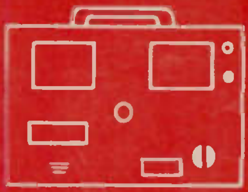
TV repair techniques



GL

No 50 GERNSBACK LIBRARY

$1.50

TV
REPAIR TECHNIQUES

Gernsback Library No. 50

PUBLISHED BY
GERNSBACK LIBRARY, INC.
New York, N. Y.

First Printing — October 1953
Second Printing — September 1955
Third Printing — March 1958

TV Repair Techniques

Introduction 5

Chapter 1—Unusual TV Troubles. . . . .*Irving Dlugatch* 7
Misplaced picture. Nonlinear sweep. Line displacement. Intermittent ghost. Types of interference. Weird sound. Loss of brightness. No horizontal deflection.

Chapter 2—Servicing Procedure. . . . .*Charles G. Buscombe* 15
Vertical sweep section. Horizontal sweep section. Video amplifier and pix detector. Sync circuits. Rolling, jitter, pulling. Hum bar. Pix i.f. Sound lost, weak, or distorted. Front end tuner. B plus circuit troubles. Low-voltage doubler or tripler. High-voltage supply. Blooming. Picture tube circuits.

Chapter 3—TV Signal Tracing. . . . . .*Eng. Staff, Scala Radio Co.* 24
Testing video amplifiers. Square-wave testing. Stage-by-stage response. Sweep-circuit testing. Checking high-voltage circuits. Which probe to use. I.f. gain and alignment. Sync and sweep circuits. Grounding the probe. Spotting flyback defects. High-voltage buzz. Probe design. Other probe uses.

Chapter 4—Servicing TV in the Home. . . . .*Albert W. Stock* 40
Sound, no pix or raster. Sound and raster, no pix. Pix and brightness, no sound. Poor linearity, horizontal or vertical. No sound, pix, or raster. Poor sound on one channel. No pix, no sound, but raster. Interference problems.

Chapter 5—TV Control Troubles. . . . .*DeLoss Tanner* 44
Vertical hold control. Vertical height control. Horizontal hold and lock. Width control. Insufficient width. Horizontal linearity. Focus controls. Brightness control. Centering controls. Other controls.

Chapter 6—
High-Voltage and Boost-Voltage Headaches . .*Jacob Dubinsky* 50
Shorted high-voltage capacitors. Defective or changed-value resistors. Blown fuse. Defective flyback. Shorted or arcing lead. Loss of high-voltage sweep. Voltage boost troubles. White vertical bars. Transient oscillations. Poor damping. Shrinkage and foldover.

Chapter 7—Picture Tube Circuit Troubles. . . . . . .*Carl J. Quirk* 57
Ion spots. Ion trap adjustment. No raster, normal sound. Distorted raster. Unstable sync. Tearing. No brightness control.

Introduction

IF you are in the business of servicing television receivers, you know that a goodly percentage of television repairs are simple ones—replacing tubes, adjusting controls, and persuading customers that no television receiver could possibly keep up with the claims made for it by the manufacturer. We don't have to tell you that a television receiver is a complex piece of equipment, and that you sometimes have to be a combination Sherlock Holmes and Einstein to track down an elusive trouble (which can eventually turn out to be a defective 10c resistor or capacitor).

You shouldn't need a book to tell you to change tubes. And as far as customer relations are concerned, if you are a born diplomat and have the patience of a Job, you have no problem. However, even if you can spot a bum tube at a hundred paces, and even if you and your customers still hold each other in mutual regard, your difficulties are by no means over. Television receivers can have troubles—real, serious, customer-losing troubles. Unless you can lick these troubles, all your skill as a tube puller won't keep you in the television repair business.

By now you may have an inkling as to the purpose of this book. We wouldn't even presume to tell you that this book will supply some sort of magic formula by means of which you can solve every tough repair job in a matter of seconds. It will, however, give you a better insight into the causes and cures of a great many rough repair jobs.

The argument is sometimes advanced that there is really no such thing as a difficult repair job . . . all that it requires is just time and patience. We'll grant the patience part. With modern TV receivers using the minimum number of tubes to do the maximum number of jobs, and with circuits so arranged that a bad resistor in one corner of the set might mean a fire at the opposite corner, the TV service technician needs a supernormal amount of patience. There's no virtue, however, in taking three hours to do a half-hour job, even if you do get a thrill of accomplishment. Time, not tools or test instruments, is your biggest investment.

This book was written by men who are practicing service technicians. What we have done is to combine their wide experience with difficult servicing problems and present them here for your help. For the most part we have tried to steer clear of theory and simply present TV problems and their cure. Theory has been included in every instance in which it was essential to an understanding of the problems involved. The material in this book is culled from articles published in RADIO-ELECTRONICS.

Just one more word of explanation. Most servicing books on this subject start in a logical manner with the front end of a set, go through the pix i.f. stages, video amplifiers, and then proceed through sync separator, sync amplifiers, and sweep circuits. Unfortunately, troubles do not follow a logical procedure. Although we may seem to have a heterogeneous arrangement, emphasis has been placed on those areas of a set in which trouble is most likely to occur, or which will present out of the ordinary headaches. Aside from an occasional shorted screen bypass or decoupling resistor the picture i.f., for example, is prone to few troubles other than tube failure or misalignment. Sweep, low- and high-voltage sections, require more servicing attention.

We are indebted to every author contributing to this book. We are grateful to Mr. Matthew Mandl, author of *Mandl's Television Servicing,* for permission to reproduce his material which originally appeared in RADIO-ELECTRONICS.

Chapter 1

Unusual TV Troubles

EVERYONE is familiar with "no output," "weak output," or "distorted output" in radio servicing. Television has its "no picture," "no sound," "no sweep," and "distorted picture." In either radio or television work, these ordinary troubles offer no problem to the expert having only the simplest equipment. Many a radio technician, however, owes his gray hairs to the puzzling intermittents and the "everything's perfect but—." What, then, of the television technician faced with a multiplicity of circuits, each capable of developing individual intermittents and unusual symptoms? Where does he begin using his elaborate service instruments?

The combination of an intermittent in some obscure circuit plus misalignment or maladjustment is enough to confound the most experienced technician. Too often, by his random twisting of controls and adjustments, he not only indicates his complete befuddlement, but manages to make matters worse. It is often much simpler to analyze the possible causes of the trouble and then proceed methodically with the proper equipment to track down the guilty component. Let's look into a few unusual problems.

The misplaced picture

The picture had a vertical slice cut off the right end and placed very neatly over the left side. In this way, it was possible to watch a ball game in which the pitcher stood behind the batter. He threw a ball off to the left where it disappeared. It reappeared at the right of the picture to fly toward the batter. Note, this is not a case of foldover where the picture is merely distorted at one side;

nor is it horizontal slipping. Fig. 101-a shows the signal as transmitted and Fig. 101-b shows the right side transposed to the left. A photo of this trouble is shown in Fig. 102. Let's analyze this condition.

The slopes of the sides of the tree being equal and linear, there is no possibility of nonlinearity in the horizontal or vertical sweep circuits because nonlinearity causes sections of the pattern to be abnormally cramped or stretched. Fig. 103-a shows the deflection waveshape for a normal line in Fig. 101-a. The slicing off and transposition to the left of the received picture indicates that the receiver sweep oscillator was cutting off at b and starting a new line while the transmitter sweep continued to B. Thus the part of the picture between b and B in Fig. 103-a appeared at the beginning of the lines instead of the ends where it belonged.

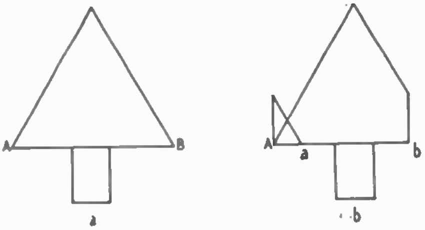


Fig. 101. Correct oscillator sweep (left) and delayed oscillator sweep (right).

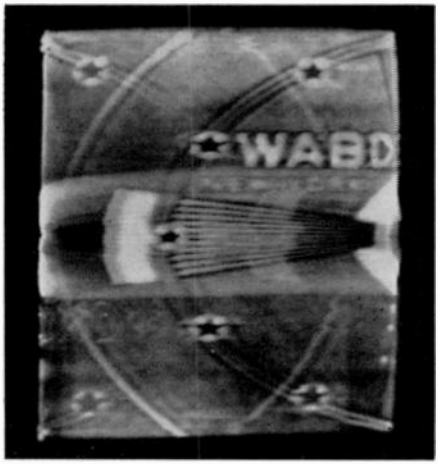


Fig. 102. A pattern affected as shown in Fig. 101.

Obviously the receiver's horizontal sweep was running at exactly the same speed as the transmitter's but starting just a little late.

By signal tracing in the sync circuits, the trouble was located in a sync coupling capacitor which had changed value.

Another type of deflection-circuit trouble is nonlinearity which causes crowding or stretching at the sides and top or bottom of the picture. Figs. 104-a and 105-a show nonlinear vertical and horizontal deflection voltages, while Figs. 104-b and 105-b show the resulting distortion in the picture.

When the vertical deflection wave curves, the downward sweep of the beam is slowed up, permitting more horizontal lines to be scanned in a given period and producing cramping or crowding. The center portion of the sweep is linear, and the lines are evenly spaced.

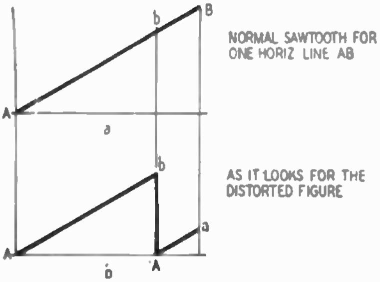


Fig. 103. *Horizontal sweep is too fast.*

When the horizontal sweep is distorted, the picture elements are crowded during the curved portions of the sweep and evenly spaced during the linear portion.

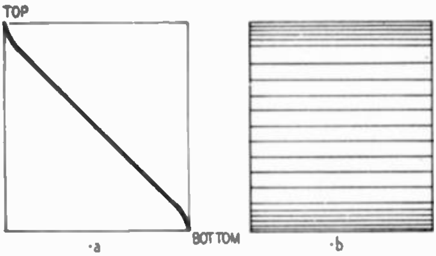


Fig. 104. *A nonlinear sweep crowds lines.*

If nonlinearity is not correctable with the linearity controls or by standard servicing practices, look for 60- or 120-cycle hum in the deflection circuits. Fig. 106-a and Fig. 106-b show how hum or ripple adds to or subtracts from the amplitude of the horizontal scanning wave and makes corresponding lines longer or shorter.

The addition of the ripple to the sawtooth will curve the sawtooth waveform. This causes over-all distortion with a sine-wave shape at the left edge of the raster. Ripple or hum in the vertical deflection circuits will cause cramping like that shown in Fig. 104-b.

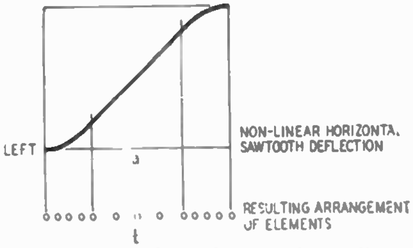


Fig. 105. Horizontal sweep is nonlinear.

Another trouble common to deflection circuits is failure of the damper tube. This is characterized by distortion or foldover at the left side of the picture. This is understandable when we recall that the damper tube stops oscillations caused by the rapid change in deflection-coil current during the retrace period. Occasionally, only a single cycle of spurious oscillation is produced during each scanning cycle. The resultant is a single white bar with no other distortion in the picture.

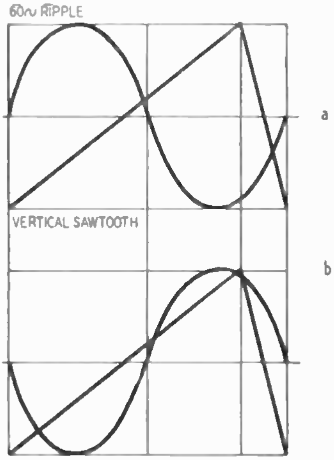


Fig. 106. Hum may cause nonlinearity.

Leftward tendencies

Sometimes one or more lines are shifted to the left without otherwise distorting the picture. Fig. 107 is exaggerated to show this condition, which is recognizable as a form of tearing—a condition usually caused by loss of sync. Deflection oscillators are usually designed to operate at frequencies somewhat lower than the 60- or 15,750-cycle synchronized rates. Naturally, they slow down to their designed frequency when sync is removed. The usual type of tearing occurs irregularly and over many lines. In this problem, the "slipping" is clean and covers comparatively few lines. Furthermore, the displacement occurs at the same place in the picture. This makes identification positive. An actual photo of this condition appears in Fig. 108.

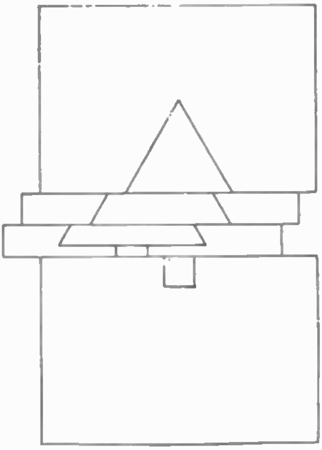


Fig. 107. Some lines shifted to side.

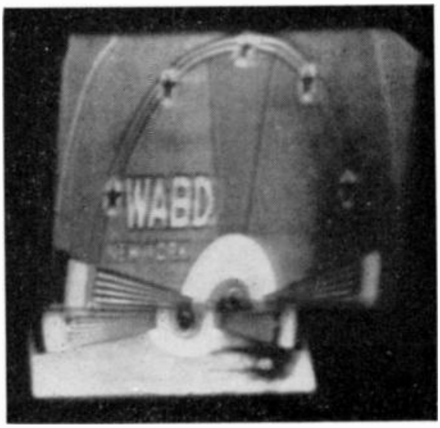


Fig. 108. An actual photo of the condition in Fig. 107.

Suppose the receiver in question uses a.f.c. as in the horizontal scanning circuit shown in Fig. 109. Capacitor C stores a charge which maintains the bias on the control grid of V1 for one frame, and the oscillator will stay locked in for this period, unless, of course R or C have undergone considerable changes in value. Checking the values of these components is the first step in finding the cause of the intermittent loss of sync.

Regardless of the type of horizontal sweep circuit involved, the trouble is not caused by an intermittent component because the displacement is clean and occurs at regular intervals. Noise pulses can be eliminated because of their irregularity. A more likely cause is an unwanted signal which adds to or subtracts from the video signal so as to destroy the sync for a few lines. Obviously the unwanted signal must occur at a 60-cycle rate to produce this effect. By signal tracing, the trouble can be traced to stray pickup in the r.f or i.f. circuits. The interference may be caused by parasitic oscillations, high-amplitude deflection voltages, or heterodynes.

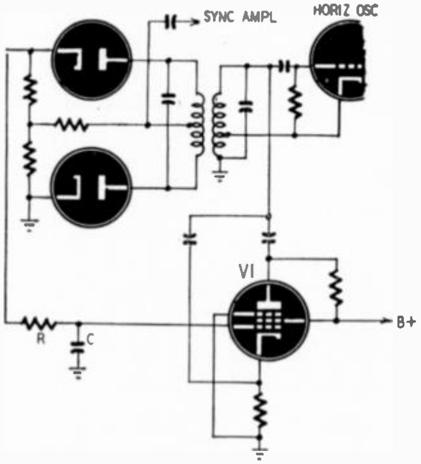


Fig. 109. Horizontal sweep with a.f.c.

The vanishing ghost

A true intermittent ghost or reflected image is not rare. It can occur any time the antenna sways or turns in the wind. The cure is a good antenna installation. We are more concerned with non-reflected streaks and intermittent shadows which appear in the picture. Consider what will happen to a picture when an unwanted signal appears in the video amplifiers. Fig. 110-a shows the video signal during one line, 110-b a part of the positive cycle of an unwanted signal, and 110-c shows how the sum of the video and interfering signals places the video signal nearer the white region. When the interference goes negative, the video signal goes closer to the black region. If the interference is a 60-cycle sine wave, half the picture will be brighter and half darker than normal.

If the interference is a frequency higher than the line scanning rate, each line will be modulated with white or black dots and vertical lines will appear in the picture.

When sound gets into the picture, we see bars, streaks, or patches, depending on the amplitude, phase, frequency, and duration of the interfering signal.

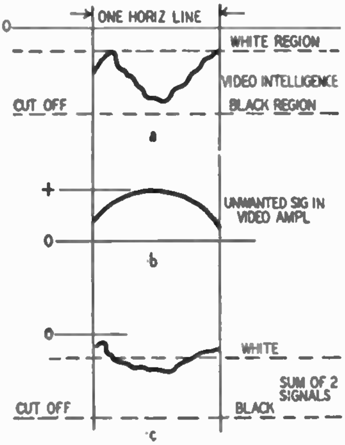


Fig. 110. *How interference affects image.*

These three types of interference are easily recognizable and methods for curing them are obvious.

1. Long, dark, horizontal streaks following a thin, horizontal, black object against a white background. This may be caused by misalignment of r.f. or i.f. circuits or by faulty peaking in the video amplifier circuits.

2. White streaks forming at the edges of white objects against a dark background. This is particularly noticeable at the hairline on an actor's face. This trouble is also traceable to faulty aligning or peaking.

3. Muddy, washed-out pictures and visible retrace lines can result from turning up the contrast control to compensate for low emission in the picture tube. Advancing the contrast control raises the gain of the i.f. amplifiers, which may alter the over-all response curve and cause smearing like that just described. For further information read the chapter on Television Interference.

Weird sound

Most cases of distorted or missing sound are due to improper operation of the receiver's controls but some may be traced to excessive oscillator drift. A bad tube is usually at fault when poor front-end design is not evident. Misalignment of the r.f. and i.f. stages is an obvious cause of the same trouble. (A common mistake is to realign the picture i.f. rather than the sound stages. The sound i.f. bandpass is not as wide as that of the video i.f.; therefore the former is more critical.)

Loss of brightness

Service technicians have evolved a fairly standardized procedure when servicing this trouble. They rotate the brightness control watching the effect on the raster or picture (or may even measure the bias voltage on the picture tube); they adjust the ion trap for maximum picture brightness, and they may even clean the face of the mask and the tube, since high voltage and dust seem to go hand in hand. If none of these remedies help, the finger of suspicion points at the picture tube. It would seem that either a new picture tube or a picture tube rejuvenator are required.

Before starting his sales talk about the virtues of a new picture tube, the service technician should go back to the ion trap once again. Sitting as it does on the hot neck of the tube (a very unfavorable condition for permanent magnets) it is very possible for the magnet to lose its field strength. Substitution is *not* always a positive test. Make sure your test magnet hasn't been forced to spend its time in the company of other magnets (or in regions of strong magnetic fields) and that it hasn't been dropped or abused.

No horizontal deflection

The complaint was little or no horizontal deflection; there was a vertical line or band in the center of the screen; and second-anode voltage was low. This is a rather rare trouble which is likely to give you considerable difficulty. Trouble is probably caused by an open capacitor (0.1 µf or so) connecting one end of the horizontal deflection coil to B plus. The horizontal yoke aids in producing the kickback and boosted voltages used for supplying the picture-tube second anode and B plus to the horizontal output and other stages. When this capacitor opens, the yoke is effectively disconnected from the circuit and the anode and boosted voltages are too low. Replacing the capacitor clears up the trouble.

In some sets, one side of the yoke connects directly to B plus and the linearity coil, and the other end to the damper-tube plate through the capacitor mentioned above.

Chapter 2

Servicing Procedure

TELEVISION servicing is a two-step process. The first step is to determine in which particular circuit the defect occurs. The next step, of course, is to find out just which particular component is defective. Read this chapter for an explanation of how to localize TV troubles by recognition of symptoms.

Vertical sweep section

If unable to lock (even momentarily) with hold control, oscillator trouble is indicated. Substitute tube; check socket voltages to localize defective component; look for leaky coupling capacitors and changed resistor values. Where there is complete or partial loss of vertical deflection, determine whether oscillator or amplifier is at fault. One method is to feed 6 volts from the heater circuit through a .25-μf capacitor to the amplifier grid. If height increases, amplifier is probably O.K. Presence of sawtooth at amplifier grid can also be determined by an a.c. voltage check or by coupling this point through a blocking capacitor to video or audio amplifier, using picture tube or speaker as an indicator.

If oscillator is at fault, check its components as mentioned above, not neglecting integrator network and coupling capacitor from sync circuits. Resistance check the blocking oscillator transformer. Where manual control is possible for short intervals, and oscillator tube is O.K., it can be assumed that sync pulses have been lost or attenuated in preceding stages (sync amplifiers, separators, limiters, integrator or even in video stages). Where vertical amplifier is at fault and there is sufficient signal drive on its grid, try tube substitution. Next check for signal at amplifier plate, and if none, measure socket voltages and look especially for open cathode circuit, shorted cathode bypass, or open output transformer primary. If signal is O.K. at plate, test for break in transformer secondary or vertical deflection yoke. Shorted yoke turns will produce a *keystone* raster.

In general, where symptoms are loss of height with sync instability (*rolling*), the oscillator and integrator circuits may be suspected. Where problem involves height and linearity, the amplifier or its output coupling is probably responsible. For picture *bounce* check vertical oscillator and sync separator tubes. The trouble can also be in the integrating network of resistors and capacitors at input of vertical sweep oscillator. For more detailed analysis of vertical sweep troubles, read Chapter 12.

Horizontal sweep section

If unable to lock the horizontal oscillator with hold control or other frequency adjustments, try tube substitution followed by the same socket voltage measurements and component tests mentioned for vertical oscillator troubles. If picture can be locked in but will not hold, or evinces *pulling, bending, horizontal shift, jitter or tearing,* trouble may lie in a.f.c. circuit or sync stages.

Drive is normally adjusted for maximum raster width and brilliance without vertical overdrive bars on screen. Excessive drive will shorten life of the high-voltage rectifier tube. If linearity is impaired, correct with linearity control or slight readjustment of drive. If drive adjustment causes loss of sync, correct with hold control.

Video amplifier and pix detector

Symptoms: Raster O.K., no picture; or picture having poor contrast; distorted pictures (smearing or phase reversals). Sound may or may not be impaired, depending on whether set is intercarrier or dual channel. Sync may or may not be unstable.

Start by substituting tubes, then if necessary apply signal tracing, using one or more of following methods:

(1) Inject audio to picture tube input (grid or cathode); attenuate signal at the generator and adjust brightness control until developed sound bars appear light gray. Feed signal to preceding points, noting increases or decreases in bar contrast. Continue as far as detector load resistor. Where there is no improve-

ment in contrast when input signal is shifted from plate to grid of any tube, that stage can be considered at fault.

(2) Follow up by checking socket voltages, continuity of peaking coils, load resistor values, and low-frequency compensating components. Where raster brilliance is consistently too high or too low, and brightness control has negligible effect, look for defective coupling capacitor from video output to picture tube control grid.

(3) With antenna connected and station tuned in, adjust fine tuning control for maximum contrast. With signal tracer follow signal from detector load resistor through amplifier to picture-tube input, noting relative changes in level. Audible indication of this signal is of course the raspy tone commonly referred to as sync buzz.

The signal injection method of tracing can make use of an a.f. generator, neon relaxation oscillators, or sawtooth voltage taken from the vertical sweep oscillator through a blocking capacitor. In an emergency, you can always use filament voltage picked up from one of the tubes. Apply this a.c. signal through a .1 µf capacitor.

Sync circuits

Symptoms: Partial or complete loss of sync as evidenced by *rolling, jitter, pulling, or tearing.*

Assuming oscillators are running at correct frequencies and are capable of being triggered, determine if pulses are reaching point of sync takeoff by observation of sync and blanking bars on picture tube. This is done by adjusting hold or centering controls. By manipulating brilliance and contrast controls, sync bar should normally appear very dark against the gray background of the blanking bar. If not, a previous stage is responsible for attenuation of sync voltage.

Try substitution of all sync-amplifier and separator tubes, including the a.f.c. control tube. Trace pulses from takeoff point up to inputs of vertical or horizontal oscillators. (Some attenuation normally results between input and output of clipper tubes.)

If pulses can be traced up to integrator, follow through integrator or a.f.c. (depending on whether vertical or horizontal sync is at fault). Substitution of the integrator is readily accomplished with one of the printed-circuit types. If necessary, check socket voltages of a.f.c. tube, followed by associated component testing. Particularly investigate feedback loop, then make various adjustments required.

Where *hum bar* appears on raster or in sound, trouble is often due to cathode-heater leakage in a video or sync tube or poor filtering in the low-voltage supply. These are very common causes of sync instability.

(A set should never be considered to have good sync unless the picture locks in abruptly with the vertical hold control and shows no signs of vertical jitter or rolling when changing channels. You have horizontal stability when the hold control is not particularly critical and pix does not tear when channels are switched.)

Picture i.f. amplifier

Possible symptoms (depending whether set is intercarrier or dual-channel): No pix, no sound; sound but no pix; poor pix contrast or resolution; pix smear with sync instability.

(The video amplifier can also be responsible for these symptoms, so it is up to the technician to decide which stage to investigate first.) In intercarrier models try tube substitution in all stages. In dual-channel receivers if sound is O.K. be concerned only with those tubes following sound takeoff. The picture i.f. is prone to few troubles other than tube failure or misalignment. Occasionally, however, a shorted screen bypass capacitor or a defective decoupling resistor may be responsible. The troublesome stage can be localized by signal tracing with one of the following methods: (1) With antenna attached and set tuned to an operating channel, use crystal probe to follow signal from mixer output through various stages, toward detector. Trouble will be found in stage following point where signal was last recorded. (2) Inject a suitable signal into check points in the i.f. amplifier, working back from detector toward front end. An AM or sweep generator may be used for this purpose, or, lacking these, use a noise signal from the vertical sweep amplifier or damper plate with a suitable isolating resistor and capacitor in series with the lead.

Sound i.f. det.—audio

Symptoms (raster and picture O.K.): Sound may be completely lost, weak, or distorted.

If audio amplifier or speaker is suspected, touch hot end of volume control for the usual hum or growl. If not heard, try tube substitution. Use click test by pulling sound channel tubes from sockets. Next use signal tracing, employing neon oscillator or noise signal taken from vertical oscillator or damper. Another method is to feed signal through a small capacitor from different points in a.f. amplifier to the hot end of video detector load resistor. Sound bars on picture tube will indicate where signal is present. If a.f. section is O.K., first make certain that front-end oscillator is not mistuned, then proceed to trouble-shoot sound i.f. strip. This can be done with either a generator or noise signal as mentioned previously. Signal *crossover* method may be employed by using crystal tracer probe between i.f. test point, and either audio or video amplifier inputs.

Where minor sound misalignment is apparent, a tolerable job of sound i.f. alignment can be done by ear. The procedure is to adjust the fine tuner for the best possible sound, then detune *slightly* in the direction necessary to obtain the best picture. Leaving tuner set on the edge of sound signal, adjust all tuned circuits in sound strip for maximum volume from speaker (not forgetting the sound takeoff trap). Again adjust tuner in direction of best picture, peaking tuned circuits again for loudest sound. Repeat as often as necessary until optimum picture and sound are received at one setting of fine tuner. Next step is to adjust secondary of discriminator transformer for minimum audio distortion and sync buzz. This method cannot be used on intercarrier receivers for the obvious reason that sound is fixed at 4.5 mc and misalignment of this strip will only weaken or distort the sound.

The front end tuner

Symptoms: Raster O.K., no picture, no sound; picture but no sound, or weak distorted sound; poor contrast with excessive snow.

