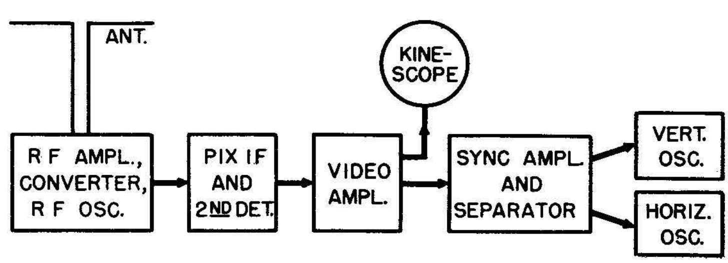


Fig. 1. Block diagram showing the path of sync signals from the antenna to the deflection oscillators. By learning to interpret the relative amplitude of sync signals as they appear on the kinescope, it is possible to tell—1. Whether faulty sync is due to trouble in stages to the left of the kinescope or to those to the right of it. (See Fig. 1). 2. Whether vertical blanking trouble is due to insufficient low-frequency response in the rf-if-video amplifier. 3. Whether horizontal blanking troubles are due to poor frequency response or to incorrect horizontal sync phasing.

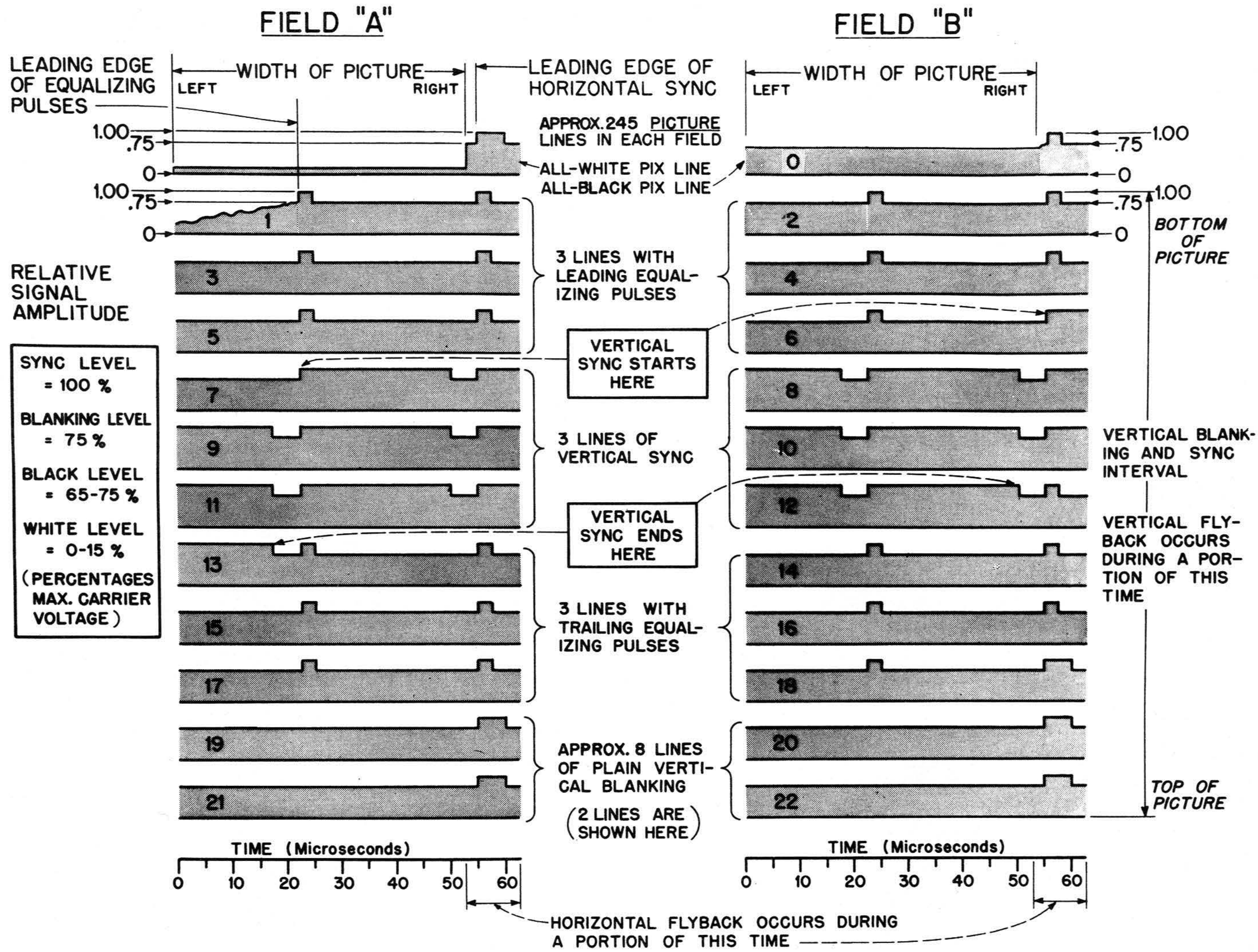


Fig. 2—Waveform of television blanking and sync signals, drawn to scale in voltage amplitude and in time, and arranged in line-under-line sequence for easy comparison with these signals as they appear on the kinescope. Photographs Fig. 3 to 9 show how the blanking and sync signals appear on the kinescope.

	Approx. Duration
Complete horizontal line	63 u sec.
Horizontal blanking	10 u sec.
Picture portion of horizontal line (63 minus 10)	53 u sec.
Horizontal sync	5 u sec.
Equalizing pulses and short horizontal sync pulses	2.5 u sec.

5. *The waveform of horizontal blanking and sync* for each of the approximately 490 picture lines is shown at the top of each field in Fig. 2, and in more detail in Fig. 7.

6. *Horizontal sync on lines 6 to 11* is obtained by the rise in signal voltage from 75% to 100% near the right-hand side of these lines. Note that the leading edge of each horizontal sync pulse starts at the same instant in each line.

7. *Vertical sync* in field B starts near the right-hand end of line 6. Vertical sync in field A starts near the center of line 7. This difference may be noted also by careful inspection of Fig. 5 and 6. The time interval (1/60 second) between the start of vertical sync is precisely the same in successive fields. It is this fact, combined with the odd number (525) of horizontal scanning lines, that provides interlacing of the two fields.

8. *Equalizing pulses* are provided near the center of lines 1 to 18 to compensate for a difference in sync voltage conditions at the start of vertical sync in the two fields. In field A, the start of vertical sync is one-half line from the preceding horizontal sync pulse. In field B, the start of vertical sync coincides with the horizontal sync pulse at the end of line 6. The equalizing pulses, by their effect in the vertical integrating circuit, serve to smooth out the difference in signal-voltage conditions at the start of alternate fields, thus permitting the vertical oscillator to be triggered at exactly uniform time intervals from field to field. Even a slight difference in the time interval from one field to the next would result in imperfect interlacing.

Practical Pointers

Here are some important practical facts about blanking and sync signals:—

A. The vertical blanking signal can be brought into view on the kinescope by carefully adjusting the vertical hold control so that the picture moves slowly downward out of sync. The horizontal blanking signals can be brought into view by adjusting the horizontal sync phasing control (if there is such a control on the receiver) or, in some sets, by adjusting the horizontal hold control.

To observe and check the relative amplitude of blanking and sync signals, it is necessary to reduce the contrast (not enough to lose sync) and increase the brightness until the sync becomes just blank. Under this condition, in a normal receiver the blanking becomes grey, as shown in Fig. 3, 7, and 8.

When sync troubles are analyzed, it is sufficient for most purposes to view only the vertical blanking and sync signals which, as mentioned previously, can be brought into view easily and quickly by means of the vertical hold control.

B. *In a normal receiver, the blanking signals are slightly darker than the darkest picture signals, and the sync is decidedly darker than the blanking, as shown in Fig. 3.*

C. If blanking is as light as, or lighter than, the darkest picture signals, it will be difficult or impossible to blank out the vertical return lines at normal contrast settings. (The vertical return lines slope upward from left to right across the picture). Poor vertical blanking is usually caused by insufficient low-frequency response in the video amplifier. It may also be caused by poor low-frequency response in the rf-if amplifier due to the picture carrier being too low on the slope of the response curve.

D. The horizontal phase and hold controls should be adjusted to obtain approximately equal amounts of blanking signal at the left- and right-hand sides of the picture. The horizontal blanking on each side of the picture can be brought into view by temporarily shifting the centering control or the focusing coil. In order to see the blanking signals, it is necessary to adjust contrast and brightness so that sync becomes dark grey. Horizontal sync is to be considered as part of horizontal blanking when the picture is being adjusted for equal blanking on both sides.

If there is no blanking on one side of the picture, a portion of each horizontal return line will be unblanked. Picture signals on the unblanked portions will appear as faint and indefinite forms that are most evident in black areas of the picture. This trouble will not be present if there is some amount of horizontal blanking on each side of the picture.

E. The kinescope serves as a monitor to show whether poor sync action is due to trouble in circuits ahead of the kinescope or beyond it, as indicated in Fig. 1.

In case of sync trouble, the first step is to inspect the vertical sync and blanking signals as they appear on the kinescope. If the sync is normal, that is, if it is definitely darker than the blanking and the darkest picture elements, it may be assumed that the trouble is in the circuits between the video amplifier and the deflection oscillators. If the sync is not normal, that is, if it is not definitely darker than the blanking and picture signals, the trouble is in the rf, if, or video amplifier. The trouble in this case may be due to poor low-frequency response in the video amplifier, poor rf-if alignment, or undesired limiting action in the video amplifier.

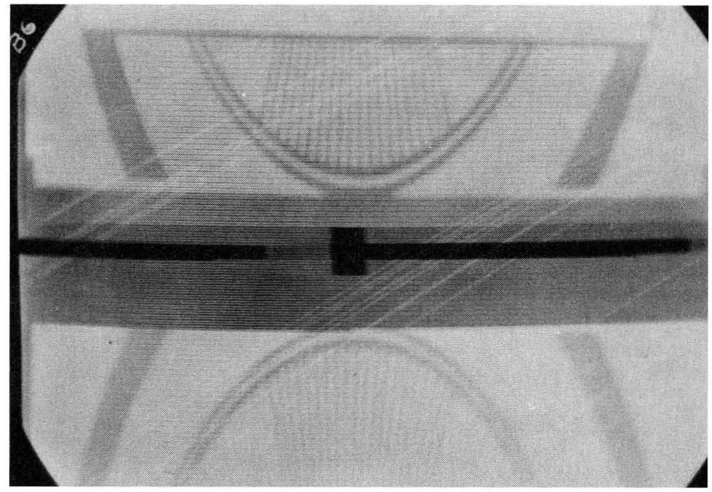


Fig. 3—Vertical blanking and sync, showing only a portion of the total width of these signals. The blanking should be slightly darker than the darkest picture elements, and sync should be definitely darker than the blanking. Refer to detailed views in Figs. 4, 5, and 6.

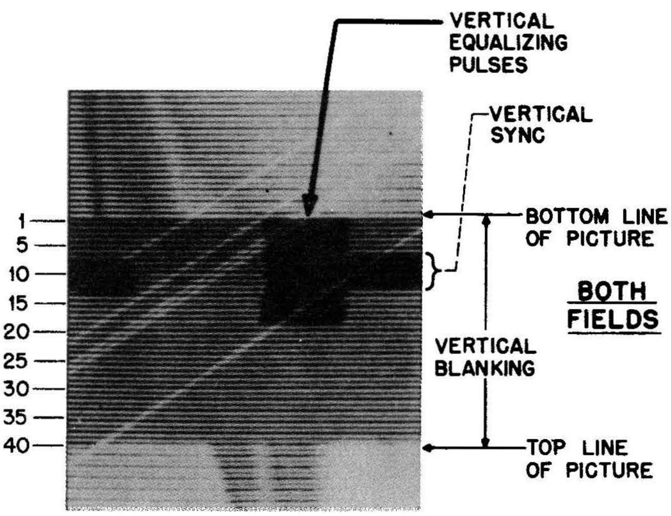


Fig. 4—Portion of vertical blanking and sync, including equalizing pulses. This photograph shows both fields, with a total of approximately 39 lines of vertical blanking. The lines are numbered to correspond with Fig. 2.

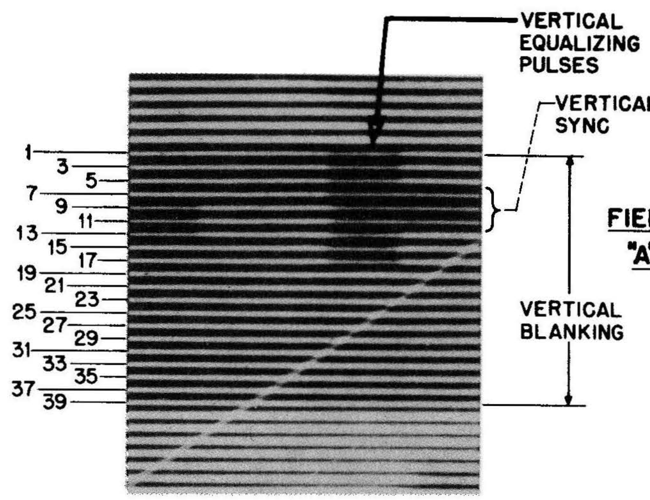


Fig. 5—Same as Fig. 4, but showing field A only. (The photographs in Figs. 5 and 6 were made with a camera shutter speed of 1/100 second.)

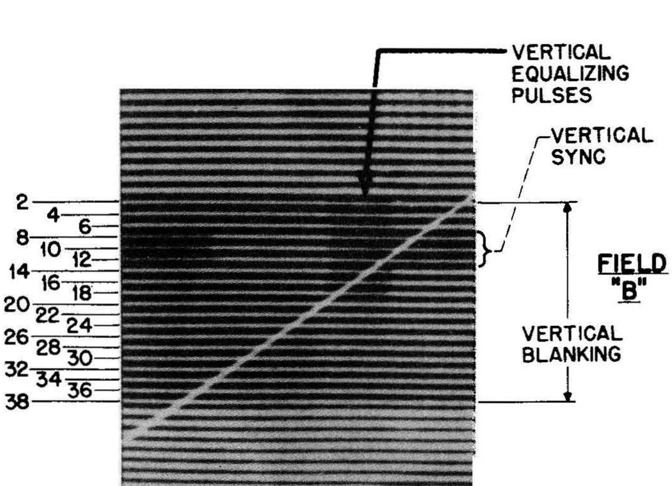


Fig. 6—Same as Fig. 4, but showing field B only.

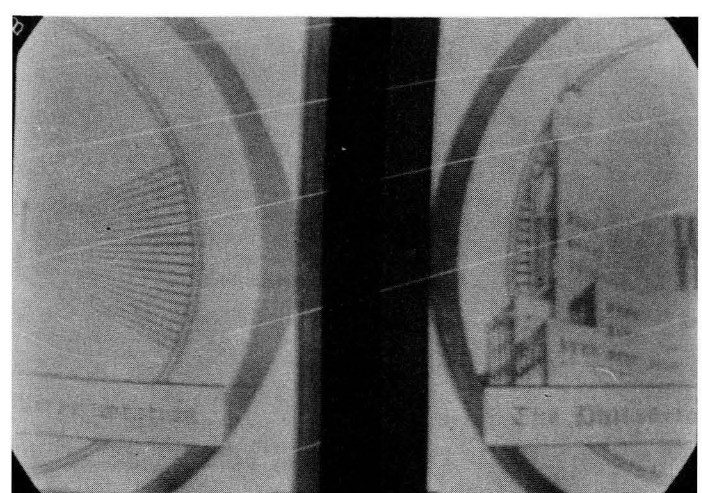


Fig. 7—Photograph of horizontal blanking and sync signals.

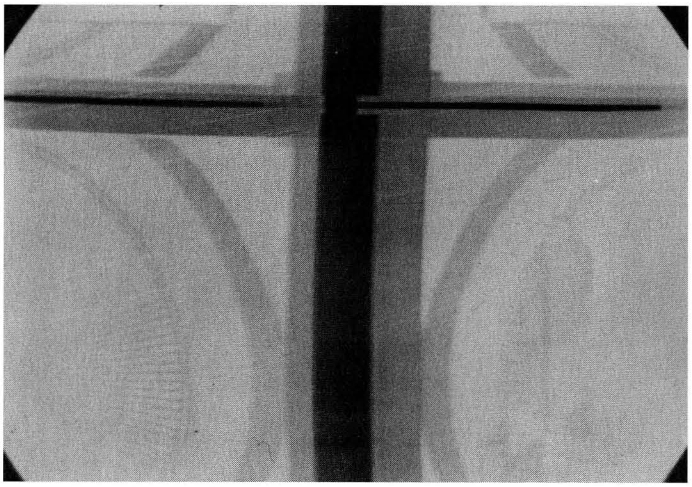


Fig. 8—Horizontal and vertical blanking and sync signals. Refer to detailed view in Fig. 9.

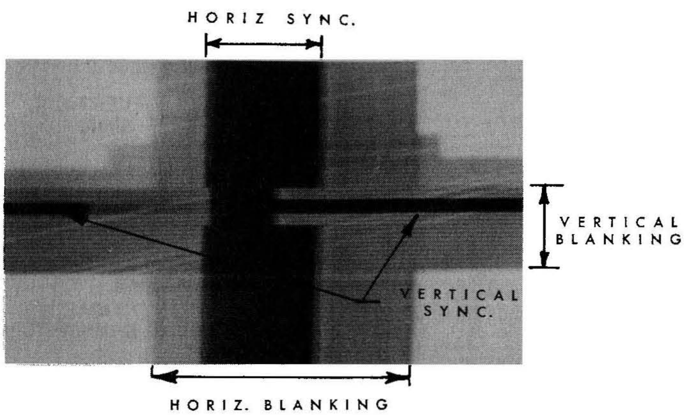


Fig. 9—Enlarged section of Fig. 8, showing a portion of the vertical and horizontal blanking and sync signals. The short-duration horizontal sync signals are shown in lines 0 to 5 and 12 to 17 in Fig. 2.

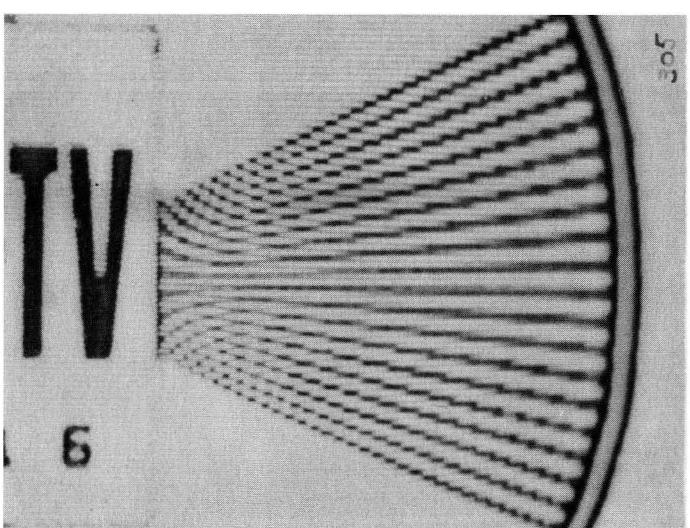


Fig. 10—This photograph was made with a camera shutter speed of 1/100 second to show how the horizontal wedge of a test pattern appears when formed by only one field: Every other horizontal scanning line is missing. The effect resembles, but is not the same as, an out-of-interlace condition.

PART X

More on Horizontal-Deflection Troubles

This article covers additional horizontal-deflection troubles, including those that are encountered in the "direct" deflection type of circuit. This circuit, *Fig. 1*, is used in many receivers of recent design.

As shown in the July, 1949 issue of RCA Radio Service News and, in greater detail, in the RCA Pict-O-Guide, most of the troubles in the horizontal-deflection circuit of a television receiver produce, in the picture, one or more of the following visual symptoms:

1. Insufficient width, excessive width, or poor horizontal linearity.
2. Bright or dark vertical bars on the raster.
3. Fold-over at left- or right-hand sides of the raster.
4. Absence of raster, due to lack of high-voltage.

Failure of the horizontal oscillator, discharge, or output circuits, or their supply voltages, will result in failure of the high voltage. When the high voltage fails, either partially or completely, there is a complete absence of a raster or a picture on the kinescope.

Insufficient Width

Insufficient width may be due to one or more of the following items:

1. Reduced amplitude of the output signal from the horizontal oscillator. (The horizontal-deflection signal is generated in the horizontal oscillator which acts through the horizontal discharge and output circuits to energize the horizontal-deflection coils.) Weak output from the horizontal oscillator may be due to a defective tube or other component, or reduced plate voltage in the oscillator circuit.

2. A weak tube, a defective component, or reduced plate voltage in the horizontal-discharge or horizontal-output circuits.

3. Low line voltage, a weak power rectifier, or other defect in the B+ circuit.

Reduced Line Voltage

The effect of reduced line voltage on the size of the picture is shown in the three superimposed photographs of *Fig. 2*, which were taken at three different values of line voltage: 125, 115, and 105 volts.* (The brightness control was readjusted slightly in each case to maintain approximately the same brightness level. Other controls were not touched The receiver under test had automatic gain control so it was unnecessary to adjust the contrast control.)

The fact that it is possible to increase the height of the picture beyond the top and bottom of the picture tube should not be regarded as an indication that the line voltage and B+ voltages are adequate. Although a television receiver may appear to have more reserve power available for vertical deflection than is ever required in actual use, even at the lowest probable line voltage; actually, this reserve power may not

*An RCA TV Isotap, WP-25A, was used to obtain the three different voltages.

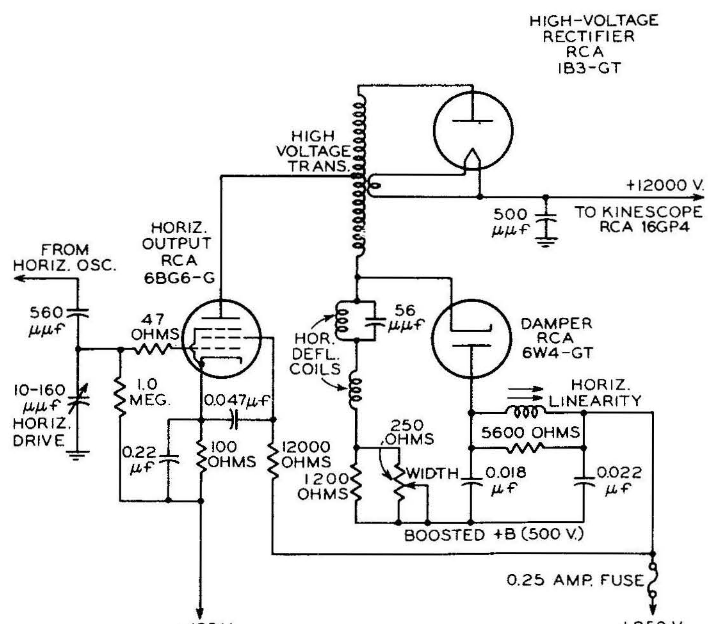


Fig. 1. "Direct" horizontal-deflection circuit used in RCA model T164 and many other recent models. Note that the horizontal-deflection coils are connected in series with the plate winding of the high-voltage transformer, which is an air-core type. In earlier models, the horizontal-deflection coils are connected to a secondary winding on an iron-core, high-voltage transformer. This RCA direct-deflection type of circuit has higher power efficiency than earlier circuits.

be usable because the linearity of the picture obtained with extended vertical deflection probably would be unacceptable. On the other hand, there is comparatively little reserve power available for extra horizontal deflection even at normal line voltage. Although low line voltage is seldom a problem in obtaining sufficient vertical deflection, it may be one of the causes of insufficient width.

Obtaining Increased Width

Occasionally it is necessary to obtain more width than was provided in the original design of the receiver. For example, more width is required when the mask is changed from a straight-sided shape to one with curved sides. In such cases of insufficient reserve power for the extra horizontal deflection, it is necessary to alter the deflection circuit slightly. In horizontal-deflection circuit similar to that used in the RCA model 630TS, additional width can be obtained by connecting a capacitor of approximately 0.05 μf across the width coil, or by opening the width coil. The effect of opening the width coil in this deflection circuit is shown in *Fig. 5.* In some projection-type receivers, it is possible to obtain appreciable increases in width and height by moving the deflection yoke slightly back toward the socket-end of the picture tube. This expedient is seldom practical on other types of receivers due to beam cutoff by the neck of the tube.

To locate the cause of insufficient width, it is advisable to first try new tubes in the horizontal oscillator, discharge, output, and damper circuits, and in the B+ rectifier circuit. Also check the line voltage.

If the line voltage is normal, and if a new tube does not correct the condition, it is necessary to check the voltages and components in the horizontal oscillator and deflection circuits. If possible, check the peak-to-peak input and output voltage of each tube in the horizontal circuits, using a good cathode-ray oscilloscope, such as the RCA WO-57A, or an electronic voltmeter that can read peak-to-peak voltage, such as the RCA WV-97A.

Fig. 2. Effect of line voltage on picture width and height is shown by these three superimposed photographs taken with line voltages of 105, 115, and 125 volts. The picture size is smallest with 105 volts, and largest with 125 volts. When sufficient width cannot be obtained by means of the width and drive adjustments, it is advisable to check the line voltage.

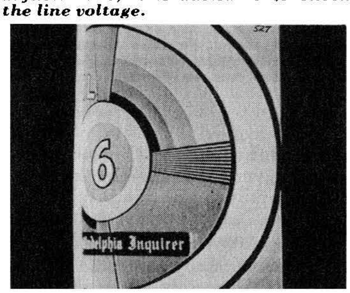


Fig. 3. Fold-over at left due to short-circuited width coil in RCA 630TS.

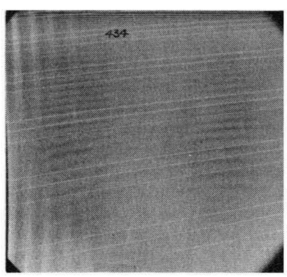


Fig. 4. Ringing in horizontal-deflection circuit, evidenced by vertical bars at left side of raster, due to open 56-μμf capacitor across one-half of horizontal-deflection coil in the "direct" horizontal-deflection circuit of Fig. 1.

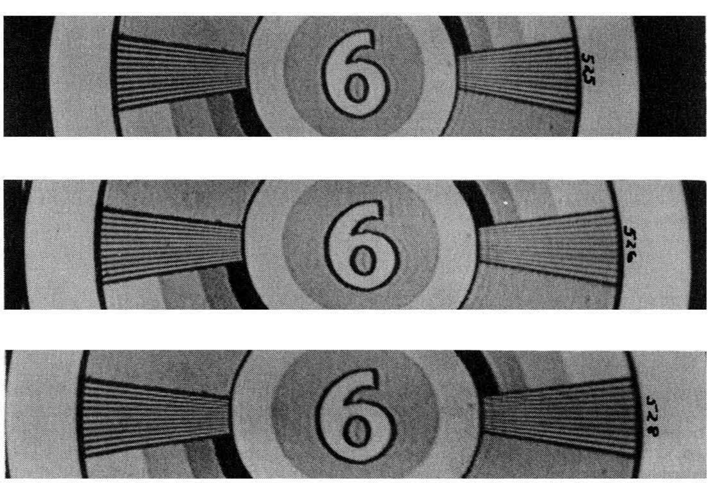


Fig. 5. Effect on width of picture produced by adjustment of width coil in model 630TS type of horizontal-deflection circuit.
a. Coil adjusted for minimum width.
b. Coil adjusted for maximum width.
c. Increased width, obtained by opening the width coil, with some sacrifice in horizontal linearity.

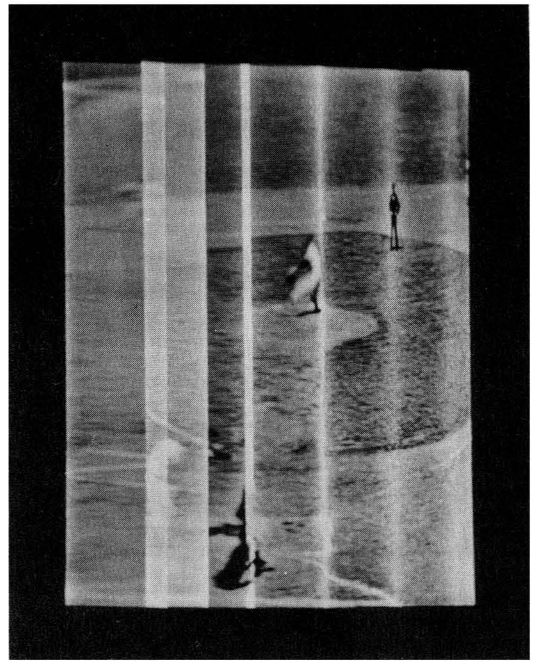


Fig. 6. Fold-over and bright vertical bars produced by an open 0.018-μf capacitor in the damper circuit of Fig. 1

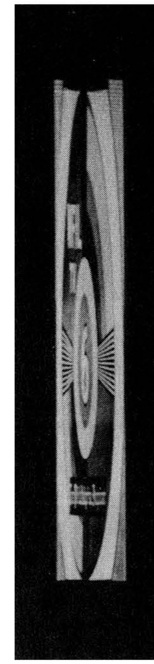


Fig. 7. Extremely narrow picture produced by a shorted 0.018-μf capacitor in the damper circuit of Fig. 1.

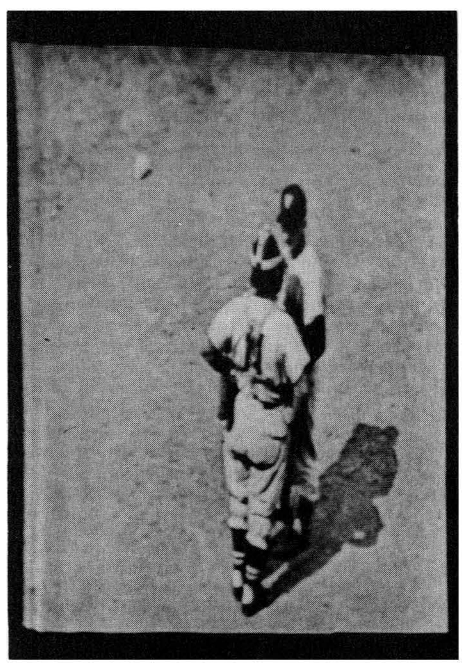


Fig. 8. Narrow picture produced by an open 0.022-μf capacitor in the damper circuit of Fig. 1.

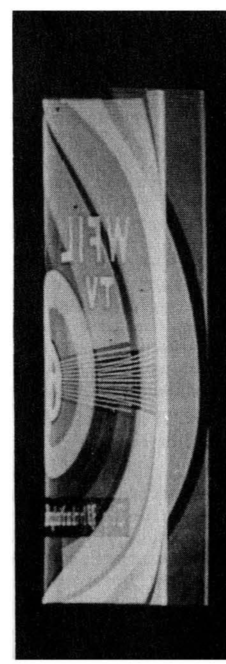


Fig. 9. Fold-over at left and narrow picture produced by a shorted 0.022-μf capacitor in the damper circuit.

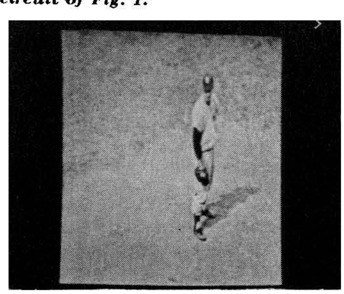


Fig. 10. Narrow picture width produced by an open linearity coil in the damper circuit of Fig. 1. This fault may affect the horizontal-output tube and the 12,000-ohm screen resistor, and result in complete absence of raster.

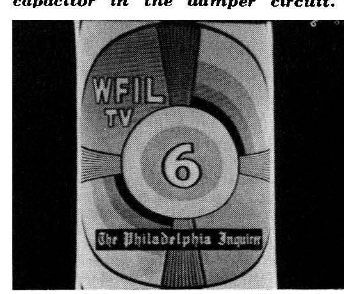


Fig. 11. Fold-over at left and right sides of raster produced by changing the grid resistor of the horizontal output tube from 1.0 megohm to 60,000 ohms. Circuit shown in Fig. 1.

PART XI

Automatic-Gain-Control Troubles

Automatic gain control (AGC) in the television receiver regulates the gain of the rf and picture-if amplifiers in order to maintain approximately the same peak amplitude of signal input to the picture second-detector and video amplifier on weak, medium, and strong TV signals. The AGC is normally inoperative on extremely weak signals.

The gain of the rf and picture-if amplifiers is controlled by varying the negative grid bias on some of the tubes in these amplifiers. The controlling negative bias voltages are furnished by the AGC circuit.

Typical symptoms of AGC trouble include:

1. Loss of picture and sound, caused by excessive magnitude of the negative bias voltage from the AGC circuit; this bias cuts off the rf and picture-if amplifiers, thereby preventing the passage of signals.

2. Horizontal pulling in picture, as shown in *Fig. 2*, caused by compression of sync amplitude due to insufficient bias voltage from the AGC circuit. This results in excessive rf-if gain and excessive signal input to the video amplifier.

3. Overloading on strong TV picture signals, as shown in *Fig. 3*, caused by incorrect setting of AGC threshold adjustment, or trouble in the AGC circuit.

Trouble in the AGC circuit may produce either excessive or insufficient negative control bias voltage. When the bias voltages are too high, the rf and picture-if amplifiers become partially or completely cut off, thereby reducing or preventing the passage of TV signals, and resulting in loss of picture and possibly of sound. When the bias voltages are too low, the gain of the rf and picture-if amplifiers becomes excessive for the incoming TV signals, and overloading may occur in either picture-if or video amplifier. Usually, the first symptom of overloading, or limiting, is compression of sync amplitude, resulting in poor sync action as shown in *Fig. 3*.

Some AGC circuits include a threshold adjustment that must be set correctly to avoid both excessive and insufficient gain in the rf and picture-if amplifiers. Effects of incorrect adjustment are shown in *Figures 2, 3, 6, and 7*.

In receivers where the input signal for the AGC circuit is taken directly (not through a blocking capacitor) from a direct-coupled video amplifier, certain troubles in the video amplifier can cause excessive negative bias voltages to be delivered by the AGC circuit. In such receivers, a trouble in the *video amplifier* may result not only in loss of picture, and possibly the raster, but also in loss of sound.

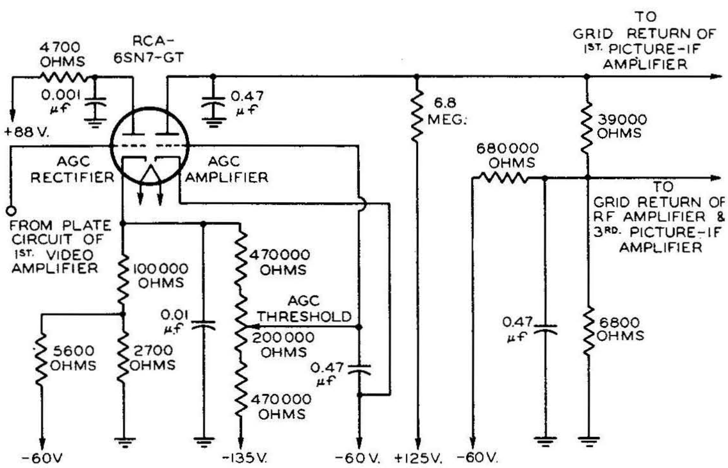


Fig. 1. Simplified diagram of automatic-gain-control circuit used in RCA Victor model T-164 and numerous other models. The AGC section furnishes negative bias voltages, ranging up to about—15 volts, for controlling the gain of the rf and picture-if amplifiers. The magnitude of the control bias voltages depends on the amplitude of the TV signal fed into the AGC circuit. The input signal is obtained from the video amplifier.

