SERVICING TV RECEIVERS FOR PICTURE DISTORTION

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STUDY SCHEDULE NO. 64

For each study step, read the assigned pages first at your usual speed, then reread slowly one or more times. Finish with one quick reading to fix the important facts firmly in your mind. Study each other step in this same way.

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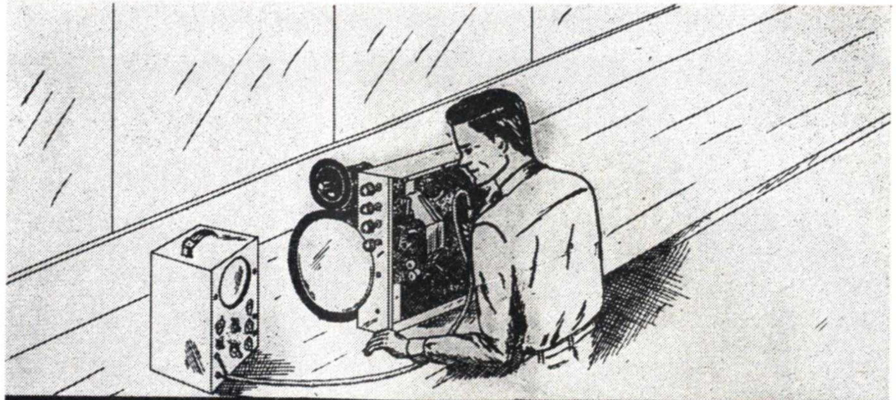


SERVICING FOR PICTURE DISTORTIONS

IN ANOTHER LESSON, we have described the various conditions that cause what might be called a dead receiver, and have shown how effect-to-cause reasoning can be used to localize the trouble. We have also described various defects that may occur in the sweep and sync systems. We shall now discuss the servicing of TV sets to remove picture distortions.

Sweep and sync defects may be said to cause picture distortions of one form or another. In this Lesson, however, we shall refer to distortions as being cases in which the picture is normal except that it is blurred, or is covered by some pattern that indicates a receiver defect.

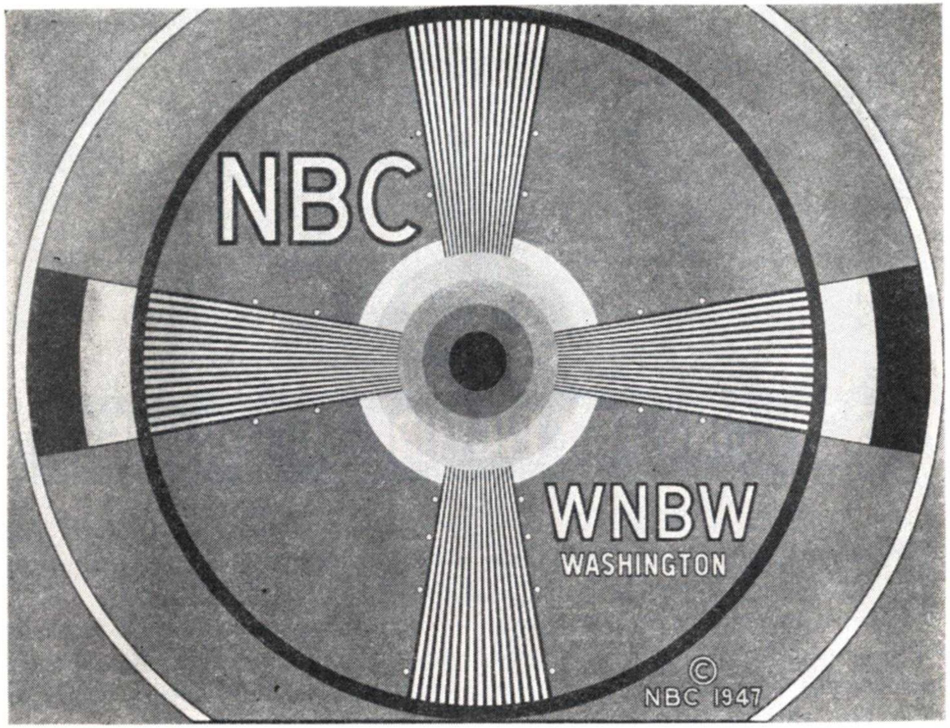
Once again, we shall find that an examination of a test pattern will show at least which section, and possibly even which stage or part, is defective. If you can do no better than locate the defective section by examining the pattern, you can use the usual testing methods to locate the actual defect. Since one of the most useful devices for making such tests is an oscilloscope, we shall devote a section of this text to showing you how to use it for this purpose.

Now, let's learn what causes various kinds of picture distortions and how you can determine what the source of a particular distortion is.

BLURRED PICTURE

A good description of what we call a "blurred" picture is that it looks somewhat like a drawing that has been smeared by someone's running his hand over it while the drawing ink was still wet. Some of the blurring, particularly when it occurs across a white area, appears to be a shadow streak across the picture. Because several defects create blurred pictures that look very much alike, it is usually necessary to study the test patterns very carefully to reach a logical conclusion as to the source of trouble.

There are four basic troubles that will cause a blurred or smeared picture. One is improper focusing. Another is a loss of low-frequency re-



Courtesy NBC

FIG. 1. Normal pattern.

sponse, which is always accompanied by an excessive phase shift. A third is a loss of high-frequency response, and a fourth is a strong ghost that is only slightly misplaced from the original image. Let's consider each of these.

IMPROPER FOCUS

A very definite blurring of the entire image occurs if the focus control is misadjusted or if any defect causes the focus to be abnormal.

Perhaps the best way to determine exactly what an out-of-focus picture looks like is to throw the focus control out of adjustment on a set with a test pattern tuned in. The general effects can also be observed by examining Figs. 1 and 2, which show a normal and a blurred pattern respectively.

As we said a moment ago, it isn't always easy to determine whether blurring is due to improper focusing or to some other cause. One basic test is to examine the image from a position a few inches away from the face of the tube. At close range you should be able to distinguish the individual lines. If you cannot see the individual lines, either the set is not properly focused or the blurring is caused by a ghost. Other sources of blurring cause smear *along* the lines, but not between them.

Another general test is to turn down the contrast control until a picture cannot be seen (or to tune to a channel that does not have a signal), then turn up the brightness control enough

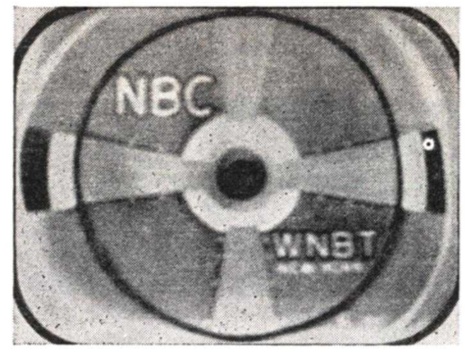
to let you see the raster. (Don't turn the brightness up too high, however, because doing so will naturally defocus the electron beam.) Poor focusing is indicated if the raster appears to be a smear of light rather than sharply-defined individual lines. This is easiest to see in the vertical retrace lines, which will tend to be broad and fuzzy, rather than sharp if the focusing is improper.

Another simple and quick test is to try a readjustment of the focus control. If this clears up the trouble, obviously the only thing wrong was that the control was improperly adjusted. If readjusting the control tends to make matters better, but you reach the end of the control's range before the picture becomes normal, some defect is producing an improper current flow through the focus network.

In a set that uses an electrostatic picture tube, the focus adjustment usually varies the voltage on one of the anodes in the gun. Voltages that are higher or lower than normal on this element (or, for that matter, on any other element in the gun) will prevent proper focusing. In a set that uses an electromagnetic picture tube, either an excessive current or too little current through the focusing coil will disturb the focus. An incorrect positioning of the coil will also affect the focus—in some receivers, in fact, the focus is adjusted by moving the coil. (In a few sets, p.m. focus magnets are used instead of an electromagnetic coil. Loss of magnetism may make it impossible to focus with such units; try a replacement.)

A multiple ghost may produce a pattern very similar to that caused by improper focusing, but if the blurring shows up on the raster when there is no picture, the focus is to blame.

If you attempt to improve the focus by adjusting the focus control, you may find that one setting of the control gives best definition on the vertical wedges of a test pattern, whereas a different setting gives best definition on the horizontal wedges. There is not much that you can do about this condition, because it is a result of the basic design of the focus coil and of the picture tube itself. By orienting the tube differently (if it is electromagnetic), and possibly by moving the focus coil, you may be able to



Courtesy RCA

FIG. 2. Out of focus.

correct the condition somewhat. Usually, however, the best you can do is make a compromise adjustment. It is the general practice in such a case to use the adjustment that gives the best definition for the vertical wedges.

SMEARING

As we just said, you can be sure that blurring is caused by improper focusing or possibly by a multiple ghost rather than by a loss of either the high or the low video frequencies if you cannot see the individual lines in the picture even at close range. Conversely, if you can see the lines, but the picture is blurred, you can be sure that the set is properly focused, but that there is a loss of low or high frequencies within the set. Loss of such frequencies causes blurring along each line, but not between the lines.

We are talking about a direct-view tube when we make this statement. Even at best focus, the lines tend to overlap somewhat in the picture on a projection set. This effect is deliberately introduced so that the enlarged image will not exhibit too much of the line structure. Therefore, this test does not hold very well for projection sets.

When you suspect that there is a loss of high or low video frequencies, you can usually confirm or dispel your suspicions by examining the horizontal and the vertical wedges in a test pattern. Both wedges will be sharp and clear if the low- and high-frequency responses are normal. If both responses are not normal, one wedge or the other will be affected, as we shall now see.

High-Frequency Loss. The vertical wedges consist of lines that cross the scanning lines. The frequency needed to produce each line properly becomes increasingly higher as the wedges taper toward the center circles. If the high-frequency response of the set falls off, therefore, these lines tend to blur together as they approach the center circles. As a matter of fact, the actual point at which the high-frequency response falls off can be judged by how far down you can see the lines of the vertical wedges on a *standard* test pattern like the one shown earlier in Fig. 1. It is not always possible to determine the fall-off point on a non-standard pattern, however; and, unfortunately, many stations use test patterns that are non-standard. If the test patterns of your local stations are not standard, you will have to learn to judge from them whether or not a set is defective in its high-frequency response.

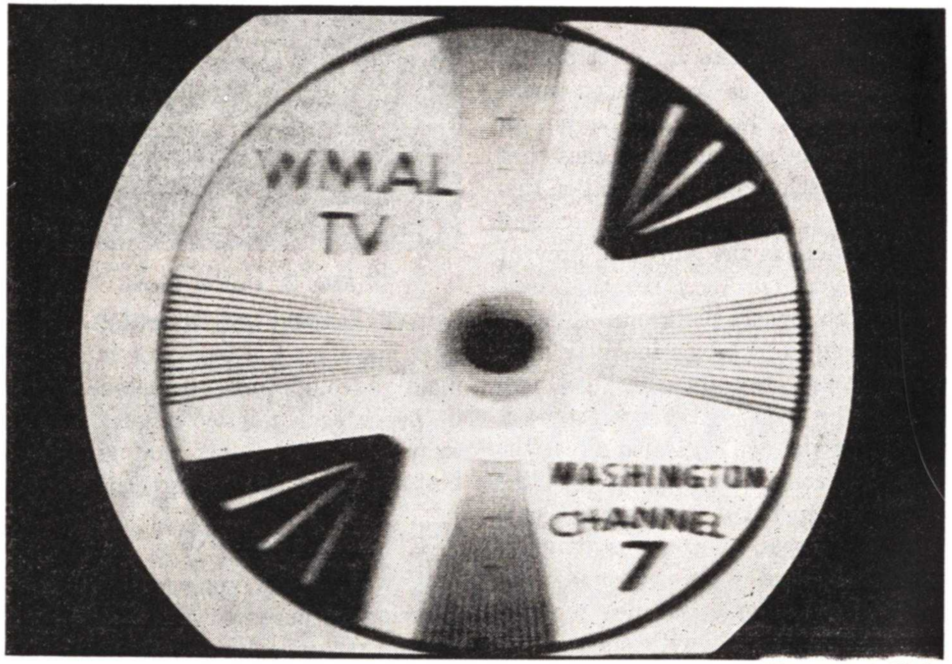


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FIG. 3. Loss of high frequencies.