If there is no sound or picture, particularly on high channels, but considerable interference from FM and auto ignition, the oscillator is probably inoperative or badly mistuned. Replace the tube, and adjust oscillator slug or trimmer to bring in sound and picture.

Weak picture and sound and high noise level, may be due to a weak oscillator or defective mixer or r.f. tube. Try substitution. If no improvement, investigate for possible antenna trouble, such as change of orientation, loose or open connections, or a broken transmission line.

These symptoms on only one or two channels may indicate misalignment of r.f.-mixer adjustments. To verify this, try peaking them for improved picture contrast on a troublesome channel. (Final alignment of this section must be done with proper equipment, otherwise picture quality may be impaired.) Picture-sound mistracking cannot always be blamed on the tuner. However, a similar condition may prevail which tuner adjustments will correct. This is where picture is received at one extreme of tuner range and sound is either missing or weak and distorted. The procedure here calls for setting fine tuner at midposition, and adjusting the over-all oscillator slug for best sound and picture on the highest channel. Try all other channels and if necessary adjust their individual oscillator slugs without touching fine tuner. A little extra effort spent on this operation will please the customer, as it saves him the annoyance of having to manipulate the tuner every time a new channel is selected.

B-plus circuit troubles

Possible symptoms: No raster or sound; raster dim and of small size; poor focus; sync instability; weak sound (any one or combination of these symptoms may be noted).

If tubes fail to light, the first things to look for are an open a.c. line, a defective interlock, or a blown fuse. If tubes are lit check for presence of normal B+. A loss of more than 10% in the B+ can cause most of the above-mentioned troubles. For this condition try substitute replacement of rectifier tubes or selenium units. Where sparking occurs in a rectifier, check for a shorted input filter. If filter chokes or resistors show signs of overheating, check other filters and bypass capacitors and investigate the possibility of one or more tubes drawing excessive current. This latter trouble can be verified by removing tubes one at a time and noting the B+ voltage changes. Normally, pulling most of small tubes will result in an increase in the B+ of 10 to 20 volts. Removal of power amplifiers (vertical, horizontal, and audio output) will raise B+ 50 to 100 volts, depending on the set. Where removal of a tube causes a greater increase than this, its circuit should be checked for a leaky coupling capacitor, and loss of bias or screen voltage. If focus pot (shunted across focus coil) overheats, look for open focus coil. The rectifier tube itself may be shorted or gassy.

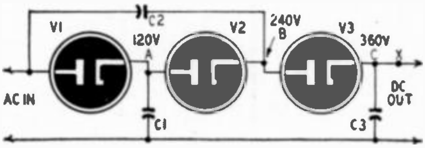


Fig. 201. Half-wave tripler schematic.

The low-voltage doubler or tripler

Where output from this type of supply is low or zero, it is not advisable to start with rectifier substitution, as a shorted filter capacitor might damage one or more of the substitutes. Start by disconnecting the set load at point X in Fig. 201. Under this no-load condition, voltages at points A, B, and C should be approximately as indicated. If there is no voltage at any point, check for a.c. up to the first tube via the ballast resistor and input filter. Output at B but not at C, indicates defective V3 or C3. If there is voltage at A but none at B, check V2 and C2. No d.c. at A indicates V1 or C1 is at fault.

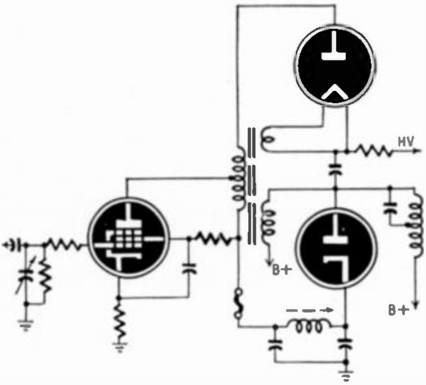


Fig. 202. Typical flyback high-voltage circuit.

Where selenium rectifiers are used, follow the same procedure, making certain that substitute rectifiers have adequate current capacity.

The high-voltage power supply

Symptoms: Sound O.K., no raster, or dim raster; *blooming.* In receivers using the flyback type of power supply shown in Fig. 202, first check for presence of h.v. on the anode lead, and measure it if possible. This should be done at both ends of the filter resistor under varying load conditions by adjusting the brightness control over its full range. Next, touch the anode lead to the picture tube, noting intensity of the spark. If weak with brightness control at maximum, trouble may be a weak picture tube, loss of anode No. 1 voltage, or a defect in the brightness control circuit. If h.v. is low or nonexistent, try to draw a corona arc from the plate cap of the h.v. rectifier tube. If this is O.K., trouble will be a bad rectifier, filter capacitor, or resistor, or a grounded anode lead. Verify by tube substitution, disconnecting one end of the capacitor, or shorting out the filter resistor. If there is no corona arc or a very weak one, cause may be overload conditions as before or trouble at some prior point. Next try to draw a corona arc from the plate of the horizontal output tube or tubes. If this is O.K., fault lies in the h.v. winding of the transformer. Look for indications of coil heating or a broken lead to the rectifier plate. If the arc is absent or very weak at the output plate, check the d.c. voltage *at the low end of the transformer primary,* and back through the fuse, linearity coil, and the cathode and plate of the damper tube. The boosted voltage at the transformer primary should be 75 to 150 volts higher than the voltage at the damper plate. If the boosted voltage is low, the damper tube may be weak, or there may be insufficient drive to the amplifier grid. Absence of boost voltage may be caused by an open fuse or linearity coil, by shorted linearity capacitors, or by a grounded transformer primary.

Where the boosted voltage to the horizontal output tube is normal, yet corona arc at the plate is weak or absent, check for signal drive to the grid. If this is normal (at least 20 volts peak to peak), try tube substitution and tests on the cathode and screen circuits. Continued trouble is probably due to shorted turns in any winding of flyback transformer. Resistance check of flyback transformer may check good, yet transformer may have shorted turn. Substitution is the most reliable verification. Insufficient signal voltage at the horizontal output grid indicates incorrect drive adjustment, a shorted drive control, or trouble in the oscillator circuit.

A typical h.v. doubler-tripler circuit is shown in Fig. 203. If normal h.v. is not obtained at the end of the output lead, checks should be made at both ends of the filter resistor. Work back to the plate cap of V1, following the procedure given in the section on low-voltage doublers and triplers.

The quickest and most reliable method of testing h.v. capacitors is to charge them from a h.v. source, conveniently obtained from the anode lead of another receiver. A good capacitor will hold its charge for at least several minutes, as evidenced by a loud crackling discharge spark after the charging potential has been removed.

Where severe raster blooming occurs, check the voltage regulation of any of the foregoing supplies. The h.v. should not vary more than 1,000 volts as the brightness control is varied from minimum to maximum. This test must be made with the picture tube connected and showing a raster. Blooming is usually caused by a weak rectifier or an increase in the value of a resistor in the h.v. section.

Picture tube circuits

Symptoms: Sound O.K., no raster or dim raster; poor focus; silvery appearance to certain picture elements; or a tendency to phase reversal.

If the h.v. measures O.K. with the brightness control fully advanced, note spark intensity as the anode lead is contacted to the picture tube. If normal, try adjusting the ion trap, or if no raster is obtainable, check for a short in the tube. If there is no spark or a weak spark (discounting charging current of the tube capacitance) test for presence of anode No. 1 voltage. Next check for defects in the brightness control circuit. This can be easily done by testing the polarity and voltage variations between grid and cathode at the picture-tube socket as the brightness control is varied over its full range. The grid voltage should change from zero to 50 volts or more *negative* to the cathode. Trouble here may be due to a defective brightness control, fixed series resistor, or leaky coupling capacitor from the video output. Additional troubles causing brightness disorders are covered in Chapter 5 and Chapter 8. A suspected tube should be verified finally by substitution.

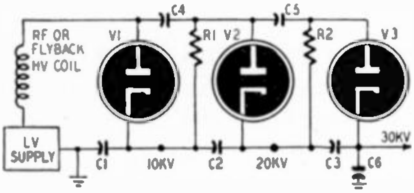


Fig. 203. High-voltage tripler circuit.

Chapter 3

TV Signal Tracing

SIGNAL tracing in TV receivers differs in several respects from signal tracing in radios. First, the range of frequencies found in TV circuits is very much broader than in radio. Second, the supply and signal voltages in TV chassis cover a much wider range than in radio work. Third, the circuit impedances in TV receivers range from less than one ohm to as high as 10 megohms or more. Fourth, signal tracing in radios is usually concerned with sine-wave signals, while these are the exception rather than the rule in TV. TV circuits often operate with two signals present at the same time, such as the FM sound signal and AM picture signal, or 60-cycle vertical sync signal and 15.75-kc horizontal sync signal.

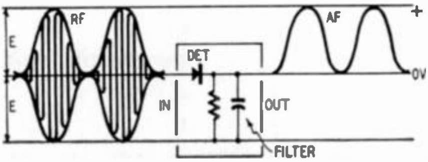


Fig. 301. Crystal rectifies wave and filter removes r.f.

The operating frequencies in the r.f., i.f., and—under some conditions—in the video amplifier of a TV receiver are too high for the usual service scope to display directly. For this reason, signal tracing in the r.f. and i.f. amplifiers requires a *demodulator,* or detector, probe which rectifies the modulated waveform and recovers the modulation envelope. For example, the picture carrier frequency of a modulated wave may be 55.25 mc, while the video modulation envelope may represent a frequency, at any particular instant, of perhaps 1,000 cycles. The scope can display the 1,000-

cycle output from the demodulator probe, although it cannot reproduce the modulated carrier. The input and output from a service scope probe is shown in Fig. 301.

Demodulator probes are usually built around crystal-diode detectors, because these devices are compact, have good frequency response, and do not require a source of heater voltage.

Both series- and shunt-type detectors (see Fig. 302) are used in commercial probes, and it will be found that the series type is the more sensitive for signal-tracing purposes. However, it will also be found that the series probe is the least suitable for video-amplifier testing, and will seriously distort the sweep output waveform.

For this reason, practical crystal demodulator probes usually have moderate sensitivity, an input capacitance approximately equal to that of a picture tube, and a time-constant suitable for demodulating carrier frequencies which have been modulated by frequencies as low as 60 cycles.

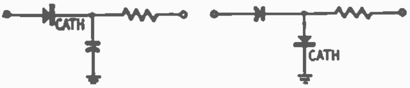


Fig. 302. Series detector (left) and shunt detector (right).

Shunt-type probes are generally found most suitable for signal tracing as well as for video-amplifier checking.

Testing video amplifiers

There are two general methods of testing a video amplifier. One technique is to apply a sweep signal to the input of the amplifier, and to display the amplifier output on the scope screen. Most service scopes will not respond to frequencies of 4.5 or 5 mc, and a demodulator probe must be used to develop the visual-response curve. The video sweep signal used in such tests varies from a low frequency of about 100 kc to 5 or 6 mc, 60 times a second.

A demodulator probe which is satisfactory for i.f. signal tracing may be quite useless for video-amplifier testing. The reason is that the response of the video amplifier depends in great part on the *shunt capacitance* across the output. If this shunt capacitance is greater than the input capacitance of the picture tube, the high-frequency response will appear to be very poor. On the other hand, if the shunt capacitance of the test circuit is less than the input capacitance of the picture tube, the frequency response will appear to be better than it really is.

Obviously, the input impedance of the demodulator probe must equal the picture-tube input impedance. The probe must also have good response to 60-cycle square waves, because the demodulated sweep output is of the same general form as a 60-cycle square wave, and if the time-constant of the probe is too long, the scope will indicate a true rise but a false fall of the response curve.

Square-wave testing

The square-wave test is more informative than the sweep-frequency test, because it shows up phase distortion as well as frequency distortion in the video amplifier. Phase distortion is just another way of expressing abnormal time delay, which means that small picture elements may arrive slightly later or slightly earlier than large picture elements regardless of their positions in the original picture. Accordingly, phase distortion causes the small picture elements to be displaced horizontally with respect to the larger picture elements, and the observer describes the picture as "smeary."

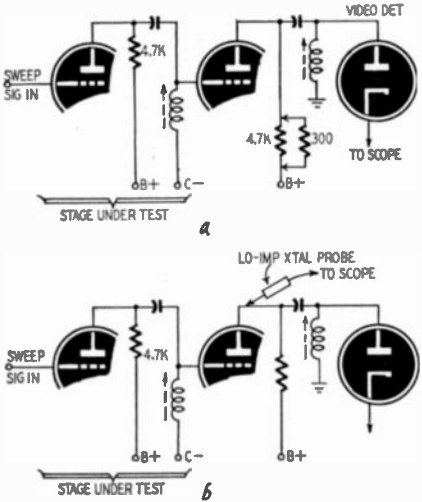


Fig. 303. Illustration (above) shows use of shunt. Low-impedance probe (below) shunts the following stage and feeds the scope.

For accurate square-wave tests on video amplifiers, the vertical-deflection amplifier in the scope must have better frequency and phase characteristics than the TV receiver. Otherwise, the output from the video amplifier must be applied directly to the vertical-deflection plates of the scope. (This gives the best possible frequency and phase response from the scope, but has the disadvantage of providing only $\frac{3}{8}$-inch to $\frac{5}{8}$-inch deflection on the scope screen.)

Never feed the output of the video amplifier directly through a cable to the input of the scope. Any usable length of cable will have very much greater capacitance than the grid-cathode circuit of the picture tube, and the square-wave response on the scope screen will be grossly misleading.

To avoid such distortion, a low-capacitance probe must be used, and this probe should have the same input capacitance as the picture tube.

If the output of the video amplifier is applied directly to the deflection plates of the scope, the connection must be made with a short, *unshielded* test lead.

Of course, the socket is removed from the base of the picture tube in all such tests, because the input capacitance of the scope setup is substituting for the input capacitance of the picture tube.

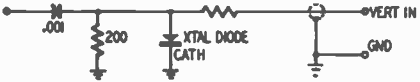


Fig. 304. Low-impedance probe circuit.

Stage-by-stage response

The reader no doubt will point out that he requires another important application from his crystal probe—namely, the ability to reproduce stage-by-stage i.f. response curves. Some TV receiver manufacturers suggest this method of i.f. alignment.

There are two general methods of making such a stage-by-stage alignment, one of which requires a crystal probe. These two methods are indicated in Fig. 303. In the first method (*a*), the picture detector serves as a demodulator for the alignment of any one stage. In *b* the demodulator probe serves this purpose, and the use of a number of shunting resistors is avoided.

A low-impedance probe is usually considered necessary for this sort of work, as illustrated in Fig. 304. However, if a 300-ohm, 2-watt resistor is shunted temporarily across the plate load of the circuit to which the crystal probe is applied, the usual crystal probe will serve quite well. The shunt resistor swamps out the unwanted resonance of the plate load, and the crystal probe demodulates the sweep output from the stage under test.

Accordingly, a low-impedance crystal probe is not necessarily required, and a probe that is satisfactory for video-amplifier work also serves satisfactorily for stage-by-stage i.f. work.

Sweep-circuit testing

Unlike radio testing, TV testing is concerned with *shapes* of waves in very many cases, and with various *types* of voltages. For example, a normally operating TV receiver may produce the typical waveforms indicated in Fig. 305, while a "sick" receiver may produce the variants shown in Fig. 306. And every little variant has a meaning all its own; the problem of the technician is to learn to read this new language, and to be able to spot the receiver component responsible for the waveform distortion.

These waveforms also represent different kinds of voltages. The TV technician hardly ever speaks of r.m.s. voltages used so widely in radio work. Instead he speaks of peak-to-peak voltages, positive-peak voltages, and negative-peak voltages. These relations are shown in Fig. 307.

Fig. 305. Normal current trace in horizontal yoke. Note trace of ringing at start of each sawtooth.

The probes used to apply these waveforms to the input of the scope must also attenuate their voltages by known factors, so that their peak-to-peak (or other) values can be read from the scope screen. It is customary in probe design to make the attenuation factor either 10-to-1, or 100-to-1. That is, if we apply a 100-volt wave to the input of a 10-to-1 probe, 10 volts will be applied to the input of the scope. Then, if the scope screen has been calibrated for a sensitivity of 1 volt per square, the 100-volt wave will produce 10 squares of deflection of the screen.

The technician does not want to recalibrate his scope every time he plugs in a probe, and he does not have to—provided he uses such a *decimal* probe—that is, a 10-to-1, or 100-to-1 probe; he merely adds *one zero* to his original calibrating factor.

When checking the waveform across the horizontal-deflection coils, the low-capacitance probe, which is also an attenuating probe (usually 10-to-1), can be utilized to advantage, not to provide increased input impedance, but to attenuate the source voltage to a point at which the scope amplifier is not overloaded.

Another important consideration concerns checking the waveform at the grid of the vertical blocking oscillator. In this circuit the oscillator grid leak is sometimes as high as 10 megohms.

The technician who attempts to test such a circuit will find that the input impedance of a direct cable to the scope is *far too low* for this application. Its capacitance will shunt the oscillator tank circuit, will cause a loss of signal voltage, and may seriously disturb circuit operation.

To avoid this difficulty, the technician may try a low-capacitance probe. Although the probe will eliminate the first difficulty, it usually will introduce another: The *input resistance* of the probe, being less than 10 megohms, will drain away too much of the d.c. bias voltage, again seriously disturbing circuit operation. When this difficulty is encountered, the technician must use a blocking capacitor in series with the low-capacitance probe.

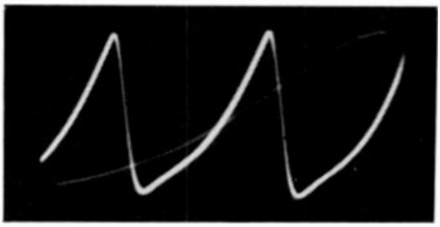


Fig. 306. Distortion in horizontal yoke current.

Special low-capacitance probes are available which do not offer a d.c. path to ground, and thus eliminate grid-bias disturbances.

Checking high-voltage circuits

High voltage can do harm in these ways: It may *overload* the scope amplifier and distort displayed waveform, without doing actual physical damage to the scope. It may puncture blocking capacitors, and char or burn out attenuator resistors. It may arc through insulating washers and carbonize terminal strips.

The plate of the horizontal output tube represents a typical circuit point that is potentially dangerous to the scope input system.

The voltage at the plate of the horizontal output tube, or at the plate of the high-voltage rectifier tube is always "high" as far as conventional scopes are concerned. To protect the scope against physical damage in such tests, a high-voltage a.c. probe is required. Such probes are constructed as capacitance dividers.

Which probe?

The specific probe needed for any trouble-shooting job depends on the type of signal to be traced. This, in turn, depends on which circuit of the TV is under test, and whether or not the receiver can supply its own test signal.

Suppose, for example, you have a crystal demodulator probe tracing a signal through the i.f. amplifier of a TV receiver. If a normal TV-station signal can be traced, the display on the scope screen should look like Fig. 308. (In this case the scope sweep was set at 60 cycles, with internal sync, to show one vertical blanking and sync pulse.) On the other hand, if the TV signal is weak, the scope trace may be too small to be useful. The only solution here is to substitute an AM generator for the TV station, and drive enough signal through the TV i.f. amplifier circuits to give a usable indication on the scope without overloading the receiver circuits.

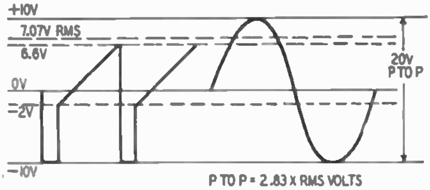


Fig. 307. Irregular waveforms are usually measured in terms of peak-to-peak voltages.

Even with comparatively strong generator signals, excessive hash from stray fields around the TV chassis may obscure the scope trace unless the probe is provided with a shielded output cable.

Crystal demodulator probes can be given various response characteristics, either for better waveform reproduction or greater sensitivity, or to provide a better impedance match for certain types of tests. For example, the video waveform in Fig. 308 can be seen in better detail (Fig. 309) by using a probe with less sensitivity but better frequency response. Fig. 309 is a much more accurate picture of the vertical blanking interval. However, the TV technician is usually more than willing to sacrifice fidelity of waveform to get increased sensitivity for probing in low-level circuits like the mixer and first-i.f. stage.

A crystal probe designed for maximum sensitivity may be ideal for simple signal tracing, but it will not be suitable for checking video-amplifier response, or observing critical waveforms in sweep and high-voltage circuits. Since the technician usually does not want to invest in several specialized probes for different applications, commercial probes generally represent compromise designs which will meet the greatest number of application requirements in a satisfactory manner.

I.f. gain and alignment

In simple signal tracing with a high-sensitivity crystal-demodulator probe, the technician is interested only in the relative change in the height of the pattern from stage to stage. Tests are usually made from plate to plate, rather than from grid to grid, since the plate circuits usually have lower impedance than the grid circuits, and are not loaded down to the same extent.

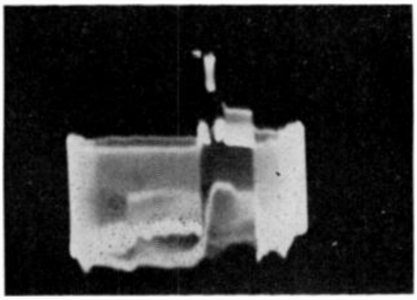


Fig. 308. Video waveform seen with crystal-demodulator probe.

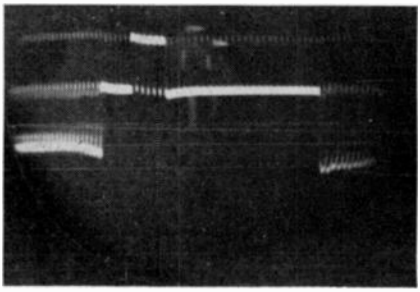


Fig. 309. Vertical blanking shown in detail.

When tracing a *sweep signal* through an i.f. amplifier for alignment, the scope should show a pattern like Fig. 310 or Fig. 311. (The over-all selectivity is poorer in the early i.f. stages, and the pattern occupies a greater horizontal span on the scope.) It is a common error to assume that a pattern like Fig. 310 always represents a true single-state or two-stage response. Actually, the true response of a single stage or a series of stages cannot be obtained unless the crystal probe is applied *across the plate load* of horizontal output grid for normal peak-to-peak voltage. If it is low, the trouble is in the oscillator. If the drive is normal, it indicates trouble in the horizontal output system (usually the transformer, if the tube is all right). This solves the problem of whether the boost voltage is low because of insufficient oscillator output, or because of other defects.

Some of these horizontal sweep voltages are high enough to damage the scope input circuit unless a suitable *high-voltage capacitance-divider* probe is used. (If you make a mistake and use a crystal probe or a low-capacitance probe at this point, you can probably kiss the probe and the scope input circuit goodby. A breakdown here may even burn out the flyback.)

A typical high-voltage waveform is shown in Fig. 315. Like the sync and other sweep waveforms, these kickback waves should have the shapes and peak-to-peak amplitudes specified by the manufacturer.

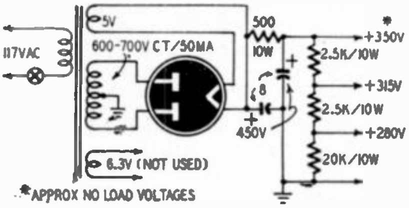


Fig. 314. Boost-voltage substitution unit.

Although crystal probes require no adjustments, a high-voltage capacitance-divider probe must be adjusted to provide the right input attenuation factor for each type of scope. Low-capacitance probes are also adjustable for minimum waveform distortion. Probe manufacturers supply the necessary instructions with their products.

Grounding the probe

Technicians sometimes overlook the importance of grounding the probe correctly. The probe must be grounded as close as possible to the signal take-off point in the receiver. Unless this is done there may be spurious patterns due to ground-current effects at high frequencies. Many technicians think they can dispense with the annoyance of connecting and disconnecting the probe ground in i.f. signal tracing simply by running a permanent ground lead from the scope case to the receiver chassis. In practice, a lead this long almost invariably causes erratic operation.

Grounding requirements are less severe with low-capacitance probes—in fact, with this type of probe the ground connection may sometimes be omitted—*but a high-voltage probe must always be grounded!* Unless the ground lead *on the probe* is clipped to the receiver chassis or B minus line the whole test system will be hot, and you may get a severe and possibly dangerous shock. Remember, even *before step-up* in the flyback transformer, there is a 6,000-volt pulse at the plate of the horizontal output tube!

When alternate light- and dark-gray vertical bars appear at the left side of the raster it may be difficult to tell at a glance whether the difficulty is due to ripple in the high-voltage supply, or to some other cause. But with a high-voltage capacitance-divider probe the technician can see the high-voltage ripple on his scope screen, and measure its peak-to-peak voltage. He is then in a position to discuss matters in practical terms.

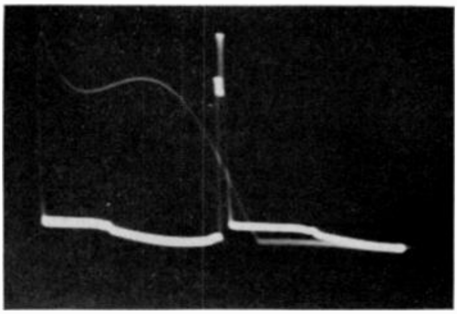


Fig. 315. Normal 6-kv flyback pulse at plate of horizontal-output amplifier.

Similarly, when there are slight rapid fluctuations in picture brightness, you may suspect intermittent leakage in a high-voltage filter capacitor. Of course, a substitution test will answer the question, but you can save time and difficulty with a capacitance-divider probe and scope. In the case of an intermittent leak in a high-voltage filter capacitor, the a.c. ripple across the capacitor will jump substantially during the brightness fluctuations. This test is more accurate than using a v.t.v.m. and high-voltage d.c. probe, because the pointer response of a v.t.v.m. is very sluggish compared with the inertialess response of the electron beam in the cathode-ray tube. These rapid voltage variations are almost completely smoothed out by the mechanical inertia of the meter movement in the v.t.v.m., but they are reproduced faithfully on the scope screen when you use a capacitance-divider probe.

A high-voltage capacitance-divider probe is almost an absolute necessity for checking the shape and peak-to-peak value of the voltage waveform at the plate of the horizontal output tube. This is a key test point in cases of sweep-circuit trouble, and the alert technician usually starts his trouble-shooting here. We cannot hook the scope directly to the plate of the horizontal output tube. The high a.c. voltage at this point would promptly burn out the scope input circuit, as the blocking capacitor in the average scope is rated at only 600 volts.

We cannot use a low-capacitance 10-to-1 probe at the plate of the horizontal output tube because the 6,000 to 7,500 volts peak-to-peak at this point will invariably flash across the probe network which is not rated for this type of testing. Some technicians make a practice of using a gimmick for this purpose, or merely hold the tip of the 10-to-1 low-capacitance probe *near* the insulated lead to the plate of the horizontal output tube. Although these expedients will show the a.c.-voltage waveform on the scope screen, they are worthless for checking peak-to-peak voltage, and in most cases we must know the exact value of this voltage to get a true picture of conditions in the circuit.

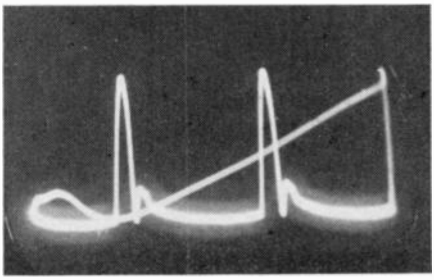


Fig. 316. Sweep waveform at plate of horizontal-output tube.

Another highly questionable expedient in making these tests is to use a high-voltage d.c. probe (actually intended for use with a v.t.v.m.) with the scope. This is even less satisfactory than a 10-to-1 low-capacitance probe, because the unshielded multiplier resistor in the high-voltage d.c. probe is highly susceptible to hand-capacitance effects and 60-cycle stray fields. Besides, the scope pattern changes with the slightest movement of the probe.