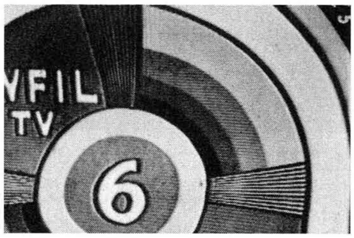


Fig. 2. Horizontal pullir g at top of raster, due to compression of sync amplitude, caused by incorrect setting of AGC threshold adjustment. In this case the threshold adjustment is set so that the AGC bias voltages for the rf and picture-if amplifiers are insufficient, resulting in excessive gain and excessive signal input to the video amplifier, where limiting action clips, or compresses, the sync amplitude. The reduction of sync amplitude may be observ d by inspection of vertical sync on the kinescope, as shown in Fig. 7.

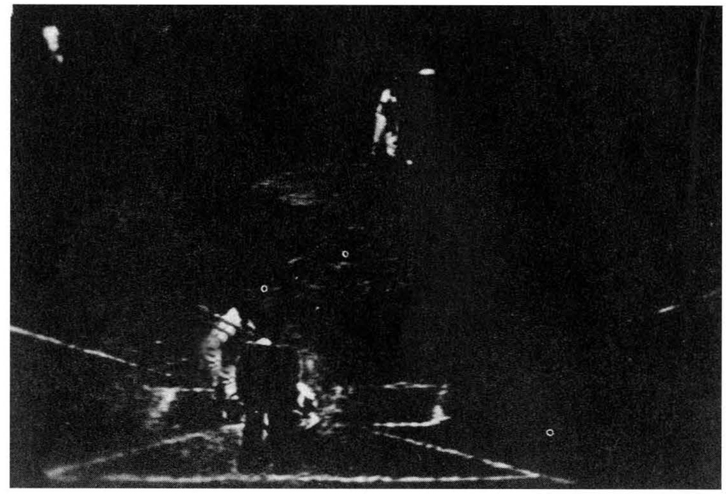


Fig. 3. When the AGC threshold adjustment is advanced slightly more than shown in Fig. 2, the grey and the black picture elements become compressed, as shown above. Further advancement may result in complete loss of picture, except on very weak stations, for which the AGC is inoperative and the threshold adjustment has no effect.

There are many different varieties of AGC trouble, some obvious, and some obscure. Very frequently the obvious symptoms of trouble appear to have no possible connection with the AGC circuit. *The technician's salvation in such cases is the fact that it is always possible to override the AGC voltages temporarily by means of an external battery and potentiometer.* In many cases the use of a battery and potentiometer will restore the picture, or sound, or both, and thereby permit an intelligent diagnosis of the trouble. When both the picture and sound are missing, it may be difficult to begin localizing the fault.

The battery and potentiometer should be connected as shown in *Fig. 4*. The 0.1 μf capacitor is added to avoid hum pickup in the leads. For purposes of trouble shooting it is usually satisfactory to use the same voltage for biasing both the rf and the picture-if amplifiers, even though different AGC voltages are used in the receiver for each amplifier. In extremely strong signal areas, it may be necessary to provide additional bias, up to a total of about −15 volts, for the rf amplifier.

When the battery and potentiometer are used, in some cases of obscure trouble, it may be worthwhile to isolate the AGC circuit by disconnecting its input and output leads.

In some receivers it is possible to connect an external potentiometer, without a battery, to the AGC circuit in order to override the AGC voltages. For example, in the circuit shown in *Fig. 1*, a ¼-megohm potentiometer may be connected from plate to cathode of the AGC amplifier, after this tube is removed from its socket. Unfortunately, removal of this tube from this particular circuit also disables vertical deflection so that it becomes impossible to use the raster or picture for diagnosis.

An external battery and potentiometer are recommended to provide a flexible arrangement that can be used with any receiver without disturbing the function of any circuit except that of the AGC circuit.

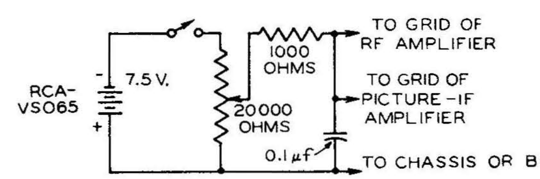


Fig. 4. The visible symptoms of AGC trouble are frequently misleading. For this reason, a "bias box", connected as shown above, is extremely helpful in determining whether the AGC circuit is at fault. The bias box is used to override the bias voltages furnished by the AGC circuit.

It is advisable to make a habit of checking the AGC voltages on both weak and strong signals. The voltages should be measured at the grids of the controlled tubes and also at the output of the AGC circuit, in order to reveal possible troubles between these points. An RCA VoltOhmyst such as the WV-97A is recommended for AGC measurements because its isolating probe introduces negligible resistive and capacitive loading in the grid circuits.

Fig. 5. Normal intensity of snow on a weak-signal picture, with the AGC threshold adjustment set correctly. The effect of incorrect adjustment is shown in Fig. 6.

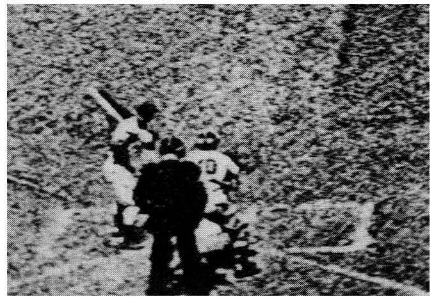


Fig. 6. Intensity of snow is increased, without a corresponding increase of picture signal, when the AGC threshold adjustment is advanced too far.

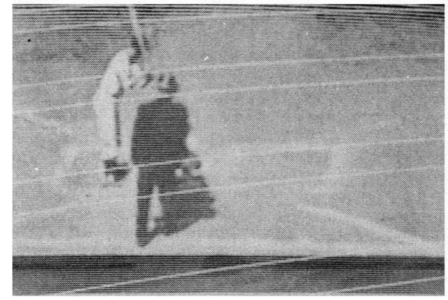


Fig. 7. Reduction of sync amplitude due to incorrect setting of AGC threshold adjustment. The vertical sync shown above is only slightly darker than vertical blanking, indicating that the sync amplitude has been reduced (compressed, limited, or clipped). The sync should be considerably darker than the blanking. Another example of the same condition is shown in Fig. 2.

PART XII

Visible Symptoms of Hum Trouble

Undesired hum voltages in a television receiver may produce either visible or audible symptoms, or a combination of both. This article covers the localization of hum troubles that produce visible symptoms in the picture, with or without any accompanying audible effects.

Success in visual analysis of hum troubles depends on the correct answers to the following questions:

1. Do the visible hum symptoms occur at 60 cycles, or at 120 cycles?
2. Are there changes of brightness (one or two cycles of hum bars*) between the top and bottom of the picture?
3. Is there horizontal pulling (one or two cycles) between the top and bottom of the picture?
4. Are the symptoms in items 2 and 3 *both* present in the picture?
5. Do the visible symptoms in items 2 and 3 remain in view on the raster, or disappear, when the picture signal is removed?
6. Are the visible symptoms accompanied by excessive audible hum from the speaker?

Each of these symptoms furnishes a definite clue, and the combination of such clues generally points unerringly to a particular section of the receiver. After the trouble has been localized, a routine check of the tubes, (and other components) and voltages in the suspected section will reveal the exact fault.

To become expert in recognizing and isolating the sources of hum trouble, it is advisable for the serviceman to duplicate the conditions shown in the accompanying photographs. The effects of leakage between the heater and cathode of a tube can be simulated by connecting an adjustable resistor from the cathode to the ungrounded heater terminal. This method does not always duplicate the exact effects of emission-type leakage, but it is entirely satisfactory for purposes of study.

For simplicity in this article, it is assumed that the receiver is operated from a 60-cycle supply, in which case the visible hum symptoms occur at either 60 or 120 cycles per second. If the receiver is operated on a 50-cycle supply, which is used in some areas, the hum symptoms will occur at 50 or 100 cycles. When the receiver is operated through an inverter from a dc supply, the rate of any visible hum symptoms depends on the frequency of the inverter output.

Two Principal Types of Hum Symptoms

One of the first steps in localizing the source of hum trouble is to determine, from an analysis of the visible symptoms, whether the hum is occurring at a 60- or 120-cycle rate.

Hum at a 60-cycle rate generally indicates heater-cathode leakage in a tube.

Hum at a 120-cycle rate usually indicates trouble in the B-supply circuit.

A few exceptions to these general rules are mentioned later.

It is easy to determine whether the visible symptoms are occurring at 60 cycles, or at 120 cycles:

If there is only one cycle of hum bars, and/or one cycle of horizontal pulling, between the top and bottom of the picture, the trouble is caused by 60-cycle hum (usually caused by heater-cathode leakage). If there are two cycles of hum bars, and/or two cycles of horizontal pulling, between the top and bottom of the picture, the trouble is caused by 120-cycle hum (usually caused by trouble in the B-supply circuits).

120-Cycle Hum Symptoms

Most television receivers utilize full-wave rectification in the B-supply circuit. The output of a full-wave rectifier, operating from a 60-cycle supply, consists of 120-cycle pulsating dc. The pulsations are normally smoothed into pure dc by the action of filter capacitors and chokes. However, if there are any serious defects in the filtering circuits, such as open filter capacitors, some or all of the B+ and B— voltages will have excessive 120-cycle ripple, or variation in voltage, which may produce 120 cycle hum trouble in several sections of the receiver.

Open filter capacitors in the B-filter circuit produced the visible

*A hum bar is a change in brightness between the top and bottom of the picture or raster. See Fig. 1.

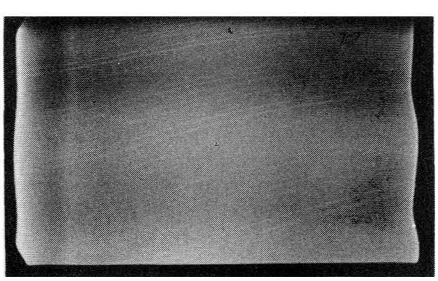


Fig. 1. Two cycles of change in width, and two cycles of change in brightness (hum bars) between the top and bottom of the raster (vertical oscillator running at 60 cycles). The two cycles occur in 1/60th second, indicating that the hum trouble is 120 cycles and that it originates in the B supply. The trouble was caused by open B+ filter capacitors, which resulted in excessive 120-cycle ripple in the B voltage, changing the width and brightness of the raster at a 120-cycle rate. Figures 2 to 9 show examples of 60-cycle hum trouble caused by heater-cathode leakage.

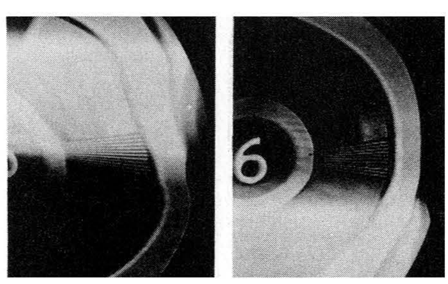


Fig. 2. One cycle of change in brightness (60-cycle hum bars) and one cycle of horizontal pulling, between top and bottom of picture, indicates heater-cathode leakage in the rf, if, or video amplifiers. The trouble in this example was caused by a defective tube in the picture-if amplifier. The 60-cycle leakage current flows through the cathode resistor and modulates the TV signal. The position of the hum symptoms is shifted, as shown above at left and right by reversing the power-cord plug.

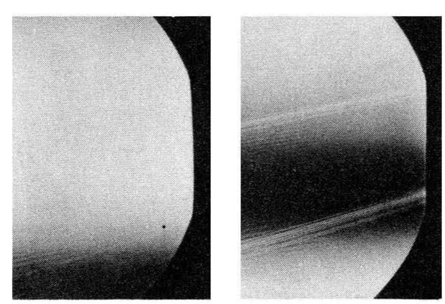


Fig. 3. The presence of 60-cycle hum bars on the raster alone (without TV or other signal) indicates heater-cathode leakage in the video amplifier section, which includes the 2nd detector, dc restorer, and kinescope. Normally, the vertical oscillator tends to sync on the leading edge of the dark bar, as shown above at left. The entire dark bar may be brought into view by adjusting the vertical hold control, as shown above at right. The leakage in this example was simulated by connecting a 1000-ohm resistor from the cathode to the ungrounded heater terminal in a video stage that has a 330-ohm cathode resistor. (Refer to Fig. 5.)

hum symptoms shown in *Fig. 1*, where there are two cycles of change in the amplitude of horizontal deflection (two cycles of variation in the length of the horizontal scanning lines), between the top and bottom of the raster. Also, there are two cycles of hum bars, or graduation in brightness, between the top and bottom of the raster.

When the photograph for *Fig. 1* was made, the vertical-hold control was adjusted for the correct vertical-deflection rate of 60 cycles while a TV station was received, and the rf-if gain was reduced until the TV picture became invisible, leaving only the raster in sight on the kinescope. As the gain was reduced, the vertical-hold control was slightly re-adjusted to maintain the vertical-deflection rate of 60 cycles. *There are two cycles of change in width (and also in brightness) in 1/60th second, indicating that the hum voltage is occuring at 120 cycles per second, and that the trouble, therefore, is in the B-filter circuit. If the hum symptoms occurred at 60 cycles, there would be only one cycle of change in width (and brightness) between the top and bottom of the raster.*

Excessive hum voltage on some or all of the B-output taps usually affects more than one section of the receiver, and results in some or all of the following symptoms:

1. **Excessive audible hum from the speaker,** caused by hum voltage on the B+ or B− leads to the audio amplifier. The intensity of the hum is not affected by turning the audio volume control.

2. **120-cycle hum bars** (two cycles of change in brightness between the top and bottom of the raster), caused by hum voltage in the B-supply to the video amplifier. *The hum bars in this case are present on the raster with or without a picture.* If there is 120-cycle hum on the B-supply to the rf-if amplifiers, but none on the video amplifier, the hum bars disappear when the TV picture is "killed" by removing or disabling one of the tubes in the picture-if amplifier. (It should be noted that faint hum bars can be seen on almost any receiver when the raster is viewed in a darkened room at low-brightness level.)

3. **120-cycle change in width between the top and bottom of the raster,** caused by hum voltage in the B-supply for the horizontal-deflection section. The change in raster width is present *with or without* a TV picture. Under normal conditions, the left- and right-hand edges of the raster are substantially straight and parallel.

4. **120-cycle horizontal picture pulling** (two cycles of variation in horizontal-sync phasing), caused by hum voltage in the B-supply for the horizontal-afc section, the sync-separator section, the video amplifier, or the rf-if amplifier.

If the hum voltage is present only in the horizontal-afc or sync-separator sections, the pulling will not be accompanied by hum bars. If the hum voltage is present in the rf-if or video amplifiers, the pulling is generally accompanied by hum bars.

When some or all of the above symptoms are present, it is advisable to check the B-supply filter circuit. A simple check can be made by connecting an external electrolytic capacitor temporarily across each of the suspected filter capacitors, in turn, and noting whether the symptoms disappear.

60-Cycle Hum Symptoms

It is well to remember that 60-cycle supply voltage is present only in the power transformer, the power-rectifier plate circuit, and the heater circuits. The transformer and the rectifier plate circuit are rarely responsible for producing 60-cycle hum symptoms; a few exceptions are noted later. Visible symptoms of 60-cycle hum can almost always be traced to the heater circuits, or more specifically, to heater-cathode leakage in a tube. Such leakage permits the effect of the 60-cycle heater voltage to get into the television circuits via the cathode circuit of the tube.

Leakage between the heater and cathode of a tube may be caused by (a) faulty insulation between the two elements, or by (b) emission of electrons from heater to cathode, or vice versa, depending on the voltage difference and polarity of the two elements.

Leakage of any type between heater and cathode results in a flow of 60-cycle "hum" current through the cathode circuit during at least a portion of each 1/60th second. Such leakage current *may or may not* produce audible or visible hum symptoms, depending largely on the value of any resistance or 60-cycle impedance in the cathode circuit. Even a small amount of leakage current is likely to cause hum symptoms if there is a high value of resistance or 60-cycle impedance in the cathode circuit. Conversely, a large amount of leakage current is unlikely to cause hum trouble if there is no resistance or 60-cycle impedance in the cathode circuit.

The above factors (the voltage difference, and polarity, between heater and cathode, and the value of resistance or 60-cycle impedance in the cathode circuit) account for the fact that a particular tube may cause hum trouble when it is used in one circuit of a receiver, but may operate without any sign of hum trouble when transferred to a different circuit.

Diode circuits, such as second detectors, dc restorers, horizontal-sync discriminators, and FM-sound discriminators, usually have a high value of resistance in the cathode circuit, and therefore are easily affected by heater-cathode leakage.

When the visible hum symptoms occur at 60 cycles, which generally indicates heater-cathode leakage, the following information may be applied in localizing the faulty tube:

1. **60-cycle hum bars,** or one cycle of change in brightness between the top and bottom of the picture, as shown in *Figures 2 to 7*, inclusive.

Temporary "kill" the picture by removing a tube from the picture-if amplifier if necessary. If the hum bars remain present on the raster, it indicates that the trouble is in the video amplifier, which includes the second detector, the dc restorer, and the kinescope. Try new tubes in this section.

When a tube with heater-cathode leakage is used in the video amplifier, which has good response at 60-cycles, the hum voltage passes through the amplifier and appears on the kinescope, regardless of whether a signal is passing through the receiver.

If the hum bars disappear when the picture signal is killed, it indicates that the trouble is in the rf or picture-if amplifiers, including the rf oscillator and the converter. Try new tubes in these sections.

60-cycle hum voltage, produced by heater-cathode leakage in an rf or picture-if tube, cannot by itself pass through these amplifiers which respond only to rf or if signals. However, such hum voltage, can and does act to modulate any rf or if signal that is passing through the amplifiers. *For this reason, the effects of heater-cathode leakage in the rf or if amplifiers do not appear on the kinescope unless a signal is being received.* The signal does not have to be from a TV station. It can be "grain noise," FM, or other signals, as shown in *Fig. 4*.

As mentioned previously, there is unlikely to be hum trouble from heater-cathode leakage in stages where the cathode is connected directly to the chassis or B−. This fact can sometimes be used to advantage in isolating a faulty tube. For instance, if the symptoms indicate that the hum trouble is caused by heater-cathode leakage in the rf or picture-if amplifiers, it is possible, in many receivers to temporarily short out the cathode resistor of each stage, in turn. The hum symptoms will disappear when the cathode resistor of the faulty tube is shorted out. This method is useful only where the normal operation of the stage is not seriously altered when the cathode resistor is short circuited. It is not advisable, in any case to short out a cathode resistor permanently. The correct remedy, after isolating the faulty tube, is to install a new tube.

2. **60-cycle horizontal picture pulling,** or one cycle of horizontal pulling between the top and bottom of the picture, as shown in *Figures 2, and 6 to 9*.

When 60-cycle horizontal picture pulling occurs, without accompanying 60-cycle hum bars, as shown in *Figures 8 and 9*, the trouble is most likely to be found in the horizontal-afc and oscillator sections, or in

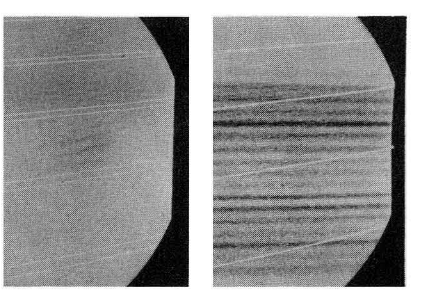


Fig. 4. Heater-cathode leakage in a tube in the rf or picture-if amplifier modulates any signal passing through these amplifiers, including "grain noise" or "snow" signals, as shown at left, or FM signals, as shown at right. Note that in each case the top portion of the raster is devoid of signal. The leakage current reduces the gain of the stage during the time corresponding to the blank portion.

The same effect is evident at the center of Fig. 6, and the top and bottom of Fig. 7. Like many other troubles in electronic equipment, heater-cathode leakage can be intermittent, starting or stopping as the tube warms up. The particular tube used when these photographs were made had intermittent heater-cathode leakage.

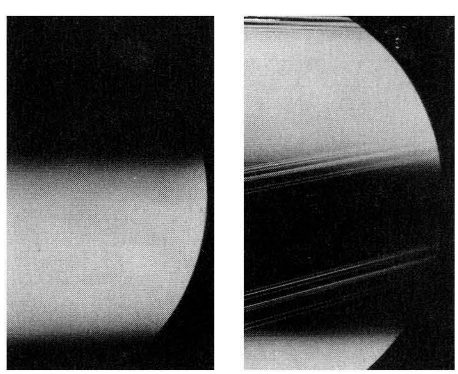


Fig. 5. Same trouble as in Fig. 3, except that the heater-cathode leakage is 400 ohms instead of 1000 ohms; note that the 60-cycle hum bars are more pronounced.

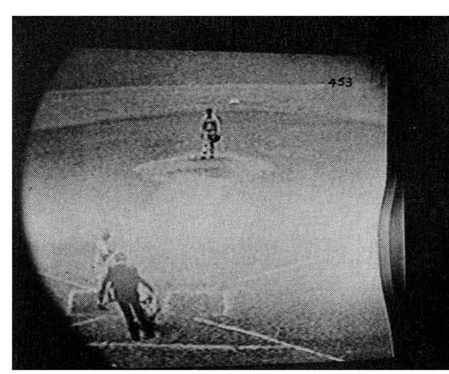


Fig. 6 In addition to 60-cycle change in picture brightness, heater-cathode leakage in the rf, if, or video amplifiers may also produce 60-cycle horizontal pulling in the picture. Both effects are evident in this example, which was produced by heater-cathode leakage in a tube in the picture-if amplifier (Refer to Fig. 7 and the note at the end of the caption for Fig. 9.)

the sync-separator section. Heater-cathode leakage in these sections may produce 60-cycle variation in horizontal-sync phasing, which appears as 60-cycle horizontal picture pulling. *The pulling is present only on the picture, not on the raster, and it disappears when the TV signal is removed.* The remedy is to try new tubes in these sections.

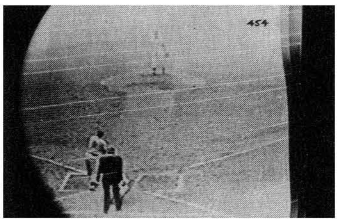


Fig. 7. Same condition as in Fig. 6, except that the position of the hum symptoms has been shifted by reversing the power-cord plug.

There are many additional reasons for horizontal picture pulling. For further information on this subject, the reader is referred to an article by the author entitled "Horizontal Pulling," which appeared in the March and April 1951 issues of "Radio and Television News."

3. **Combination of 60-cycle hum bars, and 60-cycle horizontal picture pulling,** as shown in *Figures 2, 6, and 7.*

The effects of hum voltage due to heater-cathode leakage in a tube in the rf, if, or video amplifiers may produce both 60-cycle hum bars and 60-cycle horizontal pulling. The presence of the 60-cycle hum bars indicates that the trouble is *ahead* of the kinescope (in the rf, if, or video amplifiers). The procedure for localizing the faulty tube is, therefore, the same as given previously under item 1 for "60-cycle hum bars."

Again it is pointed out that the second detector, dc restorer, and kinescope are part of the video-amplifier section—*heater-cathode leakage in these tubes produces the same type of hum symptoms as those produced by the amplifier tubes in the video section.*

Stationary and Moving Hum Symptoms

Hum bars and horizontal pulling (resulting from hum trouble in the receiver) may remain stationary or may move slowly or rapidly up or down on the picture. In either case, the effect depends on whether or not the ac line supplies for the receiver and the TV camera are in sync. There is no practical way to control this effect at the receiver.

"Hum Symptoms" Due to External Interference

External interfering signals with 60- or 120-cycle AM or FM modulation (such as generated by some types of diathermy equipment) may produce visible symptoms similar to internal hum. When the hum symptoms are produced by external interference, they are usually accompanied by a visible beat.

In the case of *60-cycle* hum symptoms, a simple and positive check can be made by reversing the power-cord plug. If the 60-cycle hum bars or horizontal pulling are caused by internal hum trouble, such as heater-cathode leakage, the hum symptoms will shift in position by about one-half of the height of the picture whenever the plug is reversed. Reversal of the plug has no effect on the position of "hum symptoms" resulting from external interference.

A Few Exceptions

1. Visible hum symptoms resulting from trouble in the B-filter circuit normally occur at 120 cycles, but in the rare case where one-half of a full-wave rectifier circuit opens, any resulting hum symptoms occur at 60-cycles.

2. The filter capacitor at any one of the output taps on the B supply usually serves to prevent common coupling between the sections of the receiver that are fed from the particular tap. If the capacitor opens, there may be interaction between the sections. For example, an open filter capacitor in the B-feed to the vertical-output section may permit vertical-deflection voltage to set up 60-cycle hum symptoms in other sections. In general, when it is observed that signals in one section are modulating other sections, it is advisable to check the filter capacitors.

3. If 60-cycle hum bars remain present on the raster when the picture signal is killed, it generally indicates heater-cathode leakage in the video amplifier. In very rare cases, an exception may be found in the presence of a strong 60-cycle ac field from a power transformer located too close to the socket-end of the kinescope. An example of this rare effect is shown on K-3 in the RCA Television Pict-O-Guide* (Vol. 1).

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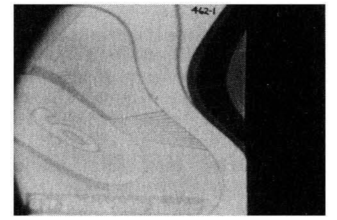

Fig. 8. 60-cycle horizontal picture pulling, without any 60-cycle change in brightness, indicates that the trouble is in the horizontal-afc or oscillator sections, or in the sync separator. The absence of 60-cycle hum bars indicates that the trouble is not in the rf, if, or video sections. The horizontal pulling shown in this example was produced by heater-cathode leakage in a horizontal-afc tube. The pulling is evident only when a TV signal is being received; it is not present on the raster alone. (See the note at the end of the caption for Fig. 9)

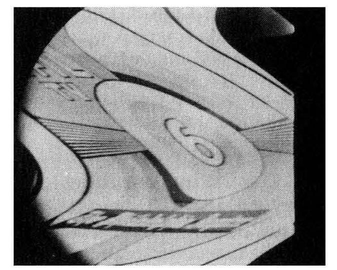

Fig. 9. Severe 60-cycle horizontal picture pulling produced by heater-cathode leakage in a horizontal-afc discriminator. Horizontal picture pulling results from variation in horizontal sync phasing. (Note—In making the photographs for Figures 6, 7, 8 and 9, the picture on the kinescope was intentionally moved toward the left in order to bring the right-hand edge of the raster into view to show that the edge of the raster is straight; horizontal picture pulling does not affect the shape of the raster.)

PART XIII

Microphonic Troubles

Wires, components, and tube elements in the receiver may be shaken or vibrated by sound waves from the speaker, or by sound vibrations that are transmitted through the cabinet and chassis as a result of the motion of the speaker cone.

Vibration of wires, components, or tube elements, with respect to each other or with respect to the chassis, produces slight variations in the capacitance and inductance of a circuit. Relative vibration of the elements inside a tube produces slight variations in gain also.

Minor variations of capacitance and inductance, due to a normal amount of mechanical vibration, have no noticeable effects in any circuit except the rf oscillator, in which even the slightest changes in circuit constants produce considerable variation in the frequency of the rf oscillator. Such variations in frequency, or frequency modulation, can result in an audible microphonic whistle.

Minor variations in gain, due to mechanical vibration of tube elements, have no noticeable effects except in the horizontal afc tube, where slight changes in gain can produce an appreciable amount of microphonic horizontal picture pulling.

The term "microphonic" is applied to these troubles because the electrical action is a result of mechanical vibration, as in a microphone.

Microphonic RF Oscillator

One of the most common types of microphonic trouble is a sustained whistle (or howl, growl, or squeal) resulting from mechanical vibration in the rf-oscillator circuit. This trouble can be identified by the following symptoms:

1. The whistle is present only when a sound signal is being received. The signal may be from a TV, FM, or other station, with or without modulation.

2. The whistle is most likely to occur when the receiver is operated at moderate to high volume level. The whistle stops when the volume is reduced to a low level.

3. The trouble is most likely to occur on the high-band channels (7 to 13).

4. The whistle may cease during certain sound modulation, which breaks up the rhythm of the mechanical vibration.

5. The whistle may be stopped temporarily by tapping the cabinet, the chassis, or the rf-oscillator tube. The tapping disturbs the rhythm of the mechanical vibration.

6. The whistle can sometimes be stopped permanently or "semi-permanently" by slightly moving or tilting the rf-oscillator tube in its socket.

7. The trouble does not occur in inter-carrier type receivers.

The complete cycle of operation of a microphonic trouble is as follows:

(a) Sound waves or transmitted vibrations from the speaker set up mechanical vibrations in one or more of the wires, components, or tube elements in the rf-oscillator circuit.

(b) This mechanical vibration produces slight variations in the capacitance and inductance of the oscillator circuit, which causes corresponding frequency variations, or frequency modulation, of the rf-oscillator signal.

(c) The frequency modulation of the rf-oscillator signal produces corresponding frequency modulation of the sound-if signal.

(d) The frequency modulation of the sound-if signal is detected in the sound discriminator, which produces audio-frequency output.

(e) The audio-frequency output of the discriminator is amplified in the audio amplifier, and produces motion of the speaker cone.

(f) The motion of the speaker cone produces sound waves and mechanical vibrations that tend to increase the amplitude of vibration in the rf-oscillator circuit.

(g) The above action is repeated, with reinforcement on each cycle, until a stabilized condition is attained. The result is an audible whistle that may last indefinitely, or occur intermittently, as an annoying background to the station's sound.

When the rf-oscillator signal is frequency modulated, it produces the same amount of FM in the *picture-if* signal, as in the sound-if signal, but there is rarely any visible evidence of this modulation in the picture. The FM response of the picture-if amplifier and second detector is much less than the FM response of the sound-if amplifier and discriminator, due to the difference in the slope of the two response curves.

Inter-carrier receivers are not affected by a slight percentage of FM in the rf-oscillator signal. In inter-carrier receivers, the final sound-if signal of 4.5 Mc is formed by the difference-frequency beat between the sound-if and picture-if signals. Although these two signals are frequency modulated as a result of FM in the rf-oscillator, the two signals vary up and down together in frequency, and the difference between their frequencies remains constant at 4.5 Mc. Hence, FM in the rf-oscillator signal does not appear in the final sound-if signal of 4.5 Mc, and there is virtually no possibility of microphonic whistle due to normal mechanical vibration in the rf-oscillator circuit of inter-carrier receivers.

Remedies For Microphonic RF Oscillator Troubles

1. *Try several new tubes in the rf-oscillator circuit.* When new oscillator tubes are tried, it is advisable to maintain the following conditions:

(a) Leave the chassis and speaker in the cabinet.

(b) Tune the receiver to the station for which the microphonic whistle has been most troublesome.

(c) Place the original tube shield and weight on each of the new tubes.

(d) Tune the receiver correctly, and set the volume at the level used by the customer, or slightly higher.

(e) Replace the back cover (or top) on the cabinet while each new tube is being checked.

The first and last precautions are necessary to maintain normal acoustic conditions inside the cabinet.

If it is found that a new tube corrects the trouble, it is necessary to check and readjust the oscillator frequencies.

If the use of new oscillator tubes proves unsuccessful, it may be assumed that the trouble is caused by vibration of one or more of the components or leads in the rf-oscillator circuit.

2. *Try "floating" the speaker.* If the microphonic whistle is caused by vibrations that are transmitted through the cabinet and chassis from the speaker (rather than by sound waves), it may be helpful to "float" the speaker on rubber grommets.

To avoid possible waste of time, it is advisable to make a preliminary check to determine whether floating of the speaker is actually helpful in the particular receiver: Remove the speaker mounting screws or nuts, and have an assistant hold the speaker in approximately its normal location, being careful that the frame of the speaker does not touch the cabinet or the mounting bolts. Check the receiver for microphonic action. If the whistle is diminished or stopped, it indicates that the speaker should be floated. Double check by pressing the speaker against the cabinet to make certain that the whistle recurs.

Use rubber grommets, with metal limit bushings and washers, of the type that are used to float the speaker in some receivers. The grommets require ⅜-inch diameter mounting holes in the speaker frame.

If the microphonic whistle is caused almost entirely by sound waves from the speaker, the trouble can *occasionally* be reduced or eliminated by placing a sheet of soft wall-board between the speaker and the rf tuner.

3. *Check the rf-oscillator circuit for vibrating components.* A method for locating vibrating components in the rf-oscillator circuit consists in damping out vibration by pressing lightly on each part with a suitable probe while the receiver is in operation, and while the microphonic whistle is present. When the probe is pressed on the microphonic component, the whistle will diminish or stop. More than one component may be involved.

To apply this method, remove the chassis from the cabinet and expose the rf-oscillator circuits by removing the shielding from the rf tuner. In turret-type tuners, remove all coil strips except the one that is in use (if removal of the strips is necessary to provide access to the rf-oscillator circuit).

Feed an rf signal into the receiver. Tune the receiver to the TV channel that has proved troublesome, or use a strong unmodulated signal from an accurate television signal generator, such as the RCA WR-39C. *A strong unmodulated signal provides the most rigorous check for microphonic action in the rf oscillator.* Tune the generator to the rf sound-carrier frequency of the selected channel. Keep the generator away from the speaker, and, if necessary, mount the generator on a thick soft-rubber pad to avoid microphonic action in the generator.

Mount the speaker on a small baffle of wood or cardboard, and place it near the rf tuner. Advance the volume control until the microphonic whistle occurs. Do not increase the volume any more than is necessary to maintain the whistle.

Press the end of the probe (which should be a long, thin, low-loss plastic stick) against each resistor, capacitor, lead, coil, tuning adjustment, switch plate, fine-tuning cam, etc., in the rf-oscillator circuit. If the whistle is diminished or stopped by pressing the probe, against one or more of these parts, it may be assumed that these parts are vibrating and are responsible for the microphonic action.

The acoustic and vibration conditions are altered considerably by removal of the chassis from the cabinet, and by removal of the shielding from the rf tuner; consequently, it may be impossible to produce the microphonic whistle, even with the speaker close to the rf-tuner, and with the volume control advanced. If the whistle cannot be produced, the microphonic parts can be located by *lightly* tapping each component with the probe. Tapping produces momentary vibration and frequency modulation, which results in a "pinging" sound from the speaker. The parts that are most susceptible to microphonic action produce the strongest pinging sound.

When the microphonic parts have been located, the next step is the reduction of the amount of vibration, a change in the frequency of the mechanical resonance, or a reduction of the amount of variation in capacitance and inductance that results from the vibration. These corrective measures require care because even slight changes in the position of components and leads may shift the oscillator frequency by an excessive amount.

The following information may prove helpful:

(a) *Variations in capacitance and inductance are greatest when the vibrating component is close to the chassis, close to leads, or close to other components,* including brackets, shields, and insulating material. Microphonic action can be reduced by moving the vibrating component away from other parts and leads, or by shifting the other parts and leads away from the vibrating component.

(b) Vibration of resistors and capacitors can be damped to some extent by weighting the leads with solder, but this reduces the series inductance.

(c) Flat-shaped capacitors should be oriented edge-wise to the chassis, rather than parallel, in order to reduce the amount of variation in capacitance and inductance resulting from vibration of the capacitor.

(d) Loose turns on rf coils should be cemented sparingly with good coil dope. Loose tuning cores and loose core-adjustment screws should be cemented.

(e) Mechanical vibration of switch wafers can be damped by cementing rubber pads between adjacent wafers, as is done in early types of RCA rf tuners.

Rubber pads can sometimes be used to reduce vibration of the fibre cam-type, fine-tuning control. Any rubber that is used in the rf-tuner should be sulphur-free because sulphur fumes tarnish the silver plating on switches, and cause noisy contact. A simple check for the presence of sulphur can be made by leaving a sample of the rubber and a small piece of freshly-polished silverware in a closed box or paper bag. If the silver becomes tarnished, the rubber is not satisfactory for use in the rf tuner.

(f) Do not shift the position of components and leads any further than is necessary to stop the microphonic action. If any parts are shifted in position, it is necessary to check and readjust the oscillator frequencies. Check the frequencies again after the shielding is replaced on the rf tuner.