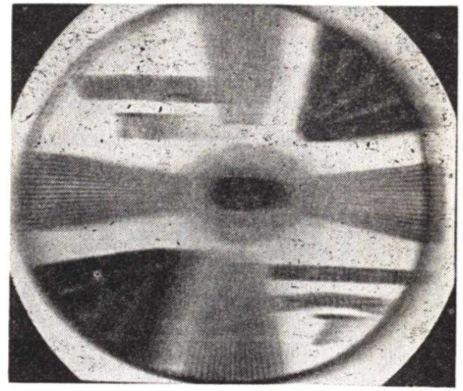

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FIG. 4. Loss of low frequencies.

The effect produced on a typical test pattern if the high-frequency response of the video i.f. or the video amplifier is reduced for any reason is shown in Fig. 3. Notice that the lines in the vertical wedges tend to blend together, and appear more smeared than do those in the horizontal wedges. Such a loss of high-frequency response may be caused by a drift in the alignment or by defects in the video section, such as shorted peaking coils or an increase in the load resistance.

Low-Frequency Loss. On the other hand, if the difficulty is caused by a loss of low frequencies (which will be accompanied by a phase shift if the trouble is in the video amplifier), the horizontal wedges will appear grayer than do the vertical wedges, and the letters in the test pattern will be followed by smears at their right. Fig. 4 shows one example of loss of low frequencies. Study these first four figures carefully, comparing them point by point, to see just how each of these defects is made apparent by a test pattern.

There are many possible causes of a loss of low video frequencies. Such a loss may occur because of an open coupling condenser or an open by-pass condenser in a low-frequency compensating filter. It can also be caused by a misalignment of the video i.f. stages that brings the video i.f. carrier too far down on the skirt of the response curve. If such drifting occurs, the low-frequency response may be decreased so much that the set will lose vertical sync as well as exhibit a smeared picture. Incidentally, the synchronization may also be affected if the trouble is in the video amplifier, and the sync take-off is beyond the point where the trouble exists.

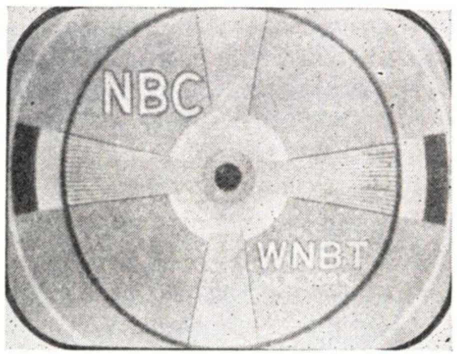
Thus, if you find it difficult to maintain vertical sync in a set that has a smeared picture, you can be reasonably sure that the smearing is caused by a loss of low-frequency response rather than by poor focusing, or by a loss of high-frequency response.

Remember that it is possible for transmission difficulties to produce smeared pictures. It is always advisable to refer to a monitor set to be certain that the set that you have for repair is really to blame. Also, careful questioning of the customer may give you helpful clues to the general nature of the defect. Any difficulty that has come on quite gradually, over a long period of time, probably is caused by failing tubes or by a shift in the alignment. On the other hand, any very sudden change probably means that some part has broken down.

If you suspect that the alignment of a set is faulty, the quickest general test is to use a sweep generator and an oscilloscope to view the response curve of the video i.f. amplifier and the front end to determine whether or not alignment is needed. We shall describe alignment procedures elsewhere.

IMPROPER CONTRAST

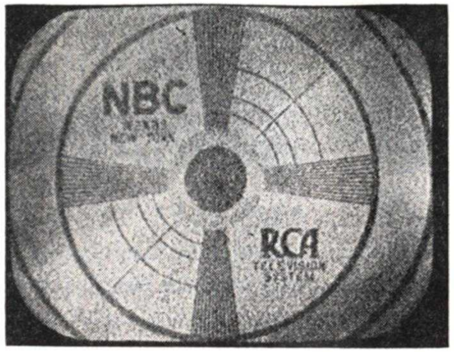
If the contrast of a picture is considerably higher or lower than normal,



Courtesy RCA
FIG. 5. Low contrast.

probably all that is wrong is that the contrast control is improperly adjusted. However, improper contrast may also be caused by a fault within the receiver.

Low Contrast. If the contrast is below normal, as shown in Fig. 5, and increasing the setting of the contrast control does not make the picture more than light gray in appearance, see if there is an excessive amount of snow or noise in the picture. A typical



Courtesy RCA
FIG. 6. Snow.

picture with snow is shown in Fig. 6. The fact that a picture lacks contrast and has considerable snow in it may indicate that the signal being picked up is weak or is not being transferred properly from the antenna to the set. On the other hand, this kind of picture may be caused by a reduction in the overall gain of the set, which may be the result of improper operating voltages or a defective tube.

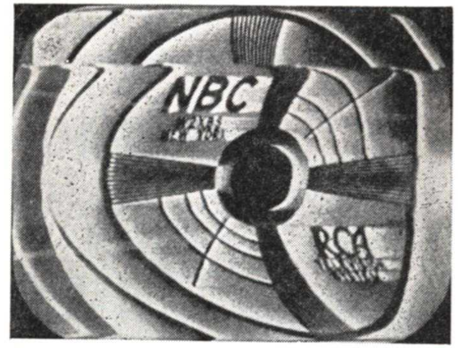
As a first step toward locating the trouble, you should find out if the contrast is low on all signals. If the contrast is low on only one station, the difficulty must be in the alignment of the front end if there is anything wrong with the set. (You must be careful about this; in some locations, the response to one or more stations may be below normal because of some local reception condition.) If the contrast is low on all stations, however, some more general defect is indicated.

If the set has been installed properly and has the proper type of antenna for reception at its location, and if normal results were once obtained, you should first check the installation for defects if you find that the contrast is low on all stations. To do so, disconnect the transmission line and connect an indoor antenna to the set instead. If reception improves, or at least gets no worse, when the indoor antenna is substituted for the outdoor one, there may be a defect in the outdoor installation. Look first for an open or a shorted transmission line, as these are the most common defects.

Incidentally, if the set has automatic gain control, you must use the signal-to-noise ratios as your basis for comparing the reception with one antenna to that with the other. Signal strength alone is not a good point of comparison, because the a.g.c. system will attempt to bring the signals to about the same levels. If the a.g.c. system is able to equalize the signal strengths, the antenna that produces less audible noise—if any gets through the f.m. system—and less snow in the picture is the one that gives the better reception.

Once you are satisfied that the antenna and transmission line are normal, carefully observe the effect produced by operating the contrast control. If the picture tends to tear up as the control is advanced, much as is shown in Fig. 7, but it remains gray and washed out, two facts are immediately obvious. One is that a normal signal is passing the point or points at which the contrast control operates, since the control is able to produce overloading of some later stage (which is the reason why the picture tears up). Since the picture remains gray, however, it must be that either this signal is not reaching the picture tube properly, or the picture tube or its supply voltages are not normal.

If you find this condition, you can localize the defect more closely by examining the set to determine what type of contrast control is used. If it is one of the kinds that vary the bias on the i.f.-r.f. stages, it is quite likely that the overloading is occurring in the



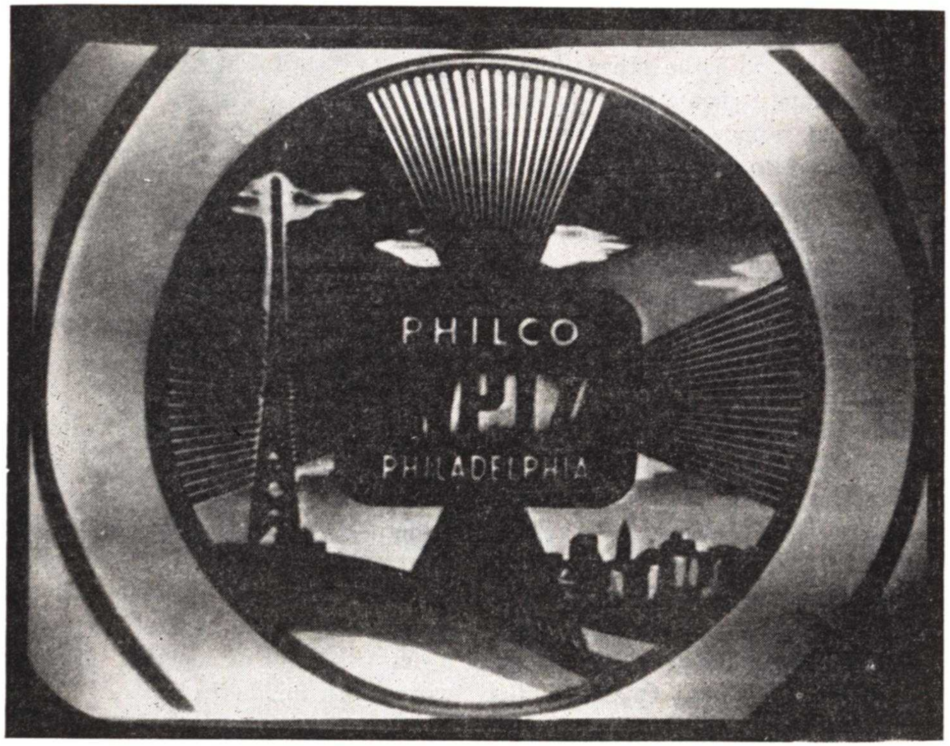
Courtesy RCA
FIG. 7. Excessive signal (may be caused by setting contrast control much too high).

last i.f. stage, and that the defect lies somewhere in the video amplifier. If the set uses a.g.c., determine whether the contrast control varies the a.g.c. voltage or is located in the video amplifier. If it is in the video amplifier, the trouble has to be near the picture tube or output video stage. On the other hand, if the control varies the a.g.c. threshold, something may be wrong with this network.

High Contrast. It is just as possible for the picture to have too much contrast as it is for it to have too little contrast. Figs. 7 and 8 show different degrees of excessive contrast. In Fig. 7, the signal is so strong that some stage has been overloaded; here a strong signal is further indicated by an excessive blackness. (Compare with the over-all grayness of a weak signal.) If this happens in an inter-carrier set, a buzzing sound may be heard, because the overloading produces cross-modulation products.

In some cases, the overloading may be so severe that the picture becomes inverted—black becomes white, and vice versa. Such an inversion does not always mean that overloading has occurred, however. This condition can be caused by improper tuning, for instance. It may also occur if you happen to interchange tubes while you are servicing a set. In some sets, it is possible to put the wrong tube in the video detector socket; the tube will still work as a detector, but its plate and cathode connections may be reversed, with the result that the picture phase will be inverted. Ordinarily, of course, such a change will cause other peculiarities in the picture at the same time, but the first characteristics you notice may be the reversed image. You should suspect that an interchange of tubes has occurred if the picture phase is inverted suddenly during servicing of the set, and nothing is apparently wrong with the contrast control.

Generally speaking, a set can be



Courtesy Philco

FIG. 8. Excessive contrast (usually caused by setting contrast control somewhat too high).

Courtesy Philco

FIG. 9. Excessive brightness.

overloaded only if it is located where the signal is very strong. Of course, this condition would have existed since the set was placed in operation in that location, in which case it may have been corrected before by an attenuating pad in the transmission line. If this pad becomes defective, the set will be overloaded. If the pad is not defective, or if none was needed previously, and the station has not increased its power, the fact that a set overloads means that the contrast control has lost its ability to cut down the signal sufficiently. This may be the result of an open bleeder network that makes it impossible for the control to apply sufficient bias.

IMPROPER BRIGHTNESS

The brightness control is almost the opposite of the contrast control in its effect on the picture. If the brightness control is set too low, the picture appears quite dark and has a very compressed range of shades of gray from light to black. In fact, the picture appears almost over-contrasty. On the other hand, if the control is set too high, the picture becomes washed out and resembles an under-contrasty picture. The vertical retrace lines become visible, as shown in Fig. 9, if the brightness control is set slightly too high.

