

**ART MARGOLIS**

**SERVICING SYNC CIRCUITS**

**\$5.65**  
(In the U. S.)

# SERVICING SYNC CIRCUITS

**ART MARGOLIS**



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# INTRODUCTION

TV RECEIVER repair is entirely different from design in its approach to electronics. The designer creates something that never existed before. The service technician restores original performance when it has deteriorated.

Both are technical arts, but of a different nature. The designer must have a knowledge of troubleshooting but he needn't go into fine points. The troubleshooter must have a knowledge of design but he needn't go into fine points either.

In fact, a troubleshooter can involve himself in a morass of deep theory that will tend only to confuse him and slow down his job. I am of the firm belief that a troubleshooter should concern himself mostly with troubleshooting. Since the TV receiver is already there, why think about the designer's work when you are trying to fix it? Think about fixing it.

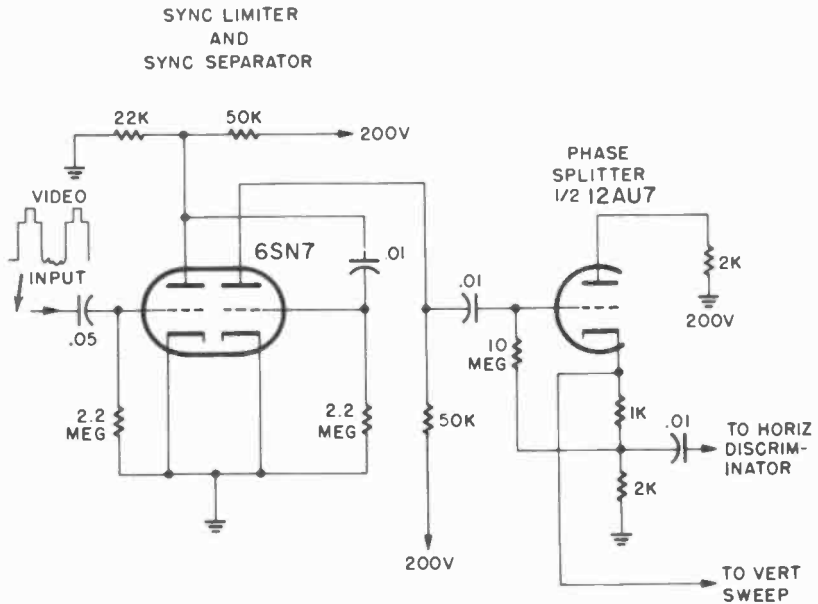
There are some areas of theory where design and repair overlap. Fine. Learn these small areas. Keep the rest of the technical mumbo jumbo for your hobby work or spare-time study.

In this book I hit heavily on repair as I see it. Specifically, I cover the techniques required to pinpoint components that cause sync troubles.

When I say sync I refer only to the vertical and horizontal sync components in the composite TV signal. The color-burst pulses, which are called color sync, are not included. In this book, we deal with those pulses that lock the vertical and horizontal sweep oscillators of the TV receiver into step with the TV station's transmission. The action is the same for both monochrome and color sets. The color burst signal locks the *colors* in place and has nothing to do with sweep oscillators.

Most of the book deals with common tube circuits. These are mainly the TV's you are called upon to repair. When you run into variations

of these common circuits, use the same techniques but adjust your thinking to the circuit differences.



*The typical sync separator in color TV is identical to its black-and-white counterpart. The horizontal sync operates at 15,734 Hz for a color program and 15,750 for black and white. The vertical sync operates at 59.9 Hz for color and at 60 for black and white. These slight frequency differences between color and black and white have no effect on troubleshooting.*

Transistor sync circuits are found in some TV's and the last chapter is devoted to them. You'll find that the sync-servicing techniques used for tubes also apply when you combine them with transistor-testing techniques.

Although I emphasize techniques, I have also covered some theory as it applies to repair, but no more. There are numerous books on electronic theory you can read if you want to dig deeper into the working of circuits. My main interest is to show you how I fix TV's day in and day out. Perhaps from my experience and point of view you can find information to help you get sync jobs off the bench quickly and easily.

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# SERVICING SYNC CIRCUITS



## Chapter 1

# Sync Trouble Photo Index

WHEN a TV set owner sees a sync trouble condition, he'll describe it as "no picture." When a do-it-yourself fan sees the same screen symptoms, he'll say, "The picture won't lock in," and he'll test all the tubes in his TV. When a new TV service technician sees the trouble, he'll call it "sync trouble" and replace the sync tubes. When an experienced TV technician sees the condition, he stops and looks and listens and twists the dials and thinks. Then he makes a calculated move which either cures the trouble or readies him for troubleshooting that will quickly consummate the repair.