(g) The rf oscillator is coupled to the converter, and the converter is coupled to the rf amplifier: Excessive vibration of a component or lead in the converter or rf amplifier can produce appreciable frequency modulation of the rf-oscillator signal.

4. *Use of external speaker.* Microphonic whistle, and other microphonic effects are usually most troublesome in commercial installations, such as bars, restaurants, and public places, where the receiver is operated at high volume level. A simple remedy in such locations is to remove the speaker from the cabinet, and mount it on a suitable baffle some distance from the receiver. Removal of the speaker decreases the intensity of the sound waves inside the receiver, and virtually eliminates the possibility of microphonic trouble.

If a small speaker is used in the receiver, it is not difficult to sell the owner on the advantage of using a larger, external, pm speaker.

When an external speaker is used, it is advisable to leave the audio-output transformer in the receiver, and run two leads from the secondary of the transformer to the voice coil of the external speaker. Ordinary lamp cord is satisfactory for this purpose. The dc resistance of the voice coil in the new speaker should be approximately the same as that of the original speaker. The voice coil in the original speaker should be disconnected.

Sound Bars In The Picture

"Sound bars" are horizontal bars that *vary in step with the modulation of the signal from the station.*

The number of bars varies with the frequency of the audio signal. At moments when the sound frequency is 300 cycles, there are five horizontal dark bars; when the sound frequency is 3000 cycles, there are 50 horizontal dark bars (one dark bar per 60 cycles).

The intensity of the bars varies with the strength of the audio signals. At moments when the audio signal is strongest, the bars also are strongest; at moments when there is no audio signal, the bars are absent.

There is a tendency to classify all varieties of sound bars as "microphonic." Actually, only a few types of sound bars are caused by microphonic action. Both microphonic and non-microphonic sound-bar troubles are described below.

1. *Microphonic tube in the rf, picture-if, or video amplifiers.*

A microphonic tube in the rf, picture-if, or video amplifier may produce sound bars in the picture when the receiver is operated at high volume level. The bars are not present at low volume level. These same symptoms also apply to the following trouble:

2. *Inadequate or defective filtering in the plate or cathode supply circuits of the audio-output stage.*

When the receiver is operated at high volume level, there are large audio-frequency variations of current in the plate and cathode circuits of the audio-output stage. These large current variations impose a varying drain on the B-supply. If the plate and cathode supply circuits are not adequately filtered, the current variations in the audio-output stage may produce an appreciable amplitude of audio-frequency ripple in the B-supply voltages. This ripple can affect the operation of various sections of the receiver, producing audio-frequency variations in picture-signal gain, in width, in horizontal sync phasing, and other effects. The general effect is the appearance of sound bars in the picture. *The bars are not present at low volume level.*

When sound bars can be eliminated by reducing the volume level, it is necessary to determine whether the trouble is caused by microphonic action, or by inadequate filtering in the plate or cathode circuits of the audio-output stage. To determine which condition exists, open the voice-coil circuit of the speaker and advance the volume control. *Opening of the voice-coil de-energizes the speaker and eliminates possibility of microphonic action.* If the sound bars remain present, it indicates that there is inadequate filtering in the plate or cathode suppply circuits of the audio-output stage. If the bars disappear when the voice coil is opened, it indicates that the trouble is probably due to a microphonic tube.

When this check is made, it is advisable to substitute a dummy-load resistor in place of the voice coil. The resistor should have approximately the same value as the dc resistance of the voice coil. The volume control should be set at the position where sound bars are visible, but below the overload point of the audio amplifier. After making this check, remove the dummy-load resistor and reconnect the voice-coil.

If the check shows that the sound bars are caused by microphonic action, check the rf, picture-if, and video tubes, either by *lightly* tapping each one to locate the faulty tube, or by substituting a new tube in each socket. Also try a new tube in the horizontal afc circuit.

If the check shows that the sound bars are caused by inadequate filtering, check the electrolytic filter capacitors in the plate and cathode circuits of the audio-output stage, and also the capacitors in the B-supply circuit, or try shunting an external electrolytic capacitor across each of the filters. If it is found that the original capacitors are good, and if the trouble cannot be corrected by the use of additional capacitors, it is advisable to find out whether the manufacturer has issued instructions on circuit changes to correct the trouble. All receivers of a particular model may exhibit this trouble when they are operated at high volume level, but actual complaints about the trouble may come from only a few commercial installations where the receivers are operated at high volume.

3. *4.5-Mc beat and herring-bone sound bars.* Sound bars may appear in the picture if the 4.5-Mc beat signal between the sound-if and picture-if carrier gets through the video amplifier to the picture tube. The appearance of these bars is quite different from the appearance of the bars for the two previous troubles. The 4.5-Mc signal produces approximately 240 fine dark vertical or slanting lines in the picture. The FM sound modulation in the 4.5-Mc signal produces horizontal herring-bone sound bars in the 240 lines. The bars vary in step with voice and music. Unlike the two previous troubles, *the intensity of the bars is not affected by adjustment of the volume control.*

In inter-carrier receivers, the presence of a 4.5-Mc beat in the picture may be caused by incorrect alignment of the picture-if amplifier, or the 4.5-Mc. transformer or trap(s) in the video amplifier.

In receivers that have a separate sound channel, the presence of a 4.5-Mc beat in the picture may be caused by incorrect tuning of the receiver, or by incorrect alignment of the sound-if traps in the picture-if amplifier, or the 4.5-Mc trap in the video amplifier.

4. *Harmonic of sound-if signal.* Harmonics of the sound-if signal are present in the output of the sound-if amplifier. If the frequency of one of these harmonics falls in the rf band of a particular channel, and if there is sufficient coupling between the output of the sound-if amplifier and the rf circuits of the receiver, the harmonic will produce a beat pattern in the picture. The beat frequency is equal to the difference in frequency between the rf picture carrier and the particular harmonic. The FM sound modulation in the harmonic produces horizontal herring-bone sound bars in the beat pattern. The bars vary in step with the modulation. *These bars are not affected by adjustment of the volume control.*

There is a simple check to identify this type of trouble: Temporarily remove a tube from the sound-if amplifier. Removal of the tube kills the sound-if output and also the harmonics. If the beat pattern and sound bars disappear when the tube is removed, the trouble is caused by a harmonic of the sound-if signal getting into the rf circuits.

5. *Microphonic tube in the horizontal afc circuit.* Vibration of the elements in the horizontal afc tube may cause variations in the gain of the tube and corresponding variations in horizontal sync phasing (horizontal picture pulling). If the vibrations are caused by sound waves, or by transmitted vibrations from the speaker, the horizontal pulling occurs at the sound frequency, and therefore has the appearance of sound bars. The amount of pulling varies with the intensity of the sound signal. *This trouble is not present at low volume levels.*

To become acquainted with this trouble, tap the horizontal afc tube *lightly*. Tapping may produce horizontal pulling or ripple in a portion of the picture. *A certain amount of microphonic ripple is to be expected under this relatively severe check.* Try several tubes in the afc socket, tapping each tube. Note that the microphonic action is less in some tubes than in others.

This microphonic action in the horizontal afc tube may be remedied by trying several new tubes and selecting the one that is least microphonic. If the afc tube socket is shock-mounted, arrange the leads (under the socket) to permit free-floating action. If these remedies are unsuccessful, the trouble probably is not caused by microphonic action. In this case, check for inadequate filtering, as described in item 2.

If a new tube is placed in the horizontal afc socket, check the horizontal-control action and make any necessary adjustments as specified by the receiver manufacturer.

Microphonic Troubles vs Intermittent-Contact Troubles

It is helpful to make a sharp distinction between microphonic troubles and intermittent-contact troubles.

The term "microphonic troubles" should be restricted to cases where mechanical vibration of a component or tube produces an undesired electrical effect, but does not result in an intermittent contact, short circuit, or grounding.

Vibration of the elements in a 6SN7-GT tube in a horizontal afc circuit may produce microphonic horizontal picture pulling. The same tube, however, can be used in any other 6SN7-GT socket of the receiver without trouble. When normal vibration in a 6SN7-GT produces an intermittent contact or short circuit between two of the elements, the tube should not be used in any circuit.

Vibration is involved in both of these examples, but the first case is a microphonic trouble, and the second case is an intermittent-contact trouble. These examples show that there is a considerable difference between the two types of trouble.

In factory parlance, intermittent-contact trouble is known as "NWT," which means "noisy when tapped." Intermittent-contact trouble may show up under slight vibration, such as can be created by the speaker, or the trouble may show up only when the parts are vigorously vibrated by rapping the chassis with a tool, or by running the sound level so high that the parts vibrate.

Intermittent-contact troubles are caused by such things as (a) unsoldered joints, (b) cold-soldered joints, (c) stray strands of wire, (d) stray lumps of solder, (e) bare wires that are too close to other bare wires, or too close to the chassis, or too close to bare contacts, etc., etc.

The RCA test equipment recommended by the author of this series, in the earlier issues, has in several instances been superseded by later models. The following RCA instruments are currently recommended for TV servicing: WO-56A—7″ Oscilloscope; WO-57B—3″ Oscilloscope; WR-39C—Television Calibrator; WR-59B—Television Sweep Generator; WV-97A—Senior VoltOhmyst; WV-77A—Junior VoltOhmyst.

AUDIBLE HUM AND BUZZ*

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This article covers the localization of troubles in the receiver that cause *audible* hum and buzz, without any accompanying visible symptoms. In cases where audible hum is accompanied by visible hum symptoms, it is preferable to concentrate on the visible clues.

The troubles that cause hum are different from the troubles that cause buzz. For trouble-shooting purposes, it is helpful to recognize the difference between these two sounds:

A hum is a "smooth" low-frequency sound.

A buzz is a "raspy" low-frequency sound.

Hum is produced by 60- or 120-cycle voltages that are sine-wave in shape, or that contain only low-frequency harmonics. When audible hum develops in a receiver that has been free from such trouble, it can usually be traced to heater-cathode leakage (60 cycles), or to trouble in the B-filter circuit (120 cycles).

Buzz is produced by square-wave vertical sync, vertical blanking, and low-frequency picture signals, or by saw-tooth vertical-deflection voltage. These square-wave and saw-tooth voltages have a repetition rate of 60 cycles but contain numerous harmonics; the harmonics that are within the frequency range of the audio amplifier and loudspeaker contribute the raspy quality of the buzz. Heater-cathode leakage, however, can also cause a raspy buzz-like output.

Some Terms

When picture signals get into the sound, they produce a buzzing noise that is generally termed "picture buzz."

Any buzz produced by picture signals can be identified easily because the tone and intensity of the buzz change on different televised scenes and on different "commercials." No other type of buzz has this identifying feature. For instance, buzz caused by vertical-deflection voltages (due to undesired coupling between the vertical-deflection section and the audio amplifier) remains unchanged in tone and intensity, regardless of changes in the picture.

The term "picture buzz" identifies the sound of the noise, but does not indicate how the picture signals are getting into the sound. Picture buzz may be caused by a variety of troubles, including: Cross-modulation between the picture and sound carriers; coupling between the kinescope metal cone (or inner coating on glass-envelope type) and the audio input; coupling between the output of the video amplifier and the input of the audio amplifier; 100 per cent modulation dips at the transmitter (which affect inter-carrier sets), and other reasons.

The terms "picture signals" and "video signals" are used interchangeably in two different ways. Occasionally they are used to mean only those signals that represent the dark and light areas in the picture, but in most cases they are used to mean the composite signal, which includes picture, sync, and blanking. The latter meaning is always implied in referring to a "picture buzz," because, in a receiver, the picture signals are always accompanied by the blanking and sync signals. It is the effect of the composite signal that produces "picture buzz."

Only the low-frequency components of the composite picture, blanking, and sync signals can get through the audio system and become audible. The audio system in TV receivers may cut off at approximately 5000 cycles or lower. The sound quality of picture buzz is, therefore, due to the 60-cycle vertical blanking and sync signals, and to the low-frequency picture signals, which represent large dark and light areas in the picture.

The term "sync buzz" is often used instead of "picture buzz," but the term "sync buzz" should be restricted to the rare cases where vertical-sync pulses from the sync separator are getting into the sound.

Audio Hum

In cases where there is hum (not buzz) from the speaker, and the hum is present on all channels, including blank ones, first determine whether the intensity of the hum varies with adjustment of the volume control:

If the intensity of the hum *does not* vary with adjustment of the volume control, the trouble is generally in circuits AFTER the control.

If the intensity of the hum can be reduced to the vanishing point by turning the control counter-clockwise, the trouble is generally in circuits AHEAD of the control. (One exception is mentioned later).

In cases where the intensity of the hum *does* vary with adjustment of the volume control, try a new tube in the sound-discriminator circuit. If the hum stops, it can be assumed that the original tube had heater-cathode leakage, which introduces 60-cycle heater voltage into the audio-input circuits.

It should be remembered that the discriminator tube and the discriminator-output circuits are a part of the audio-input circuit, and are subject to the same hum troubles, such as heater-cathode leakage, and electrostatic pickup of hum, buzz, and other extraneous signals.

In cases where the intensity of the hum *does not* vary with adjustment of the volume control, the following "process of elimination" may be used:

1. Try a new tube in each stage of the audio amplifier. If the hum stops, the trouble was probably due to heater-cathode leakage in the original tube.

2. If new tubes do not eliminate the hum, remove the audio-output tube: If the hum is still present, there is something radically wrong in the audio-output transformer or speaker circuit, which should be checked in order to locate the fault.

3. If the hum stops when the audio-output tube is removed, put the tube back in its socket, and remove the first-audio tube.

4. If the hum is still present with the first-audio tube removed, it indicates that there is excessive hum-voltage ripple on the B-supply bus to the audio amplifier, or on the grid-bias bus to the output stage. Check the electrolytic capacitors in these supply circuits.

5. If the hum disappears when the first-audio tube is removed, put the tube back in its socket. The hum should reappear. If the grid resistor of the first-audio stage is returned to chassis, temporarily short-circuit the resistor. The hum should disappear, providing the previous checks have been made properly. If the grid resistor of the first-audio stage is returned to a B− point, check the electrolytic capacitor in this circuit.

6. If the above steps have been followed correctly, the trouble will be localized to the audio-input circuits, which should be carefully traced and checked. See that all unshielded audio-input wiring, components, controls, and switches are kept away from the ac power-supply leads, the power-rectifier circuit, the filter choke, and the heater wiring.

It must be stressed that the above procedure is based on *hum* trouble, *not* buzz trouble. If there is any question on this point, remove the following tubes: The horizontal oscillator, the horizontal-output tube, the vertical oscillator, the last picture-if amplifier, and the last sound-if amplifier. Removal of these tubes disables the horizontal oscillator and high voltage, the vertical deflection, the picture, and the sound, thus eliminating virtually all possible sources of buzz in the receiver. Removal of the horizontal output tube is necessary because removal of the horizontal oscillator tube alone would result in excessive dissipation in the horizontal putput tube and possible tube failure. If the hum is still present, it is undoubtedly "audio hum" and the above procedure should be effective in locating the trouble. In ac/dc sets, of course, this procedure cannot be followed.

A minor exception should be noted regarding the rules given above for determining whether the hum trouble is ahead of, or after, the volume control: If hum voltage is being picked up through electrostatic coupling to the lead to the arm of the volume control, or to the lead to the first-audio grid (both of these leads occur in the circuit "after" the control), the intensity of the hum will *decrease* when the control is turned counter-clockwise. This action occurs, when the control is turned counter-clockwise, because the arm is brought to chassis potential for hum voltages, and the first-audio coupling capacitor is effectively connected across the first-audio grid circuit, thereby bringing the grid closer to the chassis for hum voltages

Modulation Hum

The term "modulation hum" is used to distinguish this trouble from "audio hum." There is a great difference between the two. *Audio hum is present at all times, regardless of whether a signal is being received. Modulation hum is present only when a station is being received.*

Modulation hum is caused by the presence of undesired hum voltages in the rf or if amplifiers (including the rf oscillator and converter). The hum voltage modulates the rf or if signal. *The modulation is AM,* except in cases where the hum trouble occurs in the rf-oscillator circuit and produces both AM and FM.

Modulation hum in TV receivers is usually caused by:

(a) Heater-cathode leakage in any tube through which the rf or if sound signal passes.

(b) Excessive hum-voltage ripple on the plate, grid, or screen supplies for any tube through which the rf or if sound signal passes.

If there is hum trouble in any tube through which both the sound and picture rf or if carriers pass, the effects are always more evident on the picture than in the sound, because the action of the sound-if limiter and discriminator tend to wipe out amplitude modulation on the sound-if carrier.

Modulation-hum trouble may not affect all of the TV stations. For instance, if the trouble is caused by heater-cathode leakage in an rf or if tube, and if the particular tube is almost cut off by agc action on a strong local station, the hum voltage will not modulate the signal of this particular station.

In AM radio receivers, modulation hum can be easily identified by its tuning action. The hum becomes audible when the receiver is tuned to the station, and it disappears when the set is tuned away from the station. It is for this reason that modulation hum in AM receivers is often described as "tunable hum."

The tunable action of AM modulation hum is entirely different in FM receivers, and on the FM sound in TV

*In receivers having a transformer-type power supply.

receivers. Because the limiter and discriminator tend to eliminate any amplitude modulation that is present on the signal, the intensity of AM modulation hum *decreases* when the receiver is correctly tuned to the station. Correct tuning is the point where the frequency of the sound-if signal is the same as the center frequency of the discriminator. The intensity of modulation hum increases when the sound-if signal is tuned slightly above or below the correct point. This tunable action of modulation hum is evident only on TV receivers that have a separate channel for the sound-if signal. In inter-carrier receivers, the sound if (4.5 Mc) is fixed in frequency and it cannot be altered by turning the tuning control of the receiver. *Hence, in inter-carrier receivers, there is no tunable action in cases of modulation hum.*

The cause of modulation hum in TV receivers may be determined by:

(a) Trying new tubes in all stages through which the rf or if sound signal passes. (Only those stages that have a resistor or 60-cycle impedance in the cathode circuit are likely to show any effect from heater-cathode leakage).

(b) Using a voltage-calibrated oscilloscope (such as the RCA WO-56A) to check for excessive hum-voltage ripple on the plate, screen, and grid supplies for the rf and if amplifiers.

(c) Checking the alignment of the sound-if amplifier and the sound discriminator with reliable sweep equipment (such as the RCA WR-59B Television Sweep Generator, and the WR-39C Television Calibrator). Incorrect alignment greatly reduces the ability of the limiter and discriminator to wipe out amplitude-modulation hum and buzz.

(d) In inter-carrier receivers, it is important to align the sound-if amplifier and discriminator exactly at 4.5 Mc in order to obtain the greatest reduction of AM hum and buzz. (The RCA WR-39C Television Calibrator incorporates a 4.5-Mc crystal to assure utmost accuracy for this work.)

In cases where hum is present on only one station, it is always advisable to check another receiver to determine whether the hum is present on the station's sound carrier.

For general background information, it is helpful to consider another cause of modulation hum which occurs, under certain conditions, in AM radio receivers (especially in ac/dc sets) that have a small loop or "hank" antenna.

In many locations, considerable signal energy from one or more of the local broadcast stations is picked up by the power line. The strength of such signals at the receiver may be affected by the action of the power rectifier. On positive half-cycles of the power-supply voltage, the rectifier and first filter capacitor form an effective rf short circuit across the line; on negative half-cycles, the rectifier is effectively an open circuit. This action may produce a variation, at the power-line frequency, in the strength of the line-pickup signal. If some of this hum-modulated signal is coupled into the antenna-input circuit, hum will be evident on the sound of the particular station. Remedies for this type of modulation-hum trouble in AM radio receivers include:

(a) Use of line-bypass capacitors, or a line filter, to prevent entry into the receiver of signals that are picked up by the power line.

(b) Use of a grounded electrostatic shield between the primary and the secondary windings of the power transformer to prevent entry of the line-pickup signals.

(c) Use of an electrostatic shield around the loop antenna, to prevent electrostatic pickup of the hum-modulated signal.

(d) Use of an outdoor antenna, to provide "clean" signals of sufficient strength to swamp the effect of the hum-modulated signals.

TV receivers generally have built-in power-line filters that eliminate almost all possibility of this particular variety of modulation hum.

Zero Picture-Signal Buzz

In inter-carrier receivers, the sound-if signal of 4.5 Mc is formed at the second-detector by the difference-frequency beat between the picture- and sound-if carriers. The frequency of this beat depends solely on the difference in frequency between the rf picture and sound carriers. The specified standard separation between the picture and sound carriers is 4.5 Mc, hence the beat is 4.5 Mc.

The 4.5-Mc beat, which has sound frequency modulation, is amplified in the 4.5-Mc sound-if amplifier and fed into the sound discriminator. The audio output of the discriminator is amplified by the audio amplifier, and fed into the speaker. Obviously, if there is no 4.5-Mc beat, there will be no sound output.

In order to obtain a 4.5-Mc beat signal at the output of the second detector, it is necessary that *both* the sound and the picture signals be present in the input to the second detector. If *either* the picture or sound signal is missing for any reason, there will not be a 4.5-Mc beat, and, consequently, there will be no sound output from the speaker. If the station shuts off its picture carrier so that there is no picture signal at the receiver, there will also be an absence of sound, despite the fact that the station is transmitting its normal frequency-modulated sound carrier.

Suppose that the station transmits a normal FM-sound carrier, but that it reduces the picture carrier to zero amplitude for a short period every 1/60th of a second, or at a rate of 60 times per second. During these short periods when the picture carrier is cut off, there can be no 4.5-Mc beat and no sound output from the speaker. The resulting 60-cycle interruption in the sound produces the effect of 60-cycle buzz. The tone of the buzz will change with different scenes.

Before inter-carrier receivers were introduced, it was general practice in TV stations to operate the transmitter in such a way that the amplitude of the picture carrier was reduced to zero, or modulated down to zero, for the whitest portions in the picture. Such reductions to zero amplitude, repeated at the field frequency of 60 cycles, produce picture buzz in the sound of inter-carrier receivers. Consequently, ever since the inter-carrier receivers have come into common use, the operators at TV stations maintain the amplitude of the picture carrier so that it does not fall below approximately 10 per cent. In this way, there is never any complete interruption in the picture carrier and, therefore, no interruption in the 4.5-Mc beat and no buzz.

Occasionally, in the process of making adjustments at the station, the carrier may unintentionally be modulated down to zero amplitude for short periods, thereby producing picture buzz in the sound of inter-carrier receivers. This trouble, which was fairly common at one time, is now seldom evident.

On a complaint of picture buzz in an inter-carrier set, it is advisable to check the same station on other inter-carrier receivers to determine whether the same buzz occurs at the same time on all receivers. *If the buzz is not present on the other sets, the trouble is not caused by the station.* The faulty receiver should then be checked for other causes of picture buzz as described in this article.

Cross-Modulation Buzz

When two rf or if signals of different frequencies are amplified in the same stage, there is a possibility that the modulation on one signal may appear on the other signal, and vice versa. When this trouble occurs, it is termed "cross modulation." Operation on a non-linear portion of the grid-voltage—plate-current curve may produce cross modulation in an amplifier tube.

When cross modulation occurs in a stage that is used to amplify both the picture and sound carriers (rf and if), the FM sound signal acquires amplitude modulation from the AM picture signal. If this amplitude modulation is not eliminated by the subsequent action of the sound-if limiter and sound discriminator, the characteristic noise of picture buzz will be heard in the sound output from the speaker. The tone and intensity of the buzz change on different televised scenes.

In the first post-war television receivers, such as the RCA Model 630, the rf amplifier is the only stage that amplifies both the picture and sound signals. The possibility of cross modulation in these receivers is slight, but it can occur on strong signals if the rf bias is incrorrect.

In later receivers, the first stage or the first and second stages of the picture-if amplifier are used to amplify both the sound-if and picture-if signals. Cross modulation can occur in these stages if the input signal to the stage has excessive amplitude, or if the bias is incorrect, or if the tube has a restricted linear operating range.

In inter-carrier receivers, the entire if amplifier is used to amplify both the picture-if and sound-if signals. Also, in some inter-carrier receivers, one or two stages in the video amplifier are used to amplify both the video signals and the 4.5-Mc sound-if signals. Cross modulation can occur in any of these stages, for the reasons given in the previous paragraphs.

Cross-modulation buzz can be demonstrated on strong stations, by temporarily short-circuitng the agc bias-voltages for the rf and if amplifiers. The lack of bias will cause excessive gain and signal over-load, with resulting cross modulation and buzz. The same effect can be obtained by incorrect setting of the agc threshold adjustment (or switch) which is used in some receivers.

The following suggestions may be helpful in cases of cross modulation:

(a) Check the frequency response and the gain of the sound-if amplifier and limiter. Check the response of the sound discriminator, which should be linear, and centered at the correct frequency. In inter-carrier receivers it is especially important to align the sound-if amplifier and discriminator exactly at 4.5-Mc. Correct alignment and gain is essential to obtain the greatest possible reduction of any AM picture signals that are present on the FM sound-if carrier. Use dependable and accurate alignment equipment: *The writer strongly recommends the RCA WR-39C Television Calibrator, the WR-59B Television Sweep Generator, and the WO-56A 7-Inch Oscilloscope.*

(b) Check the over-all frequency response of the rf and picture-if amplifiers. Realign if the response is appreciably different from that recommended by the manufacturer of the receiver.

(c) Check the agc voltages on the rf and if bias bus and also at the grids of the agc-controlled tubes. Use a good vacuum-tube voltmeter, such as the RCA WV-97A Senior VoltOhmyst, to prevent loading these circuits.

(d) Try new tubes in all stages that pass both sound and picture signals. If the buzz is diminished when a new tube is used in a particular stage, try several new tubes in this stage, picking out the one that gives best results.

(e) If cross modulation is present on only the strongest station, try increasing the bias on the rf amplifier.

(f) In inter-carrier receivers that use one or two stages in the video amplifier to amplify the 4.5-Mc sound-if signal, determine whether the cross modulation is occurring in the video stages: Temporarily substitute a carbon potentiometer in place of the second-detector load resistor, to permit reducing the amplitude of the signal input to the video amplifier. The "pot" should have approximately the same value as the load resistor. Connect the video-input lead to the arm of the pot. Reduce the video-input signal, by means of the pot, to about one-half of normal. If the buzz ceases, it indicates that the cross modulation is occurring in the video amplifier. In this case, remove the pot, restore the original connections, try new tubes in the video amplifier, check the voltages on the video tubes, and try changing the bias slightly on each stage. Excessive change in bias may affect the video signals.

To avoid unnecessary waste of time on cases of cross modulation, it is always a good practice to find out whether the trouble is chronic in the particular model, and whether the manufacturer has recommended any changes to correct the trouble.

High-Voltage Buzz

Due to the regulation characteristics of the high-voltage supply, there is considerable low-frequency variation in the high-voltage for the picture tube. The voltage is highest at times when the beam current is cut off by long-duration black signals, such as vertical blanking. The voltage is lowest at times when the average beam current is highest, which occurs during large, wide, white areas in the picture. Any variations in high voltage are repeated at the field frequency of 60 cycles.

If there is stray capacitive coupling, *even a few micromicrofarads*, between the high-voltage circuit and the audio-input circuits, the variations in high voltage are likely to produce a buzz in the sound output from the speaker. The intensity and tone of the buzz change on different televised scenes and on "commercials."

This type of buzz, which will be referred to as high-voltage buzz, can be identified as follows:

(a) The intensity of the buzz decreases when the brightness control is turned down.

(b) The intensity of the buzz decreases when the contrast control is turned down.

(c) The buzz ceases when the high-voltage lead is disconnected from the picture tube, or when the socket is removed from the rear of the picture tube.

High-voltage buzz is generally found only in receivers where the audio-input circuits, such as the sound discriminator, volume-control wiring, or first-audio tube circuit, are within a few inches of the high-voltage-electrode connector, and where there is no electrostatic shielding between this electrode and the audio circuits. In receivers where all of the audio circuits are underneath the chassis, the chassis acts as an electrostatic shield. In receivers with glass-type picture tubes having an outer conductive coating, the outer coating acts as an electrostatic shield, *provided the coating is connected to the chassis*. The coating serves no purpose unless it is connected to the chassis.

Frequently, high-voltage buzz can be corrected by simply making a good connection between the chassis and the outer coating on the glass-type picture tube.

If the receiver has a metal-type picture tube, or a glass-type tube without an outer coating, high-voltage buzz can be eliminated by shielding any audio-input wiring and components that are within a few inches of the high-voltage electrode. Shielding may be accomplished by covering the audio components with a metal shield and by replacing the audio leads with shielded cable. This shielding must be connected to the chassis.

Vertical-Deflection Buzz

If there is coupling of any type between the vertical-deflection section and the audio amplifier, the high-amplitude saw-tooth voltages that are present in the vertical-oscillator and vertical-amplifier sections may cause a buzz in the sound output from the speaker.

Vertical-deflection buzz can be identified as follows:

(a) The tone of the buzz varies when the frequency of the vertical oscillator is changed by turning the vertical-hold control.

(b) The buzz disappears when the vertical-oscillator tube is removed.

(c) The buzz is present on all channels, including unused ones, and it continues if a tube in the sound-if amplifier is removed.

Checks (a) and (b) show that the buzz is due to vertical-deflection voltages. Check (c) shows that the pulses are being coupled into the audio amplifier, and also that the buzz is not due to cross-modulation of any kind.

If the checks show that the buzz is due to vertical-deflection voltages, inspect the chassis to determine whether the wiring, transformers, tubes, or other components in the vertical-oscillator and vertical-amplifier sections are close to the sound-discriminator or audio-input circuits. If some of these parts are close to the discriminator or audio-input circuits, try electrostatic shielding to decrease the coupling. A piece of tinfoil, wrapped in paper or plastic sheet to prevent accidental short circuits, may be used while these checks are made. The shield must be connected to the chassis.

In a number of cases of vertical-deflection buzz, it was found that the vertical-output transformer was mounted too close to the audio-input circuits. The buzz was eliminated by wrapping a sheet of insulated tinfoil around the transformer, and by connecting the tinfoil to the chassis.

In cases where vertical-deflection buzz is not caused by electrostatic coupling, check the electrolytic filter capacitors in the supply leads to the vertical section. Open filter capacitors in these supply circuits may permit common-impedance-coupling between the vertical section and the audio amplifier or the rf-if amplifier.

Snapping, Crackling, or Sizzling Sounds (High-Voltage Breakdown)

Intermittent faint snapping or crackling sounds generally indicate high-voltage arc-over. The sound may be accompanied by corresponding noise from the speaker, and also by momentary horizontal tearing of several lines of the picture. Continuous faint sizzling sounds may be accompanied by raggedness in horizontal deflection.

Continued arc-over, and also corona, produces the characteristic odor of ozone. *When ozone is detected, look for corona or arc-over in the high-voltage circuits.*

The location of an arc-over can usually be determined by sight or by sound, but in some cases the arc-over may occur inside a high-voltage filter capacitor, or in some other component or unit where it cannot be seen. When trying to locate an arc-over by sound, turn the volume control counter-clockwise to eliminate any interfering noise from the speaker. When looking for an arc-over, or for corona, darken the room.

In cases of sizzling, accompanied by horizontal raggedness, a common cause is a slight sparking at the point where the chassis is connected to the outer conductive coating on a glass-type picture tube. If this trouble exists, the connection should be improved in some convenient and permanent manner.

In cases where there is a snapping or crackling sound of high-voltage arc-over, but where the arc-over cannot be seen, it is advisable to try a new high-voltage filter capacitor.

If a new capacitor is not immediately available, the original capacitor may be checked indirectly as follows: Turn off the set, discharge the capacitor, disconnect the capacitor, and turn the set on. Disconnection of the capacitor causes a reduction in the high voltage and a decrease in brightness. If the arc-over does not occur with the capacitor disconnected, the arc-over probably took place inside the capacitor. In this event, install a new capacitor and operate the receiver to make certain that the trouble has been corrected.

Visible arc-over and corona from leads, transformers, or other components can usually be eliminated by shifting the position of the leads or components slightly, by eliminating any sharp points on wire and solder, and by use of high-voltage plastic insulating material wherever necessary.

Buzzing Transformers

In tracking down the cause for audible hum and buzz, first determine whether the sound is coming from the speaker or if it is being created by mechanical vibration or buzz in a transformer.

The alternating or pulsating currents that flow through the coils of a transformer set up fluctuating magnetic forces that tend to make the laminations and coils vibrate in step with the changes in current. Precautions are taken in the design of transformers to prevent mechanical vibration. The laminations are tightly clamped together and are usually dipped in varnish to form a non-vibrating block; the coils are thoroughly impregnated in wax or varnish to form a non-vibrating unit; the coil assembly is tightly wedged on the core, and the core-and-coil assembly may be "potted" or buried in an insulating compound which further restricts vibration. Yet, in spite of these measures, a small percentage of transformers develop an objectionable amount of buzz.

Experience has shown that the vertical-output transformer is the chief offender in the production of buzz. The vertical-oscillator transformer may buzz, and there is a possibility of buzz in the vertical section of the deflecting yoke.

An important point to remember in connection with buzz in any *vertical* transformer, is that the tone of the buzz can be altered by changing the frequency of the vertical oscillator, by adjusting the vertical hold control. Stated oppositely, if the tone of a transformer buzz changes when the vertical-hold control is turned, the buzz originates in a transformer in the vertical section of the receiver.

The power transformer is probably the second chief offender in producing buzz. Any power transformer is likely to buzz if it is greatly overloaded by a short circuit across a winding or across a portion of a winding. A short circuit, however, usually produces other and more important symptoms, such as failure of operation, overheating, blown fuses, etc.

Vibration of the core or coils in a horizontal-output transformer may produce a high-pitched whistle at the horizontal frequency of 15,750 cycles, which is beyond the hearing range of the majority of men, but may be annoyingly audible to women and young persons.

Mechanical vibration in an audio-output transformer produces thin sounds of voice and music, or "singing." Any sound from the audio-output transformer is generally masked by the stronger sound from the speaker.

On rare occasions, sounds may come from a defective tubular capacitor (which has not been properly impregnated, and in which the foil has been wound too loosely) if the amplitude of the voltage fluctuations across the capacitor is in the order of several hundred volts.

Almost all complaints involving buzzing transformers come from installations where the receiver is operated at low volume level in a quiet room. When the receiver is operated at high volume level, or is used in a noisy room, the sound from a buzzing transformer is likely to pass unnoticed. The intensity of the sound is influenced by the acoustics of both the cabinet and the room, which may deaden or reinforce the sound. Listening checks for buzzing transformers should preferably be conducted under quiet conditions. (The same precaution applies when investigating complaints of low-level hum or buzz in the sound output from the speaker.)

To prevent possible confusion when checking for buzzing transformers, it is advisable to kill the audio output of the receiver, either by removing the audio-output tube, or by short-circuiting the primary of the audio-output transformer.

Buzzing Power Transformers

If the buzz seems to be coming from the power transformer, temporarily remove or disconnect the power rectifier, thus eliminating all other possible sources of hum or buzz in the receiver. The heater load alone is generally sufficient to continue the buzz. If the power transformer is buzzing, try tightening the bolts that clamp the laminations together. Don't draw up too tightly on the bolts, because they have an annoying habit of shearing off.

If tightening of the bolts does not reduce the buzz sufficiently, disconnect the power cord, remove one or both of the end bells (covers), and check to see if the coil assembly is tightly wedged on the core. The transformer may have wedge-shaped pieces of impregnated hardwood or fibre inserted between the core and the inside of the coil form. Tap the wedges tightly into position; drive in new wedges if necessary.

Look for loose laminations on either end of the stack. In some transformers the laminations are bonded into a solid block by means of varnish. If loose laminations have been added, in order to obtain the required core thickness, they may be contributing to the buzz. Apply a coat of varnish to the loose laminations and, while still wet, replace them in the core. Reassemble the transformer, tighten the bolts, and check for buzz. If the buzz has been reduced sufficiently, replace the rectifier and recheck. If the buzz is objectionable, it may be necessary to replace the transformer.