There are several defects within a receiver that may affect the brightness. Whenever you find difficulty in setting the brightness to the proper level, you should first determine what kind of video amplifier the set has. If a d.c.-coupled amplifier is used, any abnormality in the operating voltages on any of the stages in the video amplifier may make it impossible to set the brightness control properly. If the amplifier is a.c. coupled, on the other hand, the only defect in the amplifier that can produce this effect is leakage in the coupling condenser between the picture tube and the output video stage. If this condenser is not leaky, the only other possibilities are improper operating voltages on the picture tube, a defect in the brightness control itself or in its supply, or a defective picture tube.

If you find that rotating the brightness control of an a.c.-coupled set seems to have no effect on the brightness, most likely the control is defective, although it is possible that cathode-to-heater leakage in the picture tube may be the source of trouble. If the control is part of a voltage-dividing arrangement in the power supply, don't overlook the fact that an open in the voltage-dividing circuit could cause the loss of control action.

PICTURE DISCOLORATION

The black-and-white image produced on a direct-view tube is achieved by depositing a mixture of several different phosphors on the tube face. By themselves, some of these phosphors would produce a blue image, others would produce a yellow image. The proper combination of the two phosphors gives an acceptable white. If something goes wrong during the manufacture of a tube so that one or the other of the phosphors predominates, however, the picture on that particular tube may appear to have a blue-white, a yellow, or a brown tint. In a good tube, any tint should be barely noticeable, and it should not change appreciably during the useful life of the tube.

If a customer complains that the picture on his set has *turned* yellow or brown, you will usually find that this is the result of a decrease in the output of the high-voltage supply. Such a decrease causes the electrons in the cathode beam to strike the phosphor with less energy than is normal, with the result that the phosphor is not excited sufficiently to glow white. If this occurs, the picture will also become somewhat enlarged, because a reduction in the high voltage decreases the stiffness of the beam so that the deflection system can over-sweep it. The image may also appear somewhat fuzzy and out of focus around the edges of the picture.

Since all these indications point to some defect in the high-voltage supply, a check of the high voltage and a check of the components should bring you to the trouble. If the set uses an r.f. high-voltage supply, the decreased output may have been caused by a frequency drift. If the set uses a fly-back supply, a reduced output from the horizontal sweep output tube may be the cause. The latter condition can be caused by a weak tube, by lower-than-normal operating voltages, or by a reduced amount of drive from the horizontal sweep shaper

circuits. A check of the tube, its voltages, and the drive will show whether or not any of these is at fault.

About the only other condition that may affect the ability of the face of the tube to reproduce a picture properly is that a black or brownish spot may develop in the center of the tube face. Very little or no picture will be visible in the affected area. This spot is the result of ionic bombardment of the center of the tube face. This condition is likely only on those few large tubes that have no ion traps. On these tubes, ion traps were omitted because it was assumed that the ions would spread out so that this burning of the screen would not occur; this doesn't always happen.

When an ion spot develops, the tube must be replaced. If the tube has lasted a reasonable length of time, the fact that it has developed a spot should not be considered surprising. If the spot occurs within a short period of time after the tube has been put into use, however, it would be well to consult the set or tube manufacturer to learn whether or not the particular set or tube requires special treatment to prevent the development of a spot.

While we are discussing picture tube troubles, let us mention that you may find that the picture tends to "bloom" or grow larger as the set warms up. If the blooming is excessive, you will usually find that it is caused by a shift in the operating potentials applied to the picture tube. A gradually developing cathode-to-heater leakage, or changes in the low-voltage or high-voltage supplies may change the operating characteristics. Incidentally, it is normal for the picture to bloom somewhat if you increase the brightness by turning up the brightness control.

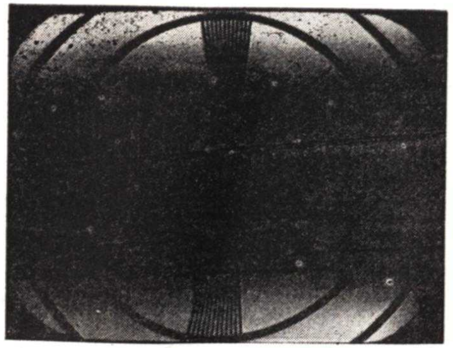
Interference Overlays

So far, we have covered cases involving a dead set, troubles with the sweep circuits, and difficulties that cause smearing and other aberrations in the picture. We shall now discuss cases in which the picture is normal except that it is overlaid by some interference pattern. If hum or sound bars appear in the picture, for example, their characteristic interference patterns will be seen as an overlay on the picture. Various other forms of interference, such as those produced by diathermy and ignition noises, and by beats between r.f. signals and ghosts, may also be seen.

HUM

The normal sources of hum or ripple in a TV set are the same as in a radio receiver: cathode-to-heater leakage in a tube, or defective filter condensers in the power supply. Cathode-to-heater leakage is the most common source, because TV receivers have such high-capacity, multiple-section filters that defective filtering is rather rare.

If the trouble arises in the power supply, the hum signal is likely to get into a number of sections of the receiver at the same time, and may therefore cause rather complex effects.



Courtesy RCA

FIG. 10. 60-cycle hum.

Naturally, if an audio stage is involved, you will be able to hear hum from the loudspeaker.

The exact nature of the hum pattern produced on a picture depends on just where the hum is getting in, and on its source. If the hum is primarily in the video amplifier section and arises from cathode-to-heater leakage or from a filter defect in a set using half-wave rectification, half of the picture will be blanked once each frame in synchronism with the 60-cycle hum. Therefore, approximately half the picture will disappear behind a broad black bar. It is rather rare to find that the bar covers exactly the top or the bottom half of the picture; instead, you are much more likely to find that the bar blanks the middle of the picture as shown in Fig. 10, or that it blanks the top and the bottom as shown in Fig. 11. The exact position of the bar depends on the relative phasing of your 60-cycle power supply and that of the transmitter. If there is any drift in the frequency of either of these power supplies, this bar may move gradually up or down the picture.

Of course, if the hum is caused by

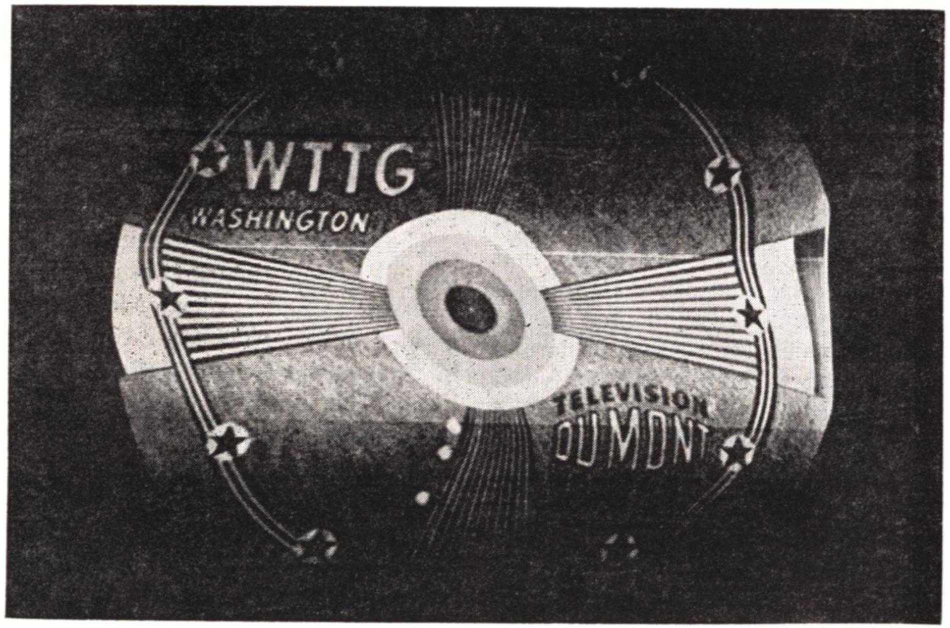


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FIG. 11. Another effect caused by 60-cycle hum.

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FIG. 12. Hum in horizontal deflection circuit.

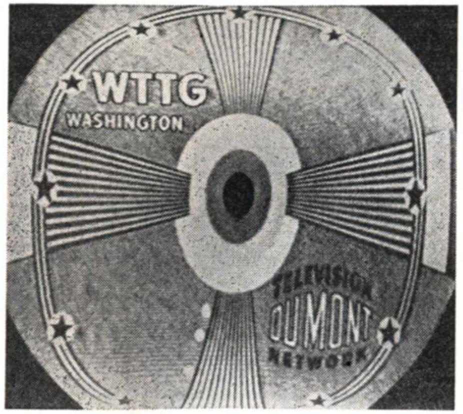
poor filters in a set that uses full-wave rectification, the ripple frequency will be 120 cycles, so there will be two bars across the picture. This clue points at once to a filter defect. A 60-cycle pattern in a set that uses full-wave rectification normally indicates cathode-to-heater leakage, but in a set that uses half-wave rectification, you must check to find the source of the 60-cycle hum.

If very much hum gets into the deflection circuits, the picture will exhibit an unusual form of distortion. Fig. 12 shows hum ripple in the horizontal deflection circuit. Notice that there is apparently a ripple from the top to the bottom of the picture along each edge. When this ripple is extreme, the distortion somewhat resembles the overloading that is seen when the contrast control is set too high.

If the ripple gets into the vertical deflection system, the picture will have a wave in it that will resemble poor vertical linearity; however, you can distinguish between the two by the fact that this wave is likely to move slowly as the phase difference between

Courtesy RCA

One momentary effect produced by hum in the horizontal sweep.



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Hum in the vertical sweep will produce a ripple that moves vertically through the picture. Here you see the effect produced for an instant by such a ripple.

the local and the station power supplies shifts.

Obviously, the ripple must be rather high in amplitude to cause so much difficulty in the deflection circuits, where the voltages are ordinarily fairly high. If hum of such an amplitude is developed in the power supply, it will usually get into the video amplifiers as well as the deflection circuits and will produce hum bars in the picture in addition to a ripple. If only a ripple is produced, therefore, the source is almost sure to be cathode-to-heater leakage in a tube in the offending deflection circuit rather than an ineffective power-supply filter.

SOUND BARS AND R.F. BEATS

If a sound signal gets into the picture circuits, the effect it produces on the picture is similar to that produced by hum. As Fig. 13 shows, a tone signal in the picture circuits produces several bars across the picture, the

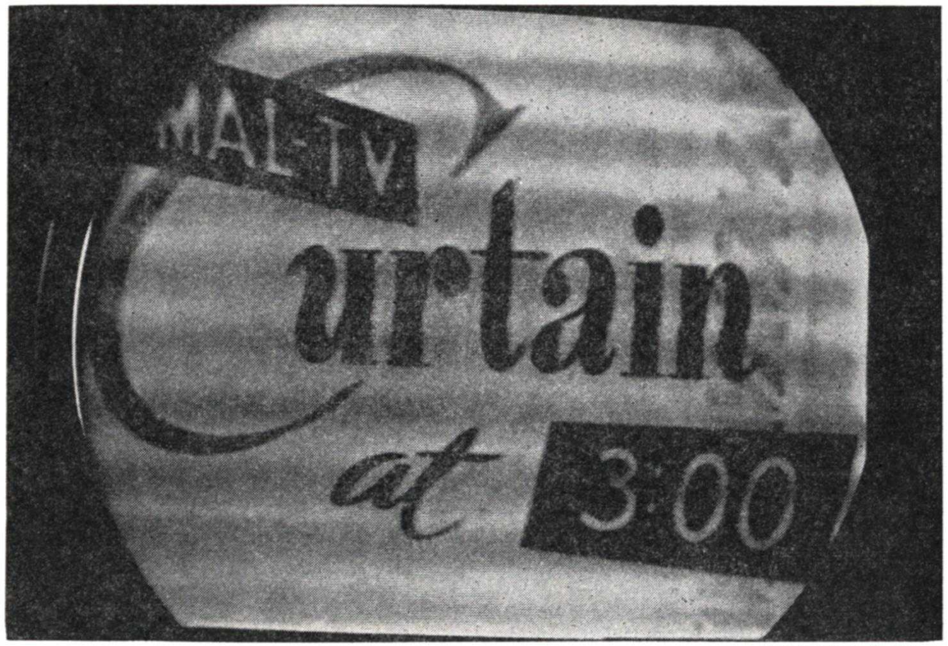

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FIG. 13. Sound bars.