Spotting flyback defects

A typical normal waveform at the plate of the horizontal output tube is shown in Fig. 316. The shape of the wave helps the technician identify certain defects in the flyback transformer, and the peak-to-peak voltage shows the condition of the drive circuit.

For example, a large negative under-shoot in the waveform

(Fig. 317) indicates excessive leakage reactance between the primary and secondary windings of the transformer. This undershoot may cause Barkhausen oscillations, which show up as one or two vertical black lines at the left side of the picture.

If the transformer has other defects, the undershoot may be followed by a large voltage ripple. This will modulate the intensity of the beam in the picture tube, especially if the receiver has no high-voltage filter network. This form of intensity modulation appears as a series of light- and dark-gray vertical bars starting at the left side of the raster and becoming weaker toward the center. The same screen symptoms can arise also from several other causes, so the scope check of the horizontal output waveform saves valuable time by eliminating certain sources of trouble.

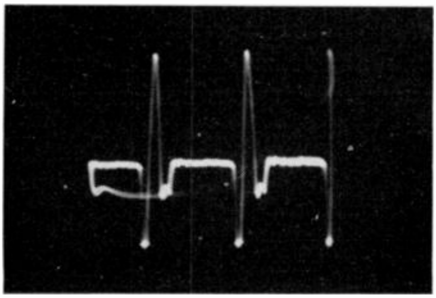


Fig. 317. Negative pulse indicates excessive leakage in flyback transformer.

High-voltage buzz

Experienced technicians have found many other uses for the high-voltage capacitance-divider probe. One of these uses is checking the output of the high-voltage filter system for *regulation buzz*. This should not be confused with sync buzz. Regulation buzz is caused by the limited current-output capability of most flyback and pulse-operated high-voltage systems—especially those that have voltage-doubler circuits. Since the picture-tube beam current is cut off for approximately 1,100 μsec 60 times a second by the vertical blanking pulse, it follows that the output voltage from the unloaded high-voltage supply will rise several hundred volts for the duration of the blanking pulse, and will then drop several hundred volts when the pulse ends and unblanks the screen. If the audio circuits and picture tube are adequately shielded, and if there are no serious faults in the audio system or FM-sound detector, this regulation buzz is ordinarily below the threshold of audibility. But TV receivers often develop buzz in service, and the test described must then be made.

Probe design

The essential elements of a high-voltage capacitance-divider probe are shown in Fig. 318. This type of probe is not frequency-compensated like conventional low-capacitance probes (Fig. 319). The chief reason for this omission is that high-voltage tests are made in horizontal sweep circuits where the highest frequency involved is only about the 10th harmonic of 15,750 cycles.

The input impedance of a high-voltage capacitance-divider probe is made as high as possible, and depends, of course, on the frequency. In order to withstand the high voltages encountered in TV test work, the first capacitor in the probe network (C1) is usually a high-voltage rectifier tube, such as a 1X2-A. The plate-to-filament capacitance of these tubes ranges between 0.85 to 1.5 μμf. Thus, the input impedance of the probe at the fundamental frequency of the flyback pulse (15,750 cycles) is approximately 6 megohms, and approximately 0.6 megohm at the 10th harmonic. Since the probe impedance even at the 10th harmonic is still much higher than the internal impedance of the circuit under test, the flyback pulse is reproduced essentially without distortion.

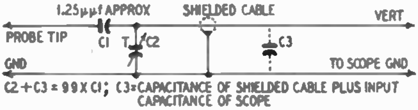


Fig. 318. Circuit of high-voltage capacitance-divider probe.

In addition to being able to withstand applied voltages up to 12 or 15 kv, this capacitor must have a physical shape that will not encourage corona discharge in the probe head.

A trimmer capacitor is provided so that the capacitance ratio C2/C1 can be adjusted to exactly 100-to-1. This attenuation factor makes it easy to measure peak-to-peak voltages. Once the scope has been calibrated for a given peak-to-peak deflection sensitivity, it is necessary only to multiply the scope reading by 100.

The calibrating trimmer capacitor is mounted in the probe head and does not have to be a high-voltage type. With a 100-to-1 ratio the calibrating capacitor need withstand only 1% of the signal voltage applied to the probe tip. The highest a.c. voltage likely to be encountered in TV work is about 15,000 volts, so that the trimmer capacitor need withstand only 150 volts.

Commercial probes are shielded to avoid hand-capacitance effects and stray-field pickup that may confuse the scope trace. Since the probe is calibrated for a given shielded-cable capacitance the calibrating capacitor C2 must be readjusted if the probe is used with different cables and scopes.

Other probe uses

A high-voltage capacitance-divider can give more accurate results than a 10-to-1 capacitance-divider probe in many circuits where the technician ordinarily uses a 10-to-1 type. It is much better, for example, for checking the waveform and peak-to-peak voltage at the plate of the damper tube or at the plate of the horizontal oscillator. The input impedance of the 100-to-1 probe is higher than the input impedance of the 10-to-1 probe, hence, imposes less loading on the circuit. On the other hand, it may be impossible to get usable vertical deflection in low-level circuits with the 100-to-1 probe.

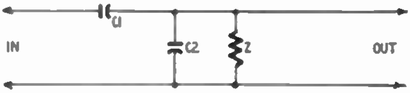


Fig. 319. Capacitance-divider probe circuit for signal tracing in low-level circuits.

Most typical service scopes have vertical-deflection sensitivity of approximately 0.02 volt r.m.s. per inch at full gain, corresponding to a sensitivity of 0.057 volt peak-to-peak per inch. Under these conditions the 100-to-1 probe will provide 1 inch of deflection with an input signal of 5.7 volts peak-to-peak. If the signal voltage is less than this, the 10-to-1 probe will probably have to be used.

Although it would be possible to provide an individual shielded output cable for each probe, the present trend is to provide a single universal shielded input cable which may be used with any one of an entire kit of probes.

Chapter 4

Servicing TV in the Home

THE outside TV service technician depends on speed of servicing either to make repairs or to pull the set after a quick check of 15 or 20 minutes has not produced results. This chapter is intended to give a practical approach to fast servicing with the limited test equipment that is carried on outside calls.

Necessary equipment includes a complete set of TV tubes, hand tools of the usual type, and in addition, a set of Allen and spline wrenches, Phillips head screwdrivers, and socket wrenches. A lack of these additional tools sometimes prevents doing a simple job such as locking down a channel indicator dial and makes a return call necessary.

The usual service troubles and the quick check method can be broken into various categories.

Sound but no pix or raster

The ion trap may be responsible, but usually it will not slip out of place except in a new installation where it wasn't properly positioned originally. Sliding it along the neck of the tube and rotating it will immediately settle that problem. *Be absolutely sure you return it exactly to its original position,* if moving it did not clear the trouble.

A quick check of the high voltage is to pull the kinescope high-voltage lead from its socket and check for an arc from the high-voltage lead to a screwdriver having an insulated handle. An arc here of sufficient intensity (as judged by comparison with other sets) indicates presence of high voltage and points toward a lack of screen-grid voltage or a defective picture tube, assuming of course, that the filament is OK as indicated by a glow in the neck of the tube.

Remove the socket from the picture tube and check the screen-grid voltage to ground. If the reading is between 200 and 300 volts, the picture tube is to be suspected since the high voltage is present, the tube is lit, screen voltage is correct, and the ion trap is correctly set. Any further cause would require bench servicing of the set. An additional check would be to touch the high-voltage lead to the h.v. anode button (glass tubes) or to the shell (metal tubes). A fair-to-good sized spark indicates that the picture tube is working.

If the high voltage is weak or missing, turn the set off and open the high-voltage shield. Check the fuse. If the fuse is good, or if there is none, replace both the rectifier tube and the horizontal output tube with new ones. High voltage now present indicates that one or both tubes are defective.

If no high voltage appears, replace all the tubes in the horizontal sweep circuit going as far back as the oscillator. If high voltage is now present, put back the old tubes one at a time to locate the defective one. Thus in two steps you have or have not located your trouble and know where you stand.

If, with a complete set of new tubes, there still is no high voltage, further trouble in the high-voltage transformer and associated components requires removal of the set. This procedure is based on a time allowance of 15 to 20 minutes and necessarily eliminates further checks which in time would locate the trouble.

Sound and raster but no pix

After the set has been on a few minutes, make a quick check of the video i.f. tubes, detector tube, and video tubes to see if they are warm. Replace any tubes that feel cool and, naturally, any that are not lit.

Check the antenna leads. Work the contrast control back and forth, and tap all of the tubes. Wriggle the kinescope socket back and forth to assure contact to the grid.

Chances are that this trouble is due to a defective tube in the picture i.f. or the video stages. Check the tubes in the tuner head in spite of the fact that you are receiving sound. If there are no results, further servicing requires removal of the set.

Pix and brightness, no sound

Run your hand through the sound i.f., detector, and audio amplifier stages to see if the tubes are all warm. Starting with the audio output tube, pull out all the tubes and push them back into the socket one at a time. A loud plop or click indicates that the tube and its circuits are probably good.

If the set has a radio and common amplifier, the radio can be used to check the audio stages. A defective speaker or output transformer may be the trouble, but a defective output tube is more common. Tubes are also a common source of trouble in the i.f. stages.

Poor linearity, horizontal or vertical

Complaints of this type can be checked by manipulating the controls on the rear apron as they are often the result of the set being poorly adjusted or turned by the customer. Position the picture at its best with the ion trap (if any), the focus coil, and the yoke before adjusting the vertical linearity. As large a mirror as you can carry with you is necessary for this. Do not depend on the customer to supply you with a mirror because many times you will get a small 2 x 3-inch pocket mirror.

Adjust the picture vertically with a combination of the height and vertical linearity controls. A little practice at this will produce results.

Next adjust the picture horizontally the same way. If there is no further servicing problem, you should get a good picture in a short time. A few extra minutes spent with this adjustment will give you a satisfied customer.

If the picture lacks width, changing the horizontal output tube or the low-voltage rectifier tube or tubes, may make an improvement, otherwise this is a job for the service bench.

No sound, pix, or raster

If all the tubes are lit, a low-voltage trouble is to be expected. Check and replace all the low-voltage rectifiers. If the low-voltage rectifier plates are excessively hot, move the hand around the set to see if there is an excessively hot tube. If you find one, pull it immediately and note if the rectifier is cooling off. If this does not produce results, a shorted filter capacitor or grounded choke may be the trouble.

If everything seems to be running fairly cool, a voltage divider or other circuit may be open. If it is a voltage divider the trouble can be fixed on the spot if the power supply can be removed and inspected easily. Otherwise, tracing the divider network in a single-chassis set is better left to the bench.

Poor sound on one channel

Remove the channel selector and fine tuning knobs and trim the oscillator adjustment from the front (this is not possible on all sets). Do this very carefully because a large change in the oscillator adjustment will require trimming all of the channels on some tuners. Always check all channels when trimming the oscillator adjustment to be sure that you have not done more harm than good.

No pix, no sound, but raster

Check the tubes in the tuner.

Interference problems

The answers to this are very indefinite unless a great deal of time is spent in locating the source of the interference and curing it at that end. Read Chapter 13.

Interference sometimes can be eliminated by connecting a piece of 300-ohm line to the antenna terminals, and, starting at the end away from the set, shorting the line every few inches. If the interference disappears at one point, clip the line and short it. Check the other channels for possible attenuation caused by this stubbing.

Conditions that the fine tuning control and oscillator adjustment will not clear up are probably due to misadjustment of some of the tuned circuits and are best left to the service bench.

If the signal level is weak on one station, wrap a piece of tinfoil around the 300-ohm line near the antenna terminals and slide it outward. This does not work on coaxial cable. Note the point where the picture brightens and leave the tinfoil clipped at this point if it does not cause attenuation on other channels.

In most service organizations the actual repair of the set is not as important as the ability to determine whether it can be repaired outside by the service technician or whether it must be removed to the shop. The procedure given in this chapter suggests a quick and efficient basis for making this decision.

The service technician will run into many different situations, such as different types of power supplies, intercarrier, etc., but this information covers a large number of the more popular present day sets.

Chapter 5

TV Control Troubles

TV RECEIVERS often leave the factory with some of their controls giving best results when set close to one end of their range. Slight aging of tubes or components can then cause the correct constants to fall outside the range of these components (usually variable resistors). Then customers are dissatisfied and extra service calls result.

All the controls (especially the "user-adjust" ones at the front of the receiver) of course should reach correct settings at approximately the center of their ranges. (Incidentally, some of the control settings—such as focus—vary with the line voltage, and the service technician will find it worth while in these cases to try to duplicate the customer's evening line voltage by using a Variac when adjusting these controls.)

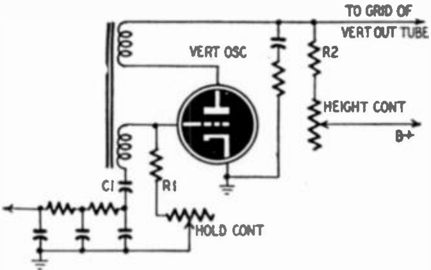


Fig. 501. A type of vertical oscillator.

This chapter will be confined to controls on modern magnetically deflected sets. Some of the older sets had circuits not used today. For example, the potentiometer as a horizontal drive control has been largely displaced by the variable trimmer capacitor.

Some manufacturers still use a variable trimmer-type capacitor as a width control.

Before making any changes in the control adjustments, check all parts in the circuit! Some component may be going bad, throwing the adjustment off.

Vertical hold control

If the picture does not sync in vertically or syncs in at the end of the control's range, first try replacing the vertical oscillator tube. If this makes no difference, check all components as above, especially the resistance of the hold control and the resistor (R1) in series with it (Fig. 501). If everything is approximately normal, increase or decrease the series resistance. If all or most of the resistance in the hold control is used to get the best setting, obviously the series resistance should be increased, and if the control is "all out" for best results, it should be decreased. Try different values till the hold control syncs in near the center of its range. In some cases, the value of C1 may be incorrect. This will affect hold range, too.

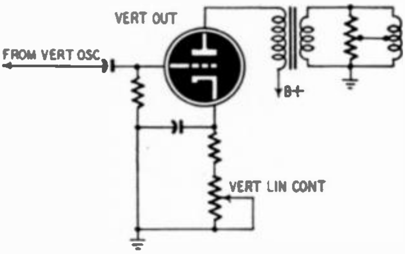


Fig. 502. Basic vertical output circuit.

Vertical height control

Values of parts in this circuit being normal, check line and B-voltages. Too low voltages can cause insufficient height (and width). Correct these troubles if present. If height is still insufficient, increase the resistor R2 in series with the height control.

Notice that the height control has its largest effect on the bottom of the picture. This is normal. The vertical linearity control (Fig. 502) usually has its greatest effect on the top of the picture. Before changing the resistor in series with the linearity control check the vertical output tube by substitution.

Horizontal hold and lock

Read Chapter 10, "Servicing Horizontal Locks." Follow manufacturers' instructions for adjusting the circuit. Since almost any component in the horizontal oscillator could be responsible for inadequate control range, the components check is especially important. Try replacing the horizontal oscillator tube first, then check the value of the hold control and its series resistor. Next in line for checking are the coils and capacitors.

Width control

Insufficient width with the control slug all in may be caused by low line voltage, poor tubes, low B voltages, or incorrectly adjusted horizontal drive control (Fig. 503). If there is not enough width with all the voltages correct, try placing a paper bypass capacitor across the width coil. Use the smallest that will do the job, as the bigger it is, the lower the high voltage will be. A typical value would be .005 µf. Disconnect width coil from circuit.

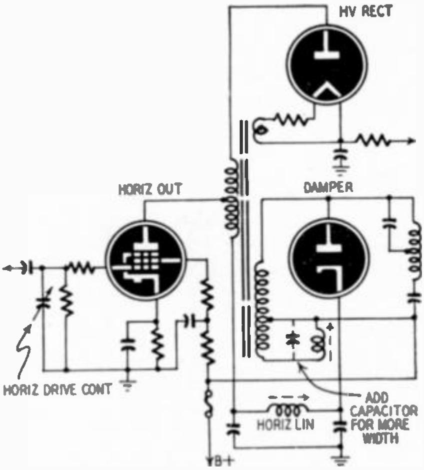


Fig. 503. A conventional flyback circuit.

Horizontal linearity

This control usually has a limited effect on the picture. It will usually suffice to just leave it alone when adjusting the set. If adjustment is necessary, remember that the width and horizontal drive controls may have more effect on horizontal linearity than the linearity control itself. Using a test pattern, adjust all three controls alternately till linearity is good.

Focus controls

If a set comes into the shop with poor focus or with correct focus at one end of its rotation, check the voltage across the coil while rotating the control toward the end where best focus is obtained. If the voltage increases, the coil has too little current through it; if it decreases, it has too much.

Check the coil's resistance. It may be partly shorted. If O.K., too much current may be due to high voltage, caused by having the drive control trimmer set too far out. If there are no drive lines in the picture throughout the pull-in range of the horizontal hold control, the drive adjustment is probably O.K. and it will be necessary to check further.

Lack of current through the focus control may be due to decreased current through stages whose return path is through it. Try replacing the audio-output tube, the horizontal-output tube and the low-voltage rectifier, in that order. Other tubes may be guilty—as may be other components. Irregularities in the values of horizontal oscillator components may cause poor focus, along with decreased brightness and decreased picture width. If everything seems O.K. but the position of correct focus is near one end of the control setting, increase or decrease the resistance in series with the focus control (Fig. 504) or shunt an additional resistor across the coil.

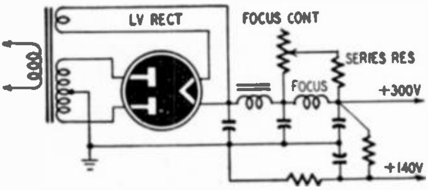


Fig. 504. Focus circuit used in some sets.

Remember also that poor focus can be caused by a bad or gassy picture tube (though this is not common). In sets using a PM focus unit, poor focus may be due to too strong or too weak magnets. Where the unit is doubted, check with an exact replacement.

Brightness control

If the brightness control cannot be turned far enough up or down (or both) check it and other resistors between the video amplifier output and the picture tube before going ahead with a general components check. In sets where the video output is coupled through a d.c. resistance path to the cathode-ray tube, the resistor values may be critical.

In some sets the control's brightest setting may be limited excessively by design. Try a slight decrease of the resistance between the control and B-plus, but don't overdo it! Lack of brightness may be due also to incorrect ion trap adjustment, which may also damage the tube.

Centering controls

If a set uses electrical centering controls and the picture cannot be correctly centered with them, it will be necessary to adjust the focus coil and possibly the ion trap and yoke. Turn both centering controls to their center setting and shove the yoke as far ahead as it will go. Adjust the ion trap and then locate the focus coil by moving and tilting it till the picture is centered. After adjusting the focus control be sure to recheck the ion trap for maximum brightness.

Do not use the ion trap to eliminate shadows. Do it with the focus coil. If shadows persist and it is impossible to get rid of them while keeping the picture centered, try rotating the tube a little.

Sets with no electrical centering controls and without the centering attachments or levers commonly found on the best modern receivers are harder to center, but the job can be done with care and patience. Remember that when the focus coil is moved the electron beam moves in a line perpendicular to the direction of movement.

Before attempting to center the picture it is often good to posision the focus coil or magnet assembly so that its inner surface is equidistant from the outside of the neck all the way round.

Other controls

If you cannot get enough volume or contrast when these controls are all the way up it is usually not the fault of the control but of some other component or adjustment which is preventing the video or audio signal from being amplified normally.

Weak sound or video may be due to a poorly adjusted fine-tuning control, poor alignment, and of course, to weak tubes or defective components.

From the customer's point of view, the fine tuning control settings are most important ones on the receiver. It is essential that they be adjusted so that stations come in best at or near their center settings. This is a question of oscillator adjustment and front-end alignment, and is covered in great detail in manufacturers' service data.

Control adjustment may seem a minor part of servicing, but it is very important in cutting service costs on future calls by reducing a situation that might otherwise call for pulling the chassis for a simple adjustment. And centered adjustments in controls accessible to the user are unparalleled prestige builders!

Chapter 6

High-Voltage and Boost-Voltage Headaches

THE vast majority of troubles of this kind (high-voltage or otherwise) will be found due to defective, weak, or gassy tubes. Obviously the best set made will not operate with bad tubes, and no competent technician will start ripping a set apart before he has assured himself that the tubes are O.K., either by using a tube checker or by replacement of the suspected tube.

If tube replacement does not solve the problem, the logical procedure is to check for the presence of high voltage at the picture tube, and then work back through all preceding circuits. Typical troubles and their remedies follow:

Shorted high-voltage capacitors

This is rare but does happen, especially in the long plastic capacitors used in Philco, Stromberg-Carlson, and others. Replace, of course.

Defective or changed-value resistors

Usually output is through a 500,000 ohm to 1-megohm filter resistor. Replace with heavier unit or with lower resistance. The filament winding for the rectifier tube often has a 2- or 3-ohm resistor in series with the 1B3-GT. These often change value. These resistors are also responsible for *picture blooming*. Keep these filament resistors away from the chassis or cage. They are "hot" and will arc over if given a chance. A common cause of trouble in high-voltage doubler and tripler circuits is the charging resistor running from the filament of one 1B3 to the plate of the other. This resistor, generally 2 megohms, is shown in Fig. 601. An inexpensive and permanent repair is to replace it with three 680,000-ohm, 2-watt resistors in series. Be careful in solder-ing the resistors together and in making the circuit connections. Make round smooth joints and solder with short leads. Keep the resistors well away from other units and especially from the 6BG6. These can arc over to the 6BG6 and actually burn a hole in the tube.

Ordinary troubles in the horizontal output stage would be:

Blown fuse

The ¼-amp fuse often burns out. Replace with same size fuse, Slo-blo type. Solder the fuse leads to the terminals of the blown fuse when replacing the fuse. This makes a permanent job and does not take up space. If the fuse is under the chassis, replace so it is topside. This will save chassis pulling later.

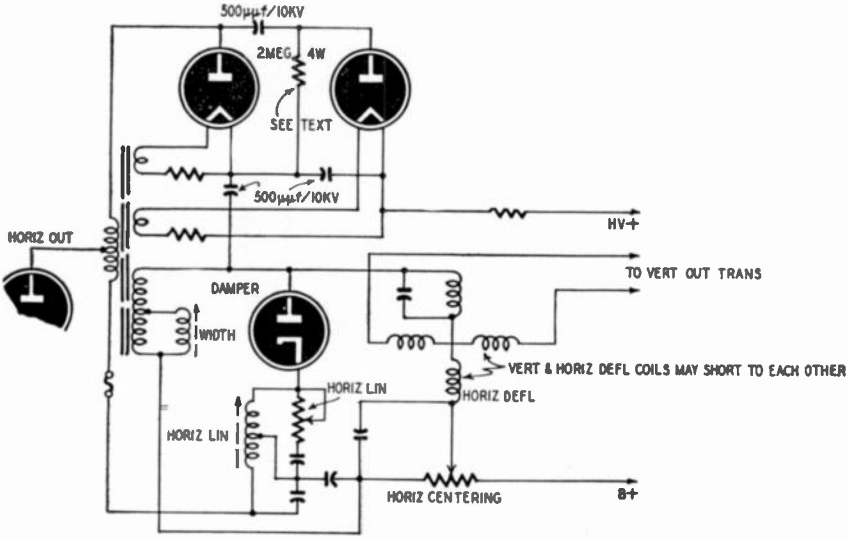


Fig. 601. Typical damper and high-voltage doubler circuit.

The cathode resistor of the horizontal output tube often changes value or burns out. This unit should be at least 2 watts. Use two 2-watt resistors in parallel to make a good heavy-duty 4-watt resistor.

Defective flyback or r.f. coil

An internal short sometimes can be seen by turning off the lights. A tiny pinpoint of white light will give it away.

Shorted or arcing lead

These can be cured by painting with high-voltage dope or by placing additional insulation between the leads.

And now we come to the damper circuit. In most sets, the damper tube actually supplies the plate of the horizontal output tube with some of its plate voltage. Obviously, if the damper tube is weak or defective the high voltage will be out or low. An open or grounded linearity coil will also stop the high voltage. Linearity, width, and ringing coils can be shorted to the slug. The result is a dead B-plus short with red-hot 5U4's or blown fuses.

Common sources of trouble are the two capacitors across the linearity coil. Although comparatively rare, vertical and horizontal deflection coils can short to each other, besides shorting internally.

Oscilloscope methods

Tracking down lack of high-voltage sweep in the earlier stages with an oscilloscope is a simple matter. If the sawtooth generator is operating improperly, or not at all, the trouble may be in the Synchrolock coil, the horizontal blocking-oscillator coil, the ringing coil, or any of the various methods used to get the initial sawtooth charge. Of course open or shorted capacitors or changed-value resistors anywhere in those circuits should not be too difficult to track down. Quickest way to check the oscillator is to measure its bias with a v.t.v.m. Oscillator plate voltage measurement means little.

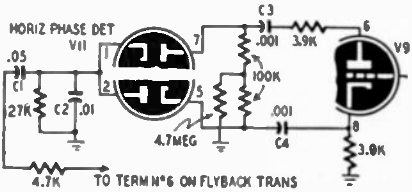


Fig. 602. Loss of high voltage can be due to unrelated circuits.

If the oscillator is working, the next step is to check the signal through the coupling capacitors, grid resistors, and input circuits right up to the output tube. Put a scope across the discharge capacitor. A sawtooth having correct peak-to-peak value indicates oscillator and discharge circuits are O.K. Follow signal to control grid of horizontal output tube. It should be trapezoidal at this point. Always check horizontal drive capacitors and circuits as well as horizontal drive variable resistors.

An instance where an apparently unrelated circuit can cause loss of high voltage is shown in the phase-detector circuit of Fig. 602.

Capacitors C2, C3, and C4 break down often. These immediately kill the high voltage. A breakdown of C1 will burn out the 27,000-ohm resistor, too. This resistor is connected across C2. Another cause of intermittent high voltage is the capacitor sometimes connected across terminals 4 and 5 of the high-voltage (flyback) transformer.

Servicing high-voltage intermittents can be quite a headache. The real rogue in this picture is the 1B3 or the 1X2-A. The tubes become intermittent and if in doubt, replace same. Don't fool around—replace both the high-voltage rectifier and also the horizontal output tube.

Another source of intermittent picture loss is a loose connection at the base of the picture tube. If the tube fails to light, check the socket connections and the tube base. Quite often you can effect permanent cures by resoldering the pins. Lay the set face down on the floor. Use a cushion or a couple of books to protect the cabinet or knobs. Now you can resolder the tube base pins and the solder will run down and make a very good contact.

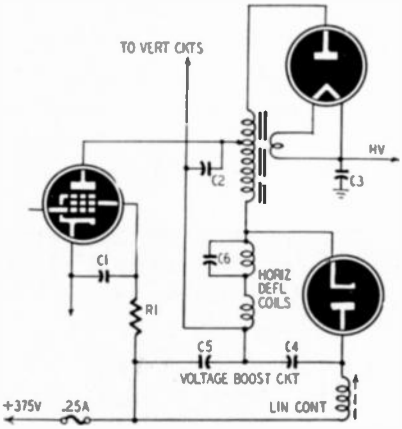


Fig. 603. Voltage boost circuit in direct drive sweep system.

Narrow pictures that cannot be widened may be caused by shorted turns in the flyback transformer or in the deflection yoke. If in doubt try a good yoke or transformer.