A quick check for buzz in the power transformer can be made by listening to the transformer in the few seconds that elapse between the time the set is turned on (from a cold start) and the time the rectifier tube starts operating.

Buzzing Vertical Transformer

When there is reason to believe that buzz is caused by a transformer in the vertical circuits, kill the audio output of the receiver and rotate the vertical-hold control. If the tone of the buzz changes, it is a definite sign that the buzz is coming from a transformer in the vertical section. In this case, temporarily remove the vertical-output tube. If the buzz stops, the vertical-output transformer is at fault. If the buzz continues and if the particular receiver has a transformer in the vertical-oscillator circuit, remove the vertical-oscillator tube. If the buzz ceases, the oscillator transformer is at fault.

Buzz in a vertical-output transformer may be caused by a partial short circuit in the transformer windings or in the circuit. The most prominent symptom in this case, is vertical-deflection trouble.

Remedies for a buzzing vertical transformer are the same as for power transformers, namely: Tighten the bolts (or clamps) that hold the laminations together, and see that the coil assembly is tightly wedged on the core. If these remedies are not successful, it is usually necessary to replace the transformer. Any attempt to repair a "potted" transformer may take too much time.

The writer has never run across a case of buzz in the vertical section of a deflection yoke, but if this trouble should occur, an inspection of the yoke may reveal the cause and suggest a remedy.

In many cases there is no visible reason for buzz in a transformer. The laminations may appear to be securely clamped and varnished into a solid block; the coil assembly may appear to be impregnated into a solid mass; the coil assembly may be wedged tightly on the core; the transformer may pass all electrical tests, including checks that reveal internal short-circuit across turns in any winding; and the transformer may function perfectly in the receiver. The trouble in such cases may be due to vibration in a section of the core or coil that cannot be seen.

Shorted Turns May Cause Buzz

Many technicians do not fully realize that an ohmmeter will NOT reveal an internal short circuit across a small portion of the turns in a transformer winding, or in any other coil. There is a manufacturing tolerance in the number of turns in the winding. If the tolerance happens to be ± 10 per cent, the dc resistance of the winding also has a ± 10-per cent tolerance. If 10 per cent of the turns are short-circuited, the windings will still check satisfactorily within the dc-resistance tolerance. Yet this partial short circuit, in the case of a power transformer, may cause buzz and overheating. In the case of a vertical transformer, the partial short circuit may cause deflection trouble and buzz. A partial short circuit in a winding of a horizontal-output transformer may cause horizontal-deflection trouble and audible 15-Kc whistle.

The value of an ohmmeter in checking a transformer winding is restricted to showing whether the winding is open, or completely shorted, or has a short across more than about 20 per cent of the turns. *It is important to remember that dc-resistance checks do NOT prove that a transformer, or any other coil, is OK.* The best check, in many cases, is to try a new transformer or coil.

A simple check for partial short-circuited winding in a power transformer can be made by operating the transformer with no load on any of the secondary windings. If the transformer becomes excessively warm during the "no-load" check, it indicates the likelihood of a partial short circuit.

15-Kc. Whistle

Mechanical vibration in the horizontal-output transformer in some receivers produces a detectable amount of high-pitched whistle at the horizontal frequency of 15,750 cycles. This sound is referred to as "15-Kc whistle."

It is generally the lady-of-the-house who mentions the whistle, because the man-of-the-house usually can't detect it and is likely to suspect that his wife is hearing things. The majority of technicians can't hear the whistle either, even if they put their ear against the transformer, which they are unlikely to do. Some technicians handle this question by looking wise and complimenting the lady on her ability to hear sounds that are beyond the hearing range of the majority of men. A hurried exit at this psychological moment, while the lady's eyes are still sparkling, usually ends the matter.

Sometimes it is possible to detect the whistle by throwing the horizontal oscillator out of synchronism with the station, so that several slanting dark bars (horizontal blanking and sync) appear across the screen. When the bars are in motion, not stationary, the whistle has a low-frequency flutter that may be audible.

Little, if anything, can be done in the way of tightening the core or coils in the average horizontal-output transformer. Sometimes, however, loosening the clamps will help. Also, because of the high-voltage insulation requirements, there is need for caution in making any changes or additions in an effort to reduce the vibration or to muffle the sound of the whistle. *If the whistle is objectionable to the owner, the usual remedy is to replace the transformer.*

If high-amplitude horizontal pulses are coupled into the grid of an audio amplifier, they may produce grid current and set up a high negative bias, thereby greatly reducing the sound output. (This trouble may be accompanied by a high-pitched whistle from the speaker. The whistle develops a flutter when the horizontal oscillator is thrown out of sync, as mentioned above.) To check for this rare possibility, *temporarily* remove the horizontal-oscillator tube while a station is being received. If the sound output increases greatly when the oscillator tube is removed, revise the lead dress and shielding of the audio circuits in order to reduce coupling from the horizontal-output circuits.

If the electrostatic shielding around the horizontal-output circuits is removed, the subsequent radiation of high-voltage horizontal pulses, and of any spurious oscillation in the horizontal-output circuit, can produce a variety of visible and audible symptoms. For this reason *it is good practice to keep the high-voltage compartment "buttoned up."*

Simple Experiments

The best way to become acquainted with the causes and effects of hum and buzz in television receivers is to duplicate some of the troubles described in this article. No special equipment is required except a television receiver and an hour of spare time.

The audio amplifier and speaker of the receiver can be used, in conjunction with a simple home-made electrostatic pickup probe, to furnish a convenient means for observing the sound effects of hum and buzz voltages in various sections of the receiver.

Connect a two-foot length of shielded lead to the high-side of the audio volume control, in series with a capacitor of about 0.05 μf. Connect the shield of the lead to the chassis. The shielded lead should have an insulating outer cover. Remove the shield from about four inches of the lead, at the free end, to afford electrostatic pickup. The unshielded portion at the end of the lead will be referred to as the "probe."

Tune in a station, and then remove the sound discriminator, or a tube in the sound-if amplifier, in order to kill the station's sound.

Vertical-deflection buzz. Bring the probe near the vertical-output transformer circuit, and note the sound of vertical-deflection buzz. Turn the vertical-hold control and note that the tone of the buzz changes. Remove the vertical-oscillator tube and note that the buzz stops.

Picture-buzz. Connect the end of the probe to the cathode of a video-amplifier tube that has a cathode resistor. Note the characteristic buzz produced by picture signals, and note how the tone and intensity of the buzz change on different scenes, especially on "commercials."

Bring the probe near the output of the video amplifier. The buzz of picture signals will again be heard.

High-voltage buzz. Bring the probe about two inches from the high-voltage electrode of the picture tube, and note the sound of the picture buzz. (If the receiver has a glass-type picture tube having an outer conductive coating, temporarily disconnect the coating from the chassis.) Turn the brightness control and note that the intensity of the buzz changes. Remove the socket from the rear of the picture tube and note that the buzz stops.

Audio hum. Introduce heater-cathode leakage in the audio-output tube, if it has a cathode resistor, by connecting a rheostat of several thousand ohms from the ungrounded heater terminal to the cathode of the audio-output tube. Note the sound of 60-cycle hum.

Bring the probe near the power transformer, the filter choke, and the heater wiring. Note the sound of 60- and 120-cycle hum. (To avoid excessive attenuation of humming sounds, the speaker should be left in the cabinet, or mounted on a baffle.)

Modulation hum. Remove the probe lead from the volume control and replace the sound-discriminator, or the sound-if tube, that had previously been removed. Simulate heater-cathode leakage in tubes in the sound-if amplifier. Note that there is little resulting hum on the station's sound, because the action of the limiter and discriminator tend to eliminate amplitude modulation. Simulate heater-cathode leakage in if-amplifying tubes through which both picture and sound signals pass. Note that the leakage produces pronounced visible symptoms in the picture, but very little audible hum (because of the action of the limiter and discriminator).

Cross-modulation buzz. While a strong station is being received, momentarily short out the agc bias voltage on the rf and if amplifiers. Lack of bias will produce overloading and cross-modulation, with resulting picture buzz in the sound.

HORIZONTAL PULLING*

By John R. Meagher
Television Specialist, RCA Renewal Sales

Part 1. Although horizontal pulling is a common trouble in television receivers, there is practically no information available on the subject. This article is designed to meet the need for authoritative data on its causes and remedies.

To simplify a rather complex story, numerous kinescope photographs are used to show the effects of horizontal pulling, as well as other visible symptoms, resulting from a variety of troubles. In many of these examples, the pulling effects are incidental. For this reason, the photographs and their explanatory captions are helpful in diagnosing other symptoms, in addition to horizontal pulling.

A Few Terms

When set owners complain of horizontal pulling, they may describe the symptoms by saying that telephone poles, doors, and windows in the TV picture appear bent, bowed over, curved, snaky, etc. Most technicians use the terms "horizontal pulling" and "horizontal bending" more or less interchangeably, usually reserving the latter for mild cases of pulling. The terms "waver" and "weaving" are generally applied in cases where the extent of pulling varies.

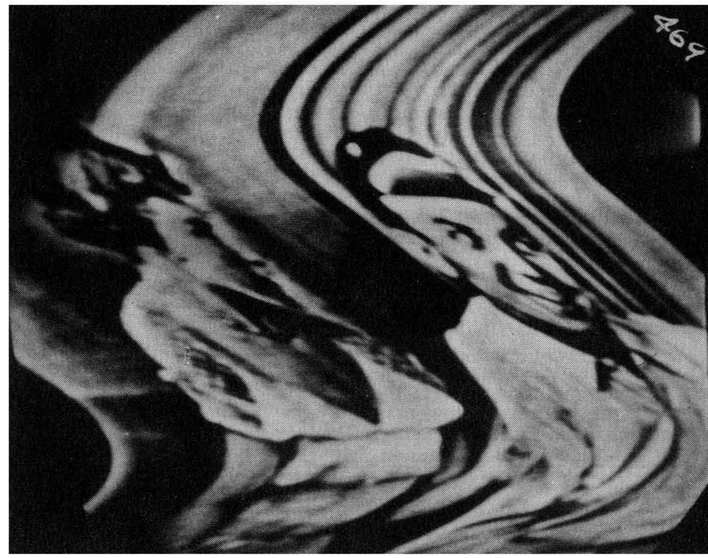
The writer uses the terms "raster pulling" and "picture pulling," because there is a real difference between the two effects, even though both produce the same outward symptoms in the picture. The troubles that cause raster pulling are usually entirely different from the troubles that cause picture pulling, as we shall see.

*Courtesy Radio & Television News. Reprinted from the March & April, 1951, issues (Vol. 45, No. 3 & 4).

Slight Bending at Top

One of the most common types of picture pulling is a slight bending, toward the left or right, at the top of the picture. The bending can usually be varied, or even straightened out, by adjustment of the horizontal hold control or the contrast control or, in some receivers, by the a.g.c. threshold control or switch. Occasionally, the bending at the top of the picture may shift, or "flag-wave," back and forth from left to right. In cases where slight bending or flag-waving at the top of the picture is normal and common in a particular model of receiver, it is often a waste of time for the technician to check for defective components. The bending, in such cases, may be more of a design problem than a service problem.

Many technicians have wondered why the top of the picture is most susceptible to horizontal pulling (or to actual tearing in receivers without horizontal a.f.c.). One reason is that the horizontal sync action is most likely to be unstable immediately following the disturbance of vertical sync. The top of the picture follows after vertical sync, hence any instability of this type that may exist in the receiver will show up at the top of the picture. Another possible cause in some receivers is that the surge in the vertical oscillator, following vertical flyback, may be coupled into the horizontal sync circuit, producing a disturbance in horizontal sync phasing at the top of the picture. A simple check for the presence of this trouble is described later.



Horizontal pulling caused by heater cathode leakage in the horizontal a.f.c. circuit.

Two Types of Pulling

For troubleshooting purposes, it is helpful to recognize that there are two basic types of horizontal pulling.

1. "*Raster pulling*," where the pulling or bending is present on the raster, *without* a picture. Naturally, any pulling or bending on the raster is equally evident on the picture. One example of raster pulling is shown in Fig. 1. Possible causes include:

(a) Troubles in "B" supply filtering.

(b) Troubles in the horizontal deflection section.

(c) Troubles in the deflecting yoke.

(d) Undesired magnetic fields near the picture tube.

2. "*Picture pulling*," where the pulling or bending is present on the picture, but *not* on the raster. Examples of picture pulling are shown in all of the photos except Fig. 1. Picture pulling is a direct result of variation in horizontal sync phasing, as described later. Possible

Fig. 1.

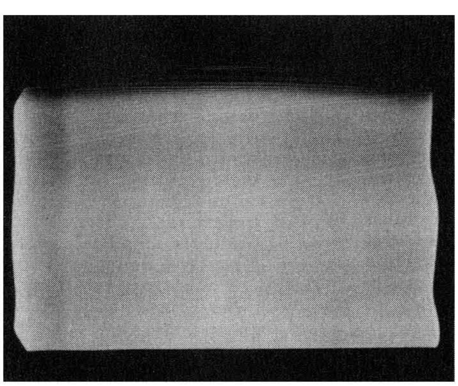


Fig. 2.

Fig. 3.

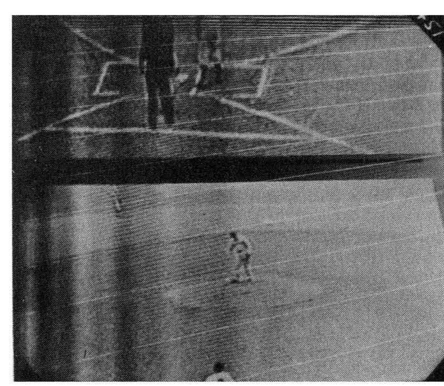


***Fig. 1.** Two cycles of bending between top and bottom of raster or 120 cycle change in amplitude of horizontal deflection as caused by open condensers in the "B+" filter circuit. The bending is present on the raster either with or without a picture.*

***Fig. 2.** Slight horizontal pulling, as evidenced by bending of the left and right hand sides of the box around "WFIL-TV," caused by an undesired magnetic field near the picture tube. The pulling, which is present on the raster with or without the picture, may be horizontal, vertical, or both depending on the location of the field. If the field is due to a magnetized portion of the shell of a metal-type picture tube, it may be detected by turning the tube, thus shifting direction of pulling.*

***Fig. 3.** Slight horizontal pulling at top of picture, accompanied by dark vertical bars at left, caused by open filter condensers in the "B+" feed to the horizontal deflection circuit. Horizontal blanking and sync signals are intentionally brought into view in this photo to show that there is no variation in width of raster but that there is variation in horizontal sync phasing at top of picture where it may be noted that shortstop and edge of picture are bent toward the left. Vertical hold control was adjusted to bring vertical blanking and sync into view in order to show that the horizontal bending exists only at the top of the picture. Also see Fig. 5.*

Fig. 4.

Fig. 5.

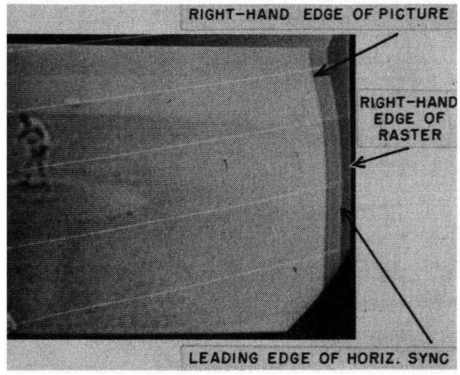


Fig. 6.

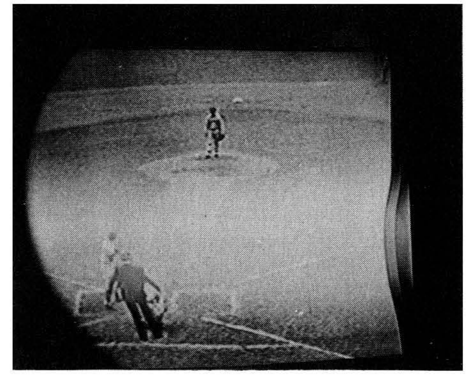


***Fig. 4.** Example of 60 cycle horizontal pulling, accompanied by light and dark areas, caused by heater-cathode leakage in the r.f., i.f., or video amplifiers. Here and in Fig. 6 picture is moved to left in order to show that edge of raster is straight without variation in width of raster (no change in amplitude of horizontal deflection). Picture pulling is result of 60 cycle variation in horizontal sync phasing.*

***Fig. 5.** Detailed section of the photo of Fig. 3. Note that the leading edge of horizontal sync, which should be parallel to the edge of raster, is not parallel (at the upper portion) thereby indicating a variation in horizontal sync phasing. Edge of raster is substantially straight, indicating pulling is not present in raster itself.*

***Fig. 6.** Same fault as shown in Fig. 4 except that 117 volt plug has been reversed which shifts position at which the picture is bent and also the position of dark and light areas by about one-half the height of picture. Note that umpire appears to be doing a balancing act. Position of bending and of light and dark areas moves slowly or rapidly up or down when TV camera supply is not synced with receiver.*

causes for picture pulling include:

(a) Poor low-frequency response in the r.f., i.f., or video amplifiers.

(b) Undesired limiting action in the video amplifier due to trouble in the amplifier or to excessive signal input.

(c) 60-cycle modulation of the horizontal sync pulses, due to heater-cathode leakage in the r.f., i.f., or video amplifiers, the sync separator, or the horizontal a.f.c. circuit.

(d) Excessive or insufficient sync signal input to the sync separator or troubles in the sync separator.

(e) Extraneous signals coupled by any means into the horizontal a.f.c. circuit.

(f) Electrical hunting action in the horizontal a.f.c. circuit.

(g) Extremely weak signals, interference, some reflection conditions, and other reasons.

It is desirable to consider the subject of raster pulling first.

Raster Pulling

Under normal conditions, all of the horizontal scanning lines in the raster have exactly the same length and the left- and right-hand edges of the raster are straight and parallel. If, however, there is any variation in the amplitude of horizontal deflection, some of the scanning lines become longer or shorter than others, resulting in the appearance of horizontal pulling or bending at the edges of the raster. One example of raster pulling is shown in Fig. 1, where 120 cycle ripple in the "B" supply, caused by open filter condensers, has produced a 120 cycle variation in the length of the scanning lines. (The vertical deflection rate in this example is 60 cycles: There are *two* cycles of bending between the top and bottom of the raster, or two cycles in 1/60th second, indicating that the variation in width is occurring at rate of 120 cycles-per-second.) *Any pulling or bending in the raster is, of course, equally evident in the TV picture.*

When the raster, without a picture, is pulled or bent, particularly at a 120 cycle rate, and is accompanied by hum in the audio, and possibly also by 120 cycle hum bars on the raster, it indicates that the trouble is in the "B" supply filter circuit. (In Fig. 1, there is a trace of 120 cycle hum bars on the raster, which has two light, and two slightly darker, horizontal areas.)

Another reason for pulling or bending of the raster is the presence, near the picture tube, of an undesired magnetic field from a speaker, transformer, or choke. Such parts are carefully positioned in well-designed receivers to avoid this type of trouble, therefore it is seldom encountered. The technician, however, should be acquainted with the effect since it is the uncommon troubles that account for many of the headaches in television service. The direction of pulling due to an undesired magnetic field may be horizontal, vertical, or a combination of both, depending on the direction of the field. One example of a rather mild case of pulling due to a magnetic field is shown in Fig. 2.

Troubles in the deflection yoke or in the design of the yoke can cause pulling or bending of the raster.

Yoke troubles can generally be identified by the characteristic shapes that they produce in the outline of the raster. They may resemble a keystone, pillow, pincushion, or barrel. The most common symptom of yoke trouble is a keystone-shaped raster. In order to observe the shape, it may be necessary to reduce the width and the height so that all four sides of the raster are in full view on the picture tube.

As every technician knows, the scanning lines can be bent up or down or pulled sideways by incorrect adjustment of the focus coil and the beam bender.

When the pulling or bending on the raster is not caused by trouble in the "B" supply or in the deflection circuits, the following simple checks will usually enable the technician to determine whether the pulling is due to yoke trouble, or to an external magnetic field.

Remove the thumbscrew on the deflection yoke and rotate the yoke by about 90°, keeping the yoke pressed forward against the flare of the picture tube. The raster will turn as the yoke is turned. If the pulling or bending on the raster is caused by yoke trouble, the *shape* of the raster will not change when the yoke is turned. If the pulling is due to an undesired magnetic field, the shape of the raster will change when the yoke is turned.

When a portion of the shell of a metal-type picture tube has become magnetized as, for instance, by accidentally touching it with the magnet in a speaker, the resulting magnetic field may cause pulling or bending of the raster. To check for such magnetization, loosen the tube clamp slightly and rotate the picture tube by about 30°. The raster will not turn when the tube is turned, providing the yoke is kept from turning. If the direction of pulling changes when the tube is turned, it indicates that a portion of the shell is magnetized. It may be possible to use a magnetized tube without demagnetizing it by turning the tube so that the magnetized portion is at the top or bottom, where it is farthest from the raster. This expedient is not possible, of course, in receivers with round masks.

To avoid high-voltage shocks, the receiver should be turned off and the high-voltage circuit discharged before any metal-type picture tube is touched.

Picture Pulling

When the cause for horizontal pulling is not immediately evident, it is a good practice to inspect the horizontal blanking and sync signals at the right-hand edge of the picture. These signals may be brought into view by moving the picture centering to the left, and by reducing the contrast and increasing the brightness to make the sync appear dark gray, as shown in Figs. 3 and 4. It may be necessary to adjust the horizontal hold control so that a sufficient portion of horizontal sync appears in view. (In some receivers, it may be necessary to adjust the a.g.c. threshold control to secure sufficient reduction in contrast, and temporarily short out a resistor in the brightness-control circuit for sufficient increase in brightness.)

By inspection of the horizontal blanking and sync signals, as in the examples shown in Figs. 3 and 5, we can immediately determine two facts:

1. The right-hand edge of the *raster* is not bent, but is straight. This is a positive indication that the particular pulling is not present on the raster.

2. The leading edge of horizontal sync is definitely pulled or bent with respect to the edge of the raster. Stated differently, there is a variation in the spacing (phasing) between the leading edge of horizontal sync and the edge of the raster. The spacing, or phasing, at the top portion of the picture is wider than at other portions. The trouble, therefore, is picture pulling due to variation in horizontal sync phasing.

Under normal conditions, when there is no horizontal pulling, the leading edge of horizontal sync is parallel to the edge of the raster and the edge of the raster is straight.

Regardless of any trouble in the receiver, the right-hand edge of the *picture* is always parallel to the leading edge of horizontal sync. The spacing between the edge of the *picture* and the leading edge of horizontal sync represents the "front porch" between the picture signals and the horizontal sync.

In Figs. 4 and 6, it may be seen that there is a variation in the spacing, or phasing, between the leading edge of horizontal sync and the edge of the raster. For instance, in Fig. 4, the spacing is wider at the top and bottom than at the center. In both Fig. 4 and Fig. 6, the edge of the raster is actually straight, although this fact is not clearly apparent because the particular trouble has darkened some portions of the picture. In working on a set, it is usually a simple matter to bring the entire edge of the raster into view by adjusting the contrast and brightness controls.

Up to this point, we have shown how any case of horizontal pulling may be quickly and easily classified into one of the two basic types—

Fig. 7.

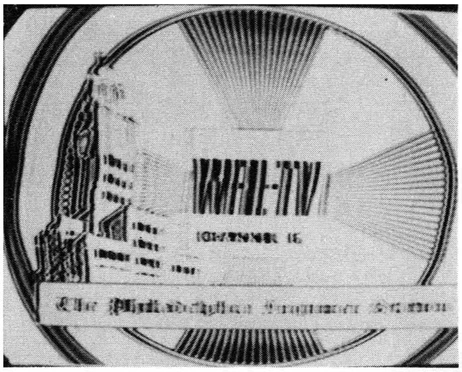


Fig. 8.

Fig. 9.

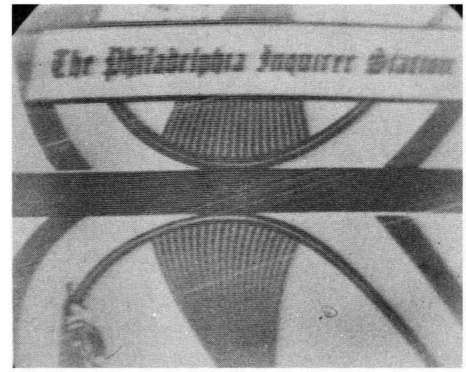


Fig. 7. Horizontal pulling caused by poor low frequency response in r.f. and i.f. amplifiers, reducing amplitude of sync signals with respect to higher frequency picture signals. The horizontal wedge, which represents low frequency signals, is faint compared with vertical wedge representing high frequency signals. Fault is poor alignment. Picture carrier is too low on the slope of the over-all response curve.

Fig. 8. Horizontal pulling caused by undesired limiting action in video amplifier which clips or reduces amplitude of sync signals making it difficult or impossible for sync separator to perform its normal function. With this type of trouble, the position and amount of pulling may vary with changes in picture content. The pulling may change from scene to scene, with motion of persons in scene, and with camera panning. Any significant reduction of sync amplitude can be detected by observing vertical sync on the tube, as shown in Fig. 9. The fault here is the incorrect setting of the a.g.c. threshold adjustment, permitting excessive signal input to video amplifier, where the limiting action reduces the amplitude of the sync signals.

Fig. 9. In this example, sync signals are completely wiped out or reduced to blanking level by undesired limiting action in video amplifier. Trouble is caused by low plate voltage on 2nd video tube. Same condition can result from excessive signal input to video amplifier, or incorrect bias and other troubles in video amplifier. There is horizontal pulling at top and bottom of picture and sync is extremely unstable. With complete absence of sync, vertical and horizontal oscillators may tend to sync on leading edge of blanking signal.

raster pulling or picture pulling. We have also discussed simple means for localizing the troubles that cause raster pulling. We will now consider the steps that may be necessary in localizing troubles responsible for picture pulling.

The composite (picture, blanking, and sync) signal from the TV station passes through the r.f., i.f., and video amplifiers, and appears on the picture tube. With normal adjustment of contrast, the blanking and sync signals are blanked out, or blacked out, and are not visible on the picture tube. They may, however, easily be brought into sight and are then extremely useful in diagnosing certain troubles.

The composite signal is picked off at some point in the receiving circuits, usually in the video amplifier, and is fed into a sync separator. Under normal conditions, the sync signals are about 33% higher in voltage than the blanking signals which, in turn, are slightly higher in amplitude than the darkest picture signals. On the basis of this difference in sync amplitude, the sync separator is designed to pass the high-amplitude sync and (by limiting and clipping action) to remove the blanking and picture signals. The output of the sync separator should consist of sync pulses only with no trace of and no effect from the blanking and picture signals.

The horizontal sync pulses that are delivered from the sync separator to the horizontal a.f.c. circuit should have uniform amplitude, uniform spacing (phasing), and uniform duration. (The horizontal sync pulses that occur during the vertical equalizing and sync interval have different duration but normally this difference is wiped out through differentiating action.)

Any trouble in the r.f., i.f., or video amplifier that acts to reduce the amplitude of sync, bringing it closer to the blanking and picture level, will make it difficult or impossible for the sync separator to function properly and may result in horizontal picture pulling or complete loss of sync.

In this connection, there are two principal troubles to watch for in the r.f., i.f., and video amplifiers:

1. *Poor low-frequency response.* The sync pulses represent relatively low-frequency signals. Inadequate low-frequency response in the r.f., i.f., or video amplifiers can reduce the amplitude of sync in comparison with the higher-frequency picture signals. The usual reason for poor low-frequency response in the r.f. and i.f. amplifiers is incorrect alignment with the picture carrier too low on the slope of the response curve. An example of picture pulling caused by incorrect alignment is shown in Fig. 7.

The usual reasons for poor low-frequency response in the video amplifier are:

(a) The resistance of a load resistor may have dropped appreciably below the specified value, due possibly to over-heating resulting from a short in a tube.

(b) A coupling condenser may have opened or may have decreased radically in capacitance value.

2. *Undesired limiting action in the video amplifier* can seriously reduce the sync amplitude. The usual reasons for undesired limiting in the video amplifier are:

(a) Excessive amplitude of signal input to the video amplifier, resulting from trouble in the a.g.c. circuit, or incorrect adjustment of the a.g.c. threshold control, as shown in the illustration, Fig. 8.

(b) Incorrect plate, screen, or bias voltages due to circuit, components or tube trouble in the video amplifier or in the power supply. An example of limiting and horizontal pulling caused by low plate voltage on a video amplifier is shown in Fig. 9.

(c) Defective or worn-out tubes in the video amplifier.

Instructions on making a visual check on relative amplitude of sync, the checks for localizing the cause of picture pulling, picture pulling due to external interference, microphonic pulling, and troubleshooting procedures are discussed in the second part of this article.

Fig. 10.

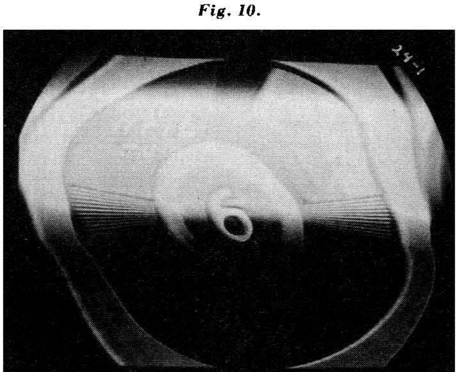


Fig. 10. Horizontal pulling, accompanied by darkening of half of picture, caused by heater-cathode leakage (60 cycles) in the r.f., i.f., or video amplifiers. There is no variation in width of raster. Pulling in picture is result of 60 cycle variation in horizontal sync phasing. This illustration is not covered in the text.

Part 2. Additional causes of and remedies for horizontal pulling.

Fortunately for the television technician, any appreciable loss of low-frequency response in the r.f., i.f., and video amplifiers and any appreciable undesired limiting action in the video amplifier can be detected very quickly by visually checking the *relative* intensity (blackness) of the vertical sync, vertical blanking, and picture signals, as they appear on the picture tube. To observe these signals, it is necessary to adjust the vertical hold control so that the picture rolls slowly downward out of vertical sync. It is necessary also to adjust contrast and brightness to make the vertical blanking and sync signals visible, as shown in Fig. 11, which represents approximately the correct *relative* darkness of these signals. For inspection purposes, it is preferable to increase the brightness slightly or decrease the contrast slightly in order to make the vertical sync appear as a dark grey, instead of the dead black shown in Fig. 11. We suggest that the reader carefully study the photographs and captions in Figs. 11, 12, 13 and 14.

In all cases of horizontal picture pulling, it is a worth-while practice to check the relative intensity of sync, as shown in Fig. 11. If the inspection reveals that the low-frequency response is poor, check the alignment of the r.f. and picture i.f. amplifier, using a good sweep generator and a crystal-calibrated marker oscillator. If the alignment is satisfactory, check the tubes, components, and voltages in the video amplifier. If the inspection reveals limiting action, check the video amplifier and the a.g.c. output voltages.

If the relative intensity of the sync, blanking, and picture signals appears normal, it may be assumed that the picture pulling is not caused by trouble in the r.f., i.f., or video

Fig. 11.

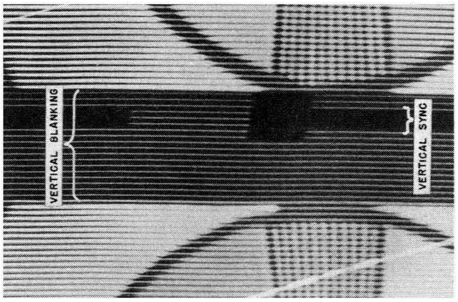


Fig. 12.

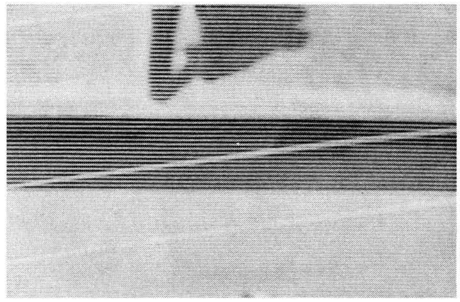


Fig. 13.

Fig. 11. Portion of vertical blanking and sync signals for single field. In making this picture and those of Figs. 12, 13, and 14, the contrast was reduced and brightness increased in order to "unblank" the blanking lines. Camera shutter was opened for only 1/60th second, which is time required for electron beam in picture tube to trace a single field of approximately 262 lines, consequently every other horizontal scanning line is absent in this photo, which otherwise represents normal signal conditions. As clearly shown, the blanking is slightly darker or stronger than darkest picture signals. Sync is considerably darker or stronger than blanking. If receiver has poor low frequency response, or if there is undesired limiting action, amplitude of sync signals is reduced with respect to higher frequency picture signals and, as a result, receiver becomes more susceptible to horizontal pulling. Examples of reduced sync amplitude are shown in Figs. 12, 13, and 14.

Fig. 12. In this case, sync signals are only slightly darker or stronger than blanking and dark-picture signals. This trouble is caused by excessive signal input and consequent limiting action in the video amplifier due to incorrect setting of a.g.c. threshold adjustment. Fig. 8 (Part 1) shows the result of same conditon on test pattern. Dark objects at top of this picture are legs and shadow of home-plate umpire.

Fig. 13. Here the sync signals are completely wiped out or reduced to blanking level by undesired limiting action in video amplifier. Trouble is caused by low plate voltage on 2nd video tube. The same condition can result from excessive signal input to video amplifier, as shown in Fig. 12, or incorrect bias and other troubles in the video amplifier. There is horizontal pulling at top and bottom of picture and sync is extremely unstable. With complete absence of sync the horizontal and vertical oscillators may tend to sync on the leading edge of the blanking signals.

amplifiers. Attention should then be concentrated on the sync separator and the horizontal a.f.c. circuit.

Localizing the Cause

The writer suggests a simple check that is occasionally helpful in isolating the cause for picture pulling. Briefly, this check consists of removing horizontal sync input from the horizontal a.f.c. circuit, free-wheeling the horizontal oscillator to obtain a momentarily stationary picture, and noting whether the pulling is still present on the picture. The check is helpful in showing whether the trouble is in the a.f.c. circuit or ahead of it. The procedure is as follows:

Make a mental note of the position and amount of horizontal pulling. Temporarily disconnect the condenser that connects horizontal sync pulses (from the sync separator) into the horizontal a.f.c. circuit. Disconnecting the condenser will throw the horizontal oscillator completely out of sync. With the horizontal hold control set at its mid-position, turn the main frequency adjustment of the horizontal oscillator to bring the oscillator to the correct frequency, as indicated by the momentary appearance of a complete picture. Then carefully adjust the horizontal hold control in an attempt to keep the picture from rolling horizontally for at least a second, or just long enough to inspect the picture and to determine whether the picture pulling has disappeared. If (with horizontal sync removed) the picture pulling is still present, the cause of the pulling is probably in the horizontal a.f.c. circuit. But if (with horizontal sync removed) the pulling is not present on the picture it indicates that the trouble is ahead of the horizontal a.f.c. circuit.

Occasionally extraneous signals from an adjacent video amplifier, audio amplifier, or other source may be coupled into the horizontal a.f.c. circuit. This possibility should be considered in cases where the previous check indicates that the cause for picture pulling is in the horizontal a.f.c. circuit.

In Part 1 of this article, mention was made of the possibility that voltage surges in the vertical oscillator circuit might be coupled back into the horizontal a.f.c. circuit and result in horizontal pulling at the top of the picture. One method of checking for the presence of such trouble is to open the condenser that couples the vertical sync pulses (from the sync separator) into the vertical integrating network and free-wheel the vertical oscillator, by careful adjustment of the vertical hold control, to keep the picture from rolling vertically. If the horizontal pulling disappears when the condenser is opened, it may indicate that additional isolation is required between the vertical oscillator and the horizontal sync input circuit.

A general method of determining whether the vertical oscillator and deflection circuits are in any way responsible for horizontal pulling is to remove the vertical oscillator and output tubes and drive the vertical deflection coil from the vertical output of another receiver which is tuned to the same station.