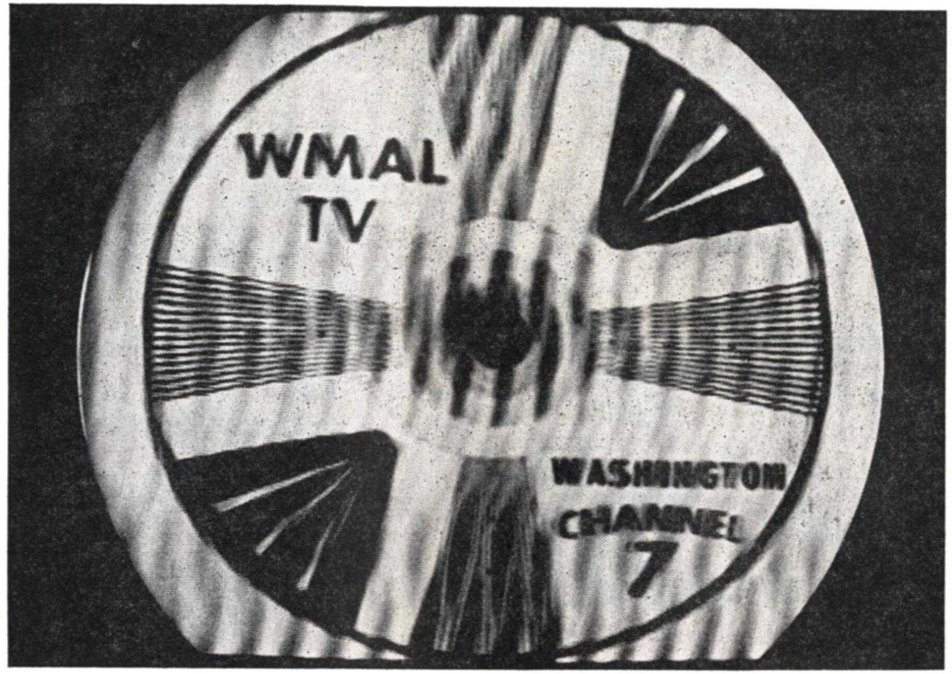

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FIG. 14. R.F. interference.

number depending on the frequency of the interference. Each alternate half-cycle of the interfering signal will produce a dark bar. Therefore, since the picture is created 60 times a second, the number of bars will be equal to the number of cycles per second of the interfering signal divided by 60. (Or, the interfering frequency is 60 times the number of bars.) If the interfering frequency is an exact multiple of 60 cycles, the pattern will stand still; if not, the pattern will appear to run up or down the picture, as long as the frequency is less than the line-scanning frequency of 15,750 cycles.

In the example shown in Fig. 13, the interference may represent the tone modulation that is transmitted along with the test pattern. The presence of 9 bars shows the frequency to be about 540 cycles (60×9); at least it is between this value and 600 cycles which would be shown by 10 bars. If the tone is not exactly 540 cycles, the pattern will run up or down on the picture.

If the sound is voice or music instead of a single tone, the number of bars in the pattern will vary rapidly, but will be exactly in step with the frequencies in the sound signal.

The presence of sound bars in the picture usually indicates improper tuning or that the set has gotten somewhat out of alignment. If the sound traps in the video i.f. amplifier are out of adjustment, for example, too much of the sound signal may reach the video detector, where slope detection may produce an audio signal that will then accompany the picture signal to the output. As we said, all such alignment problems will be discussed later.

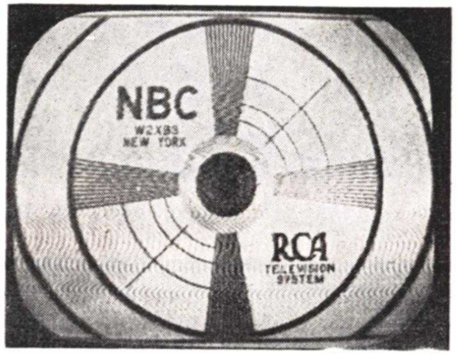
An r.f. beat between two different signals also produces a series of bars, but in most cases they are nearly vertical, as shown in Fig. 14. This comes about because the position of the bars (horizontal or vertical) depends on the frequency of the interference with respect to the horizontal or line frequency of a TV receiver. When the frequency of the interfering signal is less than 15,750 cycles, the bars are horizontal; when it exceeds the line frequency, the bars become vertical, because the interference occurs at least once every line. As you know, the number of horizontal bars is equal to the interfering frequency divided by 60; similarly, the number of vertical bars is equal to the interfering frequency divided by 15,750 (the line frequency).

The exact number of vertical bars that will be seen, therefore, depends on the frequency difference that is producing the beat note. If this difference varies (as it will, for example, if one of the beating signals is frequency modulated), the number and position of the bars will vary likewise. As you learned in an earlier Lesson, r.f. interferences may be produced by beats between signals from nearby stations, or may be the result of beats between harmonics of the local oscillator and other signals. In general, the only effective cures are re-alignment of the receiver, re-orientation of the antenna, and the installation of traps tuned to the interfering signals.

MAN-MADE INTERFERENCE

Among the most common sources of man-made interference are diathermy and ignition systems. Figs. 15 and 16 show what the patterns produced by these interferences look like.

Ordinarily, no defect within the receiver can produce these patterns, To remove diathermy interference, as you know, you may have to re-orient the antenna, shield the lead-in, install traps, and perhaps run down the source of the trouble. Re-orienting or

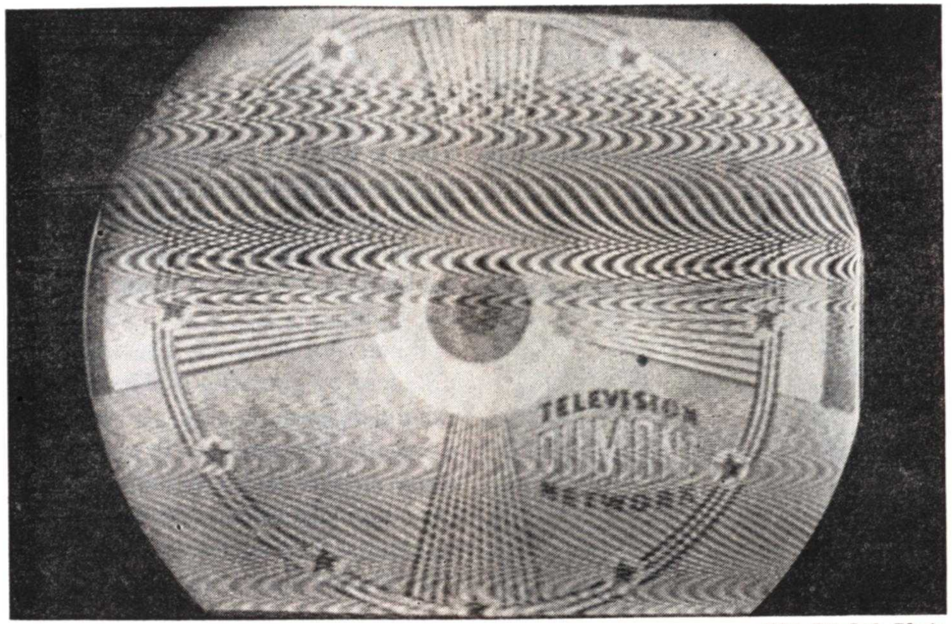


Courtesy RCA

Effect produced by weak diathermy interference.

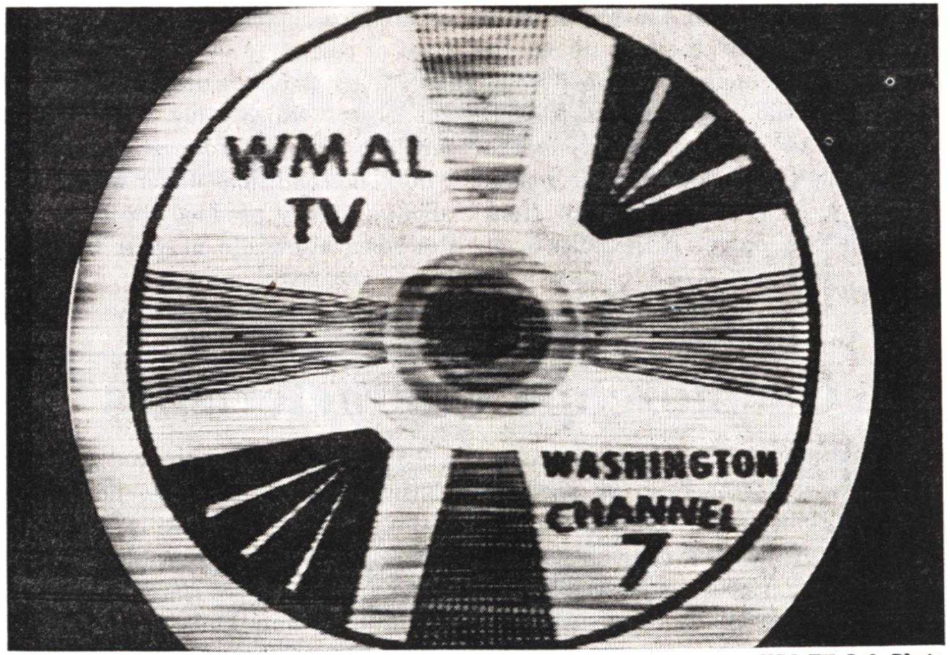
re-locating the antenna and shielding the lead-in are also the methods used to attempt to clear up interference from auto ignition systems and similar sources.

Excessive noise produced within a set may tear up the picture in somewhat the same manner that auto ignition interference does. Such noise can be caused by a poor connection or a defective tube in a video circuit. Poor contacts in the selector assembly of the input tuner are also capable of causing it. A certain amount of aud-



NRI TV Lab Photo

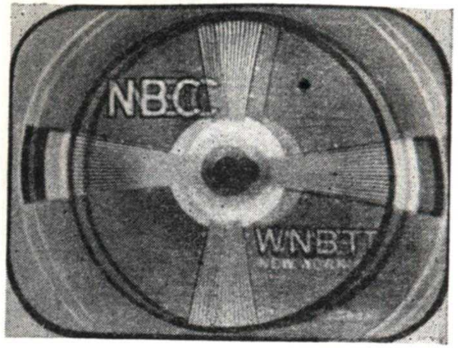
FIG. 15. Diathermy interference.



NRI TV Lab Photo

FIG. 16. Auto ignition interference.

ible noise may also be produced if this latter defect exists, but the fact that you do not hear any noise does not mean that the contacts are all right. After all, the sound channel is intended for f.m. signals, so it will tend to wipe out much of the noise.



Courtesy RCA
FIG. 17. Ghosts.

You can find out whether or not the noise is produced in the set, if it is not necessary for the picture to be present for the noise to occur, by disconnecting the antenna lead-in and observing the picture raster. If the level of the visible noise then decreases markedly, it is coming chiefly from some outside source. If the noise level does not drop much when the lead-in is disconnected, either the noise is being produced within the set or it is coming in over the power line. You can use an r.f. filter in the power line to find out if it is the source of the interference; if not, the noise is being produced in the set, and its source can be located by following an isolation procedure.

Finally, a kind of interference is produced by ghosts. Fig. 17 shows one example. Such ghosts are generally a result of reception over multiple signal paths, and the only effective cure is to re-orient the antenna, or to change its location so as to avoid the reflected signal.