Voltage boost troubles

The voltage boost circuit of the horizontal flyback system is a simple circuit consisting of a pair of capacitors and a coil. These are connected to the cathode of the damper when the horizontal output transformer has a secondary winding for the deflection coils. On occasion, however, the boost circuit may be in the *plate* side of the damper as shown in Fig. 603. This is a partial schematic of the *direct drive* type of horizontal output system. in which the deflection coils are in series with the transformer primary. The only secondary winding is for the filament of the high-voltage rectifier.

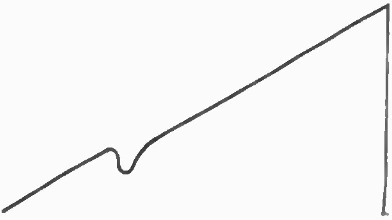


Fig. 604. Transient oscillation in sweep.

Despite the simple circuit, the voltage boost system contributes a good percentage of the many troubles which occur in horizontal sweep stages. A gassy or shorted rectifier can mean raster loss, while defective capacitors and coil affect linearity. Defective tube and components can also produce *white vertical bars* on the screen which denote insufficient damping of the transient oscillations developed during collapse of the fields in the yoke during retrace.

Fig. 605. Transient oscillation as it appears on the screen.

The transient oscillations occur at the beginning of the sawtooth sweep and thus are usually positioned near the left of the screen. They interrupt the gradual incline of the sawtooth sweep one or more times for each line traced on the screen. A single dip as shown in Fig. 601 means that the forward trace is slowed down, then reversed as the sawtooth dips. When the waveform comes out of the dip the beam within the tube moves across the the screen again. This reversal of the beam at the beginning of the trace makes this section of the scan brighter, and successive horizontal trace lines produce the vertical bar down the screen.

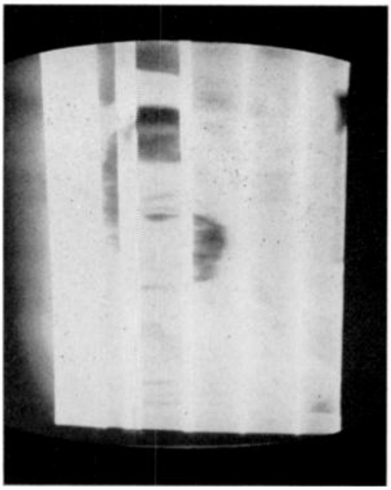


Fig. 606. Photo of multiple-bar interference.

This appears (in exaggerated form) in Fig. 605. Often the bar (or bars) may be just barely visible. (Fig. 605 has been retouched for better reproduction.)

Poor damping

If damping is exceptionally poor, the bar interference becomes more visible. Since the bar is caused by poor sweep linearity a similar symptom may be observed if the horizontal output tube or circuit develops defects. If, for instance, the drive control is advanced too far, sweep linearity is affected and a bar can be produced. Usually, however, it is located nearer the center of the screen and is often the result of a misadjustment in both linearity and drive controls.

If components in the boost circuit open, much more serious symptoms are produced. Fig. 606, for instance shows the multiple bar interference which occurs when C4 of Fig. 603 opens.

Besides the bars, horizontal shrinkage and foldover at the left are also present.

Initial trouble-shooting procedures consist of replacing the damper tube. If this fails to correct the defect, check the linearity coil for continuity and shorted turns, and check capacitors (C4 and C5 of Fig. 603) for leakage and off values. If a capacitor checker isn't available, try direct substitutes with values agreeing with the schematic. Off-value capacitors are a common cause of poor linearity and white vertical bars. Unless the capacitors are open, bridging with new ones is a useless test. If the capacitor is shorted, it also shorts the shunting capacitor. If leaky, the leak still exists despite the shunting capacitor. If off value, the shunting capacitor adds additional capacitance beyond the required amount for normal function of the circuit. Disconnect the capacitor, then try the known good one.

Chapter 7

Picture Tube Circuit Troubles

THE most expensive single item in a television receiver is usually the cathode-ray tube. This discourages the average service shop from carrying spares. The many different types used in television receivers further complicate the situation.

Therefore it is very important that the television service technician know how to isolate troubles that might be caused by a defective picture tube. He must know the various picture tube circuits currently in use. He also must understand the adjustments that directly affect the cathode-ray tube and know how to make these adjustments.

The technician who does not have the "know-how" to diagnose picture tube troubles is at a distinct disadvantage if, for example, he is called upon to service a 19- or 20-inch set located in a difficult position (on a wall) in some public place, as a wrong guess that the picture tube is defective will result in a great deal of unnecessary work without fixing the receiver.

Some of the following troubles are obviously caused by picture tube failure of one sort or another. There are, however, several conditions that could be the fault of some other component or circuit in the receiver. The important thing is to determine whether the picture tube is at fault or a contributing factor.

Ion spots

The round dark spot that appears in the center of the raster in Fig. 701 is an ion burn or ion spot. Such a spot can exist in any electromagnetic-type tube that does not use some means for preventing it.

As shown in the figure, the spot is at the center of the screen and is about the size of a fifty-cent piece. These ion spots—or burns as they are sometimes called—are a result of gas ions forming a cluster on the screen of the cathode-ray tube. With magnetic deflection the amount of deflection is inversely proportional to the mass of the object deflected. Ions are many times heavier than electrons and so are not normally deflected. Thus they form the cluster at the cathode-ray tube face, with the resultant ion spot.

A certain amount of misinformation concerning ion spots has found its way into the field. The following presentation of facts concerning ion spots may help to offset some of it.

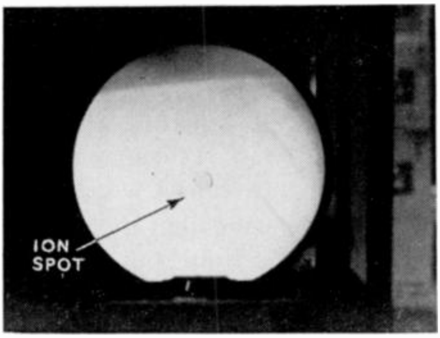


Fig. 701. Ion burn appears as small round spot at center of the raster.

Ion spots do not occur in electrostatic deflection tubes. (In electrostatic tubes the ions and electrons are deflected equally.)

Ion spots do not occur in metal-backed (aluminized) tubes. Due to the low velocity at which ions travel as compared to electrons, they do not penetrate the metallic layer as do electrons.

Ion spots *do not* result from the afterglow that occurs on many sets immediately after they are turned off. (In many cases technicians have advised their customers to turn the brightness to maximum before shutting off the set. This eliminates the bright spot at the center of the screen which was thought to produce the ion burn.)

The ion spot is more noticable if the high accelerating voltage is *lower* than normal. (This reduces the velocity of the electrons and keeps them from penetrating the ion cluster.) In other words, if the ion spot is visible at 8 kv and the high voltage is raised to 12 kv, it may no longer be present. However, this is not practical, since the higher voltage reduces picture size.

An ion burn is visible only when a raster is present. Thus, if the screen is actually burned due to a sweep failure, the burn is visible whether or not the raster is present.

Ion burns do not normally exist in tubes using ion traps. However, there have been a few cases of ion burns in such tubes in cases where the ion trap was improperly set.

Ion trap adjustment

Adjustment of the ion trap magnet (or beam bender, as it is sometimes called), although simple, is exacting. Follow the procedure exactly as outlined below. In some cases, even though the procedure is followed carefully, the desired results may not be obtained. Originally established for adjustment of single-magnet beam benders, this procedure may be used equally as well with the double-magnet beam benders.

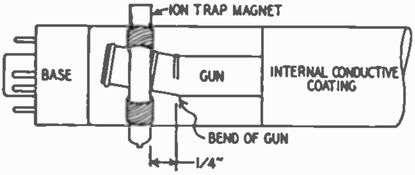


Fig. 702. Correct starting position for trap magnet.

Make all initial ion trap adjustments at the lowest possible setting of the brightness control. The correct position for the ion trap magnet is shown in Fig. 702. With the base end of the gun pointing up as shown, slide the magnet over the neck. The north pole should be to the left adjacent to pin No. 12 and the south pole to the right adjacent to pin No. 6. The magnet should be placed about ¼ inch in back of the bend in the gun for the first adjustment.

Rotate the ion trap magnet about an eighth of a turn each way and slide it back and forth along the neck, stopping at the point of maximum brightness. Keep reducing the brightness as the system is brought into line to avoid damage to the tube. After alignment at low brightness, make a final adjustment with the brightness control set to where the raster just starts to "bloom." At this point the raster begins to expand rapidly or to defocus.

If no raster appears and all other conditions are normal, the magnet polarity may be reversed. Rotate the magnet through half a turn around the neck. Then make adjustments as before; if there is still no raster, try another magnet.

Do not leave the tube on any longer than necessary when making preliminary adjustments. If the electron beam is operated at high intensity before being brought into line with the ion trap magnet, it may damage the internal structure of the tube. For the same reason, it is important that the final adjustment of the magnet be made for maximum screen brightness. Failure to do this may result in burning the limiting aperture or the release of gas into the tube.

Sometimes it is possible to get two brightness maximums when moving the ion trap magnet back and forth along the neck. The correct position is the one closer to the base of the tube. The second maximum is usually found when the magnet is close to the case of the focus coil. The magnetic shunting effect of the focus coil case on the ion trap magnet changes the field strength so that a brightness maximum is obtained in this incorrect location. Tubes should not be operated at the second maximum since spot centering is disturbed and there is a possibility of tube damage.

If the above procedure does not produce the desired results, investigate these possibilities:

The magnet may be bad. If it has been dropped, it may be completely demagnetized. To check, simply bring the magnet into contact with some magnetic metal and note if there is any attraction.

If the magnet has some magnetism, it may not be strong enough. If this is the case, a very dim raster will be present, accompanied by a bluish or greenish glow from within the electron gun. This glow indicates the electron beam is striking the limiting aperture disc instead of passing completely through the aperture. This condition may damage the tube.

No raster, normal sound

When this occurs, the owner of the television receiver invariably wants to know if his picture tube has gone bad.

Check to see if the filament of the picture tube is lit. If not, the cause may be one of the following:

The cable connector attached to the base of the CRT may be defective. Press the cable socket against the tube base to make sure that the connection is good. Carefully jiggle the leads in the cable that supply the filament power.

Check the filament continuity of the picture tube. Obviously, an open filament means that a new cathode-ray tube is necessary.

If these two checks reveal no defects, measure the voltage at the cable terminals. If the picture tube is operated in parallel with the other tubes in the receiver and they are all lit, then the trouble must be due to defective wiring. In some receivers a separate transformer or a separate winding on the power transformer is used for the cathode-ray tube filament. In these sets the trouble could be due to the separate transformer or the winding of the power transformer being defective.

Check for the presence of adequate high voltage. The best method, of course, is actually to measure the high voltage with a meter. Certain electronic-type voltmeters have high-voltage probes that can be used for measurements up to 30 kv. If a meter is not available, the presence of high voltage can be checked by drawing an arc from the high-voltage lead with a well-insulated screwdriver. The high-voltage lead should not be shorted to ground as it may damage the power supply. Simply bringing the insulated screwdriver in light contact will cause arcing if high voltage is present. If you get a spark when you touch the h.v. lead with a screwdriver, but do *not* get a spark when you touch the h.v. lead to the h.v. button of the picture tube, then you have no conductivity through the picture tube. Substitute a new picture tube. If trouble still exists, then check brightness control circuit and coupling from video amplifier. Obviously, if there is no high voltage or if the high voltage is very low, the picture tube is immediately eliminated as the cause of the trouble, as it is very seldom that two troubles occur simultaneously.

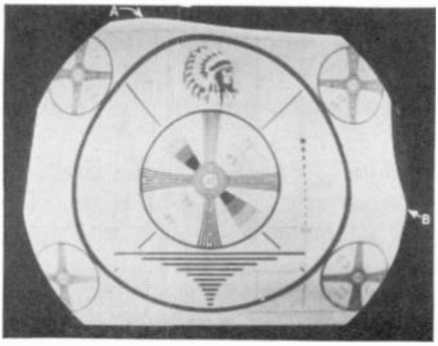


Fig. 703. Metal tube may distort the picture if shell is magnetized.

Check the ion trap adjustment. This possibility, of course, depends upon the conditions under which the receiver is tested. If the receiver is being operated for the first time in the field or if it has been moved from one place to another, then the ion trap could be at fault.

Measure the d.c. voltage between the grid and the cathode of the cathode-ray tube. Most cathode-ray tubes will cut off if the difference in potential between grid and cathode of the cathode-ray tube is 50 volts or more (grid negative with respect to cathode.)

If the difference in potential between the grid and cathode is more than –50 volts and cannot be lowered by the brightness control adjustment, obviously something is wrong with the circuit and not the picture tube.

Distorted raster

Distortion of the raster as shown in Fig. 703 is caused by a tube defect often mentioned in the literature but seldom found in the field.

The photograph is of a 19AP4 metal-cone tube, a portion of which was magnetized. The raster is pulled up in the left corner at point A and to the side at point B. Points A and B constitute the poles of a bar magnet, the bar consisting of a section of the metal cone.

This magnetization of the metal cone is a result of close contact with a strong magnetic field. The most likely strong magnet to be encountered is the magnet of a PM speaker. Obviously, if a metal-cone tube is placed on a workbench, it should not come in contact with a speaker field or any other source of magnetization.

If this condition occurs, the cone may be demagnetized by placing the magnetized portion in a strong a.c. field. The magnetized part can be located with a compass.

An a.c. field capable of demagnetizing the cone may be produced with a focus coil. Remove the case of the focus coil and apply a.c. to it through a Variac. The Variac is used to prevent excessive current flow through the focus coil with resultant overheating of the coil.

To demagnetize the cone, energize the coil and move its flat side over the magnetized area. Do not interrupt the a.c. while the coil is near the cone. The cone should be well out of the field of the coil before the coil is de-energized.

Unstable sync

Indications of unstable sync vary according to the type of sync circuits used. If the horizontal sync circuit is a simple blocking oscillator, the picture will tear horizontally. Strips of the picture will tear out to the right. This condition is characteristic of the blocking oscillator circuit when no special a.f.c. circuit is used to control its frequency. It is also possible that the picture will jump vertically, indicating loss of vertical sync.

On sets using a horizontal a.f.c. circuit, the picture will try to pull out of sync horizontally, but the effect will not be the same as that for the simple blocking oscillator. The vertical sync will also be affected.

If this condition is a result of grid-cathode leakage in the picture tube, advancing of the brightness control will eliminate the sync instability. With this trouble, the cathode-ray tube is usually the last thing considered and even then the technician may not be certain exactly how the cathode-ray tube affected the sync.

Fig. 704 is a circuit of the type in which the above-mentioned symptoms would be caused by the C-R tube.

The sync take-off point is at the picture tube grid. The 6AL5 functions both as the d.c. restorer and sync take-off tube. The composite video signal is applied to the 6AL5 cathode, and at this point the video signal is black negative; that is, the portion of the signal that corresponds to black in the picture extends in a negative direction. The sync pulses also extend in the negative direction.

In normal operation, this black negative signal drives the cathode negative and permits the diode to conduct. However, this tube conducts only during the most negative portion of the signal; i.e. during the sync pulses. In this manner the sync signals are removed.

Let us assume that leakage exists between the grid and cathode of the picture tube. When adjusted for beam cutoff, the brightness control is so adjusted that the potential of the cathode is about +50 volts. However, with the leakage path between the grid and the cathode, some of this voltage appears at the 6AL5 cathode. In some cases this voltage may be as high as +30. This voltage biases the 6AL5 so that the applied signal must overcome this voltage before the tube will conduct. Thus, most of the sync is lost and the hozizontal and vertical sweeps are unstable.

Advancing the brightness control will restore the sync to a stable condition, but this will result in very poor contrast due to excessive brightness. Increasing the brightness results in running the cathode toward ground and thus reduces the voltage at the cathode. If the cathode voltage is zero, the 6AL5 will have no bias due to the grid-cathode leakage.

A number of receivers use such a circuit arrangement. Similar indications can be expected in any other receiver if there is a d.c. circuit between the grid of the picture tube and the sync separator tube.

No brightness control

If the brightness control fails to affect brightness there may be a heater-cathode short or leakage in the picture tube. In many receivers, the brightness control is located in the cathode circuit and one side of the filament goes to ground. For this reason, a heater-cathode short will short out the brightness control. Fig. 704 shows such a circuit.

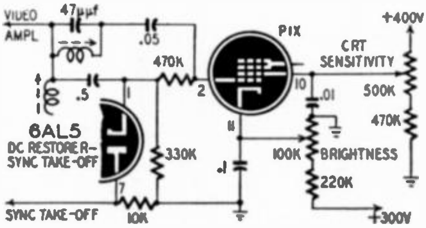


Fig. 704. Grid-cathode leakage may cause sync instability in circuits like this.

This condition sometimes can be cleared by lightly tapping the base of the cathode-ray tube. It is also possible to burn out the short by applying d.c. between the heater and cathode.

A positive solution (other than replacing the tube) is to use a separate filament transformer to supply the cathode-ray tube heater.

Disconnect the filament circuit from ground and its usual filament supply and connect it to the secondary of a 6.3-volt, 0.6-amp transformer. The transformer will permit tying the heater to the cathode. With the filament isolated from ground, the brightness control functions normally. Read Chapter 8 for a detailed description of brightness troubles.

Chapter 8

Brightness Troubles

Loss of control over brightness means simply that it is impossible to dim out the screen at any position of the brightness control.

Brightness of the raster or picture depends on the speed of the electrons in the beam striking the screen of the picture tube, and the number of electrons in that beam. The speed of the electrons is determined by the amount of high voltage. The number of electrons depends on the grid bias level and the voltage fluctuations on the C-R tube grid due to the video signals.

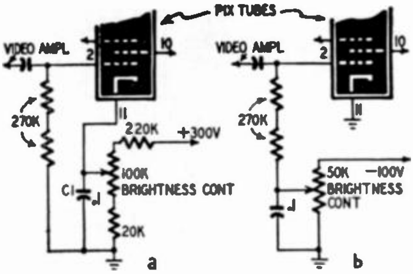


Fig. 801. *Cathode-ray tube biasing methods.*

Loss of control over brightness is *not* caused by trouble in the high voltage section, or signal circuits. It stems entirely from faulty operation of the tube bias circuit. The bias (negative grid with respect to cathode) can be varied by a control usually labelled BRIGHTNESS, BRILLIANCE, INTENSITY, or BACKGROUND. This control is used to set the over-all level of brightness in the picture. For most types of C-R tubes, a bias of approximately –50 volts cuts off electron flow, extinguishing the raster. In most receivers the normal range of the brightness control is from zero volts, or a few volts negative, to more than –50 volts.

Simplified biasing circuits are shown in Fig. 801. The bias control may be in the cathode circuit of the tube, Fig. 801-a, or in the grid circuit, Fig. 801-b. In some receivers, the video signal is fed to the cathode. These models usually use a grid-circuit brightness control.

Causes of trouble

Loss of bias control will result in loss of brightness control. There are three common defects which can affect the bias of the C-R tube.

1. Defective picture tube;
2. Defect in the immediate bias circuit of the tube;
3. Defect in some other circuit.

A defective C-R tube can cause loss of control if either of two conditions is present: a short or partial short from cathode to grid or heater; or a gassy C-R tube. When the cathode is shorted to the grid, possibly by a piece of cathode material lodged between the cathode and grid, bias no longer is present. The brilliance control has no effect in cutting down the brightness. Even under such conditions there *may* be a picture on the screen. The picture quality may even appear normal. Of course, the brightness level of the picture will usually be too high. Loss of sync, especially horizontal, may also occur. A short from cathode to a grounded heater has the same effect.

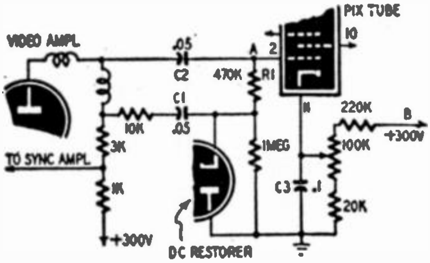


Fig. 802. *Leakage causes loss of control over brightness.*

A gassy picture tube may cause loss of control over brightness because ionization takes place inside the tube. This causes the grid to become more positive than normal. When a picture tube is gassy, a picture may still be visible on the screen. The picture usually turns *negative* (white areas black and black areas white) at high levels of contrast and brilliance.

Defects in the bias circuit of the C-R tube may include:

A shorted bypass capacitor, C1, at the brilliance control. (Fig. 801-a). With a shorted capacitor the cathode potential is the same as that of the control grid. With no bias, brilliance is maximum and the brightness control has no effect.

An open 220,000-ohm resistor in the brilliance-control voltage divider network, (Fig. 801-a); a large increase in the value of this resistor; or an open circuit at the top lug of the brilliance-control potentiometer. Under these conditions, the cathode cannot be made positive enough to cut off current flow in the tube. In circuits where the control-grid voltage is varied, similar troubles will remove the bias.

Leaky coupling capacitors at the grid of the picture tube:

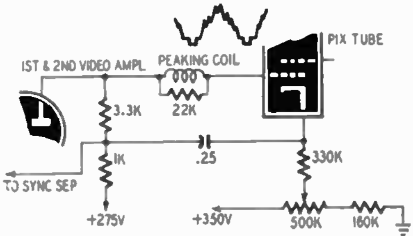


Fig. 803. Circuit showing direct video coupling.

Both C1 and C2 (Fig. 802) can become leaky enough to place a positive voltage on the picture-tube control grid. This positive voltage may be equal to or greater than the most positive voltage placed on the cathode by the brightness control. It then becomes impossible to extinguish the picture. The picture detail may be almost normal. Depending on the amount of leakage, the control may either be unable to reduce brilliance at all or just cut down brightness a little.

Direct coupling

Defective video output tube: In a number of models, the plate of the last video-amplifier tube is direct-coupled to the control grid of the C-R tube (Fig 803). Normally the plate of the video amplifier and the grid of the C-R tube are approximately +150 v. With the control potentiometer the cathode of the C-R tube can be varied from about +150 volts to +250 volts. However, if the filament of the video-amplifier tube opens, with no current through this tube the plate voltage, and the voltage on the C-R tube grid increases to the full +250 volts. With this increased voltage on the control grid of the C-R tube, it becomes impossible to cut off electron flow in the tube by means of the brightness control. This trouble can be considered a bias-circuit fault, since it upsets the bias relationship. Of course, with the video-amplifier stage defective, there is no picture on the screen, just a raster. An opening peaking coil may produce the same effect, even with a damping resistor across the coil.

The same troubles can exist in circuits where the signal is fed to the cathode. Fig. 804 shows a typical circuit. Here the functions have been transposed and the brilliancy control is now in the grid circuit. With the signal applied to the cathode, positive variations are equivalent to negative changes in the grid circuit in their effect on the electron beam.

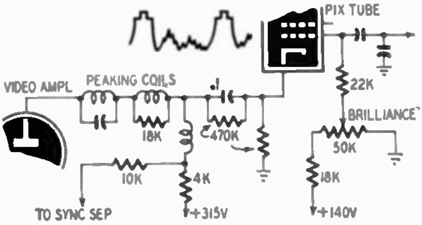


Fig. 804. Video signal fed into cathode of picture tube.

The third and fourth class of troubles originate in circuits external to the C-R tube or the bias circuit. An example of this is illustrated in Fig. 805. Symptoms: no control over brightness; picture fair, sync very poor. Sound low and distorted. Cause: a bad 6K6 audio-output tube. (Cathode shorted to filament). In this circuit the cathode of the audio-output stage goes to the +120-volt bus of the low-voltage supply (Fig. 805-a). The plate goes to the +375-volt bus from the B-supply through the output transformer primary. With the cathode shorted to the filament, the cathode is grounded, bringing the +120-volt point to above ground potential. This causes a redistribution of voltage across the low-voltage supply. The point which was +120 volts becomes just slightly positive. As a result, the operation of the C-R tube bias circuit whose cathode works off the +120-volt point (Fig. 805-b), is drastically affected. This trouble also can affect the operation of the sound i.f. stages and the sync amplifier (also connected to the +120-volt point).

With this background on likely sources of brightness trouble, localization of the defect is materially simplified. Check the picture and sound to see if there are any other apparent defects besides loss of control over brilliance. The action of the other controls should also be checked. There is no point in removing a chassis from the cabinet if the trouble is only a bad tube.

If there is a complete loss of pix, with raster and sound O.K., the fault could be an open filament in a video-amplifier stage, in models using a circuit similar to Fig. 803. On the other hand, if there are two or more defects, such as loss of sound, etc., as well as no control over brilliance, then it is advisable to substitute tubes in the other affected stages before proceeding further. If tube substitutions do not clear up the trouble, then make stage-by-stage voltage and resistance checks.

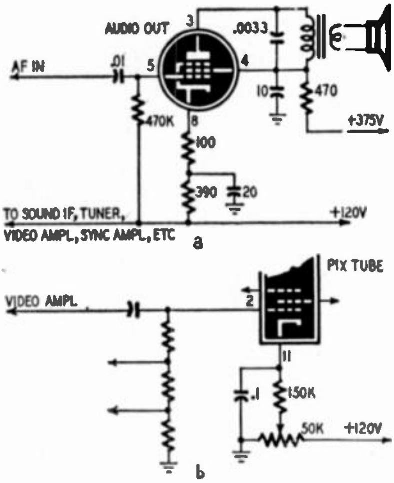


Fig. 805. *A cathode short in the audio stage grounds the C-R tube cathode.*

Assuming the indications are loss of control over brightness, and possibly some impairment of picture quality (with or without loss of sync), the trouble can then be assumed to be either in the C-R tube or the tube bias circuit. Once the chassis is out of the cabinet, the following procedures will help to localize the trouble:

Measure the voltage from the variable arm of the brightness control to ground. Rotate the control and note the minimum and maximum readings.

Measure the control grid voltage of the C-R tube, with the meter probe at the junction of C2 and R1 (point A, Fig. 802). With the meter still connected, vary the brilliance control, *even though the control is in the cathode circuit.* If the voltage reading varies as the control is rotated, a cathode-to-grid short in the C-R tube is indicated in models using the circuit of Fig. 802.

Repeat these measurements with the tube base socket of the C-R tube removed. (This removes the tube from the circuit.) Any abnormal readings observed now will indicate that the fault is not in the C-R tube but in the bias circuit. If the readings are normal, the fault must be in the tube.

In some receivers the filaments are in series-parallel, and removing the tube socket opens the entire filament circuit of the receiver. A jumper—a piece of solder will do—inserted in the filament pins of the tube socket will restore filament continuity and permit the checks outlined. This will slightly increase the filament voltage across the other tubes.

If the reading at the control-grid lug is more positive than normal with the C-R tube disconnected, the trouble probably is a leaky coupling capacitor, C1 or C2 (Fig. 802). The defect can be pinned down by unsoldering one end of each capacitor in turn and measuring the grid voltage.

If the intensity control does not vary through a proper voltage range with the C-R tube socket off, trouble in the brightness voltage divider circuit can be suspected. Possible troubles are: a shorted capacitor, C3, an open 220,000-ohm resistor or a large increase in its value, an open 100,000-ohm pot, or wrong voltage at point B (Fig. 802).

It is worth noting that there may be abnormally high positive voltage on the control grid, causing a large grid-current flow in the C-R tube with the socket on. Varying the brightness control may not have much effect in varying the cathode voltage, Fig. 802, due to the grid current flow. The fault, however, is in the grid circuit, not the cathode circuit. This becomes apparent when the readings are repeated with the socket off the C-R tube. Cathode voltage will vary normally while the control grid reading remains abnormally high.