In many receivers, the amplitude of sync input to the sync separator is rather critical; either too much or too little sync input may cause picture pulling. In cases where all components have been checked and appear to be normal and the cause for pulling cannot be localized by the methods suggested, it may be advisable to try changing the level of the sync input to the sync separator. If the sync signal for the sync separator is taken from across a resistor in the video amplifier, it may be feasible to alter the value of the resistor or temporarily substitute a carbon potentiometer to determine the optimum value.

The tubes, voltages, and load resistors in the sync separator are usually critical with respect to picture pulling. Occasionally, it may be helpful experimentally to alter the value of a plate-load resistor in the sync separator. The writer offers these comments reluctantly, because he is definitely not in favor of the practice of altering the value of one component to compensate for a defect in another component that has escaped detection.

When picture pulling is common in all receivers of a particular model, the logical procedure is to find out whether the manufacturer has issued

Fig. 14.

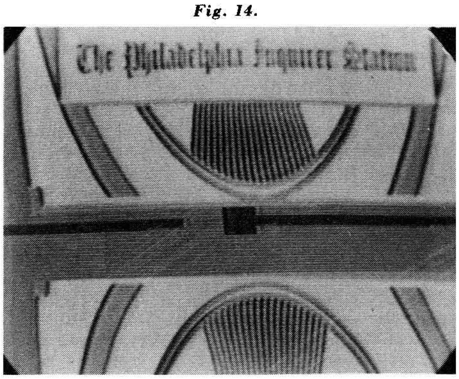


Fig. 15.

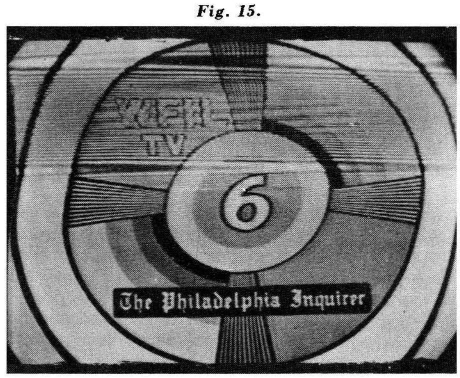


Fig. 16.

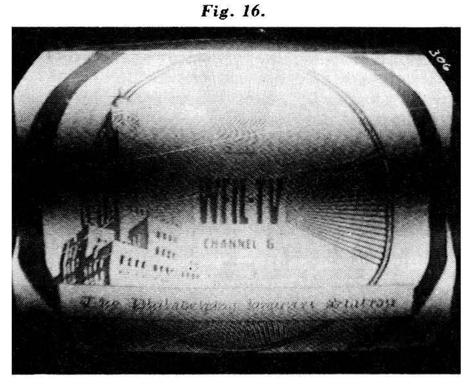


Fig. 14. Instance where sync amplitude is reduced to approximately same level as the darkest picture signals. Trouble is caused by poor r.f.-i.f. alignment, the picture carrier is too low on the slope of the response curve. Also refer to Fig. 7 (Part 1).

Fig. 15. Horizontal pulling resulting from diathermy interference. Beat in this case is a low frequency and therefore does not exhibit herringbone pattern (due to frequency modulation) usually characteristic of diathermy interference. Interference may be mistaken for another type of trouble. See Fig. 16 for high-frequency diathermy beat.

Fig. 16. Horizontal pulling resulting from diathermy interference. In this case beat is a high frequency (about 4 mc.) which makes the fine-line herringbone pattern almost invisible in some receivers. This variety of interference might be mistaken for 120 cycle hum trouble. With diathermy interference, light and dark areas may remain stationary or may move up or down depending on whether or not the power supply for TV camera and diathermy equipment are synced. Unlike heater-cathode leakage, reversal of 117 volt plug on receiver does not shift position of interference.

Fig. 17.

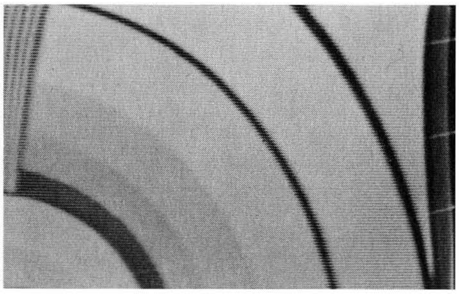


Fig. 18.

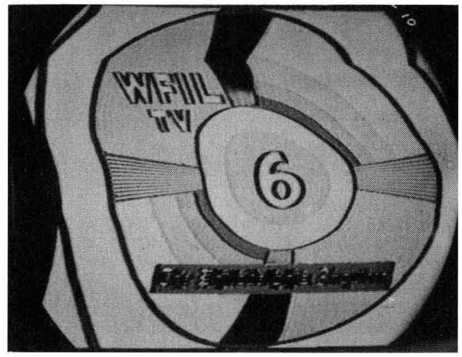


Fig. 19.

Fig. 17. Slight horizontal pulling at top of picture evidenced by bending of vertical wedge, caused by inoperative d.c. restorer (in a receiver where sync input for sync separator is taken from d.c. restorer circuit). When photo was taken, contrast and brightness controls were adjusted to show horizontal blanking signals at right side of picture. With normal contrast adjustment, bending is decidedly more pronounced. See text for other details.

The photographs of Figs. 18, 19, 20, and 21 are not referred to in the text. Their inclusion is for the purpose of amplifying the text and providing additional data.

Fig. 18. Horizontal pulling caused by poor low frequency response (or excessive high frequency response) in picture i.f. amplifier. Black smearing of vertical wedges is one indication of regeneration in amplifier which requires realignment. Regeneration in this case results from tuning grid and plate circuit of one stage in amplifier to same frequency instead of staggering tuning as required in stagger-tuned amplifier.

Fig. 19. Horizontal pulling, or in this case, horizontal damped ripple, caused by the electrical hunting action in horizontal frequency control circuit. Condition shown is produced by an open .05 ufd. condenser connected from the grid circuit to the chassis in RCA "syncrolock" horizontal frequency circuit. Amplitude and the duration of the ripple change with the adjustment of the horizontal hold control.

Fig. 20.

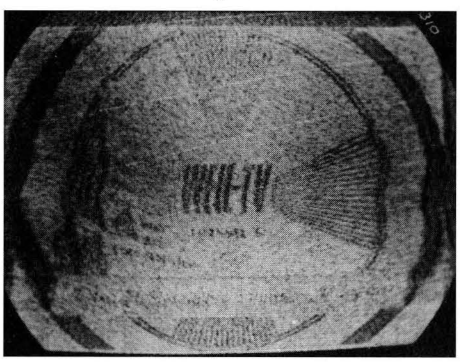
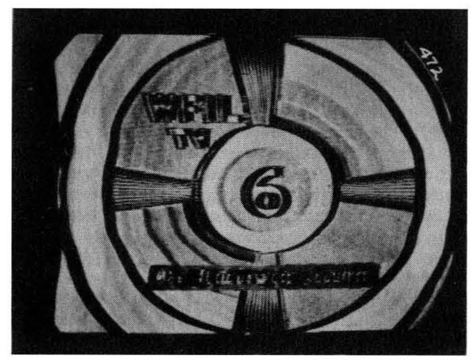


Fig. 20. Horizontal pulling may be expected on extremely weak signals. Realignment is almost always helpful in weak-signal areas. The r.f. and picture i.f. amplifiers should be aligned so that picture carrier falls at 70% or higher on slope of overall response curve when receiver tuning control is adjusted for best sound. It is also advisable to use best available antenna and booster with good signal-to-noise ratio.

Fig. 21. Horizontal pulling and unstable horizontal sync may result from certain conditions of reflections or ghosts. Ghost signal in this example is almost merged with direct signal, resulting in poor picture quality and horizontal pulling. Occasionally, when intensity of a close-in ghost is approximately the same as direct signal, the two may alternate in taking control of horizontal oscillator. In such cases, picture shifts erratically a distance equal to spacing between the ghost and direct signal.

Fig. 21.



information on modifications to correct or improve the condition.

Many technicians have learned through actual experience that the best and fastest way to locate sync troubles is by the use of a scope with adequate frequency response which is designed for use with an isolating probe.

External Interference

When external interference is present, it frequently causes horizontal pulling or weaving. Usually, in such cases, the interference is clearly evident in the picture and is obviously responsible for the pulling. Occasionally the cause and effect may be confused.

Diathermy interference produced the pulling effects shown in Figs. 15 and 16. These particular examples were photographed because they lack the pronounced herringbone pattern that normally characterizes diathermy interference and for that reason might be mistaken for internal trouble in the receiver.

Any interference that produces beat-frequency bars of sufficient intensity in the picture can result in unstable horizontal sync with accompanying horizontal pulling or weaving, particularly in cases where the beat is a low frequency signal that can readily pass through the narrow-band sync separator.

Obviously, the correct remedy for picture pulling in cases of interference is to eliminate the interference.

In all puzzling cases of horizontal pulling, it is a good practice to observe that cardinal rule of television service —"Check for presence of the same effect on other receivers in the area." This excellent rule requires modification in some cases of horizontal pulling, because it is advisable to check sets of the *same model*, or at least sets that have the same type of horizontal a.f.c. circuit. Certain rare troubles, such as phase variation in the transmitted horizontal sync signals, may produce noticeable picture pulling in some types of horizontal a.f.c. circuits, but may have only slight effect in other types of a.f.c. circuits.

Microphonic Pulling

Picture pulling may show up momentarily whenever the horizontal a.f.c. tube is mechanically shocked or jarred, as by deliberately tapping the tube or through transmitted vibrations from persons walking or dancing near the set. Any relative motion of the elements in the a.f.c. tube results in a variation in the gain, or control action, which produces a variation in horizontal sync phasing. The socket of the a.f.c. tube is usually shock-mounted to minimize such microphonic action. In cases where microphonic horizontal pulling is evident and objectionable, it is advisable to try a new tube in the a.f.c. socket.

Troubleshooting Procedure

It may be helpful to summarize some of the facts that we have discussed. We can accomplish two objects by presenting the summary in the form of a troubleshooting procedure.

1. Determine whether the condition is raster pulling or picture pulling. Raster pulling affects the shape of the raster. Picture pulling does not affect the shape of the raster.

2. If it is a case of raster pulling, make checks (depending on the particular symptoms) for trouble in:

(a) The "B" supply filter circuit.

(b) The horizontal deflection circuits.

(c) The deflection yoke.

(d) Undesired magnetic field near the picture tube.

3. If it is a case of picture pulling, remember that the horizontal sync signals must pass through the r.f., i.f., and video amplifiers and through the sync separator in order to reach their final destination in the horizontal a.f.c. circuit. Ordinarily, any trouble that causes picture pulling must be in the r.f., i.f., video, sync separator, horizontal a.f.c., or power supply sections of the receiver. With this fact in mind, apply the following checks:

(a) Check the amplitude of sync (in relation to the amplitude of blanking and picture signals), as seen on the picture tube, to determine whether poor low-frequency response or undesired limiting action has reduced the relative sync amplitude. The sync must be definitely stronger, or darker, than the blanking and the darkest picture signals, as shown in Fig. 11.

(b) If the relative amplitude of sync appears normal on the picture tube, it means that the trouble is unlikely to be in the r.f., i.f., or video amplifiers. (One of a few exceptions to this statement is illustrated in Fig. 17, where an inoperative d.c. restorer in the video amplifier has caused slight picture pulling without affecting the relative sync amplitude as seen on the picture tube.) If the sync amplitude appears normal, it leaves the sync separator and the horizontal a.f.c. circuit under suspicion.

(c) Check to determine whether the trouble is in the horizontal a.f.c. circuit, or ahead of it, by temporarily removing sync input from the horizontal a.f.c. circuit, free-wheeling the horizontal oscillator, and inspecting the picture to determine whether the pulling is still present. If the pulling is still present, the trouble is probably in the a.f.c. circuit. If the pulling disappears when sync input is removed, the trouble is probably ahead of the a.f.c. circuit; possibly in the sync separator.

TELEVISION-TUNER ALIGNMENT

by Art Liebscher
RCA Test Equipment Specialist

Television-tuner alignment can be very profitable for the serviceman; indeed, as competition increases, the ability to perform this service may become a definite asset to a service business. Fortunately, tuner alignment is not as complicated as it is often believed to be. This article outlines the general principles involved, discusses the equipment required, and outlines straight-forward techniques for tuner alignment.

To clear up any misconception that a tuner is a complicated device, consider the tuner when stripped to its essentials. Except for the switching arrangement and the usual high- and low-pass filters, it is about as simple as the input circuit of a broadcast receiver. This fact should be remembered when trouble-shooting problems arise which are common to all channels. In this case, it is good practice to work with the tuner set to only one channel position until the trouble is corrected. Afterwards, other channel positions can be compared with the initial one for sensitivity, switching noise, and general performance. After the tuner meets these tests, it is advisable to check the alignment by observing the response curves for each channel. Alignment should not be attempted until these preliminary tests have been completed. Furthermore, the serviceman should be aware that most tuners, unless tampered with, are correctly aligned This knowledge can often prevent misalignment of a good tuner.

The primary purpose of alignment is to obtain a response curve of proper shape, frequency coverage, and gain. To perform the alignment, the serviceman will require a sweep-frequency generator covering the television channels, an accurate calibrator or marker generator for frequency determination, and a high-gain oscilloscope for observation of tuner response curves. When these instruments are properly connected and adjusted, the curves appearing on the scope give all the information the serviceman needs for proper alignment of the tuner.

Most tuners merely require "touch-up" alignment in which relatively few of the adjustments are used. Generally, alignment "from scratch" is required only when a person without technical know-how, or one having inadequate equipment, has previously worked on the tuner. For the complete realignment job, it is desirable to follow a specific sequence of adjustments, the sequence depending on the type of tuner. Typical sequences are discussed in this article. However, where only touch-up alignment is required, the sequence of adjustment is usually unimportant.

As an aid to alignment, the location and purpose of each adjustable component in the tuner is specified herein by means of sketches which, together with a photograph of the tuner, form the composite illustrations. These illustrations show the *primary* effect on the response curves caused by varying each adjustment. Thus, the serviceman learns at a glance both what to do and where to do it. The shapes of the curves as they are drawn indicate only the general form of the corresponding traces on the scope. The manufacturer's service data should be consulted to determine the actual shape of the curve.

Each tuning adjustment has a definite effect on one of seven major factors which, for convenience, are designated as GAIN, FREQ., TILT, TRACK, BAND., TRAP, and PEAK. Each of these terms can be associated with one of the symbolic drawings. Arrows on these symbolic curves point out the most significant adjustment effect.

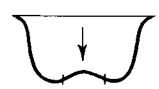
Use of the Symbolic Curves

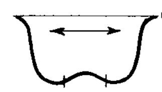
The adoption of standards for the negative downward direction of oscilloscope deflection will avoid possible confusion. The rf symbols are represented as downward because, when rf response curves are observed, the oscilloscope is normally connected through an isolating resistor to the mixer grid and circuit in a tuner, which becomes more negative as signal strength increases. The result is that these response curves usually deflect downward. The tuner if output symbolic curves are shown deflecting upward. Actually, on the scope, these curves may be either upward or downward, depending on the connections to the rectifier. For uniformity, the WG-291 crystal demodulator probe may be used, so that the deflection is upward.

Similarly, with respect to horizontal deflection, confusion may be avoided if the high-frequency ends of the response curves are on the right-hand side. This standardization places sound rf carriers to the right of associated picture rf carriers.

Heretofore, rf response curves have usually been shown deflecting upward. This convention arose in part because early scopes were not standardized to provide downward deflection on negative signals. On the basis of upward deflection, points of maximum response are called "peaks," and intermediate dips in response are called "valleys." The same terminology is used in this article for corresponding points on either the symbolic or actual oscilloscope curves, although the analogy is no longer exact.

GAIN. One of the most important characteristics of a tuner is its gain. In the symbolic curve for this characteristic, the critical region, as indicated by the arrow, is between the sound- and picture-frequency markers. Gain adjustments should be set so that the amplitude at the arrowpoint, halfway between markers, is made as great as possible. For guidance, a vertical hair-line may be superimposed on the scope at the frequency at which the amplitude is to be maximized. This maximized amplitude point often is not the peak of the over-all curve, even when the curve is of the broad single-peak type. Nevertheless, the adjustment should always be made to obtain the maximum possible amplitude at the point indicated. This setting may finally have to be a compromise because of the secondary effect of the adjustment on other factors, especially tilt and bandwidth.


GAIN

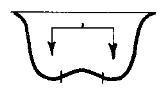

FREQ.

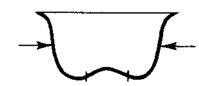
FREQ. The symbolic curve for frequency adjustment of rf, antenna, and mixer stages contains a horizontal two-headed arrow. In frequency adjustment, the major requirement is to place the over-all curve symmetrically with respect to the two markers. Although it may be simple to obtain proper placement for a single channel, compromises are often necessary to keep all the channels within satisfactory range. In addition, the FREQ. adjustment has a secondary effect on tilt and bandwidth, a factor which may necessitate further compromises.

This frequency adjustment of rf and mixer stages should not be confused with adjustment of the tuner local oscillator. The latter adjustment is called tracking.

TILT. The adjustment for curve flatness or balance is indicated by a symbol with two arrows and a pivot balance. The arrows indicate the tilting adjustments which may be necessary to obtain equalized amplitude through the top of the curve. Tilt adjustments in one channel in most tuners also affect the tilt of other channels, so a compromise is commonly required. Both because other adjustments commonly affect tilt, and because excess tilt is the most easily recognized fault, adjustment of tilt frequently suffices for "touch-up" jobs. Neither the tilt between the sound and picture markers, nor the tilt caused by valleys or peaks between these marks should exceed 30 per cent of the maximum amplitude. In some tuners, the limits for these deviations are even less than 30 per cent.

BAND. The bandwidth symbolic curve has two arrows indicating the boundaries between which frequency bandpass is measured. Bandwidth, in addition to being a function of frequency and gain adjustments, as mentioned earlier, is also affected by tilt adjustment. While

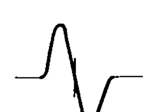

TILT

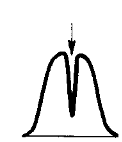

BAND

bandwidth is normally adjusted by compromising with other factors, some modern tuners having good selectivity use a special bandwidth adjustment.

TRACK. The symbolic curve for adjustment of oscillator frequency is the conventional discriminator "S" curve with the cross-over point indicated by a vertical line at the "zero-center." This symbolic curve was chosen because in separate-sound receivers, tuner oscillators are usually adjusted to agree with the cross-over point of the discriminator curve. Intercarrier sets, characterized by broad sound tuning, may be tracked with one of several different indications, all beyond the scope of this article. Nevertheless, the familiar S-curve symbol is used to indicate precise tuner-oscillator adjustment.

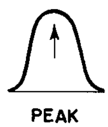
TRAP. The symbolic curve for the sound intermediate-frequency trap is an M-shaped curve with an arrow pointing to the region which should be adjusted for minimum deflection. In the actual curve the exact trap frequency is indicated by a marker which may be detected on high-gain oscilloscopes by increasing the input signal and both the vertical and horizontal gain. The expanded marker waveform divides at minimum deflection, when the trap is properly adjusted. An alternate method can be used if audio modulation is available on the marker. In this method, the curve base-line is observed for minimum modulation effect, as indicated by sharp reduction of audio waveform in the base-line as the adjustment reaches the setting for the desired trap frequency.


TRACK


TRAP

PEAK. The alignment curve for the intermediate-frequency, peaking-coil adjustment is a curve with a single peak having an arrow pointing to its center. The manufacturer's service data should be consulted for the shape and numerical specifications of this curve.

In television receivers employing the intercarrier system, the tuners operate without a trap, but may have an intermediate-frequency peaking adjustment.



Curve Limits

On some rf response curves, particularly the ones which have pronounced valleys, the limit for maximum amplitude deviation between the peaks and valleys is as much as 30 per cent of maximum amplitude. For others, particularly those which may be called flat-top curves, the tilt limit may be less. Generally, flat-top curves have both the carrier markers on the flat portion, or if that is not broad enough, the sound carrier may be near the top of the sloping portion of the curve. Manufacturers' specifications should be referred to for these limits.

Commonly, the skirts of the curves may overlap into adjacent channels. Curves that extend beyond adjacent channels usually indicate that alignment has produced broad tuning at the expense of gain.

In typical switched inductor type tuners, broader curves are observed for the high-frequency channels in each band. In variable-capacitor type tuners, the broader curves occur for the low-frequency channels in each band.

Since each type of tuner has its own response characteristics, adjustments should not be attempted without reference to the manufacturer's service data. Where a curve does not meet requirements, it should be studied to determine if the high- or low-frequency portion of the curve is at fault. A comparison should be made to find out whether the fault is common to all channels in the band. If it is not common, or if it appears only to a slight degree on other channels, re-alignment is of little value, because this condition shows that a compromise between several channel curves is already in effect.

Alignment Sequence

As mentioned previously, the arrows on the curves indicate the most important reaction of each adjustment. Often, however, additional effects may be noted on the trace when a single adjustment is changed. When adjustments are made for frequency correction, for example, gain may be lost, and re-setting of the gain adjustment may be required. When adjustments are made for tilt, bandwidth may be changed and both frequency and gain may require readjustment. To obtain compromise adjustments, the serviceman after gaining experience, will find it convenient to work with two alignment tools simultaneously, each being used on a separate adjustment.

The proper equipment connections for three frequency encountered tuners are given in this article. A sequence of adjustments is suggested for use in the relatively few major realignments.

Equipment Required

The requirements for reliable equipment for tuner alignment, as listed below, may seem overly stringent, for most test equipment now in use fails to meet the indicated limits. Actually, the equipment must meet these specifications

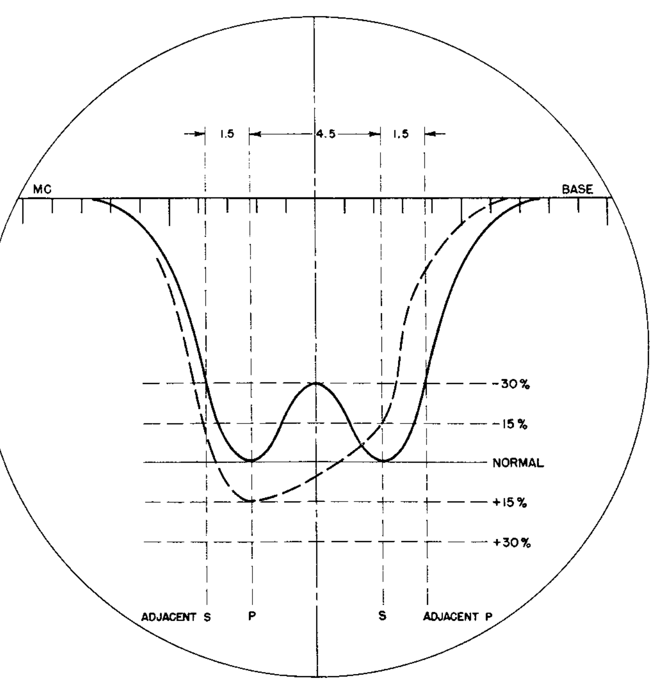


Fig. 1. Curves illustrating typical curve limits. Dotted curve just meets the limit of 30% maximum deviation between minimum and maximum points of the 4.5-Mc range. Solid curve shows the maximum permissible difference between peaks and valley.

to be acceptble for alignment of all makes of tuners.

The test signals and scope indications must be reliable. For example, if the sweep generator does not have flat output, the alignment curve will have unwarranted tilt. Under this condition, adjustment for apparent flatness results in an actual response curve which is distorted to compensate for the tilt of the generator signal (See *Fig. 2*).

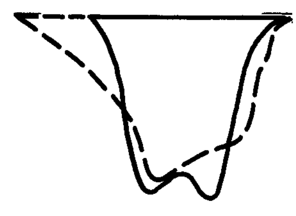


Fig. 2. Generator amplitude tilt detected by comparison. Solid curve represents tuner output when the generator used is known to have a flat characteristic. Dotted curve represents the response of the same tuner when a generator having tilted output is used.

The same sort of curve distortion can occur because of poor low-frequency scope response. The instrument must be capable of reproducing a 60-cycle square wave without the tilt exceeding 10 per cent.

Standing waves on the output cable of the sweep generator, particularly for the high-band channels, can also tilt the scope curves. Proper termination of the generator cables offers the most effective means of avoiding this trouble. The presence of standing waves is indicated by alterations in the scope picture when the cable or generator panel is touched.

Hum picked up by the scope leads or hum generated in the tuner or in the sweep generator also distorts the apparent response curve. Such hum is normally evidenced by a warped base-line. A level base-line is prerequisite to satisfactory alignment.

Generally, a 60-cycle sine wave is used both to frequency-modulate the generator output and to cause horizontal deflection on the scope. The combination of the two effects causes the horizontal (frequency) base of the response curve to be linear.

To test for horizontal linearity, a series of one-megacycle markers should be used. The spacing of these markers will be equal, if the linearity is good.

When the sweep generator does not have good linearity, portions of the response curve are bunched horizontally, while others are expanded. If portions of the response curve are stretched or compressed horizontally, when the generator is tuned toward an adjacent-channel, the existence of non-linearity in the generator output may be inferred. (See *Fig. 3*)

A recommended test equipment complement consists of the following: RCA sweep generator—WR-59 series; RCA marker generator—WR-39 series; RCA oscilloscope—WO-56 series or WO-57 series; and RCA vacuum-tube voltmeter—WV-97A or WV-77A with the RCA demodulator probe—WG-291. The equipment used should meet the following minimum specifications:

Sweep Generator

Range: 12 TV channels
Flatness: ± 0.1 db per Mc
Termination: 70 ohms unbalanced
300 ohms balanced
Attenuation: continuous down to 20 uv.
Sweep Width: 10 Mc or more (adjustable).
Linearity: ± 15% on scope.
Output: Approx. 0.1 volt into 300 ohms.
Leakage: Less than 20 uv.

Marker Generator

Range: 12 TV channels
Output: 0.03 volt or more
Calibration: Crystal, 12 pictures and 12 sound carriers
Attenuation: Approx. 100:1.

Oscilloscope

Response: 10% max. tilt on 60 cycle square wave.
Sensitivity: 30 millivolts rms per inch or better
Input: Cable, shielded, dc-blocked.
Sweep: 60 cps with phasing control.

Preparing for Alignment

Careful consideration should be given to the fact that tuners are normally well aligned when received from the factory. Therefore, the response curves should be thoroughly examined, by means of the precision equipment recommended above, before any alignment adjustments are attempted.

After the serviceman has decided that realignment is required, he should use the alignment curves as guides and follow the recommended procedure for the specific tuner. Procedures for three frequently encountered tuners are outlined in the following pages.

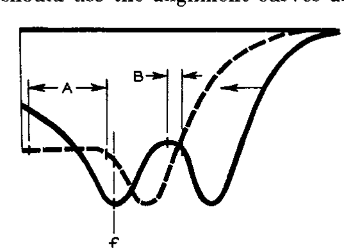


Fig. 3. Non-linearity of generator frequency indicated by apparent variation of tuner-response curve for two different settings of the generator mean frequency. Portion "A" and portion "B" represent identical frequency increments. Fixed-frequency marker "f" does not change with horizontal position of the curve, but does change vertical position as the generator frequency is varied.

If the tuner is to be aligned in the receiver, the tuner curves should

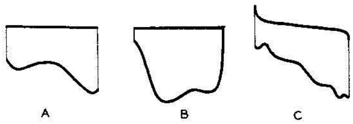


Fig. 4. Effect of oscillator and if tubes on the tuner-response curve: (a) First if tube removed to show a true curve of tuner performance; (b) oscillator tube alone removed; apparent gain increased and apparent response narrowed; (c) all tubes in place, slope caused by hum reflection and some irregularities caused by trap reflections.

be obtained with the first intermediate stage out of operation, in order that if trap and hum reflections may be avoided. Removing the first if tube is generally sufficient to avoid any curve distortion originating in the if amplifier. In some tuners, resonance in the mixer plate circuit may also produce undesirable reflections. Generally, to remedy this situation, the picture intermediate-frequency amplifier input must be loaded, or the if transformer primary must be detuned.

The tuner oscillator should be in operation during alignment. If it is not, the lack of oscillator injection voltage at the mixer grid alters its bias, and the result is an increase in the amplitude of the response curve and a distortion of its shape. *Fig. 4* illustrates both this effect and that resulting from failure to remove the first if tube.

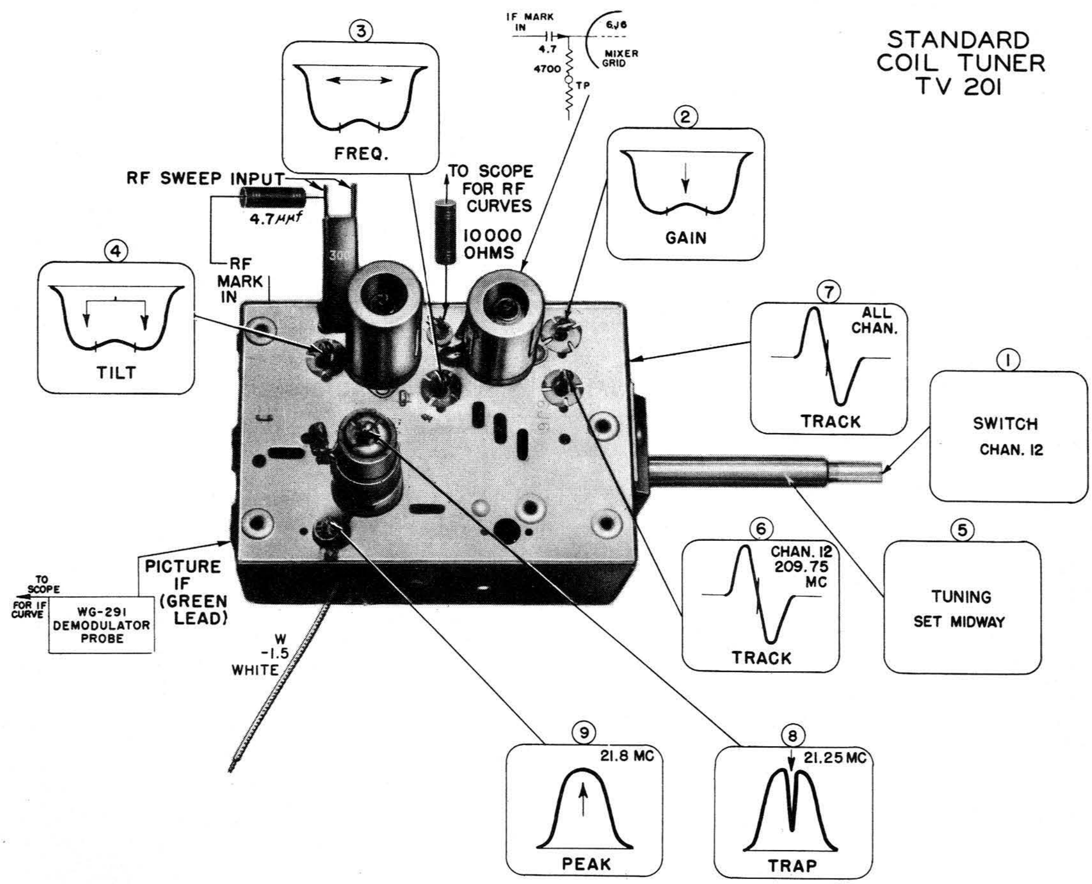
If the tuner is to be aligned independently of the receiver, all of the foregoing applies except that concerning the if tube. A substitute receiver chassis, operating at the required intermediate frequency, is needed for oscillator tracking and it can also supply power to the tuner. An unshielded if lead about 15 inches long can connect to the receiver for tracking purposes, but should be removed during curve adjustment.

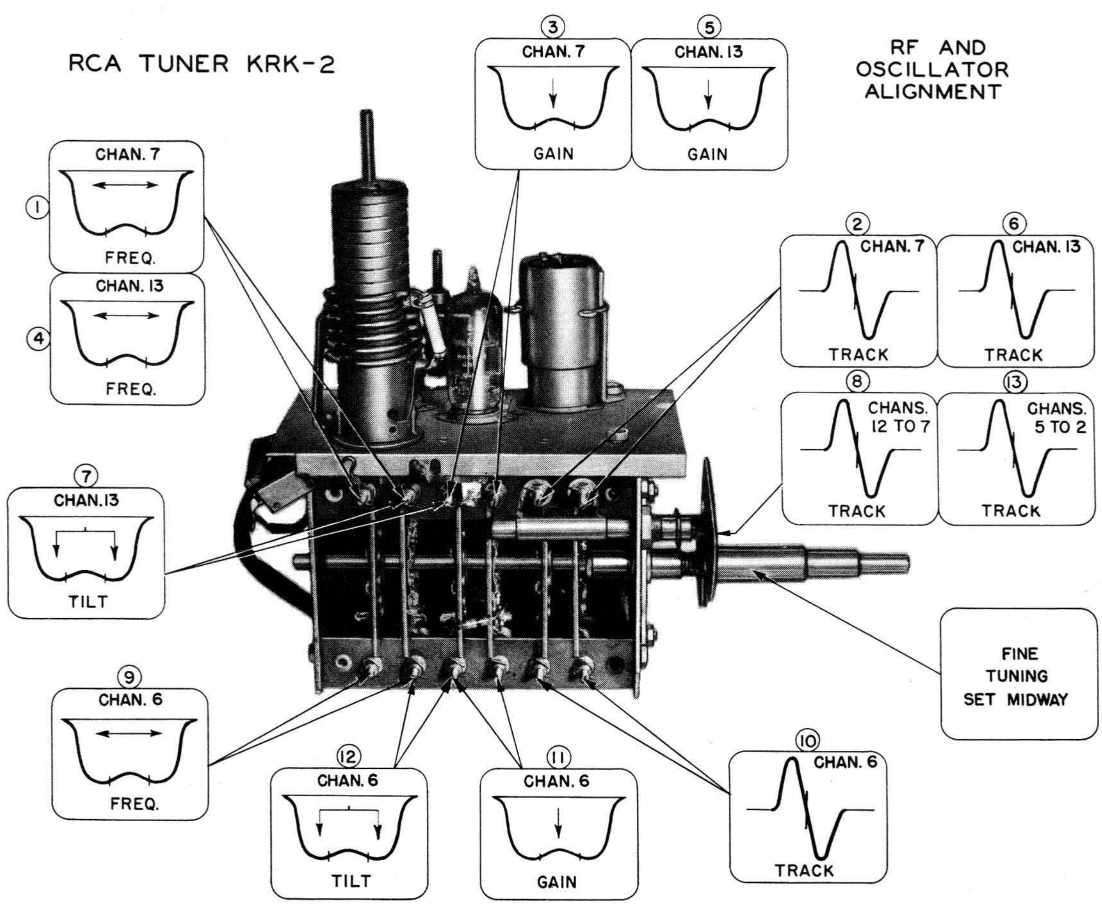
A necessary preliminary to alignment is a check of the test setup. For example, rf bias should be checked, proper connections for the test leads should be determined, and the output of the generator should be observed. All equipment should be given a 20-minute warmup to stabilize circuits affected by temperature changes.

Typical Alignment Procedure

Standard Coil Company Tuner TV201, RF Alignment: (a) Connect the sweep and marker generators to the antenna terminals; (b) remove the first picture-if tube; (c) connect a minus 1.5-volt source to the AGC (white) lead of tuner; (d) connect the scope to the test point; (e) align channel 12 in sequence indicated; (f) compare with rf alignment of other channels, and compromise wherever necessary.

Oscillator Tracking: (a) Replace the first picture-if tube; (b) connect the scope to the discriminator; (c) apply the channel-12 sweep and the sound-marker generators to the antenna terminals; (d) set fine tuning at mid rotation; (e) adjust the tracking to center the marker on the "S" curve; (f) repeat this procedure for channels 13 through 2.