Ghosts can be caused by extreme misalignment, however, and may also be produced if there is a path that will cause a regeneration of the signal with an appreciable phase delay. The latter kind of path may be the result of loss of capacity of a filter or by-pass condenser, which may then permit feedback through a power-supply circuit. The conditions under which misalignment may produce ghosts will be described elsewhere in your Course.

Oscilloscope Characteristics

As you have learned in earlier Lessons, an oscilloscope can be used in servicing sound radio receivers, but it is not one of the vital instruments for this purpose. A good oscilloscope is an absolute necessity in television servicing, however.

The signals in the various circuits of a TV set are often required to have unusual shapes that must be closely maintained if the set is to work properly. It is often possible for them to depart from these shapes in such a way that an amplitude-measuring instrument (such as a v.t.v.m.) will not indicate any change. Hence, the os-

cilloscope is particularly valuable, because it not only acts as a measuring device to show you the amount of signal, but it also lets you *see* the shape of the signal.

For this reason, an oscilloscope is much used in isolating trouble to a specific stage or circuit in TV servicing. Also, as we have said, it is an extremely useful piece of equipment for alignment.

An oscilloscope also helps you to learn what actually happens in different stages of a working TV receiver, and helps you to grasp more easily the action of the different stages, and thus obtain a more thorough understanding of the operation of the set.

TYPICAL OSCILLOSCOPE

You studied the workings of the cathode-ray oscilloscope in earlier Lessons. Let us briefly review the subject now to refresh your memory.

Fig. 18 shows a block diagram of the major sections of a service oscilloscope. The signal that you want to analyze is fed to the deflecting plates that move the beam vertically. If the voltage is large enough, switch SW_4 should be thrown to position 2 so that the signal will be applied directly to the deflecting plates. If the signal is small, on the other hand, switch SW_4 should be thrown to position 1 so that the signal will be fed through the vertical amplifier. A gain control in the vertical amplifier can be adjusted to keep the deflection within the limits of the tube face.

The signal that is applied to the vertical plates, if it is an a.c. signal, will deflect the electron beam up and down in a straight line, thus producing

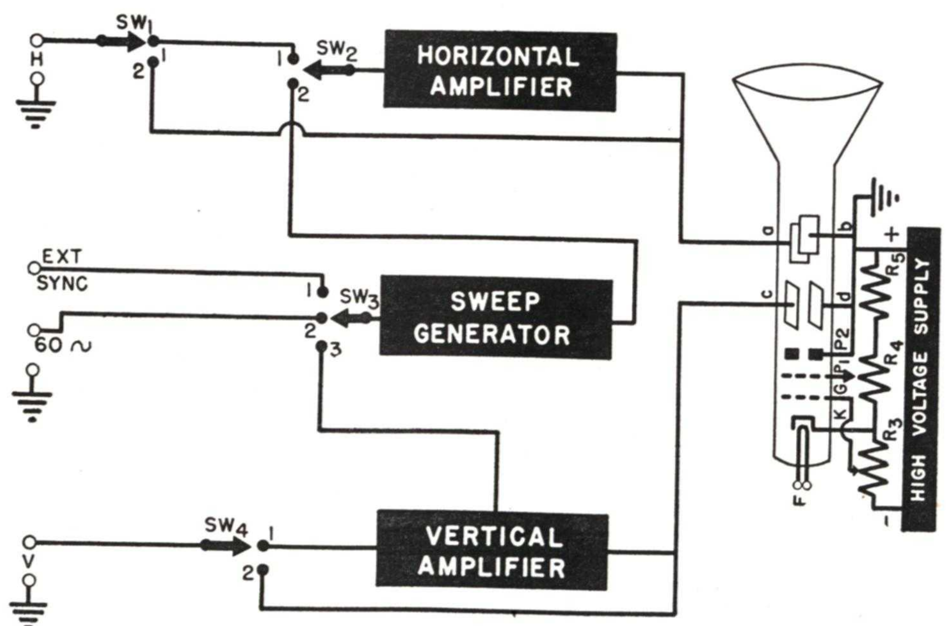


FIG. 18. Block diagram of a typical oscilloscope.

a vertical trace on the face of the tube. The height of the deflection will be proportional to the peak value of this voltage, but, of course, we cannot see its shape unless we spread out the wave trace horizontally. Therefore, we need another signal applied to the horizontal deflecting plates. This signal may come from an external source or from an internal sweep generator.

When switches SW_1 and SW_2 (Fig. 18) are in position 1, any external signal applied to the horizontal input terminals of the oscilloscope will be fed through the horizontal amplifier. If this signal is large, switch SW_1 should be thrown to position 2, in which case this external signal will be applied directly to the horizontal deflecting plates.

If the sweep generator is to be used, switch SW_2 should be thrown to position 2 so that the output of the sweep generator will be fed through the horizontal amplifier. All oscilloscopes offer three ways to provide synchronization of the sweep generator. In the one shown in Fig. 18, throwing switch SW_3 to position 1 will permit an external synchronization voltage to be fed to the sweep generator. If it is thrown to position 2, the sweep generator will be locked to a 60-cycle source, which is a very commonly used sweep rate. If it is thrown to position 3, a portion of the signal applied to the vertical amplifier will be tapped off and used to synchronize the sweep generator with the incoming signal.

In brief, this is the procedure that you should follow to operate a c.r.o. of this kind. First, turn it on and adjust the intensity and focus the controls to give a fine, bright spot. If necessary, adjust the horizontal and the vertical centering controls to center this spot in the center of the screen. Then, apply the signal to be analyzed to the vertical deflecting system, and apply either the sweep signal or an external horizontal signal to the horizontal amplifier.

If the wave shape is to be reproduced exactly, the sweep generator must produce a saw-tooth voltage that will sweep the beam from left to right at a rate that will reproduce at least one cycle of the signal to be observed. As a matter of fact, the sweep generator is most commonly synchronized to a frequency one-half, one-third, or one-quarter the frequency of the voltage being observed, because this gives more than one cycle on the face of the tube. This is desirable, because a small part of the first cycle will be blanked while the sweep generator is getting into sync with the incoming signal. By having more than one cycle, and by viewing the cycles after the first one on the screen, you can get a much more exact idea of the wave shape.

If the wave shapes are to be reproduced accurately, the sweep should have a high degree of linearity.

We mentioned applying voltages directly to the deflecting plates. Naturally, the voltage being observed has to be quite high if it is to be applied in this manner. Most oscilloscope tubes have deflection sensitivities of from 25 to 40 volts per inch per thousand volts on anode 2. Thus, if the second-anode voltage is 1000 volts, and the sensitivity is 30 volts per inch,

30 volts applied to the vertical plates will give 1 inch of deflection. However, with 2000 volts on this anode, it will take 60 volts to give an inch of deflection on this same tube. Therefore, although such an increase in the anode voltage will give a brighter trace, it will also increase the amount of voltage necessary to give a fixed amount of deflection.

For this reason, there is usually a compromise in the oscilloscope design—enough second anode voltage is used to give a reasonably bright image, but not so much that an excessive deflection voltage will be required. After all, the signals with which you are dealing are, in many cases, quite low in amplitude. As a matter of fact, you will rarely be able to apply a signal directly to the deflection plates; you will almost always use the amplifier.

Ordinary a.c.-coupled amplifiers are used in most oscilloscopes intended for service work. In a very few, however, the amplifiers are d.c. coupled. The chief advantage of the latter kind is that it can be used to measure d.c. as well as a.c. voltages, because the application of a d.c. voltage to the input terminals will cause a deflection of the spot from its center location, the amount of deflection being proportional to the voltage. Application of a d.c. voltage to an a.c.-coupled amplifier will cause a momentary deflection of the spot as the coupling condensers charge, but the spot will return to the center of the screen as soon as the charging is completed.

When an a.c. voltage is applied to either kind of oscilloscope, the spot is moved back and forth between the limits determined by the amplitude of the signal and the setting of the level control of the vertical amplifier.

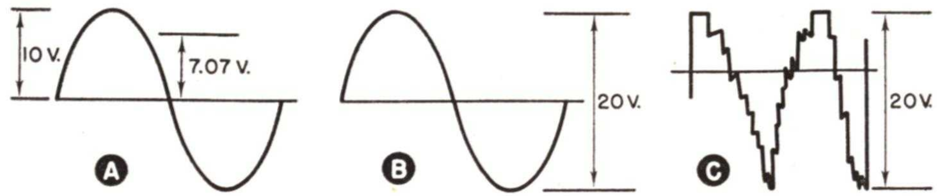


FIG. 19. Part A shows the relationship between the peak and r.m.s. values of a sine wave. Parts B and C show that the peak-to-peak amplitudes of a sine wave and a complex wave may be the same, even though the shapes of the two waves are very different.

PEAK VOLTAGES

In servicing sound receivers, in which sine-wave signals or sine-wave signals plus a few harmonics are all that we are dealing with, we rarely have to worry about peak-voltage values. We know that our meters are calibrated to read r.m.s. (or effective) values, and that the peak value for a sine wave is about 1.4 times the r.m.s. reading. Conversely, the r.m.s. value is equal to the peak value multiplied by .707. Thus, if the peak value of a signal is 10 volts, as shown in Fig. 19A, the r.m.s. value that will be indicated by a voltmeter will be slightly over 7 volts. Since the peak of a sine wave reaches the same value on either side of the reference line, as shown in

Fig. 19B, the peak-to-peak value of a sine-wave voltage (which is the sum of the two peaks) is twice either of the peaks.

In TV work, however, we are dealing with waves that are not sine waves. The wave shapes of the signals in a TV set include many combinations of square and rectangular forms, and often contain a d.c. component as well. If we try to measure the voltage of any such wave with an ordinary voltmeter or a vacuum-tube voltmeter, we shall find that our readings do not mean very much, because the relationship between the peak, r.m.s., and average values of a wave depends on the wave shape, and our instruments are calibrated for sine waves only.

We must, therefore, use some other instrument to measure the amplitudes of the signals in TV circuits. The oscilloscope is ideal for this purpose, since it can be calibrated to indicate the peak-to-peak voltage of any wave, regardless of its shape, and will let us see the wave shape at the same time. Generally speaking, peak-to-peak voltages are the only characteristics of such waves that we are interested in as far as amplitude measurements are concerned. Such factors as r.m.s., average, and single-peak amplitudes mean little when we are dealing with a wave that is not a sine wave and that may, as Fig. 19C shows, be of different peak amplitudes on the two sides of the reference line. The peak-to-peak amplitude of a complex wave, however, shows us how much signal the wave represents, regardless of its shape and of its position with respect to the zero reference line. For these reasons, service instructions dealing with circuits in which complex signals exist always give peak-to-peak values when they discuss signal-voltage amplitudes.

Calibration. If an oscilloscope is to be used as a voltage-measuring device, it must be calibrated so that we will know just what voltage is indicated by the deflection we see. Of course, the amount of deflection that is produced by any applied voltage depends on the deflection sensitivity of the oscilloscope tube. If the applied voltage is fed to the tube through the vertical amplifier, the deflection also depends on the gain of the amplifier.

To calibrate an oscilloscope so that it will measure peak-to-peak voltage, proceed as follows. First, place a transparent graph scale over the face of the oscilloscope tube as shown in

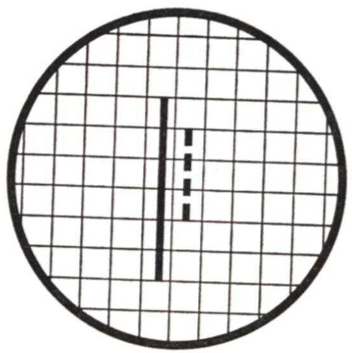


FIG. 20. Use of a grid to indicate relative amplitudes of oscilloscope deflections.

Fig. 20, if one is not already on your tube. Next, apply a sine-wave voltage having a known peak-to-peak value to the input of the vertical amplifier. Reduce the horizontal gain to zero so that only a vertical line is produced. Next, adjust the vertical gain control until as many blocks as you wish are

filled by this line. This completes the calibration process for the particular setting of the vertical gain control that you have chosen. If you now remove the known signal and apply any other signal to the vertical plates, *leaving the vertical gain control in the same position,* the amount of deflection produced will be proportional to the deflection caused by the known voltage.