A partial short between the cathode and grid of the C-R tube can be verified by an ohmmeter reading between pins 2 and 11 at the tube base. The short may be from less than one hundred ohms to over a megohm. It may be possible to clear up such a partial short by flashing the *cold* tube. Leads are connected to the plates of the low-voltage rectifier tube, where 700 volts a.c. is available. One lead is connected to the cathode pin. The second lead is tapped *quickly* several times to the control grid pin.

Summing up, loss of control over brightness is caused by bias trouble. This can be caused by troubles in (a) the C-R tube, (b) the C-R tube bias circuit, and (c) other circuits. Sound and picture quality may furnish clues to the trouble spot in the receiver. If the C-R tube or its bias circuit is indicated as the source of trouble, and a bad video-amplifier tube is not responsible, then voltage checks are made. Voltage readings are taken at the picture tube grid and cathode socket lugs while brightness control is rotated. These checks are repeated with the tube socket off. This makes it possible to eliminate either the tube or its bias circuit as the source of trouble. Further voltage and resistance checks will reveal the actual defective component.

Chapter 9

Correction of Picture Distortion

UNDISTORTED television pictures require linear scanning. For both horizontal and vertical linear scanning, the displacement of the electron beam in the picture tube must be linear with time. That is, the beam is displaced at a constant rate of speed. This ensures the picture elements being spread uniformly over the entire screen.

Correct scanning is produced in electromagnetic tubes by having a *sawtooth current* flow through the deflection coils.

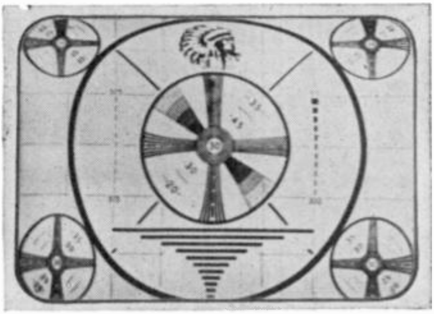


Fig. 901. *Poor vertical linearity causes compression at top of picture.*

If the deflection is not linear, that is, if the rising part of the sawtooth is curved, the reproduced picture is distorted. This distortion is illustrated by the test pattern of Fig. 901. This illustration shows nonlinear vertical deflection. The photograph, Fig. 902, shows non-linear horizontal deflection. The defective scanning causes cramping and flattening at the picture top or side.

Capacitor charge

In practically all cases, a charging capacitor in the deflection circuit (usually of the blocking oscillator or multivibrator type), produces the saw-tooth waveform. The charging-voltage-versus-time characteristic of a capacitor appears in Fig. 903-a. This curve is nonlinear. To produce a deflection waveform, the capacitor must be repeatedly charged and discharged at the same point in each case. The point of discharge usually occurs somewhere along the curve, as indicated in Fig. 903-b. Note that the repetitious charging point does not start at the very bottom.

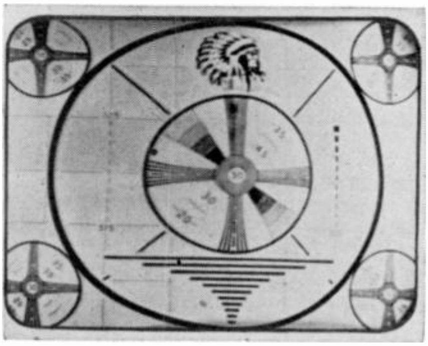


Fig. 902. Poor horizontal linearity causes compression at the side.

The capacitor charge curve is most nearly linear at the bottom rising portion. If the point of discharge occurs at a low voltage compared to the available discharging voltage, then the linearity of the sawtooth waveform is improved. However, the charge and discharge conditions within the receiver are such that a certain degree of nonlinearity always exists—enough to cause distortion in the reproduced picture.

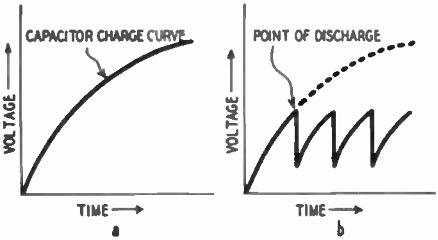


Fig. 903. Charging curves of a capacitor.

Certain other circuit operations, besides that of the sawtooth-producing circuit, may cause a linear curve to become appreciably nonlinear.

To correct these defects, special circuits are used to "linearize" the deflection signals before they are applied to the picture tube. The circuits provide correction by presenting some frequency discrimination to the nonlinear waveform or by causing the waveform to be subject to the characteristics of some deflection amplifier.

Three important types of correction circuits used in television receivers are: nonlinear amplifiers, damper tube circuits, and auxiliary time-constant circuits.

Nonlinear amplifier

If the defective sawtooth wave can be fed through an amplifier that has a nonlinear characteristic just the the opposite to that of the wave itself, we can straighten out the wave. Wave A of Fig. 904 is the nonlinear input sawtooth fed to the amplifier and B the output sawtooth signal. By operating the tube over the correct part of its transfer characteristic, the output sawtooth can be made very nearly linear.

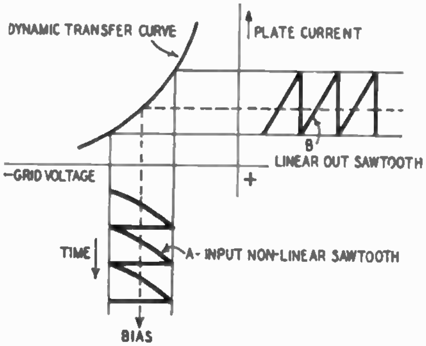


Fig. 904. Transfer characteristic compensates for nonlinear sawtooth.

The nonlinear amplifier is usually of the remote-cutoff or variable-mu type. The bias on the tube must be correctly adjusted for the input sawtooth to operate over the proper part of the transfer characteristic. In most television receivers using this method of linearization, the bias on the tube is made variable by adjusting linearity. A typical circuit appears in Fig. 905. R1 and R2 are the cathode bias resistors and C1 is the cathode bypass capacitor. By making resistor R2 variable, the bias on the tube can be changed and the correct operating point selected.

Such types of linearizing circuits are found most often in the vertical deflection circuit of television receivers where the tube usually is the vertical output amplifier. Adjustment of the linearity control in this circuit also affects the vertical size of the picture because a change in bias also changes the amplification of the tube.

Damping tube circuits

In kickback horizontal output systems a *ringing or oscillation* is produced during the retrace period of the electron beam. This is caused by the horizontal output transformer, deflection coils, and associated circuit capacitances breaking into oscillation. Oscillation may continue long enough to affect the linear rise time of the deflection waveform. To reduce this effect, a damper tube is used as shown in Fig. 906.

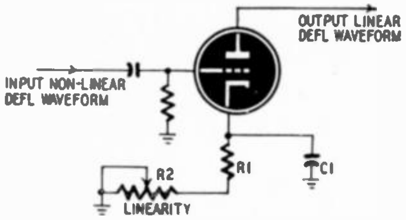


Fig. 905. Linearizing circuit that works on the tube's transfer characteristic.

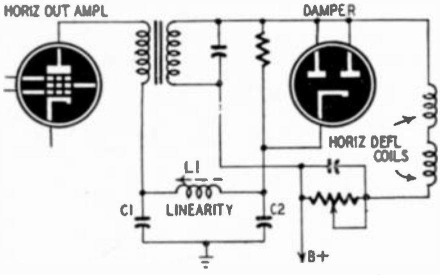


Fig. 906. A damper tube in the horizontal output helps linearize the sawtooth.

Immediately after the retrace period of the deflection waveform, a high positive pulse is applied to the plate of the damper tube and causes it to conduct heavily. This strong conduction loads the oscillatory system, and damps the undesired oscillations. Besides loading the oscillatory circuit, the damper supplies additional voltage to the plate of the horizontal output amplifier as it rectifies the positive pulse.

Although the damper tube prevents continued oscillations, enough energy is stored in the magnetic field of the oscillatory circuit to keep the tube conducting until this energy is dissipated. This energy dissipation makes the resultant current flow through the deflection coils linear, as indicated from points A to B in Fig. 907. After point B the current is no longer linear, but tapers off rapidly from points B to C.

Now the horizontal output amplifier takes over. The amplifier does not conduct during the retrace period of the beam and remains at cutoff during most of the time the damper tube is conducting because a negative pulse from the sweep oscillator is applied to its grid.

The amplifier starts to conduct when the deflection current, due to damper conduction, starts to become nonlinear. Current in the amplifier causes a continuation of current flow in the deflection coils. This initial current flow is nonlinear as from D to E in Fig. 907, and somewhat opposite in shape to that from points B to C of the same figure. After point E, the deflection current flow is linear. At point F, the retrace begins and the action starts again.

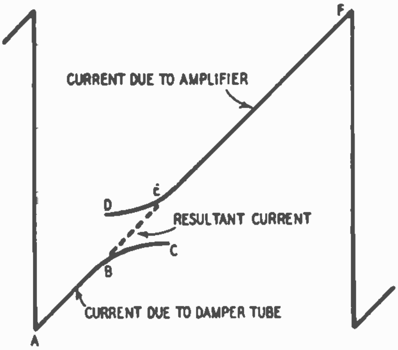


Fig. 907. Damper tube current and amplifier current produce the resultant sawtooth current.

The circuit of Fig. 906 is so arranged that the nonlinear deflection current of the damper tube and of the amplifier (currents B to C and D to E in Fig. 907) are opposite in shape and produce a resultant current that is linear. The total trace from A to F is then linear. As an additional function, the damper tube together with the amplifier produces a linear trace and is a method of linearizing the deflection waveform.

We mentioned that the supply voltage on the horizontal amplifier plate is increased due to the kickback caused by the momentary oscillation in the flyback transformer's secondary circuit. This increased voltage is applied to the plate of the horizontal amplifier tube by C1 and C2 because these capacitors become charged by the kickback voltage. This kickback voltage is pulsating and, although C1, C2, and L1 smooth out these pulsations, a certain amount of ripple voltage still exists. This ripple voltage is used to control the linearity of the resultant current.

By making L1 of Fig. 906 variable, the phase of the ripple voltage on the plate of the amplifier can be varied with respect to its grid signal. This means that the initial flow of amplifier plate current can be changed. Varying this inductance helps the nonlinear current (D to E in Fig. 907) produced by the amplifier to be exactly opposite to the nonlinear current (B to C) produced by the damper tube. In this way any nonlinearity in the dashed part of the trace is kept to a minimum.

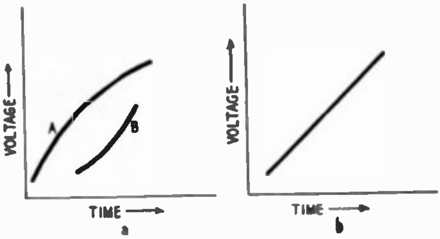


Fig. 908. Curves A and B add together to produce the linear voltage at the right.

Time-constant circuit

Another way to correct linearity is to use an extra time-constant circuit to offset the one in the circuit producing the sawtooth waveform.

The additional time constant introduces a frequency discrimination to the nonlinear sawtooth waveform to straighten it out. The graph of Fig. 908 shows what is theoretically wanted. Curve A in part "a" of this drawing is the nonlinear trace of the sawtooth waveform. Curve B is the shape of the curve introduced by the time constant. Its shape and location on the graph must be such that when combined with the nonlinear sawtooth, the result is a straight line, as indicated in Fig. 908-b.

The complete circuit appears in Fig. 909. V1 is the discharge tube of the deflection circuit, and V2 is an amplifier to which the corrected waveform is fed for amplification. Components R1 and C1 are the grid resistor and coupling capacitor of tube V2. The sawtooth producing capacitors are C2 and C3 and the resistor through which they charge is R2. Components R3 and C4 represent the additional time-constant circuit that corrects the linearity of the sawtooth waveform. Capacitors C2 and C4 are usually equal and C3 is approximately one-half their value. The corrected sawtooth deflection signal is taken across capacitors C3 and C4.

To understand how correction occurs, we will assume capacitors C2, C3, and C4 are being charged from B-plus. Capacitors C2 and C3 charge through R2 alone, but C4 charges through R2 and R3. When the discharge tube starts conducting, all the capacitors begin to discharge. Since C2 and C3 are directly across V1, they discharge very rapidly. However, C4 discharges slowly because the discharge current also flows through R3 which has a high value compared to the resistance of the discharge tube.

By the time V1 stops conducting, C2 and C3 are practically all discharged, but C4 has only given up a small part of its charge. C2 and C3 begin to charge again, but C4 continues to discharge because its previous charge is high compared to the voltage across C2. The discharge of C4 causes an additional charge on C2. In other words, the charge on C2 from the B-supply is an increasing voltage but the charge due to C4 is decreasing. When the total charging voltage on C2 equals that on C4, the latter stops discharging and starts charging through R2 and R3.

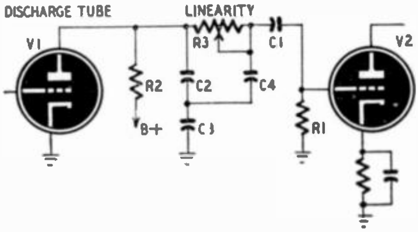


Fig. 909. Circuit for linearizing the sweep with an R-C time constant.

Across C3 we have the nonlinear deflection voltage represented by curve A in Fig. 908-a. Across C4, however, is a voltage which includes the action of C2 charging from two sources, plus the later charging action of C4. The result is a curve shaped similarly to that shown in Fig. 908-b.

So that R3 and C4 present the correct time constant to linearize the waveform, R3 is made variable.

Chapter 10

Servicing Horizontal Locks

BECAUSE the horizontal deflection generator is easily affected by weak signals, noise, and some forms of interference, the horizontal sync may be lost because of instability, maladjustments, and minor defects in the antenna, tuner, and video i.f. Many types of automatic frequency controls have been developed to hold the horizontal oscillator in sync with the horizontal scanning generator at the transmitter.

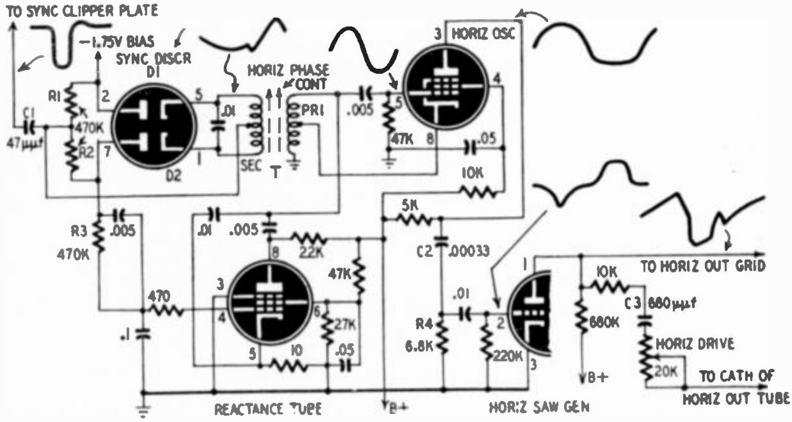


Fig. 1001. This is the widely-used synchrolock a.f.c. circuit.

In the receiver, the horizontal deflection voltage may be generated by a sine-wave oscillator, multivibrator, or blocking oscillator, and the frequency-correcting voltage may be produced by several types of discriminators and phase detectors.

The Synchrolock

Perhaps the best known of all a.f.c. systems is the RCA Synchrolock used in many versions of the 630-type chassis and in many other sets having 28 or more tubes. A typical commercial Synchrolock circuit is shown in Fig. 1001.

The oscillator is a Hartley type, operating at a natural frequency of 15,750 cycles. A reactance tube, connected in parallel with the tuned circuit, acts as a shunt reactance which can control the resonant frequency of the L-C network. The magnitude of the shunt reactance is determined by the bias voltage and transconductance of the reactance tube. With a fixed negative bias of approximately –2 volts on the control grid of the reactance tube, a change of 0.5 volt will change the horizontal oscillator frequency by approximately 100 cycles. The frequency shifts in one direction when the bias increases and in the other when it decreases.

The horizontal oscillator induces a sine wave voltage across the secondary of the discriminator transformer T so that the cathode of one diode is negative at the instant that the other is positive. Negative sync pulses are fed to C1, R1, and R2 which have a time constant which develops sharp pulses at the center tap of the secondary winding of the discriminator transformer. These pulses are applied in phase to the cathodes of the diode sync discriminator. The amplitudes of the induced sine wave and sync pulses are constant. The mixture of sine wave and pulse causes D1 and D2 to conduct when their cathodes are driven negative and voltages are developed across diode load resistors R1 and R2, respectively. These resistors are connected so the algebraic sum of their voltages is produced between ground and the junction of R2 and R3. A network consisting of the 470,000-ohm resistor R3 and the .005- and 0.1-μf capacitors filters the d.c. control voltage and applies it to the control grid of the reactance tube.

When the oscillator is in sync, the pulses arrive at the instant the sine wave on the cathodes is crossing the zero axis, as shown at a in Fig. 1002. The voltages across R1 and R2 are equal and opposite, and the net voltage is zero. Only the –1.75-volt fixed protective bias is applied to the grid of the reactance tube, and there is no shift in the frequency of the oscillator.

Now consider what happens when the oscillator shifts frequency so the negative sync pulse arrives when the cathodes of D1 and D2 are negative and positive, respectively. (See c in Fig. 1002.) During the first half of the cycle, D1 conducts and the voltage across

R1 corresponds to the voltage on the cathode of D1. At the same time, the sine wave is positive on D2 and will conduct only for the duration of the pulse which has sufficient amplitude to drive the cathode negative. The voltage across R1 being greater than that across R2, a positive voltage will be applied to the grid of the reactance tube, cancelling part of the fixed negative bias. The reactance tube draws more current, its effective reactance increases, and the oscillator frequency decreases.

The drawings at b show how a negative correction voltage is produced when the oscillator is running too slowly.

The output of the oscillator is coupled to the horizontal sawtooth generator—often called a discharge tube—through a differentiator consisting of C2 and R4. The tips of the differentiated pulse cause the sawtooth generator tube to conduct and discharge the sweep-generator capacitor C3.

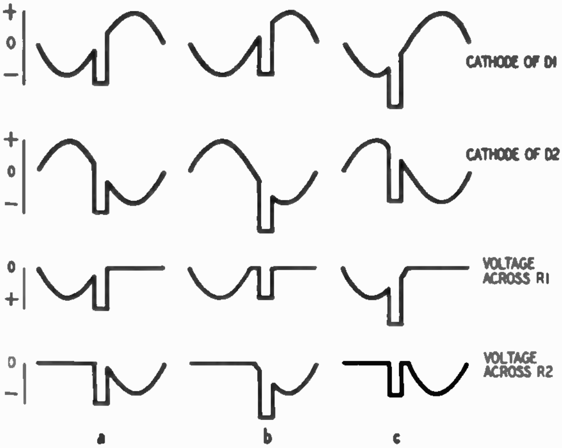


Fig. 1002. Waveforms show how sync pulses are superimposed on the sine wave output of the horizontal oscillator.

The horizontal drive control adjusts the shape of the wave applied to the grid of the output tube and is therefore capable of affecting the linearity and size of the picture as well as the high voltage.

In the 630 and most other sets, the sync pulses are positive and the plate and cathode connections are reversed on the discriminator diodes.

Synchrolock troubles

Troubles in this, and all other a.f.c. circuits described in this chapter, are shown by loss of, or unstable horizontal sync.

The primary tuning slug of transformer T in Fig. 1001 is used to set the oscillator frequency, while the secondary tuning controls the phasing, or the position on the screen at which the horizontal sweep starts. Improper setting of the phasing slug will show the left and right halves of the picture transposed, and separated by a dark vertical bar. This bar is the horizontal blanking pulse.

You can examine the horizontal blanking pulse and the horizontal sync pulse by turning the phasing slug of the discriminator transformer until the dark bar is at about the center of the screen. Adjust the brightness control until the right edge of the vertical bar is black. This will be your sync pulse. You should see the blanking bar to the left of the black sync bar. The blanking bar should not be as dark as the sync bar (about light grey). The blanking bar should be as dark as any element in the darkest part of your picture.

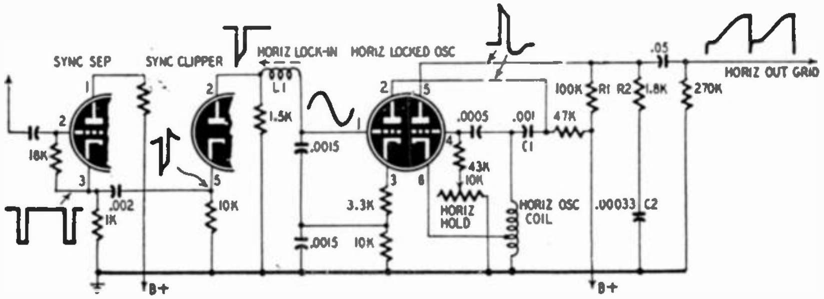


Fig. 1003. Another circuit using a sine wave oscillator. Negative pips from the sync clipper are used to control the frequency of the horizontal oscillator.

Phasing adjustment: Turn the secondary slug of the discriminator transformer until the sync bar moves off the picture. Sometimes turning this slug will cause ripples in the raster. If it does so, you can correct this unstable condition by turning the phase slug clockwise.

Horizontal tearing can be caused by a defective sync-discriminator tube or reactance tube. Check R1 and R2, the diode load resistors. These should be equal in value (about a half-megohm). Horizontal tearing will result if these resistors are open, shorted, or changed too much in value. The same effect will be noticed if the sync coupling capacitor C1 should open.

Note the 0.1-μf capacitor in the grid circuit of the reactance tube. This capacitor is a filter for the d.c. control voltage coming from the sync discriminator. If this capacitor opens, you will get unstable sync at low settings of the contrast control, although the sync may be normal at settings near maximum.

Motorola circuit

Another circuit which uses a sine-wave oscillator is employed in some Motorola (and similar) chassis. In this circuit (Fig. 1003), the negative sync pulses appearing at the cathode of the sync separator are differentiated by the .002-μf capacitor and the 10,000-ohm resistor in the cathode return of the sync clipper. The diode passes the negative pulses and clips the positive pips. The negative pips, which correspond to the leading edges of the sync pulses, are used to control a 15,750-cycle sine-wave oscillator consisting of L1, the two .0015-μf capacitors, and half of the double triode. This oscillator is locked in with the sync pulses.

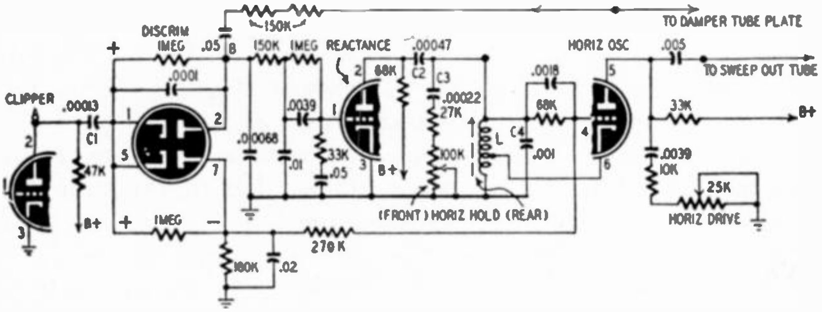


Fig. 1004. The Gruen a.f.c. circuit uses a balanced discriminator, a reactance tube, and a sine-wave oscillator.

The negative half of the sine wave across L1 drives the oscillator grid to cutoff and produces a positive pulse in the plate circuit. This plate waveform is differentiated by C1 and thus makes a pulse which triggers the grid of the blocking oscillator consisting of the other half of the double triode. The time constant of the 500-μμf capacitor and the resistance in the oscillator grid return determines the frequency of the blocking oscillator. The sawtooth which drives the horizontal amplifier is developed by the charging and discharging of C2 through R1 and R2. The voltage across R2 and C2 produces a negative spike which drives the output tube to cutoff during the retrace period.

Note that this circuit does not provide a corrective voltage to hold the blocking oscillator on frequency. Instead, it is triggered by a pulse derived from a sine wave. The locked-in sine-wave oscillator acts as a buffer to prevent noise pulses from riding through and affecting the performance of the blocking oscillator.

The Gruen system

The Gruen a.f.c. circuit used in some G.E. sets is shown in Fig. 1004. This circuit uses a balanced discriminator, a reactance tube, and a sine-wave oscillator. The Hartley oscillator is controlled by the inductance of the tapped coil L and the capacitance of C2, C3, and C4. The reactance tube acts as a resistance in series with C2 across the tank coil.

In this circuit, the discriminator produces a d.c. voltage having an amplitude and polarity determined by the phase difference between the sync pulses and the negative pulses at the plate of the damper tube. The negative sync pulses are applied to the cathodes of the discriminator tube and the pulse from the damper tube is integrated into a sawtooth by the 680-μμf capacitor connected between the upper diode plate and chassis.

The peak-to-peak voltage of the sawtooth on the plates is approximately half that of the sync pulses fed to the cathodes. When the diodes conduct because of the presence of sync pulse or sawtooth alone, the voltages across the 1-megohm diode-load resistors are equal with opposite polarity, making the discriminator output zero.

The sync pulses coming from the sync clipper charge C1 to approximately 60 volts and bias the cathodes positive by this amount. As long as this bias is on the cathodes, the sawtooth cannot cause conduction because its peak value is too low.

If the oscillator is in sync with the pulses from the transmitter, the pulses arrive at the instant that the retrace portion of the sawtooth crosses the zero axis and the voltages across the load resistors are caused by the portion of the sync pulse which is above the bias developed by C1. These voltages cancel each other and therefore no d.c. voltage comes out of the discriminator.

When the oscillator is fast or slow, the sync pulse falls on the retrace of the sawtooth. Now, the sawtooth will add to or subtract from the sync pulse on the diodes and cause a difference in the voltages across the load resistors. The algebraic sum of the voltages—positive if the oscillator is fast and negative if it is slow—is filtered and fed to the grid of the reactance tube.

If the correction voltage is positive, the plate-to-cathode impedance of the reactance tube will be lower and the capacitance of C2 will have a greater effect on the tuned circuit and lower the oscillator frequency. A negative voltage increases the plate-to-cathode impedance of the reactance tube, the effect of C2 is reduced, and the oscillator speeds up.

The .0039-µf capacitor and the series resistance to ground produce the sawtooth deflection voltage. The lower diode plate is tapped into the grid network of the horizontal oscillator. This is a form of a.g.c. which holds the amplitude of the horizontal oscillator constant.

G-E Circuit

The a.f.c. circuit in Fig. 1005 is used by G.E. in addition to the Gruen circuit. Here, an unbalanced discriminator or phase detector, d.c. amplifier, and multivibrator are used. A sawtooth from a special a.f.c. winding on the horizontal output transformer is applied to the center-tapped secondary of the a.f.c. input transformer. This voltage—in phase at the ends of the secondary—is compared with the sync pulses which are out of phase across the halves of the winding. The diodes conduct equally when the sync pulses coincide with points A on the sawtooth and the net d.c. voltage is zero.

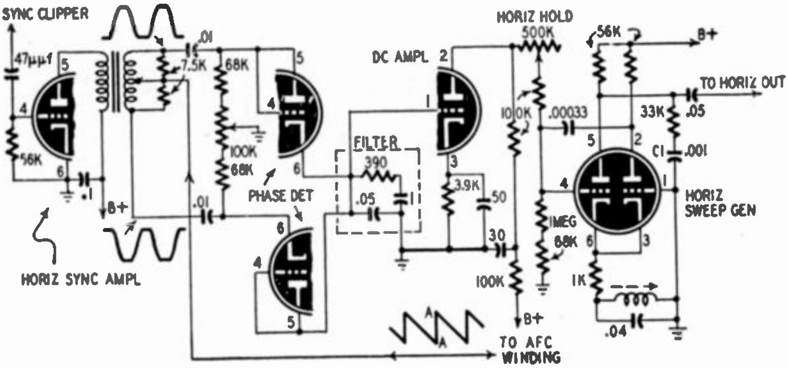


Fig. 1005. The d-c. amplifier boosts the discriminator output to get positive control over the horizontal oscillator.