IF Alignment: (a) Connect the marker generator to the mixer grid through a 4.7-$\mu\mu f$ capacitor (sweep generator remaining connected to the antenna terminals); (b) remove the first picture-if tube and connect the scope to the first picture-if grid terminal through a demodulator probe or crystal rectifier; (c) with a strong signal applied, adjust the sound-if trap to the desired frequency (21.25 Mc, for example); (d) adjust the peaking coil at the desired frequency (21.8 Mc, for example).

RCA Tuner KRK-2

RF and Oscillator Alignment: (a) Connect the sweep and marker generators to the antenna terminals; (b) remove the first picture-if tube; (c) connect a minus 1.5-volt source to the AGC (green) lead of tuner; (d) connect the scope through a 10,000-ohm resistor to the junction of L_{80} and R_6; (e) If major realignment is necessary, set all 12 core-adjustment screws in equal positions (with approximately 3/8 inch exposed). Generally, each adjustment is effected by means of a pair of these core screws. Turning a pair of associated screws in like direction has like affect; (f) for major realignment, rough out a curve on channel 7, and then follow the sequence indicated by the numbers in the accompanying photograph; (g) for adjustment 2, replace the first picture-if tube, connect the scope to the discriminator, apply channel-7 sweep and sound marker to the antenna terminals, and adjust to tentatively center the marker on the "S" curve, with fine tuning at mid-rotation; (h) removing the if tube and connecting the scope to the tuner, repeat the adjustment labelled 1, if necessary; (i) proceed in sequence through step 7. Compromise may be required between the settings for steps 1,4,3, and 5.

For each of these adjustments, check the curves for channels 7 through 13; (j) track channels 12 to 7; (k) align channel 6 (steps 9 through 12), then observe channels 2 through 6, compromising wherever necessary; (l) perform step 13.

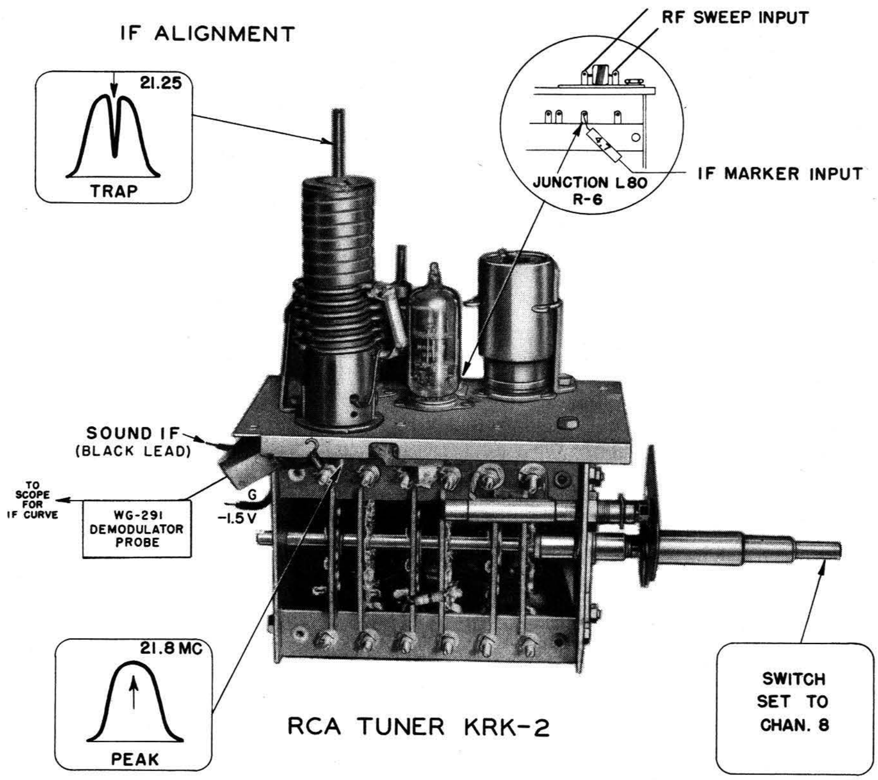
IF Alignment: (a) Apply channel-8 frequency to the antenna terminals and set the tuner to channel 8; (b) couple the marker generator through a 4.7-$\mu\mu f$ capacitor to the junction of L_{80} and R_6; (c) remove the first picture-if tube and connect the scope to the first picture-if grid terminal through a demodulator probe or crystal rectifier; (d) adjust the trap and peaking transformer at 21.25 Mc and 21.8 Mc, respectively, (for 630TS receivers).

Effects of Sarkes Tarzian RF Adjustments*

CHANNEL	MIXER	RF PLATE	ANTENNA
13	LF Tilt	Freq.	HF Tilt[2]
12	LF Tilt	Freq.	HF Tilt
11	LF Tilt	Freq.	HF Tilt
10	LF Tilt	Freq.	HF Tilt
9	LF Tilt	Freq.	HF Tilt
8	–	Freq.	HF Tilt
7	–	Freq.	HF Tilt
6	Freq.	Freq.[4]	HF Tilt
5	Freq.[2,3]	Freq.	HF Tilt
4	Freq.[2,3]	Freq.	–
3	HF Tilt	Freq.	–
2	HF Tilt	Freq.	–

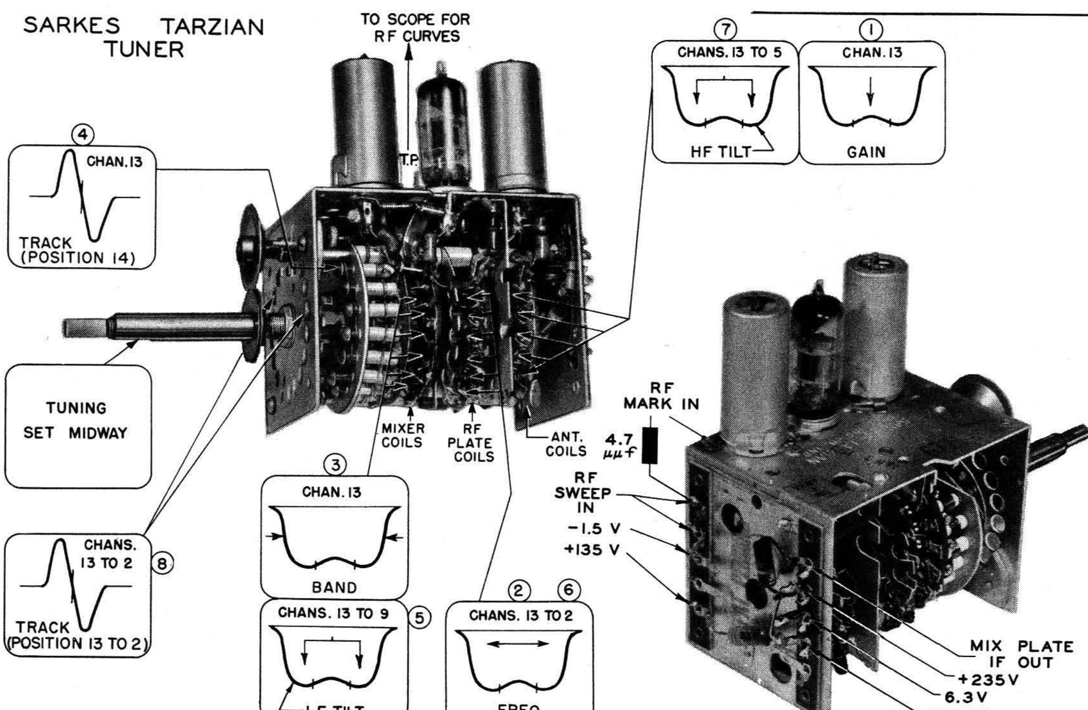
[1]Plus Bandwidth [2]Plus Gain [3]Plus HF Tilt
[4]Plus LF Tilt

*Location of three sets of adjustments is indicated on illustration. Tabulated quantities associated with each adjustment can be increased by reducing the coil inductance, either through spreading the coils, shortening the loops, or bending the loops down toward the wafer.



RCA TUNER KRK-2

SARKES TARZIAN TUNER



Sarkes-Tarzian 3-Tube Tuner

RF and Oscillator Alignment: (a) Connect the sweep and marker generators to the antenna terminals; (b) remove the first picture-if tube; (c) connect a minus 1.5-volt source to the AGC terminal; (d) connect the scope to the test point; (e) perform adjustments 1, 2, and 3 on channel 13 by manipulating the coil shapes, as described in the footnote for the accompanying table; (f) replace the first picture-if tube; connect the scope to the discriminator; apply channel-13 sweep signal and sound marker to the antenna terminals, and by means of the adjustment, which precedes that for channel 13 and which is common to all channels, center the marker on the "S" curve; (g) return to the former connections and perform steps 5, 6, and 7 for the channels indicated; (h) return to the tracking connections and track for all channels; (i) make a final curve check on channels 13 to 7 with the shield in place and the marker-generator leads removed.

TELEVISION ANTENNAS AND TRANSMISSION LINES

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PART I. ACTION OF DIPOLE AND REFLECTOR

Assume that the metal rod in Fig. 1 is supported horizontally in space to pick up signals from a TV station. The rod is cut to one-half wave length at the frequency of this station. The rod is not broken at the center, and it is not connected to anything.

The rod will intercept or pick up signals from a limited area of space that for practical purposes may be regarded as being almost as long as the rod and about a half-wave high.

A small amount of this signal will be used up in heat (current flow along the surface of the rod). The rest of the signal cannot be absorbed because there is no load. So essentially all of the signal that is picked up by the rod is re-radiated or sent out again into space.

Suppose we break the rod at the center and connect an adjustable resistance across the gap. Also, suppose that we provide some means to measure the power in this resistor, which is the load. We then adjust the resistance for the value that develops maximum power in the resistor.

The reflector acts to increase the energy in the antenna and also to decrease the radiation resistance. In effect, less energy is re-radiated by the antenna and more energy is used in the load.

The same result can be achieved by placing a rod in front of the antenna. In this position it is called a director. The two signals arriving at the antenna, also must be in phase; the phase relation in this case depends on the spacing between the antenna and director and on the length (tuning or phase) of the director.

In TV reception, a practical difference between a reflector and a director is that with a reflector, the response is cut more sharply on the low-frequency side; with a director, the response is cut more sharply on the high-frequency side.

SIMPLIFIED DIPOLE ACTION

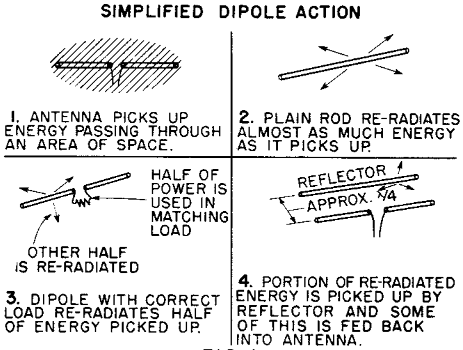


FIG. 1

Under this condition, we can assume that one-half of the energy picked up by the antenna is absorbed in the load, and the other half is re-radiated. For convenience we can assume that the re-radiated energy is consumed in another resistance, which is termed the radiation resistance.

Some of this re-radiated energy can be reflected back into the antenna by placing another rod (reflector) of suitable length in back of the antenna with a spacing of one-quarter wave or less.

The reflector picks up some of the energy that is re-radiated by the antenna. In turn, the reflector re-radiates practically all of this energy, and a portion of this is picked up by the antenna.

The antenna is now getting energy from two sources, from the station and from the reflector. For best results, these two must be in step (or phase) with each other at the antenna. This phase relationship depends on the spacing between antenna and reflector, and on the length (tuning, or phase) of the reflector.

The use of both a director and a reflector results in greater gain, but with narrow band width and low antenna impedance.

Stacked Antennas

An antenna intercepts or receives the signal in a certain area of space. If two similar antennas are used, the intercepted area is doubled and the received *power* is doubled. When two antennas are connected together, with correct phasing and matching, the *voltage* across the input impedance of the receiver is increased approximately 1.4 times.

Figure 2 shows a practical example, using two identical folded dipoles spaced one-half wave apart. If reflectors with spacing of 0.2 wave-length are used, it may be assumed that the impedance of each antenna is reduced to about 170 ohms. (For simplicity, the reflectors are not shown in Figure 2.)

The transmission-line impedance is 300 ohms. At the point where the line connects to the two antennas, the impedance of each antenna should

STACKED FOLDED DIPOLES

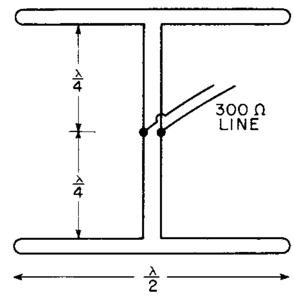


FIG. 2

"look like" 600 ohms, so that the two in parallel are 300 ohms.

Two quarter-wave lines are used as matching sections between the terminals of each antenna and the transmission line. These quarter-wave lines should have an impedance that will "transform" the impedance of each 170-ohm antenna up to 600 ohms. The quarter-wave line impedance can be computed from the relation:

$$\text{Line impedance} = \sqrt{\text{input impedance} \times \text{output impedance.}}$$

In this example the

$$\text{Line impedance} = \sqrt{170 \times 600}$$
$$= 320 \text{ ohms approximately.}$$

When tubing or rods are used for the matching sections, the diameter spacing for an impedance of 320 ohms can be determined from Figure 3. Rods of ¼″ diameter spaced 1.8″, or rods of ⅜″ diameter spaced 2.8″ are suitable in this case.

The phasing or polarity of the signal voltage from each antenna is automatically taken care of in this arrangement because the signal from each antenna travels the same distance (¼ wavelength) to reach the transmission-line terminals.

When stacked arrays for low-band channels are installed, it should be remembered that if the top antenna is not very high above the effective ground plane, the lower antenna will intercept less signal than the top antenna. As a result, the actual voltage gain of the array, compared to the top antenna alone, will be less than 1.4.

The effective ground plane may be at roof level in a building with metal framing or a metal roof.

Folded Dipoles

In a conventional folded dipole, as shown in Fig. 4a, with rods of equal diameter, each rod has ½ the total conducting areas, and the impedance is 4 times that of a plain dipole.

The impedance of a folded dipole may be increased by increasing the area of the continuous section, or by using more than one rod in parallel with the split section, as shown in Figs. 4b and 4c. When the split section has ⅓ the total area, the antenna impedance is 9 times that of a plain dipole. When the split section has ¼ the total area, the impedance is 16 times that of a plain dipole.

The presence of a reflector decreases the impedance of a folded dipole in the same ratio as for a plain dipole.

When both reflectors and directors are used to obtain maximum gain, the impedance of a plain dipole may drop to as low as 10 ohms. This value is too low for connection to a coax transmission line. However, a folded dipole with several parallel elements as shown in Figs. 4b or 4c, may be used in place of the plain dipole to obtain a higher antenna impedance to facilitate matching to a coax transmission line.

In some respects, a folded dipole may be regarded as a plain dipole shunted by two quarter-wave shorted stubs. The stubs function as parallel-tuned circuits, while the dipole functions as a series-tuned circuit. The reactances of the stubs and the dipole change in opposite directions and tend to cancel at frequencies above or below resonance. This tendency contributes to the somewhat wider bandwidth of a folded dipole as compared to that of a plain dipole.

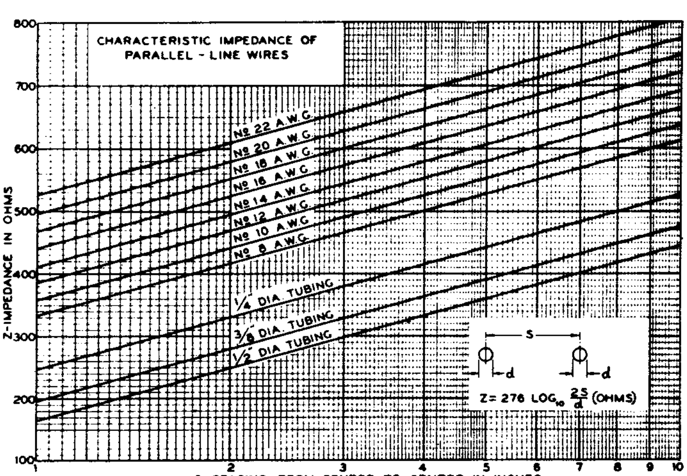


FIG. 3

Increasing Signal Input on an Incorrectly Terminated Line

As mentioned later, the impedance of the transmission line should equal the *rated* input impedance of the particular TV receiver. However, the *actual* input impedance of TV receivers does not remain constant on all channels, and frequently has a large reactive component. By "tuning out" this reactance on any particular channel, it is possible in many cases to get an appreciable increase in picture strength. Obviously, this expedient is required only on weak signals.

This improvement can be accomplished easily on installations with *ribbon*-type transmission line. The procedure is as follows:

1. Tune in the weakest TV station.
2. Grasp the transmission line between the thumb and fingers at some point along the line where it is convenient to observe the picture. Slide the fingers along the line, watching for change in picture brightness. At some point, the picture strength will increase. A quarter-wave further along the line, the picture strength will decrease.

The fingers act as a small capacitor across the transmission line. It may be necessary to vary the capacitance by increasing or decreasing the pressure or the finger area. If the effect of a larger capacitor is required, grasp the line between the palm and four fingertips.

Find the center point of the section where the hand capacitance increases the picture strength. Connect a small silvered ceramic trimmer (1.5 to either 7 or 15 uuf) across the transmission line at this point. Hold the insulation of the trimmer between the tips of the fingers and, using a fibre neut stick, adjust the trimmer for maximum picture strength. Refer to Figure 5.

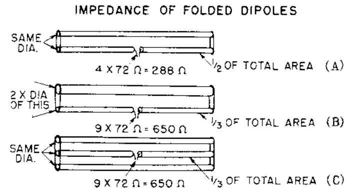


FIG. 4

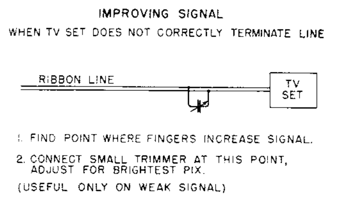


FIG. 5

Instead of a trimmer capacitor, it is possible to use a piece of metal foil, wrapping it around the line, sliding it to the position for best signal strength, adding or removing foil area if necessary, and finally fastening it in position with Scotch tape.

If hand capacitance decreases the picture strength at all positions along the line, it indicates that the receiver is correctly terminating the line on the particular channel. In this case, no improvement can be achieved.

The actual application of this method of partially compensating for an incorrectly terminated line depends on how many channels need improvement, whether a particular receiver has appreciable input reactance on these channels, and many other factors. We will leave, therefore, the actual application to the ingenuity of the TV technician. It should be noted, however, that the particular position and value of the capacitance apply only to one channel. For any other channel it is necessary to reposition the capacitor and change its value.

PART II—GHOSTS

We did not originally intend to devote much time to ghosts because the subject is generally well understood, at least in regard to the common or garden variety of ghosts. But on analyzing the subject, we were surprised to realize the great variety of ghosts that may, under unfavorable circumstances, unhappily haunt the kinescope. So we decided to make you better acquainted with them.

For instance, have you met all of the following members of the ghost family?—

- Leading ghosts
- Trailing ghosts
- Positive ghosts
- Negative ghosts
- Multiple ghosts
- Fluttering ghosts
- Transmission Line ghosts
- Tunable ghosts

If you do not recognize all of them, you may have wasted time trying to eliminate some varieties by orienting the antenna, which doesn't phase them a bit.

Trailing ghosts

The usual type of ghost, or echo, or secondary image, is caused by reflection of the transmitted signal from a building or other structure or from a hill or cliff. The reflected signal, which is usually weaker than the direct signal, arrives at the receiving antenna later than the direct signal, and the ghost, therefore, appears on the right-hand or trailing side of the original picture.

The building or other object from which the signal is reflected may be situated in various locations with respect to the TV station and to the receiver, as shown in Fig. 1.

In Fig 1A where the direct and reflected signals arrive at the receiver from the same general direction, there is no practical remedy at present to eliminate the ghost.

Occasionally, in the hope that the plane of polarization of the reflected signal has been changed from horizontal, experimenters try tilting the antenna in various planes to get it at right angles to the plane of the reflected signal. Unfortunately, such trials have usually proved inconclusive or futile.

In Fig. 1B, where the reflected signal is arriving at the receiver from one side, it can be minimized by orienting the antenna for least pickup in this direction.

In Fig. 1C, where the reflected signal is arriving at the receiver from the rear, a reflector on the antenna is helpful because it reduces rear pickup to some extent. As mentioned previously, it is not a cure-all for this condition. A reflector of large dimensions, such as a metal billboard. or a large screen of chicken wire, is generally helpful in reducing rear pickup. In a few cases, it is possible to position the antenna so it is "shielded" from the rear by a closely adjacent steel building.

In mid-city locations, it is sometimes advantageous to orient the antenna for maximum pickup of a strong reflected signal, and minimum pickup of the direct signal. This expedient may be necessary in locations where the direct signal is blocked by an intervening building, as in Fig. 1D.

In locations where several reflected signals from different buildings reach the receiver, there are several ghost images in the picture. These images are referred to as multiple ghosts, or multiple reflections. A typical condition in which multiple ghosts are produced is shown in Fig. 2.

A ghost may be either positive or negative using these terms in their photographic sense, where a negative is a reversed image; that is, the black portions are white and the white portions are black.

Whether a ghost is positive or negative depends on the relative rf phase of the direct and reflected signals. See Fig. 3. The relative phase depends on the position of the antenna. If the antenna is moved some distance toward or away from the transmitter, the relative phase changes, and the direct and reflected signals either aid or oppose, producing a positive or a negative ghost respectively.

Fluttering ghosts

When an aircraft is in the vicinity of the receiver, it reflects signals from the TV transmitter to the receiver. The receiver also gets direct signal from the transmitter. The relative phase of the direct and reflected signals arriving at the receiver changes as the plane travels along. The two signals alternately aid and oppose each other, producing a flutter in picture brightness and also a flutter in the ghost image. In TV receivers with automatic gain control on the picture—if amplifier, the fluctuation in brightness is largely eliminated. Refer to Fig. 4.

The rate of flutter depends on the position, height, speed, and direction of the plane. The rate of flutter changes as the plane moves along.

Occasionally signals from a distant TV station that is beyond normal receiving range may be seen for short periods due to reflection from a plane as shown in Fig. 5. This occurrence demonstrates that the signals are passing over-head and could be intercepted if it were possible to place an antenna high enough in the air.

The usual type of ghost appears on the *right-hand* side of the picture. It is termed a "trailing" ghost because the reflected signal travels a longer path than the direct signal and arrives later than the direct signal.

There is a condition where one or more images may appear on the left-

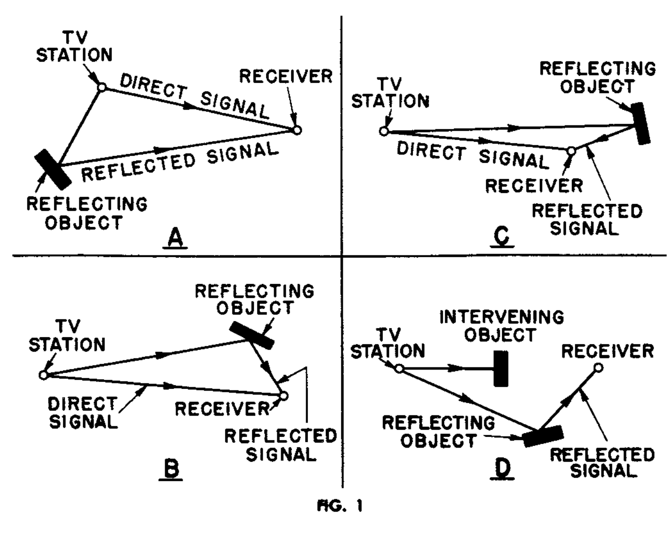


FIG. 1

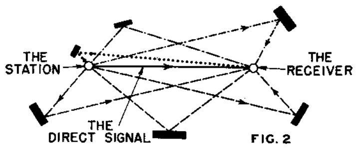


FIG. 2

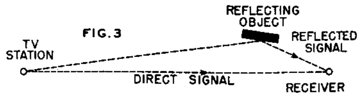


FIG. 3

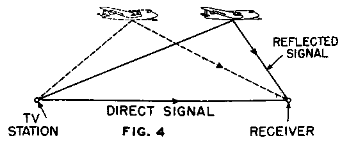


FIG. 4

hand side of the picture. We have termed these "leading" ghosts for lack of a better description.

This type of ghost appears in locations where the following conditions exist, as shown in Fig. 6;

1. Location relatively close to the transmitter.
2. Considerable signal pick-up in the rf or 1st- detector circuits of the receiver, with the antenna disconnected.
3. Long run of transmission line to the antenna.

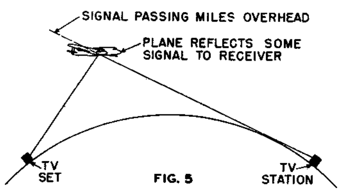


FIG. 5

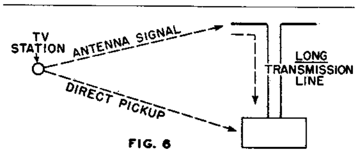


FIG. 6

Because the antenna signal is delayed traveling down the transmission line, the direct signal picked up in the rf or 1st detector circuits appear ahead, or on the left-hand side of the antenna-signal picture.

The remedy in this case is to—

1. Reduce the direct pickup in the receiver, by shielding the rf and detector circuits, or the entire chassis.
2. Increase the signal from the antenna. (If there is some type of antenna distribution system, it may be defective, or attenuating the signal too much.)

In any case where direct signal pick-up by the receiver is evident in the picture, this signal will be altered by persons moving around the room, or near the TV receiver. (Remember that movement close to an unshielded transmission line will alter the antenna signal, particularly when the receiver does not terminate the line correctly.)

Under the conditions mentioned above but where the transmission line is shorter than a few hundred feet, the direct signal will not appear as a separate image but will blend with the antenna signal to produce a picture of poor quality which will change in quality when someone moves around the room or near the receiver.

In one actual case where leading ghosts were encountered, the following checks were made:

1. With the antenna connected to the receiver, and contrast and brightness correctly adjusted, there were about 12 distinct images on the kinescope.
2. Disconnecting the antenna from the receiver, without disturbing the contrast control, it was found that there were about 10 images.
3. From this it was assumed that the antenna was contributing very little to the signal, and that most of the pickup was from signals "coming in the window" and being picked up in the rf or detector circuits. The numerous images were due to reflected signals from different tall buildings in the vicinity.
4. Shielding of the rf and detector circuits did not help in this case.
5. It was then assumed that the rf tube had no gain, to account for the fact that connecting the antenna to the receiver produced very little difference in the picture on the kinescope. This proved to be the trouble: A resistor in the rf bias circuit had dropped to a very low value, which resulted in the rf tube being biased off at all times.
6. When this trouble was corrected and the antenna was connected to the receiver, the picture contrast control had to be turned back considerably because the antenna signal was then being amplified in the rf stage.
7. Leaving the contrast control in this new setting, the antenna was disconnected, and it was observed that no images were visible on the kinescope, indicating that at this low-gain setting of the contrast control, the direct signal pickup in the rf and detector circuits was not strong enough, compared to the antenna signal, to cause trouble.
8. The antenna was then reconnected, and after some time spent in finding the correct position and orientation, the final picture was excellent with only a few very faint reflections or trailing ghosts.

Another case in a similar location was traced to a defective component in the antenna distribution system.

These two actual cases are mentioned here because usually the presence of multiple ghosts is blamed on the particular location, and on the position and orientation of the antenna. It is worthwhile, at least in strong-signal areas, to check other factors, as proved in these two instances.

In working on reflection problems, it is sometimes helpful to know exactly which building or structure is acting as the reflecting object in producing a particular ghost.

To locate the reflecting object, it is necessary first to determine the "additional airpath distance" that the reflected signal must travel. (Any reflected signal travels a longer distance than the direct signal.)

The additional air-path distance is determined from knowledge of two facts:

1. The scanning spot in the kinescope requires approximately 53 millionths of a second, or 53 microseconds, to travel from the left- to the right-hand side of the picture. (Unblanked portion of picture.)
2. Radio signals travel approximately 1000 feet in one microsecond in air. In 53 microseconds a radio signal travels approximately 53,000 feet or 10 miles. Therefore, during the time it takes for the spot to travel from the left- to the right-hand side of the picture, a radio signal travels about 10 miles. The horizontal width of the picture provides a distance scale, somewhat like the range scale on the radar "A" scope.

The procedure in determining the additional air-path distance of the reflected signal is as follows:

1. Adjust the picture width so it is the same size or slightly smaller than the mask, and adjust for the best possible horizontal linearity.
2. Measure the horizontal distance in inches between a point in the original picture, and the corresponding point in the ghost.
3. Measure the width of the picture in inches.

The additional air-path distance in feet is

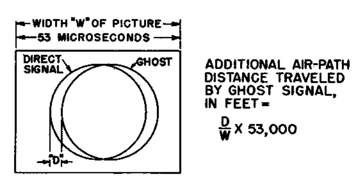
$$\frac{\text{distance between corresponding points}}{\text{width of picture}} \times 53{,}000$$

(Fig. 7)

As an example, if the distance between corresponding points in the original and ghost pictures is one inch, and the width of the picture is 8 inches, the additional air-path distance is $\frac{1}{8} \times 53{,}000$ or approximately 6,600 feet.

Note that this is the *additional* air-path distance that the reflected signal travels. It is NOT the distance from the reflecting object to the receiver or to the transmitter. For instance, if the distance from the transmitter to receiver is 50 miles, the direct signal travels 50 miles, and in the above example, the reflected signal travels 50 miles plus 6,600 feet.

In this particular example, if the reflecting object were directly in



(RADIO WAVES TRAVEL APPROX. 1000 FEET IN ONE MICROSECOND.) FIG. 7

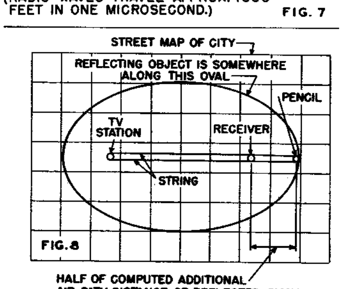


FIG. 8

back of the receiver, it would be one-half of 6,600 feet or 3,300 feet in back of the receiver.

To find the buildings or other objects that could produce a ghost with a specific additional air-path distance, it is possible to draw an oval line on a map as shown in Fig. 8. The additional air-path distance of a reflected signal is the same for all points along this line. Any large building or structure along this line can be the reflecting point.

This method is useful only when the distance between transmitter and receiver is relatively short.

Transmission-line ghosts

When the transmission line is not correctly terminated by the receiver, a portion of the signal is reflected at the receiver and travels back up the line to the antenna. If the antenna does not correctly terminate the line, a portion of this signal is reflected and travels down the line to the receiver, where it produces a trailing ghost.

With a normal length of transmission line, the reflected signal takes very little time in traveling up and down the line, so it is only slightly delayed and does not appear as a separate ghost. It merges with the original picture signal and affects the picture quality.

With a sufficiently long run of transmission line, the reflected signal appears as a separate trailing ghost.

Occasionally it is necessary to determine whether a particular ghost is due to incorrect termination of the transmission line, or to an external reflected signal. This determination will show whether it is necessary to improve the line termination or to reorient the antenna.

First determine the additional air-path distance of the ghost, as described previously.

Then determine the equivalent air-path length of the particular transmission line, which is equal to:

$$\frac{\text{length of line in feet} \times 2}{k}$$

where k is the velocity constant of the particular line and is approximately 0.83 for some types of 300 ohm ribbon line.

As an example, let us assume that the additional air-path distance of a ghost is 4,000 feet and that the 300-ohm transmission line is 500 feet long. Then the equivalent air-path length for 500 feet of 300-ohm ribbon line, for a single reflection is

$$\frac{500 \times 2}{.83} = 1200 \text{ feet (approx.)}$$

Because the ghost signal in this example has an additional air-path distance of 4000 feet, it can not be caused by reflection in the transmission line which has an equivalent air-path length of 1200 feet.

Tunable ghosts

Echoes that vary in number and intensity with adjustment of the tuning control on the TV receiver are referred to as "tunable ghosts" or tunable echoes, and may be caused by incorrect alignment of the rf-picture if amplifiers, or by regeneration.

PART III

Why does there appear to be so much contradictory information about television antennas?

In the first place, there are wide differences of opinion based on individual experience under different conditions.

For instance, technician "A" in a *strong* signal area is convinced that a certain antenna has broad-band response because it gives satisfactory reception on all of the TV areas.

But technician "B" in a *weak* signal area is convinced that this same antenna has narrow-band response, because he must use several of these antennas, each cut for a particular channel to obtain sufficient signal on each station.

Here are two different opinions. Is this a wide-band antenna, or a narrow-band antenna? How should the manufacturer rate it?

In the second place, almost all of the practical information that is available on antennas applies only to the resonant frequency. This information includes the widely-known values of dipole characteristics, such as:

(a) impedance
(b) gain from the use of a reflector
(c) change of impedance due to the reflector.
(d) and the directivity pattern

All of these characteristics become entirely different when the antenna is used to receive channels at other than the resonant frequency, and this is exactly the condition that applies in television, because in probably 80% of all TV installations, a single antenna is used to receive two or more stations on different frequencies.

Yet we continue to think and to talk about television antennas in terms of characteristics that apply only at the resonant frequency.

To illustrate this point, assume that a technician stops to admire an antenna installation. He sees that it is a plain dipole cut for one of the low channels, so he classifies it as having 70-ohm impedance. The transmission line is 70-ohm coax, so he is satisfied that it matches the antenna correctly for maximum power output. He knows that a plain dipole has a figure "8" reception pattern, with best reception at right angles to the rods. This dipole is broadside to the direction of the stations, so he is satisfied that it is oriented for best signal pickup.

Of course, the technician is correct on all of these points, providing the owner happens to be looking at the particular channel for which the antenna is resonant.

LOCAL FACTORS } DETERMINE { ANTENNA REQUIREMENTS

STATIONS, FREQUENCIES	BAND-WIDTH
FIELD STRENGTH	LO-GAIN, WIDE BAND, HI-GAIN, NARROW BAND, ONE ANTENNA, OR SEVERAL ANTENNAS
DIRECTION	
REFLECTIONS	
INTERFERENCE	
LINE IMPEDANCE	PLAIN OR FOLDED DIPOLE
COST	TYPE AND HEIGHT

FIG. 1

But suppose the owner looks at another low-band channel: The antenna impedance is no longer 70-ohms; it may be quite different. So the 70-ohm coax does not match the antenna.

Or suppose the owner looks at a high-band channel: The antenna impedance is not 70-ohms, it may be several hundred ohms; so again the 70-ohm coax does not match the antenna. The antenna does not have a figure "8" pattern; it has four major lobes at about 40° angles to the rods, so the antenna is not oriented for maximum signal on these channels.

In the third place, it does not make sense to consider the "gain" of an antenna without considering the loss in the type of transmission line that must be used with that particular antenna. We are *not* interested in the voltage up at the terminals of the antenna; we *are* interested in the voltage down at the input terminals of the receiver.

At frequencies used in radio and short-wave work, the signal loss in low-impedance coax is seldom a serious factor. But at the higher frequencies used in television, up to 216 megacycles, the gain achieved on one channel by matching a low-impedance antenna to a coax line may be outbalanced by the high losses in the coax, compared to the much smaller losses in 300-ohm ribbon line.

An additional reason for contradictory information is the fact that wide-band television antennas are not developed at an office desk with the aid of a handbook. They are developed by experimental methods with numerous measurements and comparisons every step of the way. Consequently there is disagreement in many cases between those who have become experts by reading the handbooks, and those who are actually conducting antenna measurements and comparisons under controlled conditions.

Comparison of TV antenna characteristics over all the TV channels requires a carefully chosen location, special set-up, special signal generators, special loads, and special measuring equipment; plus specialized knowledge and experience. Only a few agencies in the country are equipped at present for this work.

What is being done to clarify the situation?