For example, let us suppose that you apply a sine-wave a.c. signal of 6.3 volts r.m.s. to the vertical input as the known calibrating voltage. This signal has a peak-to-peak value of approximately 18 volts. You can find the peak-to-peak value from the r.m.s. value by multiplying the latter by 2.8 (multiply by 1.4 first to obtain the peak voltage, then by 2 to obtain the sum of the voltage of both peaks). If you adjust the vertical gain control so that the line produced by this signal includes exactly 6 blocks as illustrated by the solid line in Fig. 20, each block must then represent a deflection equal to 3 volts.

To measure an unknown voltage, all you need to do is to remove the calibrating signal and apply the signal that is to be measured to the vertical input. The deflection produced will depend on the peak-to-peak amplitude of this new signal. If a total deflection of three blocks is produced, as shown by the broken line in Fig. 20, the peak-to-peak amplitude of the new signal is 9 volts. If the deflection is 4 blocks, the peak-to-peak amplitude of the signal is 12 volts.

If the signal you are trying to measure has a much higher amplitude than your calibrating signal has, it may produce a line that goes off the screen. If so, apply the calibrating voltage again, and adjust the vertical gain control until the 18-volt signal covers only 2 or 3 blocks. Each block will now represent a higher voltage as long as the vertical gain control is at its new position, and therefore a higher unknown voltage can be measured before the deflection trace it produces goes off the screen.

Let's summarize the procedure you should follow to use an oscilloscope as a peak-to-peak voltmeter. First, measure your calibrating signal with a reliable a.c. voltmeter, then convert the r.m.s. reading that the voltmeter gives you into a peak-to-peak voltage. Next, set the gain control of the vertical amplifier of the oscilloscope to give you a convenient deflection for this voltage, and leave the control at this position when you check the unknown voltage you are measuring. If the unknown voltage is so large that it produces a deflection that goes off the screen, reduce the gain of the vertical amplifier and recalibrate the oscilloscope. If you move the gain control after a calibration before you measure the unknown voltage, your readings will be meaningless until you recalibrate.

TURNOVER

In the preceding example, we have shown how to measure a voltage to determine its peak-to-peak amplitude. Although we suggested that the horizontal amplifier be turned off so that you get a line, you can, if you wish, observe the voltage at the same time by having it deflected from left to right. Doing so will not prevent you from measuring the peak-to-peak voltage, but does make it a little more difficult.

When you are observing a signal, either to measure its amplitude or to see its shape, you may find that it is upside down compared to the picture shown in the manufacturer's test man-

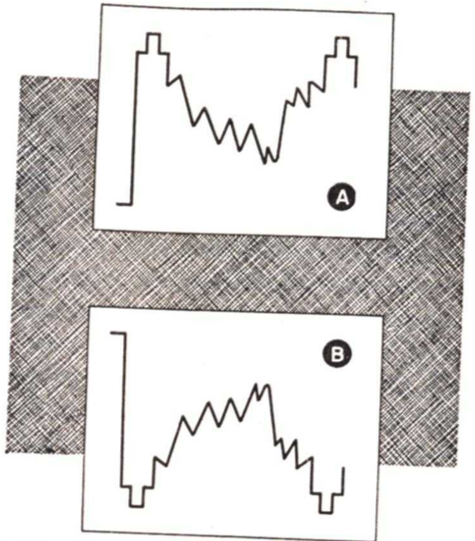


FIG. 21. Either an upright (A) or an inverted (B) trace can be used to determine the shape of a signal.

ual. This is entirely normal—whether or not it happens depends on the number of stages and the methods of coupling between stages in your oscilloscope compared to those in the oscilloscope used by the manufacturer. Thus, the manufacturer's service information may show that the signal at a certain point should look like wave A in Fig. 21, but on your oscilloscope the signal at that point may look like wave B. Since these two waves are exactly alike except that one is inverted with respect to the other, you should consider that the wave you have found is of the correct shape.

Some oscilloscopes have a phase-reversing switch that interchanges the connections between the cathode-ray tube and the vertical amplifier. If yours has such a switch, you can invert the image if it happens to be upside down. However, once you are used to it, an upside-down image is just as useful as a "normal" one is.

Of course, as you move along stage-by-stage in tracing a signal, the wave picture is naturally going to turn over every time you pass through another stage, since you invert the signal 180° in phase when you do so. In general, therefore, you should be interested only in the basic shape of the wave, and you should expect it to be upside down part of the time.

SENSITIVITY

The term "sensitivity," when it is applied to an oscilloscope, refers to the amount of signal that must be applied to the input of the vertical amplifier to produce a standard deflection. Ordinarily, this sensitivity is expressed in terms of volts-per-inch (or volts-per-centimeter), just as the deflection sensitivity of a c.r. tube is. The fact that an oscilloscope has a maximum sensitivity rating of 1 volt-per-inch, for example, means that a 1-inch deflection will be produced on the face of the oscilloscope when a 1-volt signal is applied to the input of the vertical amplifier with the latter adjusted to give maximum gain.

An oscilloscope that is to be used for TV service work must be fairly sensitive, because it must operate from rather low voltage levels in certain cases. For example, if you are signal-tracing through the sync chain, you are going to find some voltages that have very low peak-to-peak values. Also, in aligning a TV set, you will sometimes find it necessary to measure a signal after it has been fed through only one stage, the gain of which may be quite small.

In rating the vertical amplifiers of oscilloscopes, manufacturers use either an *r.m.s.* volts-per-inch, or a *peak-to-peak* volts-per-inch rating. You will have to be careful to notice which rating is used when you are comparing the characteristics of two oscilloscopes. For example, if one instrument is rated at .5 volt r.m.s. per inch, and another at 1.4 volts peak-to-peak per inch, the sensitivities of the two are the same. (Multiply the r.m.s. value by 2.8 to get the peak-to-peak, or divide the peak-to-peak value by 2.8 to get the r.m.s.)

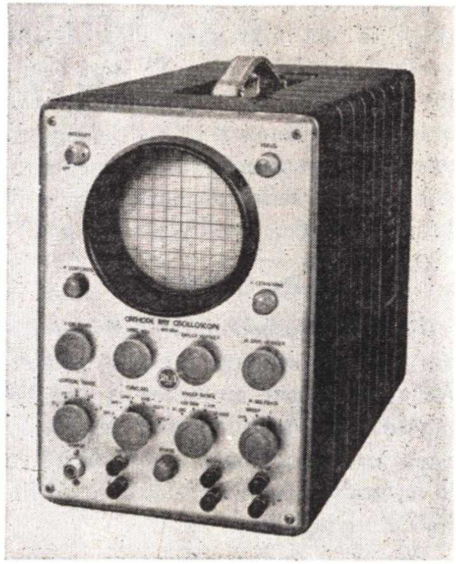
When the rating is in volts per centimeter, multiply the rating by 2.54 to find the volts per inch.

A rating of .2 volt peak-to-peak per inch is considered very good; this corresponds to about .07 volt r.m.s. per inch and to about .079 volt peak-to-peak per centimeter. Any rating smaller than these shows even more sensitivity (that is, a rating of .1 volt peak-to-peak per inch is better than one of .2). An oscilloscope having a sensitivity rating of .6 volt peak-to-peak per inch or better will be satisfactory for TV servicing use.

FREQUENCY RESPONSE

Most ordinary service oscilloscopes can be used in aligning TV sets as long as they have a good response to frequencies in the neighborhood of 60 cycles. A good high-frequency response is not needed for alignment. In fact, as you will learn in another Lesson, it is desirable to have the oscilloscope response cut off at a fairly low frequency (50 to 100 kc.) if it is to be used as an output indicator during the alignment of a set.

On the other hand, if you are going to use your oscilloscope to trace signals that may contain components ranging up to 4 megacycles in frequency, and particularly if you are going to use it for square-wave testing



Courtesy RCA

A typical oscilloscope that can be used in TV servicing.

of a TV receiver, it must have a very good high-frequency response. For square-wave testing, the response should extend to a frequency at least 10 and preferably 20 times as great as the highest-frequency square-wave test signal that will be used. For signal tracing, it is desirable to have the frequency response extend practically as high as the highest frequency that may be expected in the signal that is being traced. Therefore, oscilloscopes intended for TV work quite generally have responses extending to one or two megacycles and even more. Of course, getting the necessary gain over so wide a frequency band calls for the use of TV circuit techniques in the vertical amplifier (which is quite similar, as a matter of fact, to the usual video amplifier). The same techniques must also be used to get the good low-frequency response needed for alignment.

For these reasons, the gain-per-stage is not extremely high in the vertical amplifier of a TV test oscilloscope. Further, you will find that the older oscilloscopes that were designed primarily for sound radio servicing do not have the sensitivity and frequency response needed for TV servicing.

GAIN CONTROL

In an oscilloscope intended for ordinary radio servicing, the gain control for the vertical amplifier is usually placed right at the input terminals. Such an arrangement is not desirable in an instrument that is to be used for TV servicing, however.

When the gain control is connected directly across the input terminals, there is a fairly high capacity between the terminals. When the oscilloscope is connected to the circuits that are being tested, this shunting capacity may reduce the frequency responses of the circuits and thus affect the shapes of the waves that you are trying to see.

One way out of this difficulty is to connect the oscilloscope input terminals directly to the grid of the first tube in the vertical amplifier, and then to put the gain control between the first and the second amplifier stages. This arrangement reduces the input capacity but also makes it possible for a strong signal to overload the first tube in the vertical amplifier.

There are several methods of reducing the danger of overloading. In one design, a cathode-follower circuit is used for this purpose: the load for the first tube in the vertical amplifier is placed in the cathode circuit, and the resulting degeneration makes it possible for the grid to handle a fairly high input signal. Another arrangement makes use of an input voltage divider having very low capacity that can be switched in when necessary to reduce the strength of the input signal to some fraction of its original value—usually to one-tenth. Thus, when the divider is switched in, only one-tenth the signal is applied to the grid of the first tube.

In summary, we can say that you are not likely to overload the oscilloscope if the gain control is across the input terminals, but the input capacity may affect the circuits that are being tested. If the gain control is between the stages, on the other hand, the input capacity will be too low to cause trouble, but you will have to be careful to limit the input signal so that it cannot overload the first tube. Read the manufacturer's instructions accompanying the oscilloscope you buy to learn what is said on this subject.

Incidentally, it is possible to overload an oscilloscope if you run the gain control so high that the trace sweeps beyond the face of the tube.

You should try to keep the deflections in both the vertical and the horizontal directions well within the edge of the face. Because of this, an oscilloscope using a c.r. tube smaller than 3 inches in diameter is not practical, and those with 5-inch or 7-inch tubes are better because they permit you to use images of reasonable size without fear of causing excessive distortion because of overloading.

To sum up these requirements, an oscilloscope that is to be used in television servicing must have: high gain; good low-frequency response (down to 60 cycles or better); good high-frequency response (up to 1 megacycle or more if the oscilloscope is to be used for square-wave testing or for signal tracing); and, finally, a low input capacity so that it will not affect the circuits that are being checked.

Using an Oscilloscope in TV Servicing

As we have said, an oscilloscope can be used in TV service work to examine the wave shape and to measure the peak-to-peak values of the signal voltages in various stages. It is also useful when you are aligning a TV set.

In addition, the oscilloscope can be used to check the frequency of any signals seen. This is possible because the frequencies of the sweep generator of the oscilloscope are either marked on the sweep control, or can readily be determined by a calibration process. When the sweep generator frequency exactly matches the frequency of the incoming signal, you will see one cycle of the wave being analyzed. By referring to the calibration of the sweep generator when only one cycle is visible, therefore, you can determine the frequency of the incoming signal. If you see two cycles of the incoming signal, the sweep generator is operating at half the frequency of the signal, and so on. In each case, the frequency of the incoming signal is equal to the sweep generator frequency multiplied by the number of cycles visible. If the calibration of the sweep generator is not exact, you can determine the unknown frequency by comparison with known frequencies. The method of doing so has been described elsewhere in your Course.