If the sync pulse falls at any other point, the voltages across the diodes are unequal and a positive or negative corrective voltage is produced. After being filtered (see filter enclosed in dashed lines), the voltage is amplified by a d.c. amplifier and then applied to a grid of a cathode-coupled multivibrator-type oscillator. The filter has a time constant which averages voltages over a frame rather than over individual lines, thus making the circuit less sensitive to ignition noise and interference pulses.

The coil and capacitor in the cathode returns of the horizontal sweep generator tube are shocked into a ringing condition which produces a sine wave. The charge-and-discharge capacitor C1 converts the sine wave into a sawtooth.

Westinghouse a.f.c.

Another phase detector circuit used by several manufacturers is shown in Fig. 1006. The sync pulses from the sync separator are fed to a phase inverter which develops equal pulses of opposite polarity at its plate and cathode. The positive pulse is fed to the plate of D1 at the instant that the negative pulse is fed to the cathode of D2. A square-wave pulse from the plate of the horizontal output tube is applied to the cathode of D1 and plate of D2 through an integrator (C1, R1, and C2) that converts the signal to a sawtooth which is alternately positive and negative. Note that the voltages on the cathode of D1 and plate of D2 are in phase while the sync pulses on the plate of D1 and cathode of D2 are 180 degrees out of phase.

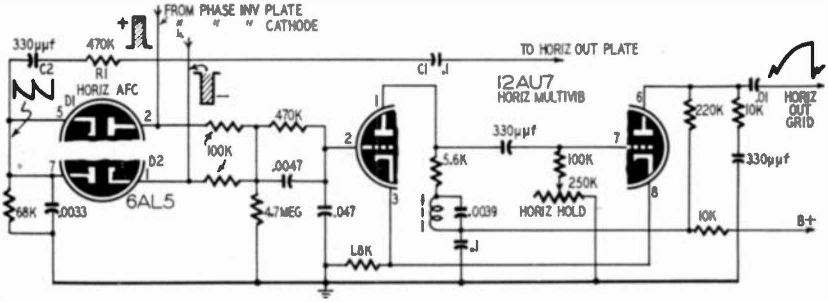


Fig. 1006. A phase inverter does the work performed by discriminators in other a.f.c. circuits.

Fig. 1007 shows the operation of this circuit. At a, the arrival of the sync pulses coincides with the leading edge of the negative-going sawtooth. The sum of the negative cathode and positive plate voltages on D1 being greater than the positive sawtooth acting alone on the plate of D2, a negative d.c. voltage appears across R2. The negative sync pulse is not shown at a because it is canceled by the negative sawtooth on the plate of D2.

At b, the pulses are centered over the trailing edge of the negative-going sawtooth and the leading edge of the positive-going sawtooth with the result that the voltages developed during successive halves of the sawtooth cycle are equal and opposite and the net voltage across R2 is zero.

At c, the pulses arrive on the trailing edge of the positive sawtooth, D2 conducts more heavily than D1, and a positive correction voltage is produced.

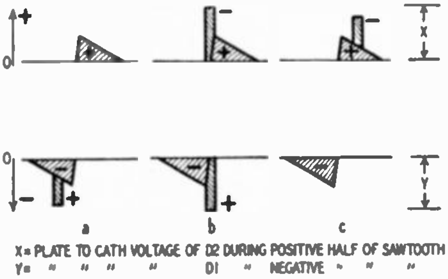


Fig. 1007. Waveforms showing how the circuit of Fig. 1006 controls the frequency.

The sawtooth deflection voltage is generated by the 10,000-ohm resistor and .00033-µf capacitor just as in the other charge-discharge circuits we have discussed.

Synchroguide

The Synchroguide circuit shown in Fig. 1008 requires only one duo-triode for the horizontal oscillator and automatic frequency control. Although the use of only one tube makes the circuit simpler than some other types of a.f.c., the adjustments are quite critical.

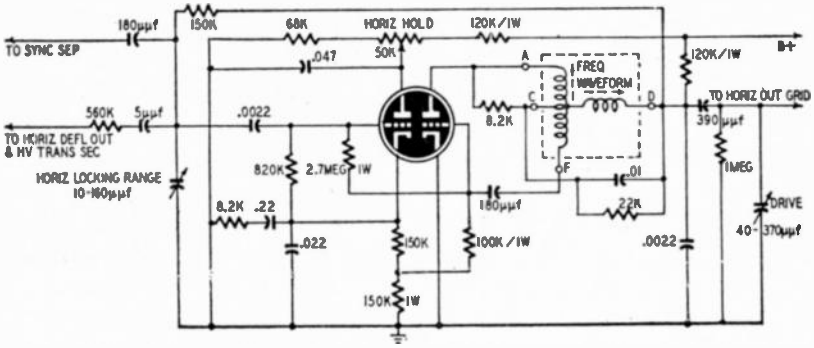


Fig. 1008. Synchroguide horizontal oscillator and automatic frequency control. The circuit uses only one tube.

The first triode is the control section, while the second half of the tube is the oscillator. The coil between terminals A and F is an autotransformer used in a blocking-oscillator type circuit and supplies the feedback necessary to sustain oscillations. The frequency of oscillation can be varied by adjusting the coil slug.

A strong negative voltage derived from the oscillator grid and the 150,000-ohm cathode resistors biases the control tube almost to plate-current cutoff. This means that a strong positive pulse must be applied to the control grid to get plate-current flow. The signal voltage on the control grid is a combination of voltages from three sources: the sync pulse coming from the sync separator; part of the output sawtooth voltage waveform from the horizontal oscillator; and a pulse fed back from the horizontal output circuit. The flow of current through the control tube depends on the phasing of these three voltages. The bias developed by the control tube also depends on the amount of plate current. This bias is developed across the 150,000-ohm cathode resistor common to both triode sections. The amount of bias controls the frequency of the horizontal oscillator. Any change in the phasing of the signals on the grid of the control tube will change the bias and shift the oscillator back to its proper frequency. The winding between terminals C to D is a ringing coil which makes the blocking oscillator more stable

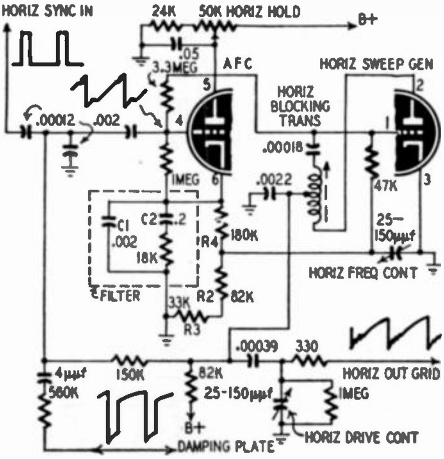


Fig. 1009. *An a.f.c. circuit of the pulse-width type which is used in some sets.*

Synchroguide troubles

If the picture tends to fall out of sync and the horizontal hold control becomes touchy, it is quite possible that a check of the control and oscillator tube and all Synchroguide components will reveal no defect. If so, realign the Synchroguide a.f.c. circuit, following manufacturer's alignment instructions for the particular model you are servicing.

Some Synchroguide components are fairly critical. In Fig. 1008, the 120,000-ohm resistor connected to the horizontal-hold control and the 150,000-ohm cathode resistors of the oscillator and control tube should be fairly close to called-for values. Use resistors with a tolerance of 5% or better. Resistors used in some commercial Synchroguide circuits are temperature compensated. If these become defective, use exact replacements to avoid horizontal frequency drift. The Synchroguide has a narrower lock-in range than the Synchrolock, and thus will not tolerate as much oscillator frequency drift. As the combined control-oscillator tube gets older the circuit tends to produce a picture showing right-hand foldover. The setting of the horizontal-locking range capacitor is important. This variable capacitor helps control the voltage amplitude on the grid of the control tube. If the setting of this capacitor delivers insufficient drive voltage to the grid, the lock-in range will be very narrow. At the other extreme (too much drive voltage on the grid), the lock-in range will be too broad. This will make the horizontal sync more susceptible to noise.

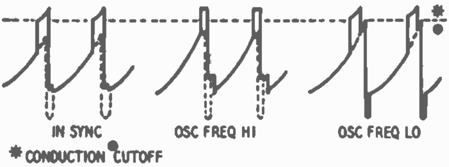


Fig. 1010. *Waveforms showing pulse width differences of the circuit of Fig.* 1009.

Pulse-width system

Fig. 1009 is one of several versions of the pulse-width a.f.c. system, and operates in much the same manner as the Synchroguide. A single 6SN7-GT is the a.f.c. tube and blocking oscillator. The grid of the a.f.c. tube is biased to cut-off by the negative voltage applied to it through the 3.3-megohm resistor connecting it to the oscillator grid.

Positive pulses from the plate of the damper tube are converted to modified sawtooth waveforms and fed to the grid of the a.f.c. tube along with positive sync pulses. Neither voltage has sufficient amplitude to overcome the bias on the a.f.c. tube but their amplitudes can be combined to cause conduction.

When the oscillator is in sync (see Fig. 1010), the leading half of the pulse is on the leading edge of the sawtooth and its trailing edge corresponds to the trailing edge of the saw. Thus the pulse is only half its normal width. The pulse falls higher on the sawtooth and more of it is clipped when the oscillator is fast. If the oscillator is slow, the full width of the pulse may fall on the leading edge of the sawtooth.

C1 and C2 charge during the time that the a.f.c. tube is conducting. The voltage on them is determined by the duration of plate-current flow. A portion of the voltage across these capacitors is applied as bias to the grid of the blocking tube. If the oscillator is slow, the voltage across the capacitor will be more positive than when the oscillator is in sync, and the oscillator speeds up until the grid bias returns to its normal value.

Troubleshooting hints

Troubles in a.f.c. circuits can be numerous and may be caused by minor changes in the values of many components. These few hints are useful when servicing a.f.c. circuits:

1. Always check the damper tube in circuits where the feedback voltage is taken from the plate of the horizontal output or damper tubes.
2. Check the feedback windings for open circuits and shorted turns in circuits like Fig. 1005.
3. When replacing resistors and capacitors in the a.f.c. circuit, always use units having tolerances equal to or closer than those of the original. Check the parts list and diagram to be sure.
4. Check all tubes which are even remotely connected with the horizontal deflection circuit. Sync separators, d.c. restorers, clippers, amplifiers, and clamps can affect the operation of some circuits.

Chapter 11

Curing Intercarrier Buzz

It has always been recognized that use of intercarrier makes it more difficult to provide "clean" sound. Circuits are being improved, but in the meantime service technicians face the problem of coping with annoying buzz. The buzzing noise often heard in these receivers is due to the vertical synchronizing pulses which pass through and are amplified by the audio system.

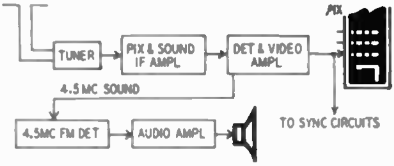


Fig. 1101. *Intercarrier receiver; sound and picture carriers are amplified.*

It is necessary first to classify the basic intercarrier circuits and find out how the trouble is caused.

In an intercarrier receiver, both the sound and picture carrier are amplified and applied to the video detector (see Fig. 1101). This differs from older split-carrier TV receiver design in which the sound carrier is rejected by traps in the video i.f. so that there is no sound interference to the picture. The intercarrier circuit requires that a definite ratio between picture carrier amplification and sound carrier amplification be maintained (Fig. 1102). The reason for this is that the picture carrier must not cause interference in the sound and the sound must not affect the picture. If the sound carrier is weak compared to the video carrier, variations in amplitude which normally occur on the video carrier will not appear when the two carriers beat together to form the 4.5-mc component used for sound reception in the TV receiver. If sound and picture carriers are both passed through the i.f. strip, a 4.5 mc beat note appears in the video detector. This beat note is frequency-modulated like the sound carrier and amplitude-modulated like the picture; the amount of each modulation and the strength of the 4.5-mc beat note depends on the strength of each carrier at the detector.

The sound carrier in the i.f. stages should be way down on the slope of the over-all response curve, and should not be above 1/20 (5%) of the flat-top maximum, to keep the beat note as free from picture modulation as possible. In Fig. 1102, the sound carrier is shown 2% upon the curve. It should not be too much less than this so that there will be enough 4.5-mc signal to give adequate sound volume. The front end, i.f.'s, traps, and alignment frequencies should be designed with this in mind.

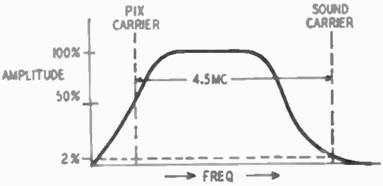


Fig. 1102. Response curve of intercarrier receiver.

The 4.5-mc beat note is normally trapped out after the video amplifier. In well-designed receivers the video detector and amplifier should pass up to 4 mc and then cut out the higher frequencies. For intercarrier, some 4.5-mc signal should go through the peaking coils and be taken out of the picture by a trap which feeds the 4.5-mc amplifier and ratio detector. A *good* ratio detector will go far toward cutting down the buzz.

The 4.5-mc beat must pass through the front end, i.f.'s, and video continuously. If any tube, such as the last i.f. stage or the video amplifier, cuts off on peaks of sync signals or picture whites, the beat note will be cut off at the same time. This will cause a buzz in the sound that cannot be removed by any means except changing the bias or other voltages or the signal strength to correct the stage that is cutting off. This should not be necessary in a well designed set unless some component is defective or changed in value.

In analyzing the output of the video detector in an intercarrier receiver, two major frequency groups are found. First, the video signal obtained by detection of the video carrier; second, a 4.5-mc component which is the difference frequency between the sound and picture carriers. This 4.5-mc component will be substantially free of amplitude modulation because of the high-ratio of picture-to-sound carrier but will be frequency-modulated the same way as the sound carrier.

Sound detection

In current designs there are two places where the 4.5-mc sound component is selected for detection. Figs. 1103 and 1104 show these to be either at the video detector or the video amplifier. The takeoff circuits shown are those most generally used. In the earlier low-cost intercarrier receivers, 4.5-mc sound was actually taken off at the plate of the video amplifier, Fig. 1104. This circuit is advantageous since the video amplifier has appreciable gain at 4.5-mc and therefore more 4.5-mc output is available compared to the takeoff point at video detector, Fig. 1103. But the sync buzz in the sound is more difficult to eliminate when the 4.5-mc is taken off the plate circuit of the video amplifier.

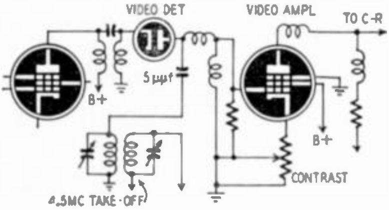


Fig. 1103. *Sound takeoff at video detector.*

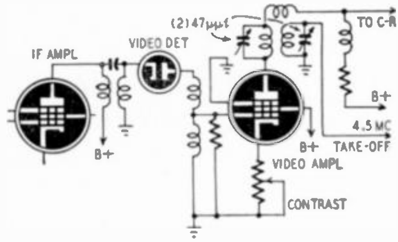


Fig. 1104. *Intercarrier circuit with sound takeoff at video amplifier.*

Sync buzz in the sound of an intercarrier receiver is inherent in the system. The 4.5-mc component (result of a beat between the sound and picture carrier) is subject to amplitude variations even though a high picture-to-sound-carrier ratio is maintained. Even though the receiver is properly designed, local conditions may cause a very strong sound carrier and a weak picture carrier to be received on one or more channels. On these stations picture-to-sound-carrier ratio may be too small and the 4.5-mc component will be more subject to AM always present on the picture carrier.

In present TV broadcast practices the video transmitter signal (normally maximum during transmission of the sync pulse) instantaneously reaches nearly zero during white portions of the picture. This means that the transmitter is nearly 100% modulated, and when this occurs the 4.5-mc sound component which depends for its existence on the picture (and sound) carrier, will vary in amplitude.

If the transmitter is 100% modulated there may be times when the 4.5-mc signal actually disappears. When this occurs at a rate coinciding with the transmission of the picture frames, a 60 c.p.s. buzz will appear in the sound output. Under severe conditions, where excessive modulation occurs and where the picture carrier is weak due to local conditions, receiver misalignment, etc., no amount of limiting action in the receiver will restore the holes in the 4.5-mc signal. However, this extreme is seldom realized, and more often it is possible to minimize if not entirely eliminate this troublesome buzz.

Thus the problem is mainly one of correct receiver alignment, and proper circuit design. Let us consider how the intercarrier circuits may be improved to give better rejection of amplitude variations on the 4.5-mc sound signal.

Adjustment procedure

Since the TV signal is ordinarily modulated about 85% the receiver must first be correctly aligned for proper picture-carrier-to-sound-carrier ratio. No distortion should be introduced which may increase the apparent modulation percentage of the video carrier.

Assuming these conditions, the first danger point to be considered in receivers that take 4.5-mc at the video-amplifier plate is the video amplifier. The polarity of the sync signal is usually negative at the grid of the video output stage. (This type of circuit can be recognized because video output is fed to the cathode of the picture tube). With normal contrast the set is adjusted so the tips of the sync pulses cause the video amplifier to almost reach cutoff. Turning the contrast control up too high or an extremely strong signal may cause the video amplifier cutoff, thus momentarily cutting off the 4.5-mc component in the plate circuit.

This will produce a buzz in the sound system and no amount of limiting action will take it out.

Another source of trouble is an a.g.c. system which allows too strong a signal to be applied to the last i.f. stage or video amplifier. The overload condition increases the degree of picture-carrier modulation, thus placing a greater burden on the limiting circuits.

Inadequate rejection of amplitude modulation in the 4.5-mc sound circuits may also cause considerable buzz. A ratio detector (the most commonly used FM detection circuit in intercarrier receivers) will not help in rejecting AM unless it is properly adjusted. Additional gain in the 4.5-mc driver stages will help considerably in improving the AM rejection properties of the 4.5-mc sound systems and thereby increase receiver immunity to sync buzz.

Sync buzz usually results from a combination of these causes and the receiver therefore must be checked thoroughly before taking any steps to eliminate the buzz.

The more common symptoms and their most probable causes are:

(a) Severe buzz on most stations when contrast control is turned on full. Usually this is a result of overloaded video amplifier when sound is taken off video amplifier.

(b) Buzz on some channels and others clean. Some stations modulate more heavily than others, particularly when sending test pattern; local conditions may cause some stations to be received with very strong sound carrier and weak picture carrier.

(c) Buzz occurs only at certain positions of fine tuning control. May be due to excessive tuning range of receiver or misalignment.

(d) Buzz occasionally during program or on certain types of stationary patterns. Usually indicates picture video harmonics getting into sound system. For example, a 2.25-mc video component may generate harmonics at 4.5-mc and interfere with normal sound signal.

If symptoms indicate an overload condition in the video or the last i.f. amplifier, increase the gain of the a.g.c. system so that for a given-strength signal more a.g.c. voltage is available. The gain of the receiver on strong signals will be reduced. This will result in reduced contrast range, but it is usually possible to effect a compromise to allow adequate contrast, yet limit the maximum signal at the video or last i.f. amplifier to prevent overload.

In sync buzz cases such as those in b, c, and d, it usually will be necessary to investigate the performance of the 4.5-mc sound system as a separate unit, determine its shortcomings, and make certain adjustments and changes.

Fig. 1105 shows a typical 4.5-mc intercarrier sound circuit including the sound takeoff point and audio amplifier. The function of the sound circuit is to amplify the frequency-modulated 4.5-mc. signal, reject any amplitude variations, and detect or convert the FM to audio. The most difficult problem is to effectively iron out AM so that no voice or sync buzz is present in the audio output. If the ratio detector is correctly adjusted there will be no trouble. The ratio detector driver is also often used as a limiter.

To properly determine the performance of the 4.5-mc sound system, a signal generator capable of simultaneous frequency and amplitude modulation is required. A less accurate but satisfactory means of testing would be with an on-the-air station.

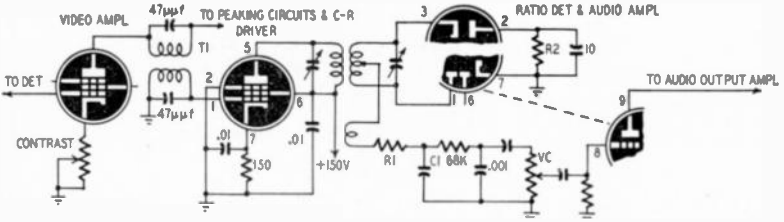


Fig. 1105. Typical intercarrier sound circuit, including sound takeoff point and audio amplifier.

Circuit changes

Fig. 1106 is a modified version of Fig. 1105, to improve rejection of unwanted AM components. Changes are:

1. Convert driver from linear amplifier to limiter by addition of Rg and Cg. Ground the cathode, and reduce screen voltage to about 30 volts.

2. Replace coupling transformer (T1) with capacitive coupling from video amplifier plate to secondary winding as in Fig. 1106. (Short-circuit primary). This will often increase amount of 4.5-mc signal available to driver grid, making possible better limiting action.

3. Adjustment of the ratio detector can be done if a sweep signal generator and oscilloscope are available. Follow manufacturer's alignment instructions or instructions in the next few paragraphs. Variation in values of R1, R2 and C1 in Fig. 1105

will affect the ratio detector's ability to reject AM. For example, reducing the value of R2 will often materially improve AM rejection of the detector but may result in decreased audio output. When R1 or C1 is varied a sharply defined minimum in output due to AM will be found. If a potentiometer whose total resistance is about 500 ohms is substituted for R1, this null point will be found and may result in an improvement in AM rejection.

Ratio detector tuning

In servicing an intercarrier television receiver to eliminate buzz, touch up the ratio detector first. Tune primary for maximum sound volume and the secondary for minimum buzz, which will also be close to maximum sound volume. Make these adjustments on a weak signal first for the maximum volume and a strong signal for minimum buzz. In most cases that alone will cure the trouble.

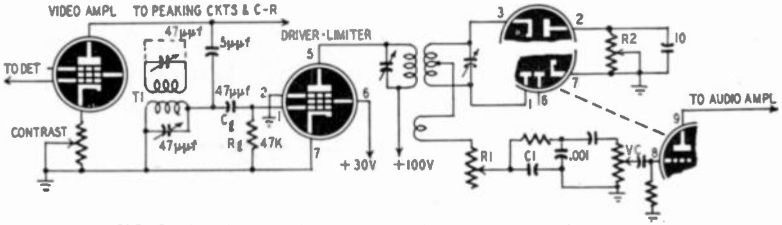


Fig. 1106. *Modified circuit of Fig.* 1105 *to improve rejection of unwanted AM signals.*

The primary and secondary tuning adjustments on the ratio detector can be recognized by their effects. Tuning through the primary will gradually increase and then decrease the sound output without too much distortion off tune. Tuning through the secondary from off tune will increase distorted sound to a maximum, clear the sound and reduce noise to a minimum, distort sound and increase noise again, and then drop off the distorted sound volume. Align the sound takeoff coil or transformer and the ratio detector primary for maximum on a weak signal and the ratio detector secondary for maximum undistorted quiet sound. If the set is badly off alignment, a signal generator will have to be used. This should be fed into the video amplifier grid. Carefully retouch the ratio detector secondary on a strong signal for minimum buzz and distortion, and then touch up the primary and the sound takeoff coil.

If the buzz persists, front end and i.f.'s should be tried. The aim here is to get the sound carrier on the right portion of the over-all bandpass curve. Set the fine tuning control in the middle of its range. Adjust the oscillator on a station, tuning until sound in the picture wipes out the picture. The sound will be loud and clear. Back off on the oscillator adjustment until the picture is clear and sharp without sound or 4.5-mc interference. The interference in the picture looks like about 300 fine vertical lines, causing the picture to appear out of focus. Tune the oscillator back and forth slightly from this point for minimum buzz. If the adjustment for minimum buzz is not at or near the point that gives a clear picture, the i.f.'s and front end will have to be realigned.

Realignment

For realignment, connect an r.f. sweep generator to the antenna terminals and a 'scope to the video detector output. Disable the a.g.c. circuit and apply a fixed r.f.-i.f. bias of the same value as that developed by the a.g.c. on an average station in the particular area. This is important, because in many sets the bandwidth changes with a.g.c. Getting the right curve with a standard value of fixed or a.g.c. bias might not mean much as far as actual operating conditions are concerned in a given area. Align the i.f.'s and front end to get the desired curve and bandwidth, as described in instruction sheets on the set.

Don't try to obtain full 4-mc bandwidth on a receiver unless there is a trap to attenuate the sound carrier. Otherwise it will not be possible to get the sound carrier far enough down on the curve. After alignment, check the sound and picture carriers. When the picture carrier is set half way up one side of the bandpass curve, the sound carrier should be far down the slope of the other side, less than 1/20 of the flat top height. After the i.f.'s and r.f. have been aligned and checked on all used channels, the oscillator should be adjusted, as mentioned above, on the air.

In strong-signal areas the buzz may persist because of overload. Check the components and voltages in the last i.f. stage and the video amplifier. Then attenuate the signal by using a pad in the antenna, reducing it to give less than a good picture at full contrast. If this clears up the buzz, it indicates overload. This can be corrected by padding the antenna, if the net picture signal strength is adequate. Or else the a.g.c. voltage could be increased by adjusting the a.g.c. threshold control or by increasing the value of the a.g.c. bleeder resistor if one is used.

The cathode-bias resistor in the video amplifier can be adjusted up and down, depending upon whether the overload is driving this stage to cutoff or toward saturation. The determination of this point is more difficult. A simpler correction is to reduce the gain of the i.f. strip below overload by increasing the cathode-bias resistor in an i.f. stage that does not have a.g.c. applied, usually the last i.f. stage. This resistor can be increased to several times its normal value as long as the tube is not biased close to cutoff.

Another cause for buzz is electrical coupling through the power supply. Usually not encountered in well designed receivers, this is not peculiar to intercarrier sound but might be present in any television receiver. To test for this, connect an oscilloscope to the B-supply of the audio and 4.5-mc stages. Examine the waveform for vertical sync pulses or vertical sweep. If more than 1 volt peak-to-peak of these waveforms is present, decouple the supply of the sync amplifier, the vertical blocking oscillator, or the vertical output tube, depending upon the waveform found in the power supply. When this is too difficult, the decoupling could be applied to the 4.5-mc stages and the audio. It is best to decouple the source, however.

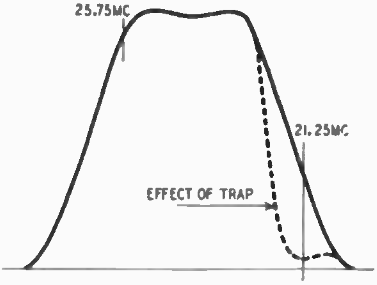


Fig. 1107. An i.f. response curve showing the effect of inserting a sound trap.

We've been talking only about elimination of 60-cycle buzz. The same factors covered in this chapter will also cause a 15,750-c.p.s. note. Practically all commercial television receivers have a narrower audio response than that, and the high-frequency noise and note are cut out in the audio stages. This can't be done for the 60-cycle buzz. The 60 cycles can't be eliminated merely by keeping the low-frequency cutoff of the audio system above 60 cycles. The buzz in the sound is due to a sharp pulse with many strong higher harmonics. Raising the low-frequency cutoff of the amplifier above 60 cycles would diminish the fundamental but would still permit the higher harmonics to come through.