This article is one step in an effort to provide impartial answers to questions about TV antennas.

We are not including any "how-to-build-it" information. Frankly, the best plan for anyone who wants to build antennas is to copy a design that has proved satisfactory for the particular set of conditions.

What is the best antenna for television?

No one antenna is "best" for all TV installations. The best antenna for a particular location depends on many factors.

What factors are involved in selecting the best antenna for a particular installation?

We will name seven factors as shown in Figure 1.

1. The number of TV stations that are to be received, and their frequencies.
2. The field strength of each station at the receiving site.
3. The direction of each station from the receiver.
4. The reflection conditions (echoes or ghosts), and the direction of such reflections, for each station.
5. The interference conditions, rf and electrical for each station.
6. The type and impedance of transmission line.
7. The price that the owner is willing to pay for material and labor to get good reception on each station.

How are these factors related to the antenna?

The number of stations, and their frequencies determine the bandwidth that the antenna must cover.

The signal strength of each station determines whether low-gain broad-band, high-gain narrow band, or a combination of such antennas must be used.

Direction, reflection, and interference conditions determine whether a single antenna, or several antennas are required so that each can be oriented for best signal and least reflections.

In addition, the line and receiver impedances may often determine whether plain dipoles or folded dipoles are required.

The cost naturally influences the final choice and may necessitate a compromise The cost also determines the height which is usually a very important factor in weak signal areas.

Let's consider a center-city location with three stations, all strong, all in different directions, and severe reflections on all. What is the best antenna?

The safest answer, without making a survey at the particular location, is to use three separate antennas with reflectors, and three separate transmission lines running to a selector switch near the receiver, as shown in Figure 2.

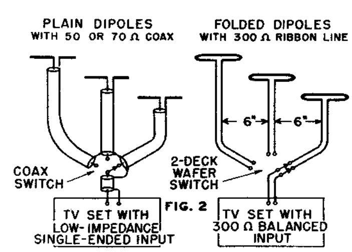


FIG. 2

Each antenna should be positioned on the roof and oriented for least reflections. The antennas should be plain dipoles for 50- or 70-ohm receivers and folded dipoles for 300-ohm receivers.

Consider a residential area in the city: Five stations, two on the high-band channels, all reasonably strong, all in the same general direction. What is the best antenna?

For receivers with 300-ohm input impedance, the best antenna in this location is an RCA-225A1 or 226A1 (the 225A1 has a reflector). This is a wide-band dipole. It was designed for these conditions. We will say more about it later.

Suppose we want to use a 50- or 70-ohm receiver in this same location: What antenna is required?

At least two antennas; one or more for the low channels and one for the high channels. Each to be plain dipole with reflector. The antennas may be connected together as specified by the manufacturer and fed into a 50- or 70-ohm line.

Let's move away from the city, say 30 miles: Three stations, one on the high band, all in the same general direction, no strong local reflections. What antenna is best?

Again, it is preferable to make a survey on the spot, but for receivers with 300-ohm input impedance, the RCA 225A1 dipole and reflector is recommended. For receivers with low-impedance input, use at least one antenna for the low-band, and one for the high-band. The antennas may be connected together as specified by the manufacturer, or separate lines can be run from each antenna to a switch near the receiver.

In very weak signal areas, what is the best antenna?

A separate "high-gain" narrow-band antenna for each of the low-band stations and one high-gain antenna for the high-band channels —(channels 5 and 6 are generally covered by a single high-gain antenna). Run a separate line for each antenna as shown previously.

It is preferable to use folded dipoles with reflectors and 300-ohm ribbon line for least loss of signal in the line.

However, if noise pickup *on the line* is excessive, use plain dipoles and reflectors with 50- or 70-ohm coax. But decide this point carefully because coax has much higher loss of signal than 300-ohm ribbon line. When coax is used for a receiver having a balanced input, use twin coax as shown in Figure 3. The transmission line may be two-conductor shielded coax or two single coax cables *of the same length* run side by side with the braid outer conductor of each cable connected to the chassis close to the rf input. The cables must be almost exactly the same length: If there is a difference of a half-wave length at some frequency, the signals from each cable arrive at the receiver in phase and cancel. A half-wave of coax on channel 13 is only about 16 inches long.

In extremely weak signal areas, a stacked array of two antennas may be used for any one station.

When you say a "separate" antenna for a low-band channel, do you mean an antenna that is cut to the correct length so it resonates at the frequency of the particular channel?

Yes. For optimum gain with a half-wave dipole on a particular low-band channel, the antenna should be cut to correct length so that it is *resonant* at the picture-carrier frequency; it should also be *matched* to the transmission line.

For satisfactory matching, use a folded dipole for 300-ohm line, and a plain dipole for 50- or 70-ohm line. The line impedance is, of course, determined by the receiver input impedance.

Such an antenna, with a correctly phased reflector, is classified here for simplicity as a high-gain narrow-band dipole.

How can such an antenna cover all the channels in the high band?

It is necessary to think in terms of percentage as shown in Figure 4.

Assume an antenna with a bandwidth of 20%—

at 60 Mc, 20% bandwidth is 12 Mc.

at 80 Mc, 20% bandwidth is 16 Mc.

at 200 Mc, 20% bandwidth is 40 Mc.

Obviously for the same percentage bandwidth, an antenna covers more channels on the higher frequencies.

Other factors, such as the ratio of rod diameter to length, increase the bandwidth at the higher frequencies, so it is possible with one plain or folded dipole to cover all the highband channels.

For maximum gain on channels 2, 3, and 4, separate antennas are required, each being designed for its particular channel. Only one antenna is generally required to cover both channels 5 and 6.

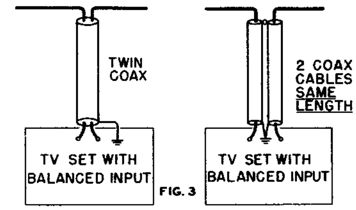


FIG. 3

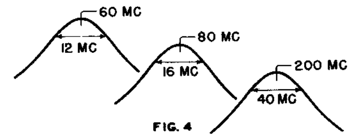


FIG. 4

The photographs of the WFIL Test Pattern which appear in the preceding articles are reproduced with permission of the station management. The pictures were made by using a receiver in good operational condition except for the specific faults purposely introduced. The quality of test patterns in no way reflects upon the quality of the transmitted signal of WFIL or the station personnel.

TV SERVICING—Supplement I

This booklet contains a new article by John R. Meagher, well-known author of the RCA PICT-O-GUIDE Series* and many other television servicing publications and articles, covering trouble shooting problems in those hard-to-service television receivers known to many a service technician as "dogs". The information in this article, which supplements the articles by Mr. Meagher in TV SERVICING,* tells the serviceman how to determine the defective component after he has diagnosed the trouble and localized it to a particular stage or section. Emphasis is on time-saving component-checking techniques and on the proper use of test equipment.

*RCA PICT-O-GUIDE Vols. I and II and TV SERVICING (Form TVS-1030) may be obtained from your RCA Tube Distributor, or direct from Commercial Engineering, Tube Department, Radio Corporation of America, Harrison, N. J.

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RADIO CORPORATION of AMERICA
TUBE DEPARTMENT **HARRISON, N. J.**

TROUBLE SHOOTING "TOUGH" SETS OR "DOGS"

By John R. Meagher
Television Specialist, RCA Renewal Sales

Experienced technicians can find the trouble quickly in about 90 per cent of the receivers that require service. But it may take several hours or even days of exasperating effort to find the trouble in the remaining 10 per cent. The latter sets are commonly, and mildly, described as "dogs", because too often they cause a loss which overcomes profits made on other sets.

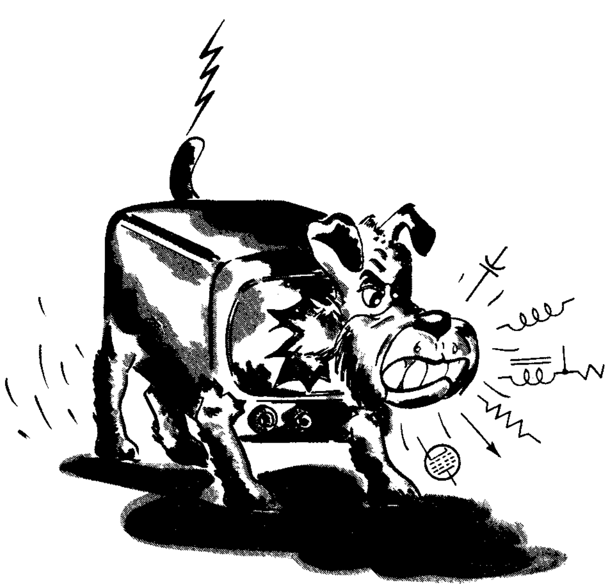
In service organizations where most of the sets are repaired in the home by experienced field men, it is only natural to expect that a larger percentage of the sets brought into the shop may be dogs.

The time spent on dogs is not wasted if it produces gradual improvement in trouble-shooting methods. A review of past experience with dogs reveals two important facts relating to trouble-shooting methods:

1. *When the trouble is eventually found, it is usually in a component that had been checked repeatedly.* Often, in the course of working on a dog, a technician will say "I know that the trouble is right in this particular section. I've checked everything in this section. I've tried new tubes, I've replaced several parts. Everything checks OK, but the trouble is still there". Yet, in many cases when the trouble is found, it is in one of the components that had been checked, double checked, and triple checked. Obviously, in such cases there must be something wrong with the method of checking.

2. *The trouble almost always turns out to be something "simple"*, like a capacitor, transformer, coil, resistor, or tube. After all, there is little else in a television receiver. The trouble may be due to slight leakage in a coupling capacitor, shorted turns in a transformer that checks OK for dc resistance, change in value of a resistor that appears perfectly normal, a defect in a tube that presumably had been checked, a stray lump of solder causing a ground or short circuit in a hard-to-see spot, or some intermittently defective part that checks okay when cold.

The trouble in many dogs is not so simple. For instance, it may be a combination of two different troubles in the same section of the receiver. Or, if a set has been worked on for several days, or by several technicians, new and weird troubles may have been added to complicate the original condition: Several leads may have been snipped open for checking purposes, and never resoldered. Worse still, the leads may have been resoldered on the wrong contacts. When a technician falls heir to such a set, he is likely to be inheriting a major headache that only patience, perseverance, and pains-taking effort can remedy.



Some technicians create their own dogs by refusing to believe the plain and honest statement that, in many cases of obscure trouble, it pays to check the over-all rf-if alignment. If someone has tampered with the alignment adjustments, or if trouble has developed in an rf or if tuned circuit, the technician may waste many hours checking components and voltages before he realizes that the receiver requires realignment. Unstable sync, incomplete blanking, weak picture or sound, distorted sound, poor picture quality, hum, buzz, snow, and interference, are some of the troubles caused by poor alignment. If the technician has a convenient set up of *good* alignment equipment, it takes about 5 minutes to connect the equipment to the receiver and to determine definitely whether the alignment is good or bad. Five minutes spent in checking the alignment may save five hours of fruitless trouble-shooting effort.

In all cases where the trouble is eventually found in a component that had previously been checked as OK, the technician should immediately question his method of checking. Why didn't the fault show up when the component was first checked? Is there something wrong with the method used in checking the particular component?

The purpose of this article is to point out, with complete frankness, the common deficiencies and limitations in the methods and equipment used for checking. This article also contains helpful information and suggestions for checking transformers, coils, resistors, and capacitors: checks which are the foundation of all trouble-shooting work.

Limitations in Methods

1. *DC-Resistance checks do NOT prove that a transformer or coil is OK.* Even if the measured dc resistance agrees exactly with the values shown in the service data, the transformer or coil may have shorted turns, or other troubles, that seriously affect its operation. Leakage between windings may not show up on an ohmmeter, but may be detected by connecting the coils between a source of high voltage and a high-impedance voltmeter. *In most cases, the only reliable method available for checking transformers and coils is the substitution of a new transformer or coil.* In many difficult service jobs, the trouble is eventually corrected by installing a new transformer or coil, despite the fact that the original unit checks OK on an ohmmeter.

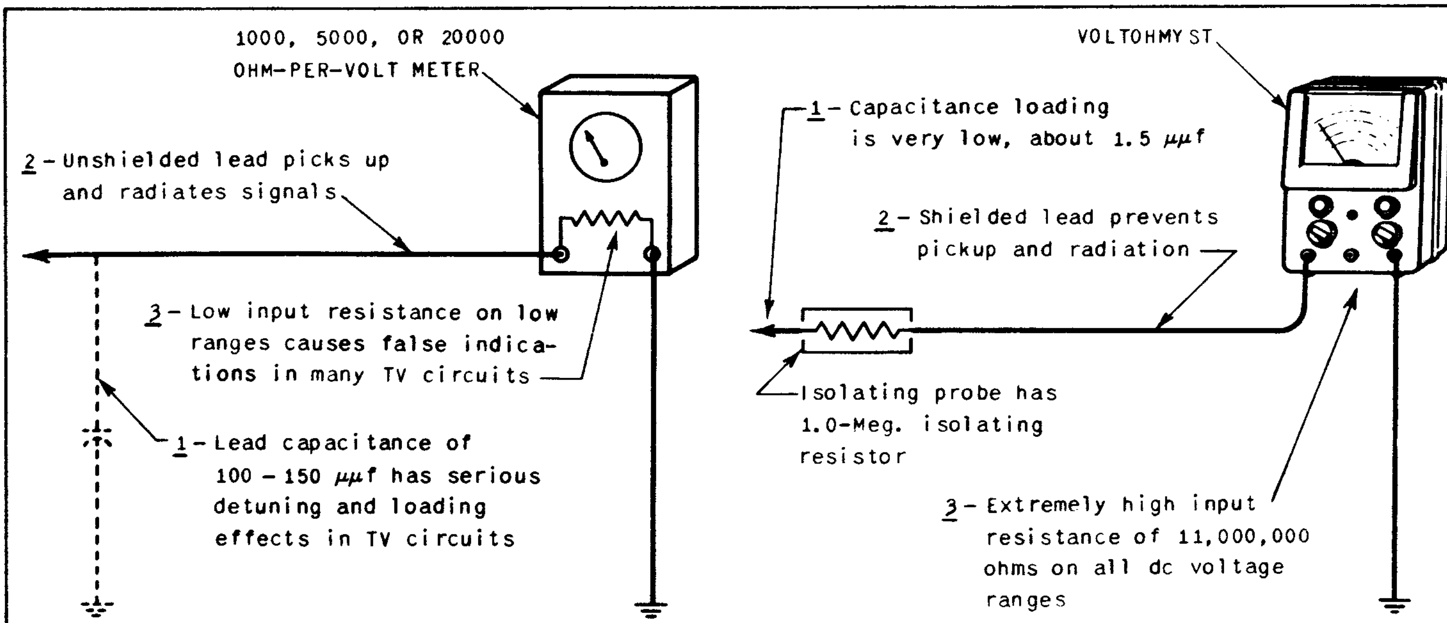
2. *Ohmmeter checks for leakage in a capacitor do NOT always reveal leakage that occurs when normal operating voltage is applied to the capacitor.* The voltage applied to a capacitor during ohmmeter check is very low, and necessarily so; otherwise the ohmmeter battery would burn out low resistance elements being tested, such as the filaments of the battery-operated tubes. The voltage across the capacitor in the receiver may be many hundreds of volts. A capacitor that checks OK on an ohmmeter may break down or exhibit leakage under normal operating voltage in the receiver. *Leakage, particularly leakage in coupling capacitors, is responsible for the trouble in a high percentage of difficult service jobs.*

3. *The color code on a resistor does NOT prove that the resistance value is correct.* Resistors can increase or decrease greatly in resistance value, or become opened, *with no outward change in appearance.* An appreciable percentage of obscure troubles are eventually traced to change in the value of a resistor that "looks" OK and has the correct color code.

4. *"Sparking tests" for high voltage do NOT prove that the voltage is sufficient.* Sparks can be drawn between the high-voltage lead and the high-voltage electrode of the picture tube, even when the voltage is less than half of normal. Spark tests can mislead the technician into believing that lack of brightness is caused by a perfectly good picture tube. There is no need to guess about the high voltage when it can be measured easily and quickly: An inexpensive RCA WG-289 high-voltage probe enables the owner of any RCA VoltOhmyst* to measure dc voltages up to 50,000 volts. (The WG-290 probe is available for voltohmmeters that have phone-tip connectors.)

*Reg. U. S. Pat. Off.

Why a Vacuum-Tube Voltmeter Simplifies Trouble Shooting



There are three basic reasons why conventional voltmeters of 1000, 5000, or 20,000 ohms per volt are NOT satisfactory for checking tube voltages in TV receivers:

(1) *The capacitance loading* of approximately 100-150 μμf completely detunes any rf or if circuit, thus greatly reducing the signal voltage and altering the agc voltage and the plate voltages in the rf-if amplifiers. In video, sync, and deflection circuits, the capacitance loading reduces the signal amplitude and affects the waveform. In rf, horizontal, and vertical oscillators, the capacitance loading reduces the frequency, amplitude, and activity of the oscillator.

(2) *The unshielded lead* picks up and radiates rf, if. and other stray signals, and may cause regeneration and misleading voltage indications.

(3) *The resistance loading* greatly reduces the voltage in all high resistance circuits. On the 5-volt range of a 20,000 ohm-per-volt meter, the input resistance is only 100,000 ohms, which causes completely false indications in all circuits of more than about 50,000 ohms. The combination of capacitance and resistance loading results in false, unreliable, and misleading indications in most of the tube circuits of a TV receiver.

In sharp contrast to the misleading indications of conventional voltmeters, the RCA VoltOhmyst gives the technician the greatest possible aid in TV troubleshooting:

(1) *The input capacitance is extremely low,* about 1.5 μμf, and therefore has minimum effect in rf and if signals, and negligible effect in all other circuits.

(2) *The input lead is shielded,* eliminating signal pickup, radiation, and the possibility of regeneration due to the feedback that is present on unshielded leads.

(3) *The input resistance is extremely high* (11,000,000 ohms) on all dc voltages ranges, even the lowest. The high input resistance insures correct indication of actual circuit voltages.

In addition to these essential electrical features, the RCA VoltOhmyst provides direct-reading peak-to-peak voltage ranges, the convenience of a single zero-adjustment setting for all "ohms" scales, and protection from meter damage on dc voltage measurements.

Limitations in Equipment

Even if the technician avoids the four pitfalls listed above, he may still be hampered and misled by serious limitations and deficiencies in his testing equipment. Most technicians, being honest and modest, blame themselves for any confusion or misleading indications that occur while using test equipment, particularly alignment equipment. In too many cases, the confusion and wrong indications are a direct result of short-comings in the test equipment itself. It will pay the technician to stop and ask himself "Is this instrument designed to give me the greatest amount of help in my work, or does it have serious short-comings that will confuse and mislead me?"

Here, briefly, are some of the things to watch out for:

1. *Ordinary voltohmmeters (1,000, 5,000, and 20,000 ohms-per-volt) are NOT satisfactory for voltage measurements in the high-resistance, high-impedance, and high-frequency circuits of television receivers.* The effects of capacitance loading, resistance loading, stray pickup, regenerative feedback, and radiation from the leads result in false voltage readings that often mislead the technician into believing that trouble exists in circuits where there is no trouble, and vice versa. The voltages indicated by an ordinary voltohmmeter in many of the circuits *in a perfectly normal TV receiver* are hopelessly different from the actual operating voltages in the set, and also from those specified in the receiver service data. Those technicians who depend on ordinary voltohmmeters are needlessly handicapping their own trouble-shooting ability. It is in the technician's best interests to use a good vacuum-tube voltmeter such as the RCA VoltOhmyst. The VoltOhmyst, with its low-capacitance isolating probe, shielded input cable, and extremely high (11-megohm) input resistance on all dc voltage ranges, has minimum loading and detuning effects on the circuit being tested and, therefore, indicates the true operating voltages.

2. *A CRO that is not designed for use with a low-capacitance probe is NOT satisfactory for checking waveform troubles in the sync separator and deflection circuits.* An unshielded input lead on a CRO picks up stray pulse voltages, and hum voltages, that obscure and alter the desired waveform. It is not satisfactory simply to use a shielded input lead, because the high capacitance of the shielded lead, plus the input capacitance of the CRO (which may total 150-200 μμf), severely reduces the amplitude and waveform of the signal at the test point in the receiver. The resulting pattern on the CRO is incorrect and misleading.

In order to localize a trouble to a particular stage in the video amplifier, sync separator, or deflection circuits, it is essential that the CRO have the following features:

(a) *A frequency - compensated isolating probe and shielded input cable.* The input capacitance of the probe should not exceed about 10 or 15 μμf.

(b) *Voltage calibration for the vertical amplifier.* Calibration is required in order to determine the voltage amplitude at any point in the waveform of the input signal. The amplitude is just as important as the shape.

(c) *Adequate frequency and phase response for observation of horizontal sync pulses.* If the CRO is designed for use with a low-capacitance probe, a frequency response flat to 0.5 Mc, and trailing off to 2 Mc or more, is more than satisfactory, provided the phase response is good. Beware of claims for wide-band frequency response measured *at the input terminals posts* on a CRO. Such claims are meaningless and misleading, because the addition of an input lead (a CRO cannot be used without an input lead) *drastically* cuts down the "rated" frequency response.

In the writer's opinion, the best CRO for television trouble shooting and alignment is the 7-inch RCA WO-56A, which has the three basic requirements listed above, plus numerous other essential features. For instance, *the WO-56A is very much faster and easier to operate for TV trouble shooting and alignment than any other oscilloscope on the market.* This truly amazing improvement in the speed and ease of operation is the result of four design features:

(a) *Motion of ONE switch instantly changes over the CRO for observation of either horizontal or vertical sync pulses.* To make this same change-over with an ordinary CRO, it is necessary to turn three different knobs and "fiddle" with two of them. Change-over from observation of horizontal pulses to vertical pulses, and vice versa, is required frequently when sync troubles in the video amplifier and sync separator are being checked.

(b) *The pattern stays locked in position on the WO-56A even when the signal level, input frequency, and gain are changed over wide limits.* Every technician knows that the user of an ordinary CRO must be continually readjusting the "vernier frequency" and "sync" controls because the pattern jumps out of sync whenever there is a slight change in input level, frequency, or gain. A special sync-limiter circuit in the WO-56A minimizes the need for continual and critical adjustment of controls.

(c) *Dual controls for coarse and vernier adjustments save time and simplify the operation.* The WO-56A has the time-saving convenience of dual controls for vertical gain, sync, sweep, and horizontal gain. These controls are positioned in a logical order so that the user doesn't have to waste time hunting around the panel in search for the right knob.

(d) *DIRECT-COUPLED push-pull amplifiers eliminate delayed action and bounce in the pattern.* The pattern on the WO-56A responds instantly to changes in level, input switching, and centering. In oscilloscopes that have resistance-capacitance coupled amplifiers with *good* low-frequency response, the pattern bounces up and down whenever the input is switched, and returns slowly to rest. Also there is an annoying lag between the adjustment of the centering controls and the resulting motion of the pattern. The direct-coupled amplifiers in the WO-56A have flat response down to zero frequency (dc), but there is no bounce and lag. The horizontal and vertical amplifiers are substantially identical, and they have frequency-compensated and voltage-calibrated input attenuators.

These four features (instant switching from "V" to "H" sweep frequencies, pattern lock-in, dual controls, and instant pattern response) eliminate the need for continual adjustment of controls, and permit the user to devote his full attention to the primary job of trouble shooting. All TV technicians know that a good CRO is a great aid in TV servicing, particularly in tracking down obscure troubles, but many technicians have shied away from oscilloscopes, except for alignment work, because of their intricacy and slowness of operation. The writer is happy to assure these technicians that the WO-56A eliminates these objections.

3. *Alignment equipment that is built to sell on "price appeal", and that fails to meet any of the minimum requirements listed below, is NOT a good investment at any price.*

(a) *The rf and if output voltage of the sweep generator must be "flat" over every swept range, and must remain flat at all settings of the output attenuator.* "Peaks and dips" in the sweep output voltage mislead the technician into believing that well-aligned receivers need realignment. When a receiver is aligned with such a sweep, the response curve appears correct, but is actually wrong. There is no satisfactory method, except laboratory analysis, to determine the flatness of output voltage. The purchaser must depend on the manufacturers' claims. In this connection, it is a significant fact that *the RCA sweep generator is the only service-type sweep in general use on TV production lines, in TV development laboratories, and in the laboratories of industrial and educational institutions.*

(b) *The sweep generator and marker oscillator must not produce unwanted and confusing response curves and unwanted multiplicity of markers.* In using alignment equipment that has excessive output of harmonics or spurious signals, it is extremely difficult, and often impossible, to determine the correct response curve and the correct marker. Such equipment is a useless investment at any price.

(e) *The sweep generator and the marker oscillator must have adequate shielding and proper cable termination.* Radiation from the equipment or cable produces— (1) spurious response curves, (2) unwanted and misleading markers, and (3) general instability and variations in the amplitude and shape of the response curve due to hand-capacitance effects. This point should be given careful consideration, particularly if the test equipment manufacturer suggests the use of "a metal top on the bench and bonding of the equipment" to reduce the effects of the undesired radiation. Adequately shielded and properly terminated alignment equipment does NOT require such artificial (and usually ineffective) aids.

(d) *The marker oscillator must have built-in crystals and built-in means for setting the variable oscillator to the crystal harmonics.* The mere fact that a marker oscillator has one or two built-in crystals, or "provision for plug-in crystals", is no assurance that the crystals are fully usable. Some marker oscillators have only one crystal that provides check points at wide intervals, such as 5 Mc. and the misleading claim is made for them that the dial can be set accurately between these check points by "interpolation". The catch in this case is that even if the *dial* is set precisely by interpolation, the oscillator *frequency* may still be off by an excessive amount. Frequent crystal check points are essential for accurate setting of the variable oscillator. The feature of "external plug-in crystals" has a misleading appeal; the technician should first check on the number and cost of the crystals that he will have to purchase to accommodate all of the different intermediate frequencies now in use, with more to come. The RCA WR-39C Crystal Calibrator has three built-in crystals and a built-in heterodyne detector, amplifier, and speaker. The method of using the crystals provides calibration at every ¼-Mc point throughout the rf and if ranges. A 4.5-Mc crystal provides the accuracy necessary for alignment of sound if amplifiers and discriminators in all inter-carrier sets. The 4.5-Mc crystal may also be used at will to modulate the variable oscillator, thus providing *both* picture and sound markers simultaneously: This feature is extremely valuable in checking and aligning rf tuners. In brief, the RCA Sweep Generator and Marker Oscillator are designed to aid the user, not to confuse or mislead him.

Hundreds of technicians have learned the hard way, through bitter and expensive experience, that the above information on requirements for testing equipment is NOT "sales talk". Many of these technicians, who spent hard-earned money on equipment that they later found by experience to be inadequate, confusing, and misleading, have asked the writer to bring out the real facts as plainly as possible. This we have now done.

Suggested Checking Methods

This section contains practical information and suggestions for checking transformers, coils, resistors, and capacitors.

Checking Coils and Transformers

Shorted turns in a coil or transformer winding may be regarded as equivalent to a short-circuited secondary winding of the same number of turns. Shorted turns may or may not cause trouble, depending on the function of the coil, the circuit in which it is used, and other factors. Even one short-circuited turn in the coil of an rf or if tuned circuit may make it impossible to peak the circuit at the specified frequency. On the other hand, a short circuit across all of the turns in a video peaking coil is unlikely to have any noticeable effect. Shorted turns in a deflection-circuit transformer may seriously affect the operation of the circuit.

Unfortunately, it is impossible to detect the presence of a small percentage of shorted turns by checking the dc resistance of the winding. The fault must usually be found in a round-about fashion. The usual method is first to eliminate all other possibilities of trouble in the particular section of the receiver by checking the tubes, components, voltages, and wiring. Then, even though the dc resistance of the particular coil or transformer checks exactly with the values specified in the service data, it is necessary to try a new coil or transformer. If the trouble disappears when the new unit is installed, it can be assumed that the original coil or transformer was faulty, possibly due to shorted turns.

There are several reasons why dc resistance checks fail to reveal a short circuit across a small percentage of the turns in a coil: (1) There is a manufacturing tolerance in the impedance and consequently in the number of turns on most windings, with a corresponding tolerance in the dc resistance. (2) The resistance values specified for coils and transformer windings in the manufacturer's service data are frequently taken from a single sample of the receiver: Any of the coils and transformers in the sample receiver may be on the low edge, or the high edge of the tolerance range. (3) There is a normal amount of error in the ohmmeter used in compiling the service data, and also in the ohmmeter used by the technician. The combination of these factors makes it virtually impossible to detect a small percentage of shorted turns by means of dc-resistance checks.

It is important to remember that dc-resistance checks do NOT prove that a coil or transformer is OK. Resistance checks are valuable in revealing open coils, completely shorted coils, shorts across more than about 20 percent of the turns, leakage and shorts between coils, leakage and shorts from a coil to the core, leakage and shorts from a coil to the outer container or to the chassis, and similar defects.

Ohmmeter checks also fail to reveal leakage or breakdown (across coils, from coil to coil, from coil to core, etc.) that may occur only when normal operating voltages are applied to the coil or transformer in the receiver. When there is reason to suspect leakage or breakdown from a coil to the core or to the chassis, a check can be made by temporarily insulating the unit from the chassis.

Checking RF and IF Coils, Transformers, and Traps

If an rf or if tuned circuit can be peaked at its specified frequency, it can be assumed that the coil is OK.

Shorted turns reduce the inductance of a coil and increase the resonant frequency of the circuit. When a circuit cannot be tuned low enough in frequency, inspect the coil for shorted turns. If the coil appears normal, and if there is a fixed or adjustable capacitor in the tuned circuit, check the capacitor for open circuit and for capacitance value. If a satisfactory checker is not available for measuring low-value capacitors, try a new capacitor. Capacitors used in rf and if tuned circuits are critical (in value, and often in construction); hence it is advisable, and frequently essential, to use exact replacements.

When the inductance or capacitance of a tuned circuit is too low, it is possible to be misled by a false peak in response which occurs when the iron core in the coil is moved through the maximum-inductance position at the center of the coil. If the core can be moved from one end of the coil to the other, there should be two different positions (one on each side of the center of the coil) at which the circuit can be resonated to the correct frequency. In some tuned-circuit transformers, and in some tuned coils that have a coupled wave trap, it is necessary to use a particular one of these two settings in order to obtain the correct coupling between windings. The correct setting is usually specified in the service data.

When it is impossible to peak a tuned circuit or trap at the specified frequency, check the dc resistance of the coil. If it is opened or shorted, inspect the coil, the leads from the coil, and the terminal connections. If necessary, temporarily disconnect and check the associated tuning, coupling, and bypass capacitors, and any shunt damping resistor. If these parts check OK, try a new coil.

Coils that are wound with spaced turns of bare wire can be checked visually: Look for shorts between adjacent turns, and for splashes of solder across the turns. If there is a tap on the coil, or a capacitor mounted on the coil, make certain that the connecting bus leads are not shorting against the coil.

Video Peaking Coils

Video peaking coils are used to "hold up" the high-frequency response, from about 2 to 4 Mc, in the second detector and video amplifier. A shorted peaking coil reduces the definition of the picture slightly. An open peaking coil may result in complete loss of picture, or serious loss of picture quality. The effects of open and short circuits may be summarized as follows:

(a) A complete short circuit, or shorted turns, in one peaking coil usually causes only a minor loss in the definition ("sharpness", or fine detail) of the picture.

(b) If the peaking coil has a damping resistor connected across it, an open circuit in the coil leaves the damping resistor in the circuit; consequently, there is seldom complete loss of picture, but there is usually a noticeable loss of picture quality and, in some cases, poor sync action.

(c) If the peaking coil does not have a damping resistor connected across it, an open circuit in the coil is likely to result in complete loss of picture. For instance, if the coil is in series with a video plate circuit, an open coil creates an open plate circuit, with resulting loss of picture.

When the visible symptoms indicate that the trouble is in the video amplifier, it is advisable to check the dc resistance of the peaking coils. The resistance ranges from about 2 to 10 ohms, depending on the size of the wire and the inductance of the coil. If a coil is found to be opened or shorted, it should be replaced.

As mentioned above, a shorted peaking coil has little effect. This fact can be used to advantage when it is found that loss of picture, or poor picture quality, is caused by an open peaking coil: *To make a temporary or emergency repair on an open peaking coil, simply connect a short circuit across it.*

If the damping resistor across a peaking coil becomes opened, there is seldom any visible effect in the picture. Lack of damping can, however, cause "ringing" in the particular circuit. Ringing may produce multiple images on all stations. The images are uniformly spaced and progressively weaker. (When multiple images are caused by external signal reflections from several surrounding objects, the images are not uniformly spaced, not progressively weaker, and are seldom identical on all stations.) Video ringing can also occur in a circuit consisting of a peaking coil connected in series with a load resistor, if the resistor is shorted out.

In order to check the dc resistance of a shunt damping resistor, it is necessary to disconnect one end of the peaking coil from the resistor. In some receivers each of the peaking coils is mounted on, and connected to, a small tubular resistor. The resistor may or may not be used to provide damping across the coil. If the resistor is intended to provide damping, it usually has a value under about 25,000 ohms. If the resistor is used solely as a convenient means for mounting the coil, it has a much higher resistance, usually one megohm or more, and, in this case, the resistor has no effect on the action of the circuit.

Width and Linearity Coils

If the raster is visible on the picture tube, adjust the iron core in the width coil, and in the linearity coil, from the maximum-inductance position (core at center of coil), to the minimum-inductance position (core out of coil). If the resulting change in width and linearity appears normal for the particular receiver, it may be assumed that the coil is OK. If adjustment of the core has little or no effect, or if this check cannot be made due to absence of the raster, disconnect one end of the coil and check the dc resistance. If the coil is definitely opened or shorted, it should be repaired or replaced. If the coil appears to be OK, check the associated circuits and components.

Horizontal and Vertical Transformers and Deflecting Coils

When the visible symptoms indicate that the trouble is in the horizontal or vertical section of the receiver, considerable time and effort can be saved by first localizing the fault to one half of the section. This step can be accomplished by checking the waveform and the peak-to-peak voltage at the output of the discharge circuit, and comparing the observed readings with the values specified in the service data. The writer recommends the RCA WO-56A 7-inch oscilloscope for this purpose. If a suitable oscilloscope is not available, measure the peak-to-peak voltage at the discharge circuit with an RCA WV-97A Senior VoltOhmyst, which has direct-reading peak-to-peak voltage scales.

Check the tubes, components, voltages, and wiring in the suspected portion of the section. Check the dc resistance of the transformers and deflection coils. Check for leakage in the grid capacitors of the oscillator, discharge, and output tubes, using the method suggested later in this section. If careful check of each component fails to reveal the trouble try a new transformer. An open or short circuit in the deflection coils usually results in a keystone-shaped raster, as depicted in the RCA-Pict-O-Guide, Vol. II, HD-10.

If the fuse in the horizontal output circuit is found to be opened, it is a good practice to inspect the horizontal output transformer for evidence of high-voltage arc-over. If there is a burnt or charred spot on one of the windings, it is generally advisable to replace the transformer. If there is no visible evidence of trouble in the transformer, install a new horizontal output tube. Also check the filament winding for the damper tube which may be shorted to ground. In either case, replace the fuse and observe the horizontal output transformer when power is applied to the receiver. If the transformer starts to arc-over or smoke, immediately turn off the power. In this case, it is generally necessary to replace the output transformer. It is also advisable to check all other components in the horizontal output circuit.

Filter Choke

When there are noticeable 120-cycle hum symptoms in the picture, in the sound, or in both, check the electrolytic filter capacitors, and the dc resistance of the filter choke. If the hum is not caused by the electrolytic filter capacitors, try a new choke.