Signal Tracing. The oscilloscope is directly usable for signal tracing in the audio, video, sync, and sweep sections. By this statement, we mean that it can be used throughout the audio amplifier just as a signal tracer would be used in a sound receiver. It can also be used to trace the video signal from the video detector through the video amplifier to the grid of the picture tube if the oscilloscope has a sufficiently wide frequency response. Finally, it can be used to follow the synchronizing signal through the sync chain and the sweep signals through the vertical and horizontal sweep chains. In each of these uses, no special equipment that is not already incorporated in the instrument is required.

Let us remind you, however, that the sweep voltages reach very high values, so it is quite easy to overload the in-

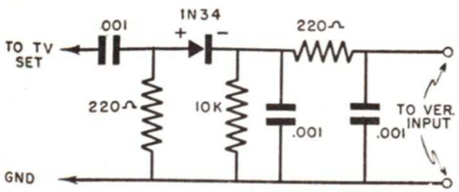


FIG. 22. Schematic diagram of a crystal detector probe.

put of the oscilloscope when you are using it to examine the shapes of sweep signals. Also, you will have to be careful about d.c. voltage levels. There may be blocking condensers in your oscilloscope that cannot withstand some of the high voltages that are found in many sweep circuits. For these reasons, you will have to measure the sweep signals with caution. In particular, unless you use a voltage divider of a kind to be described later to protect your oscilloscope, do not attempt to use it to make a direct measurement of the sweep output voltage in a set using electrostatic deflection, of the voltage at the plate of the horizontal sweep output amplifier in a set using electromagnetic deflection, or of the a.c. voltage across the horizontal deflection yoke.

The oscilloscope cannot give a useful indication of a signal too high in frequency to pass through its vertical amplifier, so it cannot be used directly in the i.f. stages. However, by rectifying the incoming signal so that the modulation is available for the oscilloscope, you can use it to trace through the video i.f. and the sound i.f. amplifiers. For this purpose, you must buy or build a special detector probe that has an extremely low input capacity. (This probe must have a low capacity so that it will not upset the resonant circuits of the i.f. amplifiers.) A diagram of a typical probe of this kind is shown in Fig. 22. The 1N34 crystal detector rectifies the i.f. signal so that the oscilloscope can follow the modulation on the signal. This probe may also be used in alignment, as we shall show elsewhere.

EFFECTS OF WAVE SHAPE

You can learn a great deal about the operation of various sections in a TV receiver by examining the wave shapes that are found in each section. You are already familiar with the fact that the particular sweep-voltage shapes desired are obtained by carefully shaping the output of an oscillator. As another Lesson pointed out, any change in the characteristics of the wave-shaping network will affect the shape of the sweep voltage, and will therefore produce non-linearity in the sweep. In turn, this will cause the picture to be non-linear in one form or another.

Your earlier Lesson on the sweep circuits showed you what the ideal wave shapes are. In a practical set, it is possible for the sweeps to depart *somewhat* from these ideal shapes without producing too much distortion. When you are examining the sweep shapes in an actual set, therefore, you should find out what the service man-

ual on that set has to say about them. The tracings in such manuals are those that are obtained from a set in good working order, and indicate just how much variation from the theoretically perfect shape you can expect to find.

As an example of what you can learn from a careful examination of wave shapes, let's suppose that we have an oscilloscope that is connected in the video amplifier, and that we have it adjusted so that we can see the horizontal line pulses and their blanking pedestals.

If the pulse and the blanking pedestal are normal, as shown in Fig. 23A, the over-all frequency response of the receiver is about what it should be, and the picture should also be normal unless some defect exists beyond the point at which the oscilloscope is connected.

On the other hand, let's suppose that the wave is distorted as shown in Fig. 23B. Such a distortion is caused by a poor high-frequency response. Compare this carefully with the correct wave shown in part A of this figure. Notice that the pedestal of the latter has a front and back porch, and that the sync pulse is properly placed on the pedestal. When the high frequencies are lost, it is impossible for the circuit to follow the sharp frequency changes that are needed to produce the porches, and the slope or rise of this nearly square pulse is rounded off. When this condition occurs, the loss of high frequencies may result in a loss of picture detail. This condition may correspond to a misalignment of the sort shown by the alignment curve in Fig. 23B.

On the other hand, if the high frequency response of a receiver is excessive, there will be an over-shoot on each vertical rise (Fig. 23C). When this occurs, the oscilloscope tracing will indicate that the voltage goes beyond the correct point, and must then fall back to the right level. Such a condition will produce a form of reversed ghost effect, because any sudden change in shading in the picture will become even more abrupt than it should be. If the picture is supposed to change from black to light gray, for example, it may, instead, change from black to white, then to gray. Conversely, if it is supposed to change from white to dark gray, it may change from white to black before it becomes gray. As a result, each sharp change in shade in a picture will be

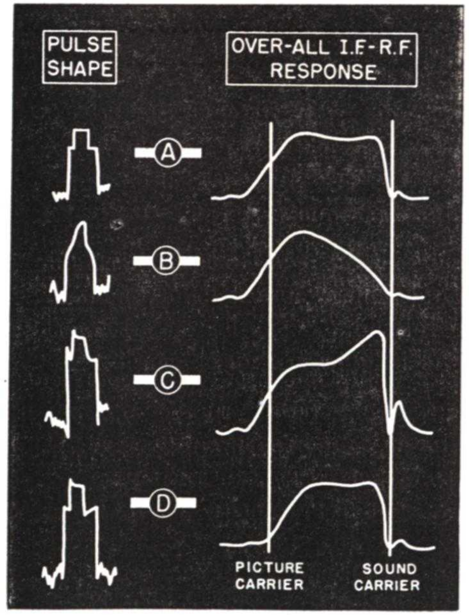


FIG. 23. Various possible shapes of the horizontal sync pulse and the over-all frequency responses that produce them.

followed by a line that is lighter or darker than it should be. If there is much "bounce" or oscillation before the voltage settles down to the required value, there may be a series of black and white lines or striations following sharp changes in the picture shading.

Finally, as shown in Fig. 23D, the set may be deficient in its low-frequency response. This deficiency is indicated by the fact that the portions of the pulses that should be horizontal or level tend to slope off instead. This condition can be caused by a misalignment that has shifted the video i.f.-response curve in such a way that the picture carrier is way below the 50% response point. Such a misalignment is shown by the response curve in Fig. 23D. (Of course, this loss of low frequencies can also be due to a defect in the video amplifier.) If the low-frequency response of a set is below normal, large picture areas that should be all of one shade will, instead, gradually trail off into a gray. Also, if the very low frequencies are lost, there will be a smeared picture, and perhaps a loss of vertical synchronization.

Frequency Response Check. If the pulse that we are viewing is the horizontal pulse, it will not indicate a loss of low frequencies under 15 to 20 kilocycles. Therefore, we will not be able to determine if there is any loss in the very low frequencies by examining the horizontal pulse.

There are, however, several other ways in which we can use an oscilloscope to check the low- and high-frequency response of a set. If you suspect that the set is misaligned, you can find out if your suspicions are correct by using a sweep signal generator and an oscilloscope to see exactly what the response of the front end and the i.f. stages is like. The method of using these instruments for this purpose will be covered when we study alignment.

If you believe that the loss is occurring in the video amplifier, you can feed signals at the frequencies you suspect through the amplifier, and determine its gain at each frequency by direct measurement. Alternatively, if a square-wave signal generator is available, you can feed a square-wave signal of about 60 cycles through the video amplifier and examine the response. If the trace produced on the oscilloscope is square, the low-frequency response of the video amplifier is normal. However, if it slopes off as does the top of the sync pulse in Fig. 23D, the low-frequency response of the amplifier is falling off, and there is a low-frequency phase shift.

SIGNAL TRACING

Most servicemen depend on a TV station for a signal source when they use an oscilloscope as a signal tracer, primarily because test equipment that is capable of simulating a TV signal is rather costly. However, the demand for such equipment is causing less expensive models to be put on the market, and eventually, the average serviceman may have a TV signal generator of his own. In such a case, the signal seen on the oscilloscope will depend on what the output signal of his equipment is.

If you do not have such a generator, but instead trace a broadcast TV signal, there are certain basic kinds of signals that you will find in each section of every TV set. The exact forms of these signals do depend, however, upon just what is coming in and upon the design of the set. Therefore, you must consult the manufacturer's service information to find out exactly what you should see when you trace through his sets.

When you examine a signal with an oscilloscope, as you learned earlier, it is desirable to have at least two cycles visible on the screen, since you can then get a better idea of the actual wave shape than you could by examining just one. The composite signal passing through the video amplifier contains not only the video signal itself, but also the line and frame-blanking pedestals on which are the line and frame sync signals—in fact, the entire modulation transmitted in the composite signal. The video signal itself is, of course, constantly changing, and it would be impossible to synchronize this to any satisfactory degree. However, the horizontal or line-blanking pulse that occurs at the end of each line, and the vertical or field-blanking pulse that occurs at the end of each field are fixed and regular in frequency; the line frequency being 15,750 cycles, and the field frequency, 60 cycles. The oscilloscope can be synchronized with either of these pulses. Since we want two complete cycles, we must set the oscilloscope sweep to half the frequency of the blanking pulse that we want to sync with. Thus, a 30-cycle sweep rate will cause a trace of the voltages that occur in two complete cycles of the vertical sweep to be produced, whereas a rate of 7875 cycles will cause a similar trace of the voltages in two complete horizontal sweeps.

Video Amplifier Tracing. The signals shown in Fig. 24 are typical of those that you might see in the video amplifier. The trace in part A of this figure shows what you will see if the oscilloscope sweep rate is 30 cycles; therefore, the two major traces seen in this figure represent two fields, and the empty area between them represents the blanking that occurs between fields. All of the lines in each field are mixed up in this kind of trace, so it gives you little information about the true nature of the video signal itself. It does give you a general idea of the appearance of the signal, however, and records the vertical blanking period with reasonable faithfulness. Also, you can use such a trace to measure the peak-to-peak value of the signal. It is

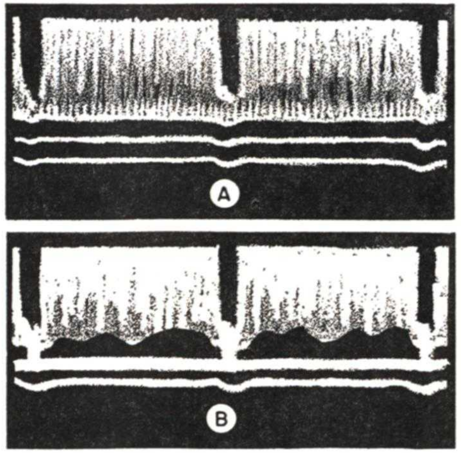


FIG. 24. Traces representing two fields (A) and two lines (B), taken from the video amplifier.

useful for you to know what this value is, because the service manual for the set will usually tell you what it should be at various points in the video amplifier. If you do not find the right value (which may be as low as 1 or 2 volts at the output of the video detector, or as much as 60 volts at the grid of the picture tube), you will know, of course, that some defect exists.

The trace shown in Fig. 24B is what you will see if the oscilloscope sweep is adjusted to be half the horizontal sweep rate of the signal. This represents two lines and the blanking space between them. Actually, of course, the trace is produced by all the lines that occur during the time that the oscilloscope is connected to this point in the amplifier, each pair of lines being superimposed on the pair that occurred before it. Since each line usually differs somewhat from all the others, the trace is not a clear representation of a pair of lines, but rather a mixture of the traces produced by a great many lines.

The peak-to-peak voltage in this case is essentially the same as that represented by the trace shown in Fig. 24A, since the peak-to-peak signal depends primarily on the height of the sync pulses above the zero level, a factor that will remain relatively constant even though the signal content itself does change.