Sound trap

We have previously explained that the theory of intercarrier requires that the sound i.f. carrier be at the bottom of the i.f. responsive curve. The solid line in Fig. 1107 shows what frequently happens. The 21.25-mc sound carrier is up on the slope of the curve and definitely *not* at the 2% point as shown in Fig. 1102. One method to improve this condition and thereby reduce the buzzing noise considerably is to re-align the i.f. section and make sure that the sound i.f. is well below the picture carrier. In some receivers the i.f. design does not permit proper adjustment. Then it may be advisable to insert a trap.

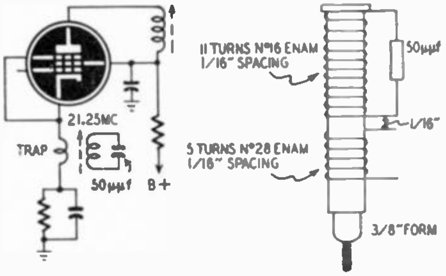


Fig. 1108. The sound trap in the cathode circuit, and winding data for the trap.

The 21.25-mc sound trap shown in Fig. 1108 is used in the cathode circuit of one of the i.f. amplifiers. The reason for using a cathode trap is that it does not require any major circuit change. The alignment of the other i.f. coils is not affected by the cathode trap except that the trap, when properly aligned, will reduce the strength of the sound carrier as indicated in Fig. 1107.

Reduced sound signal will mean a weaker signal at the ratio detector and in turn less chance of a strong AM buzz to ride through. The ratio detector is quite sensitive to weak FM signals, but strong AM signals can ride through.

Occasionally an audio lead may pick up the 60-cycle pulse while passing near a vertical sweep section component. The vertical blocking oscillator and the output transformer are especially strong radiators and audio leads should be kept away from them as much as possible. Often the pickup is magnetic, and ordinary copper shielding is not sufficient. The best remedy is to re-route these audio leads.

In a few receivers the diode used for limiting the sync pulse in the sync separator circuit is part of the ratio detector and audio amplifier tube, such as the 6S8-GT or the 6T8. In this case the buzz may be picked up inside the tube. The only remedy is to use another diode, possibly a crystal like the 1N34, located near the sync separator tube socket.

This chapter has covered a large number of causes and cures for intercarrier buzz. Don't be overwhelmed. In a normal, well-designed receiver, touching up the alignment of the ratio detector or oscillator and checking tubes and components will be all the servicing necessary in the vast majority of cases. The rest of the information may be found useful for a more general understanding and in occasional difficult servicing jobs. Remember, there shouldn't be any annoying buzz in an intercarrier set; all causes for it have their cures.

Chapter 12

Vertical Sweep Problems

A CONSIDERABLE proportion of television receiver troubles arise in the vertical sweep circuits. Fairly simple in design, the basic vertical sweep circuit consists of an integrator (or pulse-shaping network) feeding a 60-cycle control signal into an oscillator. The oscillator is either a blocking-tube or multivibrator-type oscillator. The oscillator, in turn, operates a discharge circuit in whose output we find a sawtooth-forming capacitor and peaking resistor. The sawtooth across the discharge capacitor plus the square-wave voltage across the peaking resistor combine to give a trapezoidal wave. This is applied to the grid of the vertical output tube, which amplifies this voltage, and delivers it, via an output transformer, to the vertical coils of the yoke. Before proceeding with an analysis of the various difficulties that can arise in vertical sweep circuits, the assumption is made that sync separator, oscillator, discharge, and output tubes have been replaced. For an analysis of vertical control troubles, refer to Chapter 5.

No vertical sweep

Do not confuse this with partial loss of sweep, foldover, or any form of picture compression. Complete lack of vertical sweep shows itself as a single, bright horizontal line across the face of the tube. In the event that you get no vertical sweep, consider the vertical scanning section as consisting of two portions—the vertical oscillator and the vertical amplifier. First make sure that there is no failure of the vertical oscillator by measuring the d.c.

voltage between control grid and chassis. The amount of bias voltage will vary, depending on the model and make, but should not be less than –10 volts, usually much higher. Presence of bias voltage indicates the oscillator is working. A plate-voltage check of the vertical oscillator is not too useful, although lack of oscillation is indicated by lower than normal plate voltage. If the vertical oscillator tube runs unusually hot, you may have reduced bias or complete loss of oscillation.

If the oscillator bias voltage agrees with the figures shown on the manufacturer's schematic, put your scope leads across the discharge capacitor. Start with the SYNC control on the scope at its minimum setting and then turn it slowly clockwise until the waveform locks in. Adjust COARSE and FINE FREQUENCY controls (about 30 cycles) until two waveforms appear. The waveform should be a sawtooth. Now take the scope test lead and put it on the control grid of the vertical output tube. At this point you should get the distorted sawtooth (trapezoid). Absence of this waveform indicates an open coupling capacitor between discharge circuit and vertical output stage. You can also run a quick check on the vertical amplifier by feeding 60-cycles (tapped off the filament supply) into the control grid of the vertical amplifier tube and noting if the signal is passed by the amplifier on to the vertical yoke windings. If the oscillator is working, but signal injection to the control grid of the amplifier does not produce vertical deflection, put the 60 cycles at the plate of the vertical amplifier tube (through a 0.1-μf capacitor), and finally across the vertical windings of the yoke itself.

Once you have localized the defect in a particular section of the vertical sweep circuit, a resistance or voltage check will help in finding the component giving trouble.

Insufficient height

Sometimes this is accompanied by insufficient width. If so, check low-voltage B plus line. Insufficient emission from low-voltage rectifier tube is a common cause. If two rectifier tubes are used, replace both. If a selenium rectifier is used, measure front-to-back resistance ratio (should be 10 to 1, or better). Preferred check is by substitution. Bad odor in vicinity of selenium rectifier is definite sign of defective unit. Partial short *elsewhere in receiver* can also cause decrease in power supply voltage, particularly in cases of power supplies having very poor voltage regulation.

In checking for insufficient height troubles, start with the discharge circuit. Check sawtooth waveform across discharge capacitor and follow signal through to vertical yoke windings with scope. Check the cathode-bypass capacitor of the vertical output tube by shunting it with an electrolytic capacitor of 20 µf or more. If the cathode bypass of the vertical output tube should decrease in value or become open, vertical gain will decrease due to degeneration.

Loss of height and poor vertical linearity can often be traced to a change in the value of the discharge capacitor and peaking resistor in the plate circuit of the vertical discharge tube.

Transient oscillations

Resistors, usually 560 ohms, 1/2 watt, are ordinarily placed across the vertical yoke windings to damp out shock oscillation caused by the rapid collapse of the magnetic field (during vertical retrace time) around the vertical yoke. If either or both of these resistors are open, the trouble will be shown as one or more thin, white horizontal lines across the top of the screen. Since the resistors are in parallel with the yoke windings, one end of each of the resistors will have to be unsoldered for a resistance check. The resistors are mounted directly on the terminals of the yoke winding. Another effect produced by open damping resistors is a damped oscillation across the top of the picture giving a wavy appearance starting at the upper left but dying out toward top center.

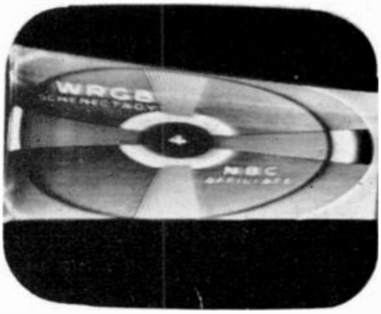


Fig. 1201. *Actual photo of keystoned picture.*

Keystoning

A keystoned picture (see Fig. 1201), has sides of unequal height. The picture is tapered either from left to right or from right to left. This trouble is caused by a short in the vertical section of the yoke. Either one-half of the vertical yoke winding is shorted, or its shunting resistor is shorted. Unsolder the shunting resistors and test them. If O.K., check the yoke itself. However, a resistance test of the yoke is not always conclusive, since a shorted turn will hardly affect the resistance of the winding. In keystoning, the quickest and best procedure is to substitute a new yoke.

Vertical nonlinearity

A decrease in capacitance of the discharge capacitor will give reduced height accompanied by vertical nonlinearity. In this case, no setting of the vertical linearity control will correct picture defect. If possible, use capacitor substitution box and vary controls until best linearity is obtained, or else make exact substitution of value recommended by manufacturer.

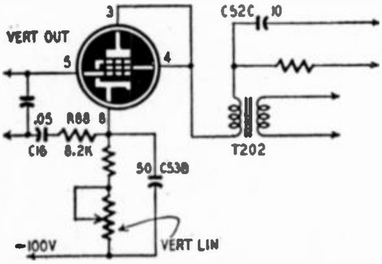


Fig. 1202. *Vertical output stage has the linearity control in the cathode circuit.*

Check these components shown in Fig. 1202; vertical output transformer, resistor R88 and capacitors C16, C53B, or C52C.

Try a new vertical output tube. If this does not improve vertical linearity, try a new cathode-bypass capacitor in the vertical output stage. After you replace the capacitor, try adjusting the vertical linearity control to see if linearity can be improved. If there is no improvement, check the series resistor connected to one end of the control and also test the vertical linearity control itself.

For a picture to have vertical linearity, it is essential that the *current* flowing in the vertical scanning coils have a sawtooth waveform. The voltage across the vertical windings that will produce such a current is a combined sawtooth and square wave known as a trapezoid. It is difficult to examine the trapezoid across the vertical deflection coils for nonlinearity for several reasons. The vertical output transformer is a step-down transformer. Putting a scope across the secondary would be putting it across a low-voltage signal source. Furthermore, the trapezoid can vary in shape, making it difficult to know just when adjustments will result in the proper waveshape. Break open the hot lead to the vertical yoke, insert a 5 or 10 watt, 100-ohm resistor, and put your scope across this resistor. Linear vertical sweep will produce a fairly decent looking sawtooth. You can now watch the effect on the vertical linearity as you change components in the vertical sweep circuit.

Vertical jitter (also called flicker or bounce)

This is sometimes accompanied by poor focus. Check all the resistors and capacitors in the R-C network (integrating network) feeding the vertical oscillator. If these components are off by more than 10%, replace them. Check the cathode-bypass capacitor of the vertical otuput stage for leakage. If only the top of the picture jitters (for about 2 inches) make sure horizontal hold control leads are dressed away from the vertical output transformer. Trace the signal through the vertical sweep circuit with your scope, until jittery waveform is seen. Make sure the "hot" lead (usually coded red) of the horizontal yoke winding is away from the vertical oscillator.

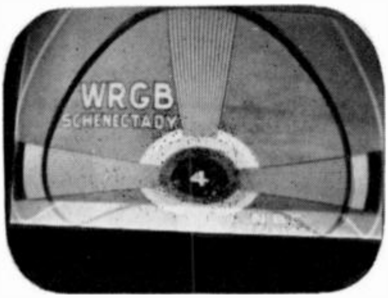


Fig. 1203. Foldover at bottom of picture.

Bars

Leakage between the heater and the cathode of the vertical output tube will produce a bright, horizontal bar across the top of the raster. Check tube by substitution.

Foldover at bottom of picture

Foldover is not unusual, but a knowledge of its various sources can save a lot of time in checking the vertical sweep circuits. The "curtain-raising" effect (Fig. 1203) is probably the most common. This is usually caused by a leaky grid capacitor in the vertical oscillator circuit, a leaky coupling capacitor in the vertical output stage, or a changed value in the vertical oscillator cathode circuit (if cathode is not grounded). The bottom half of the picture will also fold over if the grid resistor of the vertical output tube goes down in value considerably.

Make sure that the line voltage is not below normal. If set gives foldover in customer's home, but not in your shop, compare line voltages. Check the vertical output tube by substitution. Use a known *good* tube for this test. Vertical foldover can also be caused by insufficient voltage on the plate of the vertical output tube. Substitute a new low-voltage rectifier tube. If the R-C values of the discharge and peaking circuit are not within tolerance, they may also cause foldover.

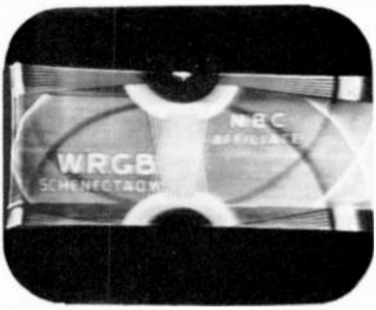


Fig. 1204. *An example of complete vertical foldover.*

In some cases the vertical circuit is operated from the boosted B plus line. A very common trouble here is breakdown or leakage in the electrolytic decoupling capacitor, and an increase in the value of the decoupling resistor. This almost invariably produces a bottom foldover.

Complete vertical foldover

Complete vertical foldover (see Fig. 1204) is caused by leakage across one of the integrating capacitors.

Vertical rolling

Rolling can be caused by wrong R-C values in the vertical oscillator (either blocking-tube type or multivibrator) or by loss of vertical sync pulses. Vary the vertical hold control. If you are able to make the picture slow down, stop or lock for just a moment, and then make it run in the other direction, look for loss of sync input as the cause of the trouble. The vertical hold control should give lock-in action at around the center of its travel. If the picture wants to lock in at either end of the pot, then check the R-C values in the oscillator circuit.

A faulty video detector germanium diode can cause vertical rolling. You can make a quick check of the crystal by unsoldering one side of the diode and testing the front to back ratio with the ohmmeter section of a v.t.v.m. The front to back ratio should be between 1,000 to 1,500. If, for example, the diode reads 500 ohms, it should read at least 500,000 ohms when the test leads are reversed. Be careful when unsoldering. Crystals are easily ruined by heat. Use a pair of long-nose pliers between the lead of the crystal and the body of the crystal itself. The pliers will act as a thermal shunt, permitting you to unsolder the joint, yet keeping heat away from the crystal.

Receivers are most susceptible to rolling in weak signal areas. This is due to the poor signal-to-noise ratio. Under such conditions the vertical oscillator can be triggered causing the picture to move up or down one or more frames. The horizontal oscillator may not exhibit this tendency since it is governed by an a.f.c. circuit. The use of a booster or antenna having higher gain will help. Weakened tubes (not necessarily defective) will cause rolling under such conditions. Replace sync separator, sync amplifier, vertical oscillator and amplifier tubes. It may even be necessary to work back from the point of sync take-off to the front end. Set a.g.c. (if any) for maximum set sensitivity. Experimentation with the grid return resistor of the vertical oscillator may be required.

Poor interlace

If you get poor interlacing on one station, but not on others, the trouble is not in the receiver but is due to the one paricular station.

Poor inerlacing can be caused by 15,750-cycle pulses leaking over from the horizontal sweep circuit into the vertical oscillator. Keep wires carrying 15,750 cycle currents away from the vertical sweep section.

The picture will not interlace properly if the vertical hold control is set so that the picture is just on the verge of rolling downward. There are a number of ways in which the service technician can judge whether or not a picture is properly interlaced. Examine the *horizontal* wedges of a test pattern (in toward the center). Poor interlacing is shown by the presence of a *moire* effect. If a test pattern is not available at the time you are servicing a receiver, you can check the interlacing by using the contrast and brightness controls. Turn the contrast control down somewhat (but not so much that the picture will go out of sync). Now increase the brightness until you can see the vertical retrace lines. If the retrace lines tend to "pair off" or come in groups of two's, then the interlacing is poor. If the spacing between all the vertical retrace lines is fairly uniform, then the interlacing is satisfactory.

Proper interlacing is helped by the pulse shaping or *integrator* network at the input to the vertical oscillator. If poor interlacing persists, check these components and replace any that are more than 10% off tolerance. Some sets have poor interlace due to faulty design. Interlace can be lost due to noise interference. Be sure to read the chapter on elimination of interference.

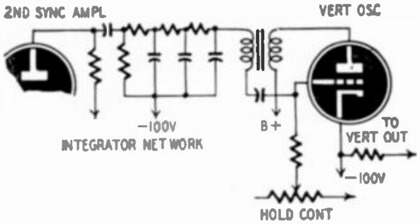


Fig. 1205. Wrong plate and integrator voltages may cause unstable vertical sync.

Oscillator time constant

A double picture results when the vertical sweep rate is reduced from 60 cycles to 30 cycles. This gives the appearance on the screen of one narrow picture *above* the other (two distinct pictures) with a blanking bar between them. This is caused by an increase in the time constant of the R-C network in the grid circuit (grid leak and grid capacitor) of the vertical blocking oscillator or in almost any of the resistors and capacitors in a multivibrator. Usually the grid resistor increases in value. If the time constant is sufficiently increased, the vertical oscillator frequency may drop to 20 cycles, and you will see a triple picture. Because of the reduction in frequency, a definite flicker will be noticed.

If the grid leak or grid capacitor should *decrease* in value (thereby decreasing the time constant), the vertical sweep frequency may rise to 120 cycles. The more rapid sweep will result in two pictures, one placed *on top* of the other. If you are unable to get a single picture at any setting of the vertical hold control, the vertical oscillator is not operating close to 60 cycles (or some multiple of 60 cycles).

Unstable vertical sync

This problem is similar to rolling, previously described. In some instances the vertical hold control will lock the picture in but the control may require frequent readjustment while the set is operating. If new tubes in the sync separator and oscillator circuits do not help, then check the grid circuit of the blocking oscillator or all R-C components if a multivibrator is used. Check the integrator network for any components that have radically changed values. Check the sync-amplifier plate voltage. Sometimes the integrator network is not returned to ground but to some negative potential, as shown in Fig. 1205. Check this voltage. If the set is not property aligned or has been tampered with, resulting in poor low video-frequency response, it is possible that the vertical sync pulses may be attenuated or completely lost.

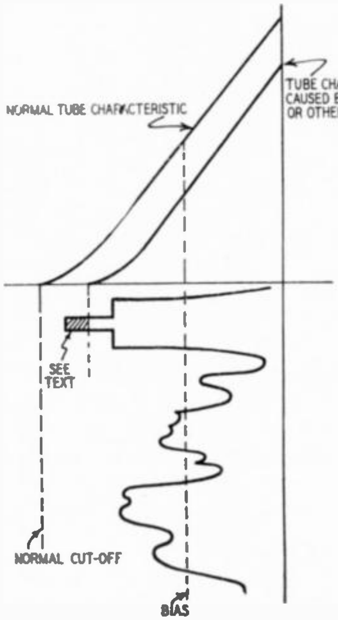


Fig. 1206. Tube aging, low voltages, or circuit defects may weaken sync by clipping signal peaks (shaded portion).

You may notice that a receiver will have good vertical sync stability during the transmission of a live show, but may fall out of sync intermittently during film commercials. Assuming that the vertical oscillator and output tubes, as well as sync separator and sync amplifier tubes are in good condition, you should check the tubes which precede the point of sync take-off (in the video amplifier). Overmodulation of the video carrier during film commercials is generally due to large transients set up by sudden changes from black to white in printed matter (and also in animated cartoons) and sometimes caused by 36-cycle and 84-cycle beats between the 24-frame film and the 60-field vertical scanning. An increase in signal strength can cause sync clipping. This can also be caused by a weak video tube since it will saturate at weaker signal strengths. Tube aging, low voltages, or circuit defects may weaken sync by clipping signal peaks (shaded portion shown in Fig. 1206). The vertical sweep system is particularly susceptible since nearly all sets are without vertical a.f.c.

Chapter 13

Television Interference

IF YOUR TV receiver suffers from a constant barrage of interfering signals which rip your picture to shreds, just follow along while we point out causes and cures for about 95% of all TVI.

Because a television broadcasting channel is 6 megacycles wide, a receiver's tuned circuits cannot be made selective enough to eliminate all interference on adjacent frequencies. Furthermore, picture and sound i. f. circuits respond to strong signals so that interference patterns appear in the picture.

Because the front end of a TV receiver cannot completely reject signals outside the 6-mc channels, such signals must be kept from the active circuits of the receiver. Exaggerated advertising has led the average set owner to believe that a TV receiver is a perfect piece of equipment and that all interference must be eliminated at its *source*. This is not true!

All users of shortwave transmitters have become TVI conscious and most of them have taken steps to keep harmonic radiation within the limits specified by the FCC—still there remains plenty of TVI. Now that transmitters are being cleaned up, the rest is up to set owners and manufacturers. Some sources of interference can be cured by shielding, traps, or filters at the receiver.

Front end overloading

This trouble produces internal harmonics. Refer to Fig. 1301. L1 is the only tuned circuit at the input of the set. This circuit (typical of many front ends) has a curve which is expected to pass the TV spectrum 54 to 216 megacycles, and cannot be expected to drop off sharply at 54 or 216 mc. Therefore, local signals from approximately 27 to 54 and 216 to 255 mc, will pass to the grid circuit with only slight attenuation. A signal on any service between 54 and 216 mc. will pass with *no* bucking. Therefore an unwanted local signal can have a much higher strength at the grids than the desired TV sigs. This may cause the first r.f. tube to act as a frequency doubler or become completely saturated. Obviously, short-wave equipment operating properly at half the frequency of a given channel can thus appear as if it had a strong second harmonic.

The cure is to prevent the unwanted signal from reaching the front end. You can do that in either of two ways. If the unwanted signal is within or above the TV spectrum, use traps tuned to its frequency in the lead-in wire. If it is below the TV band it may be a better idea to use a high-pass filter which sharply attenuates all signals below the TV band, because stations in the short-wave region often change frequency to suit communication conditions. Interference from stations above 216 mc is unusual, and for this reason low-pass filters to attenuate signals above the TV spectrum are rare. High-pass filters for TV are readily obtainable from most radio jobbers. The service technician may have to build his own traps for specific frequencies, however. Construction information on traps and filters can be found in this chapter.

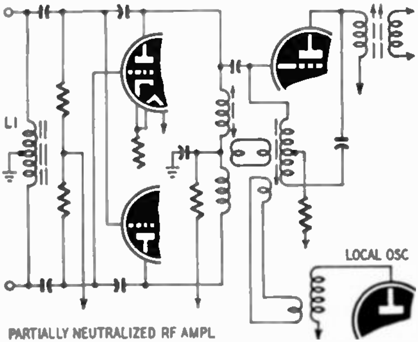


Fig. 1301. *Broad-band TV input circuit.*

Most interference is caused by equipment in the 54-mc region or below and a high-pass filter should be tried before time is consumed finding out what frequency the unwanted signal is on.

Be sure to install the trap or filter *as close as possible* to the front end of the set. Otherwise the wire from the filter to the front end may act as an antenna and pick up the unwanted signal.

Interference at the i. f.

Unwanted frequencies may be brought directly into the i.f. amplifier through the three series capacitors to the mixer grid along the top line of Fig. 1301. This type of interference is seen on all channels. It is treated by using traps.

Direct i. f. pickup

Signals at the intermediate frequency may be picked up through the bottom of the set. This usually becomes bothersome only when the picture or sound i.f. strip is very close to or on the same frequency as the unwanted signal. It shows up on all channels on either the respective picture or sound carrier. Don't confuse it with a case in which saturation of the first r.f. tube may cause severe interference on all channels, both sound and picture. Direct i.f. pickup can definitely be seen with the antenna grounded.

Complete screening of the bottom and top of the set is usually required.

Shock excitation

Strong signals below 54 mc may be picked up by the antenna and lead-in and fed to the front end of the receiver. These signals appear on the grids of the r.f. or mixer stages and may so overload them that harmonics are generated in their plate circuits. Because the plate circuits are tuned to TV channels, harmonics in this range will be emphasized and heterodyned into the i.f. channels by the mixer.

Signals most likely to cause this trouble may be generated by commercial shortwave, police, fire, public utility, and amateur transmitters; and scientific, electro-medical and industrial heating equipment operating below 54 mc. Shock excitation causes interference which blanks out all channels—active and inactive.

If the frequency of the interfering signal is known, series- and parallel-tuned traps, open quarter-wave or shorted half-wave stubs, or highpass filters may be inserted in the antenna lead-in close to the tuner.

Cross modulation

The receiver's oscillator may generate a fundamental or harmonic which beats with signals outside the TV channel. This may produce heterodynes (cross-modulation) which fall inside the channel to which the receiver is tuned. For example: When a receiver having a picture i.f. of 25.75 mc is tuned to channel 3, its oscillator is operating on 87 mc. Some of this 87-mc signal may appear on the grid of the r.f. stage and beat with a 2-meter signal on 148 mc to produce a 61-mc heterodyne (148–87 = 61) which falls directly on the video carrier of channel 3. This unwanted signal will be amplified by the 60-66-mc tuned r.f. amplifier, heterodyned by the mixer, and fed into the video i.f. amplifiers. The same reasoning is applicable to receivers operating with higher i.f.'s. Thus the set, with the help of a legitimate signal existing between the low and high channels, creates its own interference.

Likewise, when a receiver is tuned to channel 5, its oscillator —on 103 mc—can beat with a local TV station on channel 7 or 8 to produce beats in the 71-77 or 77-83-mc ranges. These beats span the carrier frequencies of channels 5 and 6 and produce interference patterns. Similar types of interference can be produced on other channels and in TV receivers of any intermediate frequency whenever the receiver's oscillator generates signals which will heterodyne extraneous signals into the TV channel being received.

The simplest way to reduce or eliminate interference of this type on a given channel is to connect a shorted half-wave stub across the set's antenna terminals. Cut the stub to the receiver's oscillator frequency. If the oscillator frequency is not in other TV channels, the stub may be permanently connected across the lead-in. In other cases, a switch may be needed to cut the stub out of the circuit. Sometimes a half-wave stub cut to the interference will do the job. If this type of interference occurs on several channels, you may have to cut separate stubs for each channel and switch them in as the receiver is tuned to different channels.

Radiation from other sets

Radiation from the local oscillator in the TV receiver may reach the antenna and be broadcast into neighboring receivers. Interference can also be picked up from FM sets since the oscillators of some FM receivers tune between 77.3 and 97.3 mc. Radiations from them will fall in channels 5 and 6 whenever the offending FM receiver is tuned between 88 and 98.7 mc. Some FM sets have their oscillators set 10.7 megacycles above the incoming signal. Radiation from such oscillators will fall in the upper TV v.h.f. channels.

Traps, stubs, and filters are usually useless in eliminating interference which falls directly on a TV channel; but if the interference is weak, cut a half-wave stub for the channel being received. Try shorting the stub with a carbon resistor between 22 and 220 ohms. Sometimes you can eliminate the interference without losing the video and sound carriers. Use the largest resistor that will reduce the interference so it is not objectionable. If this method does not work, try to locate the offending receiver. Once it is located, advise the owner to connect a booster in front of his receiver. A booster will help to attenuate oscillator radiation into the offending set's antenna. It will *not* help if the radiation is direct, rather than through the antenna.

Diathermy

Interference from electromedical, scientific, and industrial heating equipment is usually below 50 mc and can be prevented from entering the receiver via the antenna by using a high-pass antenna filter. As additional precautions try line filters and a shield around the receiver chassis.

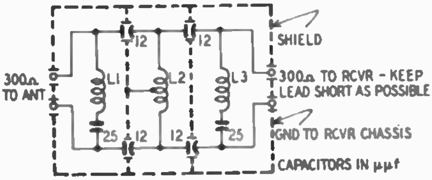


Fig. 1302. Circuit of the 300-ohm filter.

Constructing rejection circuits

Fig. 1302 shows an m-derived high-pass filter for 300-ohm transmission line. The 300-ohm filter will cut off all signals below 45 mc. L1 and L3 are 15 turns of No. 20 enameled wire closewound with an inside diameter of ½ inch. L2 is a center-tapped coil of 16 close-wound turns of No. 20 enameled wire on a ¼-inch form. Similar filters are available as kits and as wired units. A photo of the 300-ohm high-pass filter is shown in Fig. 1303. The forms on which the coils were wound have been removed.