Power Transformers

When a power transformer operates considerably hotter than usual, the trouble may be caused by external over-load in one of the secondary circuits or by internal over-load due to shortened turns in the primary or in one of the secondary windings. As mentioned previously, shorted turns in a winding are equivalent to a separate secondary (of the same number of turns), which is short circuited. The current that can flow in the shorted turns is limited by the size of the wire and other factors. There is usually higher current and higher power loss in a shorted turn on a "heater" winding than on a B-supply winding.

A power transformer can be checked for excessive power loss, due to shorted turns or other internal fault, by disconnecting all of the secondary circuits and operating the transformer until it attains maximum temperature. If the transformer becomes excessively warm or hot, on this "no load" check it is a definite sign of internal trouble.

An *external* short circuit or overload can be localized to a particular secondary circuit by the following method:

1. Remove the power plug and disconnect all of the secondary windings.

2. Remove all of the tubes from the receiver. Remove the socket from the picture tube.

3. Connect one of the heater circuits.

4. Apply power to the transformer. Look for signs of overloading. If the particular heater circuit does not cause over-load, insert the tubes that are operated from this heater winding. Look for signs of over-load as each of these tubes is inserted. If there is no evidence of over-load, it may be assumed that this particular heater circuit is OK.

5. Turn off the power, connect the next heater winding, and proceed as in item 4.

6. Check all of the heater circuits, and, finally, the B-supply secondary.

Checking Tubular Resistors

On most service jobs, the tubular resistors can be checked simply by visual inspection. If a resistor is not discolored, darkened, charred, swollen, cracked, or broken, and if the color code agrees with the resistance specified in the schematic diagram on the receiver, it may be assumed that the resistor is *probably* OK. But, if a thorough check of the tubes, components, voltages and wiring in the suspected section of the receiver fails to reveal the fault, *it is then definitely advisable to measure the actual resistance of each resistor* in the defective section of the set. Resistors can increase or decrease in resistance value, and also become opened, without the slightest alteration in external appearance. In addition, there is always a remote possibility that the color coding on a resistor may be incorrect, and that certain colors such as orange and yellow, or bluish-green and greenish-blue, may be mistaken. For these reasons, it is a good rule, particularly when working on difficult jobs, not to accept the resistors at "face value", but instead, to measure the resistance of each resistor.

A resistor rarely becomes overloaded through any fault of its own. Overload is almost always caused by an external short circuit or ground in one of the associated components. Hence, *when a resistor shows visible signs of overload, it is not sufficient merely to replace the resistor*. It is essential to check for possibility of short circuit and grounding in the associated circuit components and wiring. Resistor overload is frequently caused by excessive leakage or short circuit in an associated bypass capacitor, but it may also be caused by a defective tube, incorrect voltages on a tube, leakage in a coupling capacitor, grounding in an associated coil or transformer, or similar defects.

If the reason for the overload cannot be determined, it is advisable to install a new resistor, and to operate the receiver for sufficient time to see if the condition recurs. If the resistor becomes excessively hot, quickly check the voltages in the resistor circuit to determine the point at which the short circuit or grounding is taking place. It may be necessary to snip open any associated bypass capacitor, or other component, to determine whether it is responsible for the overload.

Many technicians have asked how much change can be tolerated in resistance values. It is impossible to give a general answer to this question because some circuits are more critical than others. For example, a change of 10 per cent in the value of a grid-bias resistor for a video stage may cause trouble, while a change of 50 per cent in the grid-leak resistor of the same stage may have little if any effect. Circuit constants are selected by the design engineers to provide the best possible performance over the range of operating conditions, including high and low line voltage, high-and-low-limit tubes, high-and-low-tolerance limits in other components, high and low room temperature, etc. If a resistance value appears to be unimportant for a particular set of operating conditions, it may possibly be important for a different set of conditions. It is therefore sensible to adhere to the specified values as closely as possible. When a defective resistor is replaced, it is good practice to replace it with a unit of equal or better tolerance, or measure the replacement with an ohmmeter.

The task of checking all of the resistors, and the dc resistance of all other components in the suspected section of a receiver, can be simplified and speeded up by the use of the RCA VoltOhmyst. Ordinary voltohmmeters, and many vacuum-tube voltohmmeters impose the continual nuisance and distraction of resetting the zero adjustment every time that the meter is switched to a different "ohms" scale. *This nuisance is eliminated in the RCA VoltOhmyst, because one setting of the zero adjustment holds good for all scales,* unless the "Ohms" battery is exhausted.

The following two points, in connection with resistance checks, are well known but can stand emphasis: (1) It is necessary in many cases to disconnect one end of the resistor, coil, capacitor, or other component that is being checked, in order to eliminate any effect from other circuit elements. (2) It is often necessary to allow time for the tubes to become cold before checking resistance in grid circuits. Depending on the polarity of the ohmmeter leads, there may be grid current, and resulting error in meter reading, if measurements are made while the tubes are still warm.

Checking Capacitors

Continual improvements in the design and construction of all types of capacitors have reduced the rate of capacitor failure to a very low level, but in view of the fact that *there are more than 150 capacitors in the average television receiver,* it is not surprising to find that capacitors are responsible for the trouble in a high percentage of all TV service jobs.

Capacitors may become opened, partially opened, shorted, partially shorted, or leaky, or may develop internal series resistance. Leakage is equivalent to having a dc resistance connected internally across the capacitor. Leakage as high as 1,000,000,000 ohms can cause trouble in certain circuits, while leakage as low as 1000 ohms has no noticeable effect in other circuits. When the leakage resistance is low, a few ohms or less, the capacitor is said to be "completely shorted", or to have a "dead short". Somewhat higher resistance is described as a "partial short". Leakage may be caused by imperfections or conducting particles in the dielectric, by carbonization of the dielectric due to internal arc-over, and by other reasons. Capacitors may develop internal series resistance, usually due to poor internal contact, which makes the capacitor less effective for certain applications, particularly in rf and if circuits. "Opened" capacitors are usually the result of internal disconnection of one of the leads. Cracking or breaking of the dielectric and silver-film plates in ceramic-type capacitors usually causes a complete open circuit or a great reduction in capacitance. Occasionally a capacitor becomes partially opened (capacitance drops to a fraction of the original value), due to internal disconnection of a portion of the plate area.

To check a capacitor for capacitance, leakage, and other factors, it is necessary to disconnect the capacitor from the circuit, and measure it on laboratory-type equipment. While this method is excellent for engineering purposes, it is too slow, and generally unnecessary, for routine service work, where it is frequently necessary to make rapid checks on a dozen or more capacitors in the suspected section of the receiver. It is usually easier and quicker to try a new capacitor, if necessary, than to disconnect and measure the suspected capacitor. In actual service practice, capacitors are checked by various indirect methods, and by substitution, as follows:

1. *Shorted bypass capacitors* are usually detected during the process of *measuring dc voltages* in the suspected section of the receiver. In any plate, screen, cathode, or grid-return circuit that requires a bypass capacitor, there is normally some dc voltage across the capacitor. (The correct voltage may be specified in the service data for the receiver, or it may be estimated from other specified voltages in the same circuit). If there is no voltage across the capacitor, or if the voltage is considerably lower than it should be, it indicates that the capacitor *may* be shorted. This possibility can be checked quickly by simply disconnecting one end of the capacitor. If the voltage in the circuit returns to normal when the capacitor is disconnected, it indicates that the capacitor is shorted. If the voltage does not return to normal, check for other faults in the same circuit, such as an open filter resistor, a ground in another component, or a defective tube. *See Fig. 1.*

When a *plate- or screen-circuit bypass capacitor* becomes shorted, it usually causes excessive current flow through any associated filter

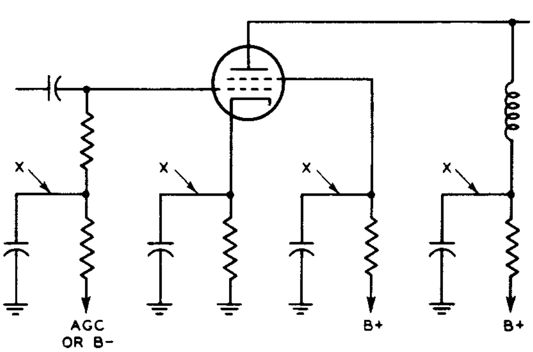


Fig. 1—The following simple method is often used to check for possibility of *short circuit* in a bypass capacitor: When the B+, B—, and agc voltages are approximately correct, but the dc voltage at any of the points marked "X" is zero, or appreciably lower than the normal value, temporarily disconnect the capacitor at this point. If the voltage at the particular point returns to normal, it indicates that the bypass capacitor is shorted. The voltage on one tube element usually affects other tube voltages. For instance, if the cathode voltage is low, the plate and screen voltages may also be low; or if the screen voltage is low, the plate voltage may be high.

(or dropping) resistor. As a result, the resistor may become burned open, or it may change considerably in resistance value. Whenever a plate- or screen-circuit bypass capacitor becomes shorted, it is always advisable to check the associated filter resistor and any other components that may have been overloaded as a result of the shorted capacitor.

When a suspected bypass capacitor is disconnected (in checking for possibility of short circuit), the absence of the bypass capacitance may affect the normal operation and voltages in the circuit. In such cases, the voltages will not return to normal until a new bypass capacitor is connected in the circuit.

(2) *Shorted or leaky coupling capacitors* are usually detected by *dc voltage measurements.* If the grid-bias voltage in a particular stage is considerably less than normal, or if it is positive, the coupling capacitor should be checked for possibility of leakage, as described later, or a new capacitor should be temporarily substituted for the suspected capacitor to see if it remedies the trouble.

In oscillator circuits (rf, horizontal, and vertical) the normal negative grid-bias voltage is produced by grid current that flows during positive peaks of the oscillator signal. If the grid-bias voltage is very low, or considerably less than normal, it is necessary to check all of the components in the oscillator circuit, including the grid capacitor.

In circuits such as the horizontal discharge, horizontal output, or some sync-separator stages, where the normal grid-bias voltage is obtained entirely or in part as a result of grid current on positive peaks of the applied signal, low bias voltage is often due to insufficient input-signal voltage.

Methods of checking for leakage in coupling capacitors are described later.

3. *Opened capacitors* are detected by temporarily connecting a good capacitor across each of the suspected capacitors, one at a time, as shown in *Fig. 2.* If connection of the good capacitor restores the normal operation of the circuit, it may be assumed that the original capacitor is opened.

Good capacitors in certain circuits may be connected or disconnected with no apparent effect on the performance of the receiver. There are several possible explanations in such cases: (1) There may actually be a slight effect which the observer fails to notice. (2) The effect may be apparent only under certain operating conditions. (3) The particular capacitor may not be essential, but may have been incorporated as a precautionary measure. For instance, in many receivers, extra capacitors and resistors are used in the intermediate-frequency plate, screen, and grid decoupling networks as an additional safeguard against possibility of regeneration.

4. *Any faulty capacitor in any circuit* can be detected by the "substitution" method, as shown in *Fig. 3.* Disconnect the "high" end of the suspected capacitor. Temporarily connect a good capacitor in the circuit. If the trouble is still present, after the new capacitor is connected, it may be assumed that the original capacitor is OK. If the trouble disappears when the new capacitor is connected, it may be assumed that the original capacitor is defective. Obviously, in the latter case, a new capacitor should be installed permanently. The new capacitor should have the correct capacitance and the correct voltage rating, or a higher rating. The new capacitor should be of the same type (paper, mica, ceramic, etc.) as the original, and it should have the same temperature coefficient, if the original capacitor has temperature compensation.

When the substitution method is used for checking *bypass and coupling* capacitors, the capacitance of the testing capacitor is not critical in most circuits. Ordinarily, the testing capacitor may have a value anywhere in the range of from ½ up to 2 times that of the original capacitor. Even a value of from ¼

Fig. 2—On difficult service jobs, it is a good practice to check *all* of the bypass and coupling capacitors in the suspected section of the receiver for possibility of *open circuit:* Temporarily connect a good capacitor across each of the suspected capacitors in turn. If connection of the good capacitor restores normal operation, it may be assumed that the original capacitor is opened.

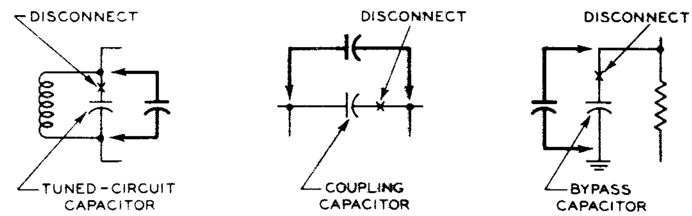


Fig. 3—Faulty capacitors can be detected by the substitution method: Disconnect one or both ends of the suspected capacitor. Temporarily connect a good capacitor in the circuit. If the new capacitor remedies the trouble, it may be assumed that the original capacitor is defective. See text for additional details.

to 10 times that of the original capacitor is likely to be satisfactory for the purpose of revealing defects in the original capacitor.

However, when *deflection circuits* are checked for the cause of poor linearity, and when *deflection oscillator and discharge circuits* are checked, the rated capacitance of the testing capacitor should be the same as that specified for the original capacitor.

In *rf and if tuned circuits,* the testing capacitor should be an exact duplicate of the original capacitor. In *rf tuned circuits,* even the lead lengths on the testing capacitor should be the same as on the original.

Many technicians keep a selected assortment of capacitors solely for use in substitution checks. The larger capacitors, such as electrolytics, may be equipped with leads and clips for convenience in connection.

Even in circuits where the capacitance value appears to be unimportant, the replacement capacitor (the capacitor that is permanently installed in place of the defective one) should be an electrical duplicate of the original. In rf and if tuned circuits, the replacement capacitor should duplicate the original both electrically and physically.

In high-frequency rf and if circuits, it is NOT good practice to parallel two or more capacitors in order to obtain the desired capacitance value: a dip or a peak may be produced in the response band of the amplifier at the resonant frequency of the paralleled capacitors, if this frequency happens to fall within the band.

Some tubular capacitors have a dark line printed around one end of the label with the words "ground", or "outer foil" to indicate that the pig-tail on this end is connected to the metal-foil plate that is on the outside of the rolled-up assembly. It is a good general practice to connect the outer-foil end of the capacitor to the grounded or low-impedance side of the circuit. When the outer-foil plate of the capacitor is grounded, it forms an electrostatic shield around the capacitor, thus reducing the amount of stray coupling to and from other nearby components and wiring.

Checks for Leakage

No resistance limits have been established in television service practice for classifying a capacitor as "leaky" or "not leaky" because the effects of leakage depend on the particular circuit in which the capacitor is used as shown in the following examples:

(a) A partial short-circuit (low-resistance leakage) of 1,000 ohms in a capacitor connected across a 100-ohm cathode resistor has very little effect on the operation of the circuit. Such leakage is likely to pass unnoticed unless the technician happens to disconnect the capacitor and check it for leakage. A leakage of 1,000 ohms in a plate- or screen-circuit bypass capacitor, or in a plate-to-grid coupling capacitor seriously affects the voltages and the operation of the circuit.

(b) A leakage of one megohm in a plate or cathode bypass capacitor ordinarily has negligible effect on the operation of the circuit, but the same leakage in a plate-to-grid coupling capacitor is practically equivalent to a short circuit in most cases, and will definitely affect the operation of the circuit.

(c) A leakage of even 100 megohms (100,000,000 ohms) in a plate-to-grid coupling capacitor is likely to cause trouble if there is a high-value resistance in the grid circuit. Consider the following conditions:

Plate voltage	= 300 volts
Normal grid bias	= −8 volts
Grid resistance	= 2.0 megohms
Leakage in coupling capacitor	= 100 megohms

In this example the voltage drop across the grid resistor due to leakage in the coupling capacitor is almost 6 volts (2/102 x 300). This voltage bucks the normal grid bias, reducing it from −8 to −2 volts. Such a large percentage of change in grid-bias voltage is very likely to cause trouble.

(d) Even a leakage of 1,000 megohms (1,000,000,000 ohms) may cause trouble, as in the following case:

Plate voltage = 300 volts
Normal grid bias = −2 volts
Grid resistance = 2.0 megohms
Leakage in coupling capacitor = 1,000 megohms

The drop across the grid resistor due to leakage in this case is approximately 0.6 volts (2/1002 x 300), which reduces the grid bias from −2 to −1.4 volts. If this condition existed in a video amplifier, it might result in sync clipping and unstable sync action.

In many cases of obscure trouble, the fault is eventually corrected by replacing a coupling capacitor that "checks OK" on an ohmmeter. When a faulty capacitor, or any other faulty component, appears to check OK, the technician is likely to spend many hours of exasperating effort checking other components before he finally decides to try a new capacitor. Obviously it is senseless to depend on checks that fail to reveal the fault:

For *practical* purposes, the best way to check for leakage in coupling capacitors is by measuring the "leakage voltage" across the grid resistor while the receiver is in operation and while normal operating voltage is being applied to the capacitor. For a thorough understanding of this method, it is necessary to understand the different ways in which grid-bias voltage is obtained, and how it can be measured. This entire subject is covered, as briefly as possible, in the following illustrations and text.

The actual grid-bias voltage is *the dc voltage between the grid and cathode*, as indicated in *Fig. 4*. Voltages shown in service data are usually measured with respect to the chassis, but in many circuits the voltage from grid to chassis is not the actual grid-bias voltage.

In *Fig. 5*, the voltage from grid to chassis is zero, but the actual grid-bias voltage, obtained by the voltage drop across the cathode resistor, is 10 volts.

In *Fig. 6*, the actual grid-bias voltage is −10 volts, measured either with respect to the chassis, or with respect to the cathode, because the cathode is connected directly to the chassis.

In *Fig. 7* the actual grid-bias voltage is −10 volts, obtained by the drop across the top resistor in the cathode circuit. The grid-to-chassis voltage is the same as the voltage across the bottom resistor in the cathode circuit.

In *Fig. 8* the actual grid-bias voltage is −10 volts, obtained by the drop across the cathode resistor. Grid-to-chassis voltage is −100 volts. Voltage measurements from grid to chassis, or from cathode to chassis, are likely to be misleading in circuits like *Figs. 7* and *8*. Refer also to *Fig. 9*.

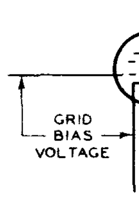


Fig. 4

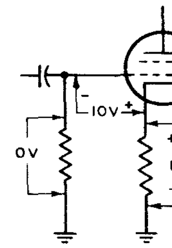


Fig. 5

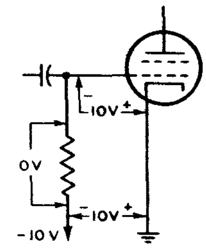


Fig. 6

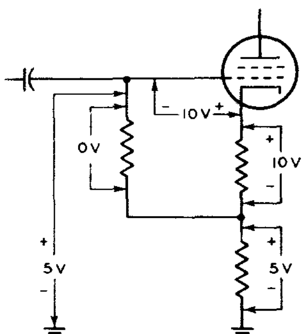


Fig. 7

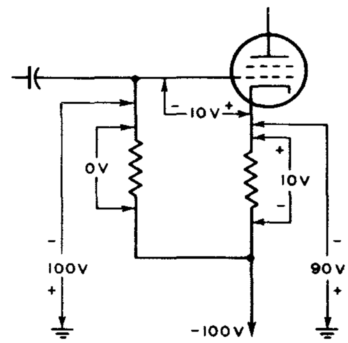


Fig. 8

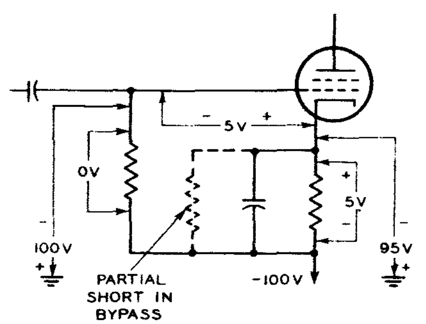


Fig. 9

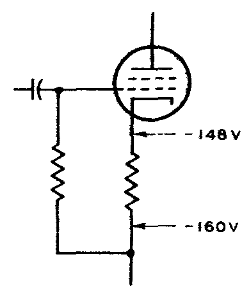


Fig. 10

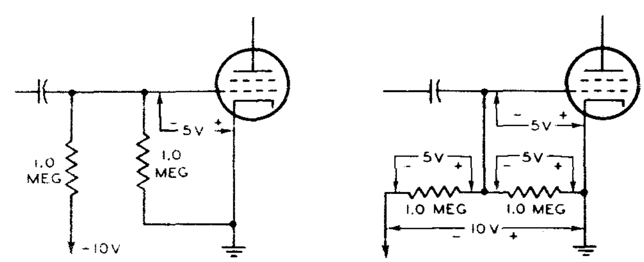


Fig. 11

Fig. 9 is the same as *Fig. 8* except that a partially-shorted cathode bypass capacitor has reduced the voltage across the cathode resistor, and also the grid-bias voltage by 50%, from 10 volts to 5 volts. If the technician measures the grid-to-chassis voltage, which is still −100 volts, and the cathode-to-chassis voltage, which is 95 volts instead of 90 volts, *he is very likely to assume that there is no trouble in the circuit*, since he is aware that the negative supply voltage (−100 volts in this example) is frequently 10% high or low. In circuits of this type, it is best to measure the voltage across the cathode resistor, and also the voltage from grid to cathode. Refer to *Fig. 10*.

The service data for the receiver may not show the voltage across the cathode-resistor, but it may give the voltage at each end of the resistor, measured with respect to the chassis as shown in *Fig. 10*. The voltage across the cathode resistor is the difference between these two voltages. (12 volts in this example).

The required grid-bias voltage for a tube is sometimes obtained by using two grid resistors to divide the voltage from an available negative-supply tap, as shown at left in *Fig. 11* and in an equivalent form at the right in *Fig. 11*. In this particular example, the resistors are equal in value, and they divide the total voltage in half, but any other fraction of the voltage may be obtained by changing the ratio of the two resistors. The effective grid resistance is equal to the value of the two resistors in parallel, or 0.5 megohm in this example.

NOTE: In conventional rf and if amplifiers, and in most video amplifiers, there is no grid current, and (if there is no leakage in the coupling capacitor) there is *no dc voltage across the grid resistor.* (An exception may occur in a stage in which the cathode-resistor bias is less than 1.5 volts and the grid resistor has a value of more than about one megohm. Then, current due to "contact potential" may produce a slight negative voltage across the resistor.) This condition of zero dc voltage across the grid resistor is shown in examples given in *Figures 5 to 9* inclusive. There is, of course, ac-signal voltage across the resistor and ac-signal current through the grid resistor. There is grid current in oscillators and in certain amplifiers, and this current produces dc voltage across the grid resistor, as shown in *Figures 12 to 15* inclusive. If the grid-coupling capacitor is shorted or leaky, the leakage current produces a dc voltage across the grid resistor, as shown in *Figures 18 and 23*.

Grid-bias voltage in oscillators is obtained (entirely or in part) as a result of electron flow from cathode to grid during the peaks of the positive half-cycles of oscillator voltage on the grid. The electrons charge the grid capacitor, making it negative on the grid side. In the time between positive peaks, the capacitor discharges through the grid resistor, thus producing a voltage across the resistor as indicated in *Fig. 12*. This voltage is termed the "developed" grid-bias voltage, and it is a measure of the oscillator activity. *If the developed bias voltage is lower than normal, it indicates trouble or misadjustment.* If oscillation ceases, the developed bias voltage drops to zero, and the plate or screen current may become excessive: A resistor may be used in the cathode circuit to provide protective bias voltage and to prevent tube damage in the event that the circuit stops oscillating.

In certain amplifiers and limiters, the grid-bias voltage is produced as a result of cathode-to-grid electron flow during the peaks of the positive half-cycles of the *applied input signal.* The developed grid voltage *(Fig. 13)* is a measure of the amplitude of the applied signal. If the developed grid voltage is appreciably less than normal, it indicates either that the amplitude of the applied signal is below normal, or that there is trouble in the circuit, including the possibility of leakage in the coupling capacitor. A resistor may be used in the cathode circuit to provide bias voltage and to prevent tube damage in the event that the input signal fails, or becomes too weak.

In *Fig. 14*, which shows the circuit of a typical horizontal-output amplifier, the grid-bias voltage is −25 volts, of which −10 volts is obtained by the drop across the cathode resistor, and −15 volts is produced as a result of cathode-to-grid electron flow during the peaks of the positive half-cycles of the input signal. The developed voltage across the grid resistor is a measure of the amplitude of the applied signal. If the developed voltage is appreciably less than normal, it indicates either that the amplitude of the applied signal is below normal, or that there is trouble in the circuit, including the possibility of leakage in the coupling capacitor.

In circuits where the cathode is returned to a relatively high negative voltage point in the B-supply circuit, as shown in *Fig. 15, it is important to realize that voltage measurements made from grid to chassis are very likely to be misleading*. The voltages in the power supply are often 10% higher or lower than the values specified in the service data. Therefore, if the grid-to-chassis and the cathode-to-chassis voltages check within ±10% of the specified values, the technician is likely to assume that everything is OK. Actually, such checks do NOT reveal troublesome changes in developed voltage across the grid resistor, nor in the voltage across the cathode resistor. Assume that the voltages shown in *Fig. 14* are correct, and that in *Fig. 15*, certain trouble has changed the developed voltage from −15 volts to −5 volts, and has changed the voltage across the cathode resistor from 10 volts to 15 volts. Also assume that the −100 volt supply actually measures −110 volts. Note that, despite the trouble, the grid-to-chassis voltage is the same in both cases. Note that there is only 5% change in the cathode-to-chassis voltage. In circuits of this type it is best to measure the developed voltage across the grid resistor, the voltage across the cathode resistor, and the voltage from grid to cathode. Measurements of this kind require the use of a high-impedance electronic voltmeter having a shielded input cable and isolating probe, such as the RCA VoltOhmyst.

The service data for the receiver may not show the developed voltage across the grid resistor, nor the voltage across the cathode resistor, but may show the grid-to-chassis voltage, the cathode-to-chassis voltage, and the measured or the "rated" voltage of the negative-supply point to which the cathode is returned, as shown in *Fig. 16*. The voltage across each resistor may be determined from these other voltages. In the example shown, the voltage across the grid resistor is 16 volts (166 — 150), and the voltage across the cathode resistor is 9 volts (150 — 141). The service data *should* give the exact measured value of the negative-supply voltage, but in many cases because only the rated voltage is given, considerable percentage of error may result when the voltage across the resistors is computed Owing to the difficulty of reading within a few volts on the higher-voltage scales of a voltmeter, the service data *should* show the developed voltage *across* the grid resistor, and the voltage *across* the cathode resistor.

In *Fig. 17* the grid-bias voltage on the second tube is −10 volts. If there is any leakage in the coupling capacitor, it will cause a volt-

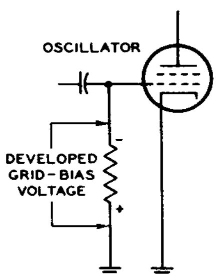


Fig. 12

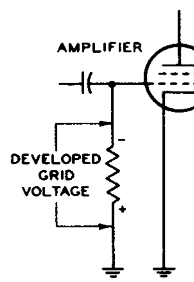


Fig. 13

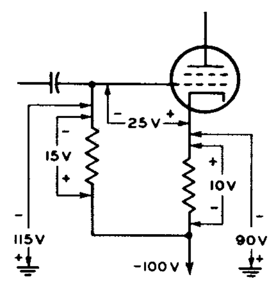


Fig. 14

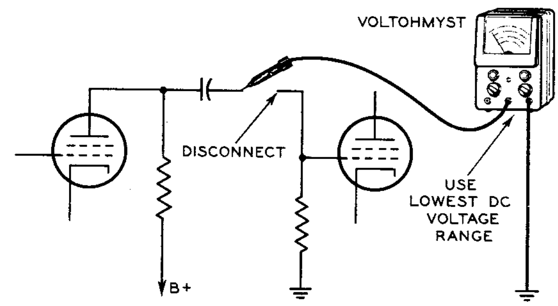


Fig. 19

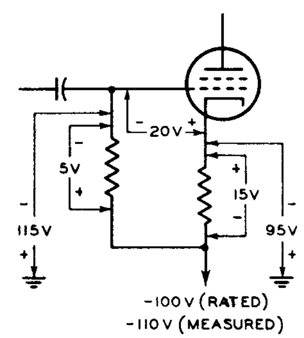


Fig. 15

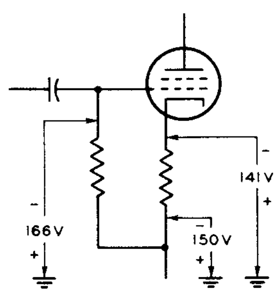


Fig. 16

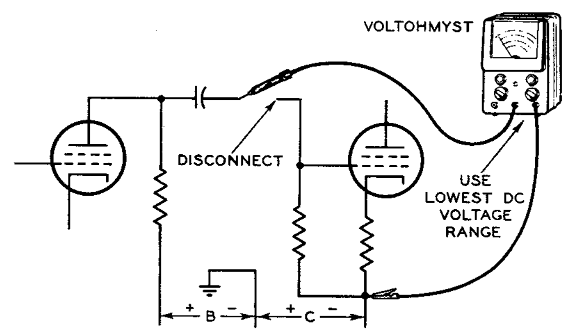


Fig. 20

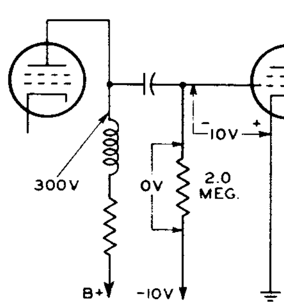


Fig. 17

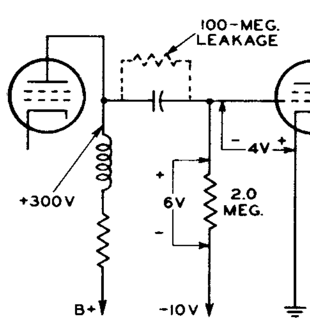


Fig. 18

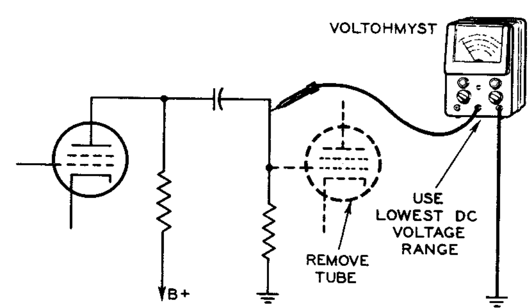


Fig. 21

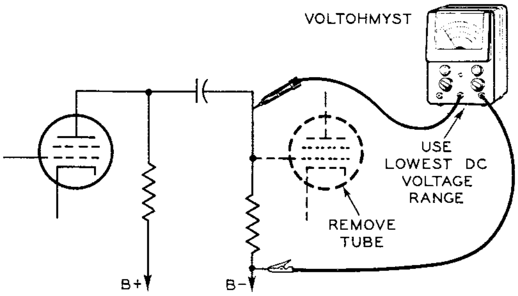


Fig. 22

age across the grid resistor that "bucks" the normal bias voltage, as shown in *Fig. 18.*

In *Fig. 18,* leakage of 100 megohms (100,000,000 ohms) causes a voltage drop of +6 volts across the grid resistor. This voltage bucks the normal grid-bias voltage, reducing it from the correct value of — 10 volts to a troublesome low value of —4 volts.

Ohmmeter checks often mislead the technician into believing that a leaky coupling capacitor is OK. The low testing voltage in ohmmeters is often inadequate to reveal high-resistance leakage, and it fails to reveal leakage that may exist when normal operating voltage is applied to the capacitor. Both of these failings can be overcome by checking the "leakage voltage", as shown in *Fig. 19, 20, 21, 22.* The check is made with the receiver turned on and with normal circuit voltage applied to the capacitor. The instant the probe is touched to the capacitor, the meter pointer will be deflected, but if the capacitor is OK, the pointer should return to zero.

If the grid circuit is returned to a negative voltage point (such as —50, —100, —150 volts) the operating voltage applied to the capacitor is equal to the plate voltage plus the "C" voltage. The full voltage is used in checking the capacitor for leakage by connecting the VoltOhmyst as shown in *Fig. 20.*

The voltage produced *across the grid resistor,* as a result of any leakage in the coupling capacitor, can be measured as in *Fig. 21* and *22.*

In circuits where the grid-return is not connected directly to chassis, connect the VoltOhmyst across the resistor, as shown in *Fig. 22,* to measure the leakage voltage across the grid resistor.

An ordinary voltmeter (1000, 5000, or 20,000 ohms per volt) gives completely wrong and misleading indications of leakage voltage, as proved in the examples shown in *Fig. 23.* In the first example, the reading on a 20,000 ohm-per-volt meter misleads the technician into believing that the leakage is only 0.3 volt, whereas the actual leakage voltage is 6.0 volts, a value which will cause definite trouble in most cases. In the second example, the leakage voltage of 0.6 volt is likely to cause trouble in a video amplifier that has a low bias voltage (in the order of 2 volts). A 20,000 ohm-per-volt meter indicates only 0.03 volts for this same leakage, thereby leading the technician into the erroneous belief that the leakage is negligible and that the capacitor is OK. (Moral: Don't handicap your trouble-shooting ability, and don't run the risk of turning simple service jobs into difficult dogs, by depending on the misleading indication of ordinary voltmeters. Use a meter that will help you, not mislead you. Use a good vacuum-tube voltmeter.

It is sometimes advisable to check for possibility of leakage in a new capacitor before installing it in the receiver. Paper, mica, and ceramic capacitors can be checked for leakage as shown in *Fig. 24.* Select B+ and B— points in the receiver that provide a voltage approximately equal to the rated voltage of the capacitor. Use a low dc-voltage range on the VoltOhmyst.

A shorted or leaky coupling capacitor in an agc-controlled if amplifier affects the voltage on the agc bus and at the grid of each of the controlled tubes. Disconnect one coupling capacitor at a time and check it for leakage voltage as in *Fig. 25.*

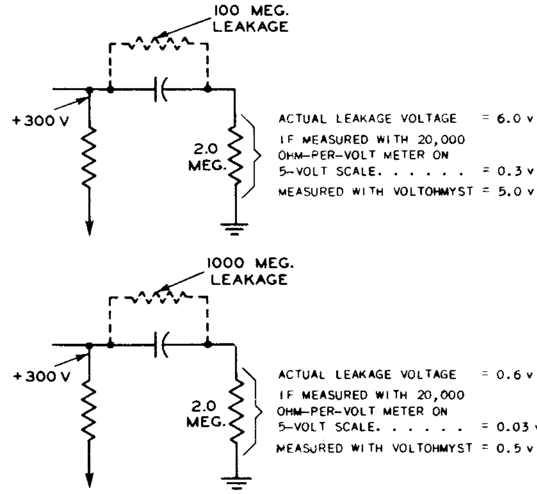


Fig. 23

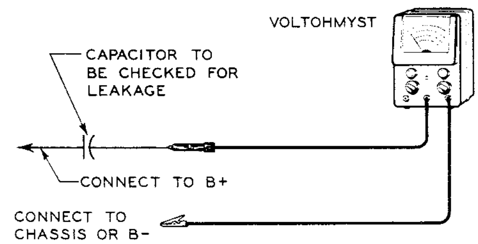


Fig. 24

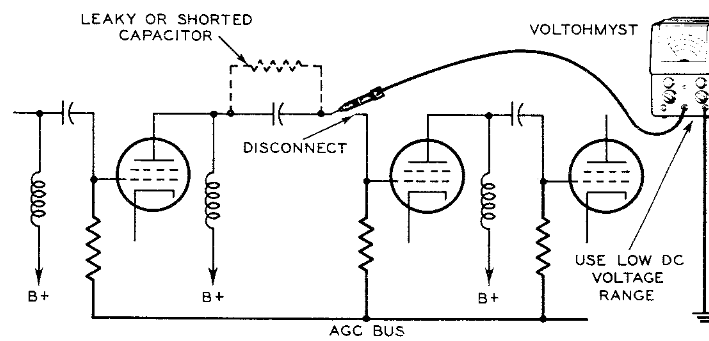


Fig. 25