As you move along through the video amplifier, this trace will be inverted as you pass each stage, but its appearance should remain relatively the same except that it will be amplified. Of course, if the signal itself changes during the time it takes you to move the oscilloscope probes, the part of the trace that represents the video portion of the signal—the "smear" between the blanking intervals—will tend to change in characteristics somewhat.

The peak-to-peak value of the signal you find at any point should correspond to the value given by the manufacturer, if the local signal strength is normal. Regardless of this strength, you can determine the gain of any stage by dividing the peak-to-peak voltage at the output of the stage by its peak-to-peak input voltage.

Sync Chain Tracing. The signals seen in the sync chain vary a great deal in their characteristics. If there is an input sync amplifier, it is quite likely to handle the entire signal, including the video portions. However, there may be some leveling or clipping in this stage to restrict amplitude changes caused by noise, so the signal may look somewhat different from that found in the video stages.

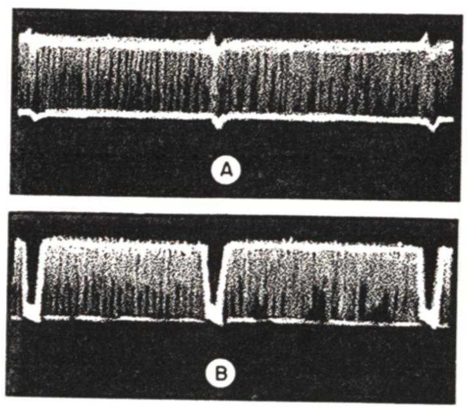


FIG. 25. Traces representing two vertical (A) and two horizontal (B) pulses, taken from the output of the clipper.

At the output of the clipper, the video signal should be almost entirely removed, and you should get a series of pulses that consist mostly of the sync pulses. Once again you can get your oscilloscope to sync with either the vertical or the horizontal pulses,

FIG. 26. Trace representing the output of the vertical integrating network.

and can therefore view them individually. A typical example is shown in Figs. 25A and 25B, the former showing two vertical and the latter two horizontal pulses.

Any sync amplifier following the clipper will increase the amplitude of these signals if it is arranged as a straight amplifier. However, a second sync amplifier is often actually a second clipper, arranged to square off the pulses, and get rid of any stray noise and any vestiges of the video signal. In such a case, the output may be below that of the first clipper, but the pulses should be more nearly square in their shapes. The voltages at the output of the clipper are usually somewhere around 50 to 75 volts, since a fairly strong signal is needed for the integrating and differentiating networks.

The output of the vertical integrating network consists of a series of pulses representing the vertical sync signal. As you will recall, this pulse is relatively broad in comparison to a line pulse (in fact, its duration is equivalent to that of three or more complete lines), but it looks rather narrow on an oscilloscope when compared to the over-all sweep time of the complete field, as shown in Fig. 26.

The pulse found in the output of the integrating network may be anywhere from 10 to perhaps 40 volts in peak-to-peak amplitude, depending on the set design. As you will recall, this pulse is used in most receivers either to unblock a blocking oscillator or to drive a multivibrator.

The wave form to be seen in and around this oscillator depends upon the characteristics of the circuit. A typical example of the wave shape at the grid of a vertical blocking oscillator is shown in Fig. 27. Here, the peak-to-peak voltage may be rather high—as much as 300 volts or more in some sets, depending on the inductive kickback of the blocking oscillator transformer. The peak-to-peak voltage at the input of a multivibrator will be considerably less.

The vertical sync signal will look

FIG. 27. Trace representing the wave shape at the grid of a vertical blocking oscillator.

somewhat like the trace shown in Fig. 28 when it is applied to the input of the vertical sweep output stage in a set that uses an electromagnetic picture tube. Here, too, the peak-to-peak voltage may be surprisingly high, perhaps as much as 150 volts or so. Of course, only the tips of the positive peaks (which may be only about 20 volts positive) are used to drive the vertical output tube.

The signal that finally reaches the vertical deflection coils in a set in which electromagnetic deflection is used has the shape shown in Fig. 29. The peak-to-peak amplitude depends

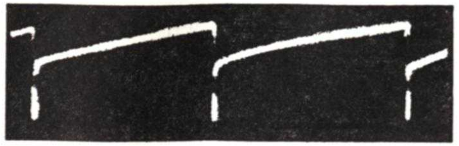


FIG. 28. Trace representing the vertical sync signal at the input of the vertical sweep output stage.

on the design of the coils; it is usually around 50 to 75 volts.

Horizontal Sweep Tracing. The shapes of the signals coming through the horizontal sync chain depend on whether the set has an a.f.c. horizontal hold system or one of the pulse-shaping types. You should consult the service manual for the set you are working on to learn what wave shapes you should expect the sync signals to have.

The wave shapes in the horizontal sweep chain depend on the kind of horizontal oscillator that is used. The horizontal oscillator is often a blocking oscillator or a multivibrator, but it is quite possible for it to be a sine-wave oscillator, particularly if it is in a set that uses a horizontal a.f.c. system.

In this last case, you will find a sine wave across the grid circuit of the oscillator but are quite likely to find a squared wave in its plate circuit. If the set uses a blocking oscillator or a multivibrator, the horizontal sweep signal will probably be shaped very much like the vertical sweep signal, except, of course, that its frequency will be 15,750 cycles instead of 60 cycles. To reproduce two cycles of this signal on the oscilloscope, therefore, you must set the oscilloscope sweep frequency at 7875 cycles.

An example of the changes that occur in a horizontal sweep circuit that starts from a sine-wave oscillator is given in Fig. 30. The grid input signal of the oscillator is shown in part A of this figure. Part B shows the signal in the plate circuit.

After shaping, the wave resembles the one shown in part C, which represents the signal that is fed to the grid of the horizontal-sweep output tube.

A signal much like that in part D may be found at the plate of the horizontal output tube, but you should not attempt to measure this pulse without using special equipment—it may be as much as 6000 volts peak-to-peak! The coupling condensers in your oscillo-

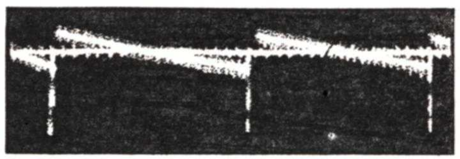


FIG. 29. Trace representing the signal applied to the vertical deflection coils.

scope cannot withstand such voltages; even if they could, these signals would drive the spot far off the screen. About the only way you can measure a voltage of this kind is to use a capacitive voltage divider that is set up to deliver a very small portion of the total signal to your oscilloscope. Any such capacitive voltage divider must use

fixed condensers rated at 10,000 volts or more, of course.

The signal across the vertical deflection coils is shown in Fig. 30E. Here, because of the resonant kickback, we again have a high peak voltage; it may be 1000 or more volts peak-to-peak. Once again, a capacitive voltage divider, made up of high-voltage condensers, must be used if the voltage is to be measured.

Summary. Keep in mind that the oscilloscope traces we have shown in Figs. 24 to 30 are typical for only one kind of set. You will find quite different signals in other sets, and until you become accustomed to the signals that are to be seen, you should always refer to the manufacturers' information to learn what the typical wave shapes and peak-to-peak voltage values are.

In our example, we have shown the wave shapes that exist in a receiver using electromagnetic deflection. Many of the same signals exist in a set in which electrostatic deflection is used; however, the signals in the sweep chains of the latter will be different, because a saw-tooth voltage must be applied to the deflection plates of the electrostatic picture tube. This saw-tooth wave is formed in the saw-tooth generator in the sweep chain, then amplified in a linear fashion to a very high voltage level. It is common to find a deflection voltage of 800 or more volts peak-to-peak applied to an electrostatic picture tube. Once again, you must use a capacitive voltage divider to measure this voltage.

As we have pointed out, the oscilloscope is particularly useful as a signal

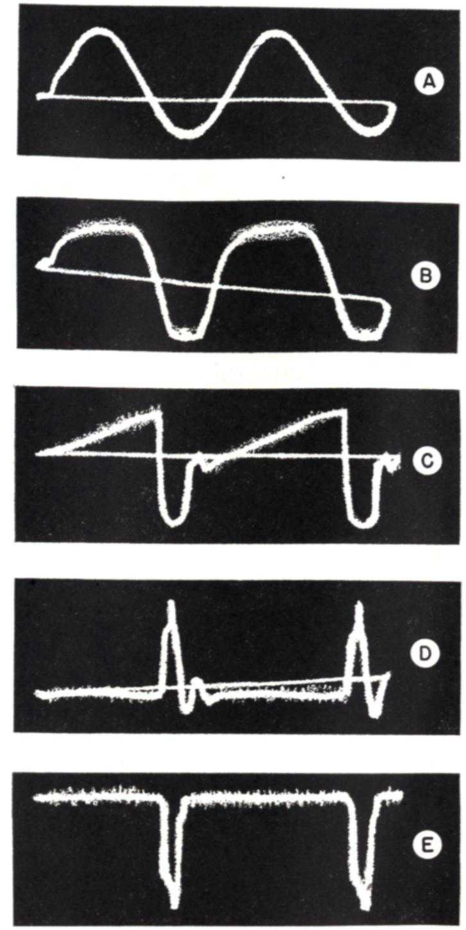


FIG. 30. Generation of a horizontal sweep signal from a sine-wave oscillator.

tracer, because it lets you measure the peak-to-peak voltage of a signal of any shape and also makes it possible for you to see the wave shape of the signal. When this wave shape departs radically from what it should be, you have a definite indication of trouble in the section or stage in which the change of shape occurs. Thus, the oscilloscope is an extremely valuable instrument for use in localizing a defect to a particular section or stage.

Most standard radio service equipment (except the signal tracer) is useful for TV servicing if it has the proper characteristics. Thus, you will not need a special multimeter for TV work as long as your present one has a meter with a high enough ohms-per-volt rating to provide high ohmmeter ranges. A high-voltage multiplier probe is the only extra equipment that is needed to extend its usefulness to television. Your tube tester is perfectly satisfactory for TV work if it can test the latest tube types. A standard R–C tester is far more useful for TV servicing than it is for radio work. Your signal generator may or may not be useful, depending on the ranges it covers; we shall discuss such generators in detail in the Lesson on alignment.

In general, most of the basic servicing procedures that you have learned to use in repairing radio receivers can be applied directly to TV service work as long as you are careful in interpreting the results of your tests. For this reason, once you obtain a certain amount of practical experience, and have learned to recognize the effects produced on test patterns by various defects, you will find it rather easy to service TV receivers successfully.

Lesson Questions

Be sure to number your Answer Sheet 64RH-3.

Place your Student Number on *every* Answer Sheet.

***Send in your set of answers for this Lesson immediately after you finish them,* as instructed in the Study Schedule. This will give you the greatest possible benefit from our speedy personal grading service.**

1. If the individual lines in a raster are not sharp when the contrast control is turned down so that no picture is visible, which one of these possible causes is to blame: 1, poor focus; 2, ghosts; 3, poor high-frequency response; 4, poor low-frequency response?

2. If it is difficult to keep a set in vertical sync, and the picture is blurred, which one of these possible causes is to blame: 1, poor focus; 2, ghosts; 3, poor high-frequency response; 4, poor low-frequency response?

3. If a set that originally showed a black-and-white picture later shows a brown-toned one, what is probably the matter?

4. If a set uses full-wave rectification in its power supply, what defect is indicated if (*a*) one bar and (*b*) two bars appear on the picture?

5. If a picture has 10 bars across it horizontally, what is the approximate frequency of the interference?

6. If a sine-wave a.c. source rated at 5 volts r.m.s. is used for calibrating an oscilloscope, what is the peak-to-peak voltage?

7. What four requirements are essential for an oscilloscope that is to be used in TV servicing?

8. Why is a detector probe needed with a TV scope to search through the video i.f. stages?

9. Why is it desirable to arrange for more than one cycle of the signal to be visible on the oscilloscope?

10. In viewing the horizontal pulse on a TV oscilloscope, what is wrong with the receiver response if the porches and flat top of the pulse are rounded instead of square?

Be sure to fill out a Lesson Label and send it along with your answers.

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J. E. Smith