The 72-ohm filter shown in Fig. 1304 is more elaborate than the 300-ohm model. It was used to prevent 75- and 20-meter fundamentals from reaching a TV receiver which had its antenna within 5 feet of the transmitting antenna. All coils are wound with No. 22 enameled wire and are ½ inch in diameter and ½ inch long. L1 and L4 have seven turns. L2 has four and one-half turns, and L3 has four turns. See Fig. 1305 for a photo of this filter.

The layout and construction are important to the performance of high-pass filters. The 300-ohm filter is not shielded because this is not necessary. If the TVI is severe, the filter must be placed in a shielded box, as was the 72-ohm job. Individual shields between the coils of the filter may also be necessary. But in most cases it is sufficient to mount the coils with their axes at right angles to each other. The components are soldered to lugs riveted to a sheet of Bakelite. The broken lines in Figs. 1302 and 1304 show how shields are placed between the coils.

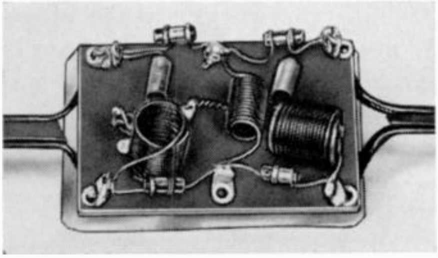


Fig. 1303. Photo of the 300-ohm highpass filter.

Figs. 1306-a and -b show parallel- and series-tuned traps made from Ohmite r.f. chokes and miniature variable capacitors. Table 1 shows the values of inductance and capacitance for traps having different ranges. Ohmite chokes which can be used are shown in the column next to the inductance.

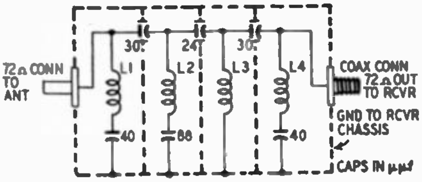


Fig. 1304. Circuit of the 72-ohm filter. Individual shields between the coils of the filter may be required. Use coaxial connectors for both input and output. Be sure to ground case of filter to receiver chassis.

The length of a half-wave stub in inches can be calculated from the formula:

$$\frac{5904 \times \text{v}}{\text{Freq. (mc)}},$$

and the length of a quarter-wave stub from:

$$\frac{2952 \times \text{v}}{\text{Freq. (mc)}}.$$

The factor v is the velocity of propagation of the signal in the line, expressed as a fraction of the speed of light, and is equal to 0.659 for coaxial cables, 0.68 for 75-ohm ribbon, and 0.82 for 300-ohm ribbon.

10- and 11-meter ham signals

The 11-meter band (27.16-27.43 mc) is within, and the 10-meter band (28.00-29.70 mc) is close to the i.f. passband of older TV receivers. Because the receiver's i.f. channel may be 6 mc wide, its tuned circuits cannot keep out signals only 1 mc away. Interference from nearby 11- and 10-meter transmitters will be picked up even when such equipment is operated well within the FCC requirements.

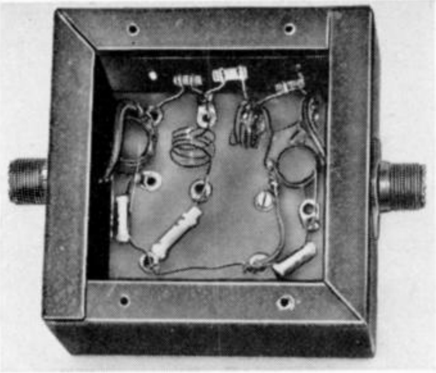


Fig. 1305. The highpass filter for 72-ohm coax.

Interference from these sources generally appears as blanketing on all channels. Remove the antenna from the receiver and short out the antenna-input terminals. If the interference is still present, the components in the i.f. channels are picking up the signals directly.

This interference can be eliminated by shielding the receiver and using r.f. filters in the power line. Because the interference can still enter the shielded receiver on the antenna lead-in, it may be necessary to use a highpass filter in the lead-in.

6-meter amateur signals

The 6-meter amateur band (50-54 mc) is adjacent to channel 2 (54-60 mc). The tuned circuits in the front end of the receiver are not selective enough to eliminate entirely a strong signal from a transmitter on the high end of the 6-meter band while receiving a channel-2 video carrier on 55.25 mc.

Because the 6-meter band is so near channel 2, highpass filters are not too effective in reducing 6-meter pickup. Series- or parallel-tuned traps tuned to the interfering frequency will work well. For best results, the stubs or traps should be tunable to follow the transmitter as it shifts from one end of the band to the other.

FM stations

The second harmonics of FM broadcast stations fall between 176 and 216 mc and can cause interference on all high-band TV channels, and images of 103- to 106-mc stations fall on channel 2. As the interfering signals are directly on the TV channels, traps and other rejection circuits are not practical. This type of interference problem can best be solved by using a highly directive beam-type, high-band TV antenna with a high front-to-back ratio. The antenna should be oriented so the FM signals arrive from the back or side. You are out of luck if the FM and TV stations are in the same direction from the receiving antenna.

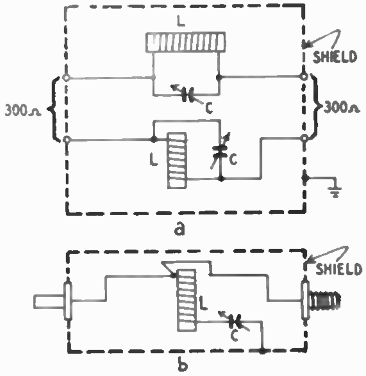


Fig. 1306. Shunt and series-tuned traps.

Electrical appliances

Cash registers, electric signs, motors, hair dryers, and numerous other electrical appliances produce sparks and arcs which generate damped waves over a wide band of frequencies.

The source of the interference can usually be located by timing the interfering signals to determine if they have a particular pattern or cycle. For example, if the interference is on and off for 50-second intervals, it may be caused by a traffic light; if it is more frequent, look for flashing signs in the neighborhood. Once you locate the offending device, make a report to its owner and to the power company. Urge the owner of the equipment to install line filters and shields to eliminate the trouble. If you cannot get action in the matter, make a report to the Radio Inspector in your district or write to the Secretary of the Federal Communications Commission, Washington 25, D. C. In the meantime, it may be worthwhile to try a high-pass filter in your lead-in and a filter in the power line.

Video-amplifier pickup

The video amplifier of the receiver responds to signals ranging from low audio frequencies to 3.5 or 4.5 mc. Strong signals below 4.5 mc will cause serious interference if they get into the video amplifier. This is particularly true of 3.5-4.0-mc amateur transmitters. Most of this type of trouble is by pickup from power lines and unshielded components in the video amplifier. Shield the receiver and install filters in the lead-in and power line to prevent it. Sometimes, shielded or coaxial transmission line will eliminate the interference that is picked up by the video amplifiers.

TABLE 1

L μh	Ohmite Type	C-$\mu\mu$f-at 3.5-10 mc	C-$\mu\mu$f-at 7-21 mc	C-$\mu\mu$f-at 21-56 mc
.02	Z-28	100		
.007	Z-50		75	
.00085	Z-235			70

Audio-amplifier pickup

Strong AM signals may be detected in the audio or video stages. All channels are affected, with or without front end and i.f. stages operating.

Pickup in the audio amplifiers is similar to that in the video amplifiers. Direct pickup in the a.f. amplifier is present when the volume control fails to attenuate the sound interference. Such interference is most common in TV-radio-phono combinations having the a.f. circuits on a separate chassis. The cure for the audio trouble here also applies to phonos, public-address systems, and radios, and is cleared in the same manner. Refer to Fig. 1307. All or one of the following steps may be necessary to clear audio trouble: Make all audio leads short. Shield hot leads in the high-gain voltage-amplifier stage or stages. When the interfering signal is coming through, touch a 3-foot test lead to each audio grid in turn until the interference gets louder. Try bypassing the grid of this stage to ground with a 200- or 300-μμf mica or ceramic capacitor. Keep the leads as short as possible. If this does not work, add an 82,000-ohm resistor in series with the hot lead to the grid. This appears as R1 and R2 in Fig. 1307. The resistor and capacitor will form a low-pass filter which shunts r.f. to ground and prevents its being detected in the a.f. amplifier.

Signals via the line cord

Most manufacturers include a certain amount of line filtering, which usually suffices. An additional line filter should be tried if the preceding cures don't completely clear the trouble for which they are intended. A line filter may be obtained readily or built from one of the many published circuits. Install close to back apron, inside or out, and ground to chassis or cold side of line. Beware of a.c.-d.c. sets. If you are using a filter on one of them, connect a .001-μf mica and 0.1-μf oil-filled paper capacitor in parallel and hook the combination between the case of the filter and earth.

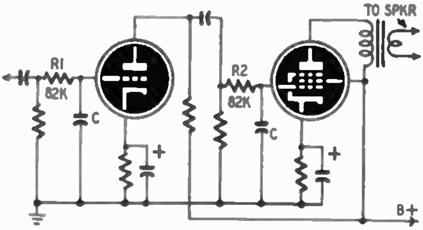


Fig. 1307. Remedies for a.f. grid detection.

Complete screening of the bottom and top of the receiver should be done carefully with the purpose in mind of keeping the r.f. from entering the set's wiring. Usually when screening is needed, only a thorough job does the trick. Copper window screening is probably best adapted to the work. Obviously one can't screen the front of the picture tube. Luckily the aquadag grounds it capacitively. But the average speaker—if left unscreened on the front—can let enough r.f. through to defeat the purpose of the whole job. In this case it may be advisable to ground the speaker frame to the chassis or B minus line. Closely bond the edges of the screening and spot-solder to chassis at regular intervals.

Chapter 14

Servicing Suggestions

ALL television receivers in use today are unfortunately not designed for the ideal 4-mc i.f. bandpass. If the video i.f. amplifier consists of only two or three stages, bandwidth is sacrificed in order to get adequate gain. This poses an impossible problem for the servicing technician when the customer insists on better picture quality.

If slight defects in the receiver are contributing to the poor definition, corrective measures can often be taken. Careful checks should be made on the focus control system, the video i.f. alignment, the r.f. tracking, and the antenna system. With these working at peak performance, remarkable improvement is often realized.

Initial checks should be made on the focus control circuit. If the focus control requires an extreme setting, or is entirely ineffective, the voltage across the focus coil as well as the current through the resistive network of the control should be tested against manufacturer's data. Changes in resistance values in the focus control circuit or a defective focus coil can bring about inability to secure good focus. Low or abnormal high voltage can also produce defocusing.

If the focus control gives best results at around mid-range but the picture is not satisfactory then the trouble, most likely, is elsewhere. This could include improper alignment of the i.f. system or poor tracking in the tuner. Improper alignment gives poor picture quality on all stations, while improper tracking may affect only *some* stations. This depends on the tuner used. Poor tracking is sometimes encountered in the drum type tuners using plug-in coils.

A contributing cause to poor picture quality would be standing waves on the transmission line. A mismatch between the line and the receiver input means that all the energy is not absorbed by the receiver's r.f. stage. The unabsorbed energy is reflected back to the antenna and sent back down the line again. Simultaneous reception of the direct signal and the reflected signal of the lead-in can displace picture line structure enough to blur the picture. The length of the line may not be sufficient to cause severe displacement—such as occurs during ghost reception. A small displacement will, however, blur the picture. This is shown in the photo (Fig. 1401) in which line reflections were present. The photo, Fig. 1402, shows the same receiver on another channel which, due to the difference in frequency, allows a better match between the antenna and receiver. Matching the transmission line to the receiver impedance will help a great deal on blurry channels. Of course, any mis-orientation of the antenna to the station being received will ordinarily make any further work on the picture in vain.

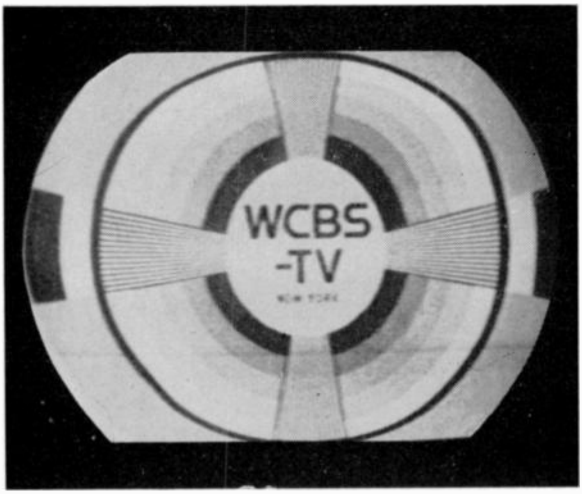


Fig. 1401. *Photo above shows blurred pattern due to line reflections.*

"Ringing" or a slight "echo" effect which causes repeats to the right of sharp vertical lines due to transient oscillations in the picture system can also cause poor picture quality. This calls for a check of the peaking coils in the video amplifier and, in addition, the r.f. tracking and i.f. alignment. If the video response curve favors the high-frequency sideband components, r.f. or i.f. stages can easily be pulsed into damped oscillations.

An oval beam within the picture tube instead of a perfectly round beam will cause poor definition. This can be ascertained by rotating the picture tube approximately 90 degrees. In such a case, if the horizontal wedge is slightly obscured but the vertical wedge is clear the opposite would be true after the tube is turned. This immediately gives an indication of an incorrectly formed electron beam which cannot be focused to a circular pin-point on the phosphor screen. Tube replacement is, of course, necessary in correcting this condition.

Servicing the pix i. f.

A television service technician must always be careful when installing new components to make sure that circuit performance is not upset. Often exact replacements are essential and original lead dress must be maintained. This is particularly true with the 40-mc video i.f. circuits. They operate at higher frequencies than the older 25-mc circuits, therefore stray capacitance between adjacent wires and parts affects performance much more.

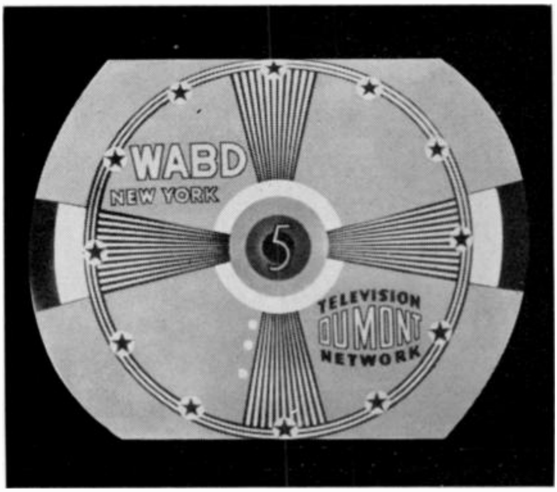


Fig. 1402. Pattern now indicates improvement due to better impedance matching.

At high frequencies capacitive effects are greater, and so more energy is lost through unintentional bypassing. Undesired coupling may occur to cause regeneration and oscillation. Remember that the shunting effect of capacitances increases as the frequency increases.

The interelectrode capacitances of the tubes are also of increasing importance in receivers using 40-mc i.f.'s. These could cause the video i.f. amplifier stage to oscillate, even though a pentode is used. Thus, neutralization is usually necessary to prevent feedback.

Fig. 1403 shows a typical 40-mc video i.f. amplifier. Usually the video i.f. is 45.75 and the sound i.f. is 41.25 mc. The amplifier is neutralized by using a screen bypass capacitor which is too small to bypass the circuit completely. Inadequate bypassing causes screen-circuit degeneration which neutralizes the signal energy that is coupled to the grid circuit via the interelectrode capacitance. This prevents the stage from oscillating. Thus, when replacing the screen-bypass capacitor in video i.f. circuits, make sure that the replacement is the same type and value as specified by the receiver manufacturer. Cut the leads of the new capacitor to the same length as the original and place it in exactly the same position as the defective one.

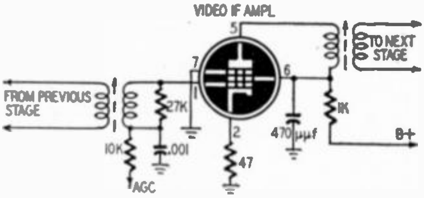


Fig. 1403. A typical 40-mc i.f. amplifier.

Note that the cathode resistor in Fig. 1403 is not bypassed. This is usually the case in video i.f. amplifiers connected to the a.g.c. line. Variations in a.g.c. cause the input impedance to change. This is minimized by cathode-circuit degeneration which results when the cathode bypass capacitor is omitted. For this reason the technician should never assume that the manufacturer accidentally omitted the bypass or left it out for reasons of economy. Never insert a cathode bypass to increase gain, since this upsets alignment and may cause the stage to oscillate. If the gain is too low, try a new tube and check components as well as voltages.

Pincushion effect

Many receivers use the curved-face (or so-called "cylindrical") rectangular tubes designed to eliminate room glare. These include the 17LP4, 17QP4, 21EP4A, 21FP4A, and 21KP4A. When a cosine-wound yoke is used with these tubes for sharp edge-to-edge focus, pincushion effects are set up.

To eliminate them, two magnet slugs are placed above and below the tube at the beginning of the flare. These magnets extend slightly beyond the frame of the yoke housing and are suspended by an adjustable wire support.

When replacing defective picture tubes of this type, the magnets may have to be readjusted, particularly if they are accidentally moved from their original position.

Unless a station pattern is on, or a cross-bar generator used, the pincushion effect may not be too noticeable. But when viewing televised scenes with vertical or horizontal sections, the viewer would notice the bending effect and distortion. Adjustments are simplified if the picture size is reduced slightly so the pincushion effect is noticeable as shown in Fig. 1404. The magnets should then be adjusted until the picture is perfectly rectangular, after which the size can be increased to fill the mask properly.

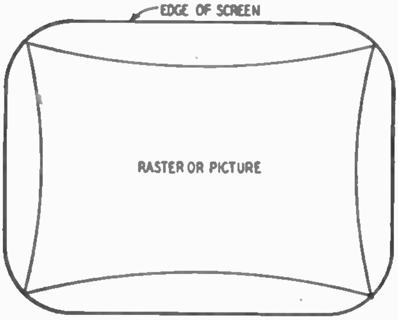


Fig. 1404. Pincushion effect as it appears in the raster or picture.

This adjustment will not correct poor sweep linearity or overdrive conditions. Such defects must still be overcome with the usual controls.

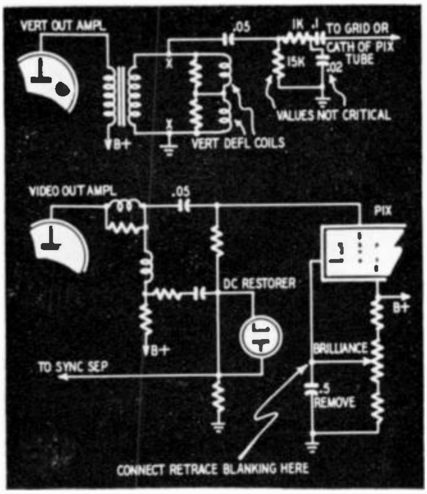
Another factor important in servicing such televisions receivers: Adjustments of the centering ring may disturb the edge-to-edge focus procured from the cosine yoke. Thus, after positioning the picture with the centering ring adjustment, check the edge-to-edge focus by closely observing whether the horizontal line trace is sharp along its entire length.

If this is difficult to see, misadjust the vertical hold control slightly until the picture rolls slowly. This will eliminate interlace and cause line-to-line pairing. Under this condition the line structure is heavier and edge-to-edge focus is easier to check. Readjust the focus control and recheck picture centering, for the focus control has a slight effect on picture position. Finally, readjust the focus control until full beam clarity is regained.

Also check the ion trap magnet. Too weak a magnet will make it difficult to eliminate corner shadows at the setting which gives maximum brightness. Incorrect ion trap magnet position will cause ion burns eventually—the length of time depending on how far off true position it is. If the magnet is weak it may have to be placed closer to the focus unit. The fields of the latter will influence the ion trap and make it difficult to adjust either one correctly. A new ion trap magnet is relatively inexpensive and can save costly picture tubes as well as permit you to make proper adjustments for better performance.

Retrace elimination

The circuit for eliminating retrace lines is simple. but several precautions must be taken to minimize loss of fine detail or briliancy. Such a circuit should not be used to correct for circuit faults or poor reception. If retrace lines are annoying, there may be trouble in the brilliancy control circuit or in the picture signal amplification. Except in extreme fringe areas, retrace lines should not show if the contrast and brilliancy controls have been properly adjusted. Poor alignment and tracking, a misadjusted ion trap, or a deficient antenna system all can contribute to insufficient blanking or improper bias in the picture tube. Thus, retrace lines are visible on most channels.



Figs. 1405, 1406. These two circuits show techniques used to obtain retrace blanking.

If the set is working properly you may see occasional retrace lines during camera changes or station breaks. If this is troublesome, or if weak fringe-area reception is to be improved, the retrace-elimination circuit can be added.

The circuit can consist of a single coupling capacitor from the secondary of the vertical output transformer to the picture tube. The R-C network shown in Fig. 1405 is preferable because of its better blanking waveshape. This type circuit is used in many Raytheon receivers. Since the output of this circuit is a shunt capacitor combination (0.1 µf in series with .02 µf), it will diminish high-frequency signal detail if applied to a circuit carrying the composite video information. If the last video amplifier feeds the grid of the picture tube, the eliminator circuit should be put in the cathode. If the video amplifier is connected to the cathode, the elimination circuit can be applied to the grid. Use the eliminator in the circuit containing the brilliancy control.

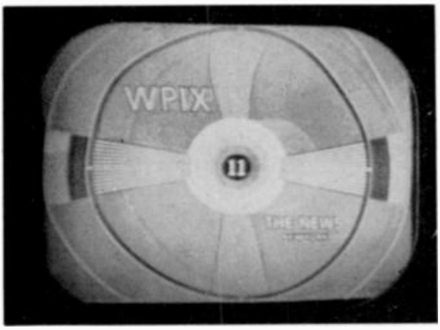


Fig. 1407. *Effect of retrace blanking. Note complete absence of retrace lines.*

Other precautions may be necessary. Refer to Fig. 1406, where a typical video output system is shown. If the retrace elimination circuit were applied to the cathode, the 0.5-µf bypass would shunt the retrace elimination pulse.

To prevent this, the 0.5-µf cathode bypass capacitor must be removed. This will not affect performance, because its duties will be largely taken over by the two series capacitors in the output of the eliminator. Since a positive pulse is needed, the terminals marked "x" in Fig. 1405 should be reversed if the system doesn't eliminate retrace. It can be tested by advancing brilliancy and decreasing the contrast-control setting. At extreme settings retrace lines may be faintly visible. For any setting less than full brilliance, retrace lines will be eliminated. Fig. 1407 shows the screen of a receiver (Admiral 30A1) which, in spite of high brilliancy and poor signal (to the point of sync instability) still has perfect retrace elimination with this circuit.

Be Sure to Read These Other GERNSBACK LIBRARY Books

43—MODEL CONTROL BY RADIO. Remote control of model planes, boats, autos. Theory and construction of coders, transmitting and receiving systems, decoders, power control circuits, servomotors, control systems. 112 pages. $1.00

44—BASIC RADIO COURSE. 26 chapters on radio theory as easy to read as a novel. Describes the action of radio circuits in a quick-to-grasp manner. Hard cloth cover. 176 pages. $2.25

45—RADIO TUBE FUNDAMENTALS. The first low-priced book to give a complete understanding of radio tubes. 96 pages. $1.00

46—TELEVISION TECHNOTES. Case histories of TV troubles. Describes and solves over 600 tough TV servicing problems. 128 pages. $1.50

47—RADIO & TV HINTS. Hundreds of shortcuts. The hints and kinks in this book are practical, and can be put to work by you. 112 pages. $1.00

48—HIGH FIDELITY. Maximum information on audio design, construction, measurement techniques. Complete section on building amplifiers. 128 pages. $1.50

49—RADIO AND TV TEST INSTRUMENTS. Build 22 instruments: Picture Tube Circuit Analyzer, Picture Tube Tester, Three-Inch Scope, Portable Generator, Signal Tracer, Practical V.T.V.M., Marker Generator, etc. 128 pages. $1.50

51—TRANSISTORS-THEORY AND PRACTICE. Semi-conductor theory, transistor characteristics, equivalent circuits, transistor amplifiers, oscillators. Gives data on practical transistor circuits, tests and measurements. 144 pages. $2.00

52—THE OSCILLOSCOPE. Chapters on waveforms, the cathode-ray tube, sweep systems, typical scopes, alignment techniques, tests, measurements, experiments. 192 pages. $2.25

53—RADIO-CONTROL HANDBOOK. For all hobbyists interested in radio control for planes, boats, trucks, tractors, etc. Practical construction ideas and suggestions. 192 pages. $2.25

54—PROBES. Explains how probes are used. Describes crystal-demodulator; voltage-doubler; balanced; low capacitance; high-voltage; isolation and direct probes, including a transistorized type. 224 pages. $2.50

55—SWEEP & MARKER GENERATORS for TV and Radio. Complete theory and use of sweep and marker generators. 224 pages. $2.50

56—HIGH FIDELITY CIRCUIT DESIGN. Feedback, drivers, inverters, power supplies, attenuators, filters, equalizers, speaker systems. Hard cloth cover. 304 pages. $5.95

57—THE V.T.V.M.—how it works—how to use it. Written by an RCA engineer, supplies full information on the theory and practical operation of the vacuum-tube voltmeter. 224 pages. $2.50

58—MAINTAINING HI FI EQUIPMENT. Service hi-fi systems. Chapters include: Hi-fi Standards; Test Instruments; Circuits; Diagnosis; Distortion; Bass and Treble Faults; Pick-ups; Styli; Turntables; Equalizers; Tuners; Adjustments. 224 pages. $2.90

59—SERVICING RECORD CHANGERS. Excellent source of profit for the service technician. Detailed drawings show how to make repairs. Full servicing information. 224 pages. $2.90

60—RAPID TV REPAIR. Alphabetical listing of hundreds of TV troubles — symptoms and specific information on repair. 224 pages. $2.90

61—TRANSISTOR TECHNIQUES. A useful guide on how to work with and test transistors; how to make transistor measurements; also supplies practical building projects. 96 pages. $1.50

62—TV—IT'S A CINCH! Snappy conversational style with hundreds and hundreds of drawings help you breeze through TV. 224 pages. $2.90

63—TRANSISTOR CIRCUITS. Over 150 practical circuits using transistors only. A guide for the experimenter interested in getting the most out of transistors. 160 pages. $2.75

64—UNDERSTANDING HI-FI CIRCUITS. A new approach to audio. Explains how modern audio circuits work and what you can expect from them. 224 pages. $2.90

65—SERVICING COLOR TV. How to repair color receivers. Illustrated with photos, drawings and troubleshooting charts. 224 pages. $2.90

66—BASIC AUDIO COURSE. Fundamental audio concepts; describes theory and operation of microphones, equalizers, amplifiers, speakers, enclosures. 224 pages. $2.75

67—ELEMENTS OF TAPE RECORDER CIRCUITS. Complete coverage of the electronic portion of tape recorders. For technicians and audiophile. 224 pages. $2.90

68—TV AND RADIO TUBE TROUBLES. Service TV and radio receivers by understanding tube troubles. Explains how to recognize symptoms quickly. $2.90

69—ELECTRONIC HOBBYISTS' HANDBOOK. Scores of circuits for the experimenter and hobbyist. 160 pages. $2.50

GERNSBACK LIBRARY, INC., 154 West 14th Street, New York 11, N. Y.