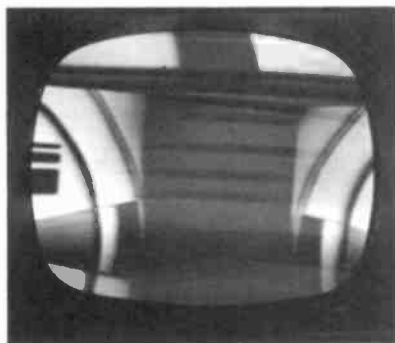
The average TV set owner calls for help right off. The do-it-yourselfer might or might not choose the proper tube to cure his trouble from the \$20 worth of various tubes the tester indicates. The new TV tech cures the trouble if it's a tube and pulls the chassis if it's not. The experienced service technician calls upon nobody but his test equipment and cures the sync trouble every time, never missing.

The following pictures are the classic symptoms that occur when sync trouble strikes. The text is the point of view the experienced technician takes when it becomes his job to take the messed-up picture and restore it to a viewable one once more.

### **Complete loss of sync**

This TV picture (Fig. 101) is going all which way. It is the familiar

loss of both horizontal and vertical sync. It comes in all different degrees. Your first step is to determine the degrees. Try adjusting the vertical hold control, ignoring the horizontal trouble. Note whether there is no vertical lock-in, good vertical lock-in or some small measure of lock-in. Remember the actual vertical sync ability.



*Fig. 101—A TV picture that has lost all vertical and horizontal sync.*

Your next step is to try the adjustment of the horizontal hold control, noting whether there is any sync ability left and how much.

A real problem occurs when both the vertical and horizontal sync ability are somewhat impaired. Once you have determined this, a mental look or an actual look at the TV's block diagram is in order—specifically the sync circuit. At this time you should try to answer this question: What circuits could cause both horizontal and vertical sync troubles at the same time?

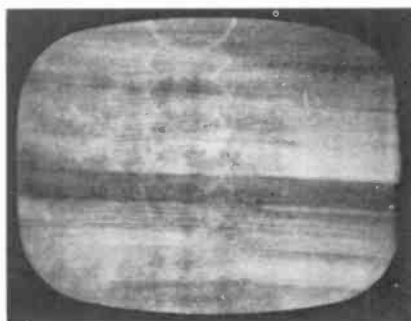
The two sync signals stay together until they arrive at the output of the sync separator. That means a breakdown in any circuit up to that point could cause both symptoms.

A breakdown in either circuit after the two syncs have been separated from each other would result in loss of only that particular pulse, not both. For both to be affected after the sync separator, two breakdowns would have to occur.

Therefore, in this case, begin troubleshooting the sync circuits preceding the sync separator output point. The first step, of course, is to change the tubes involved. If that doesn't do it, begin testing the circuits as described in Chapters 4 through 11 for the TV model you're working on. Take care to leave the new tubes in place until the repair is completed. In that way defective tubes won't complicate your troubleshooting. This is a good rule to follow on all repairs.

## Loss of vertical sync

This TV picture (Fig. 102) slides up and down like a movie film slipping. The first natural move is to try to adjust the vertical hold control, as any set owner knows. However, the technician adjusts and observes. Does the vertical hold range have a center point, that is, is



*Fig. 102—Loss of vertical sync.*

there a spot in the rotation where the picture will stop even though it won't lock? If the hold has a center point, where it rolls up on one side and down on the other side, or even if it goes the same way on either side, as long as there is a center point, it means a loss of vertical sync. The sync pulse is not performing its job of locking in the oscillator. However, the fact that there is a center point shows the oscillator is running and at the right frequency of 60 Hz (cycles per second), even if it is free-wheeling. Where can the loss of only vertical sync take place? From the block diagram (Fig. 103) we see it's after sync separation. In the sync output the integrator and input to the vertical oscillator are the prime suspects (see Chapters 11, 12 and 13).

Suppose there is no center point. The picture slips slow or fast and there is no spot in the hold range where the rolling can be stopped. It can be speeded up or slowed down but not stopped. This indicates a change in the 60-Hz vertical frequency rather than a sync loss. Suspect circuitry is the integrator and vertical oscillator, which have the most to do with the vertical oscillator frequency. Chapters 12, 13 and 14 cover these circuits.

## Vertical instability

This symptom differs from plain rolling in that there is a definite center point on the hold range and a degree of lock-in. The degree can

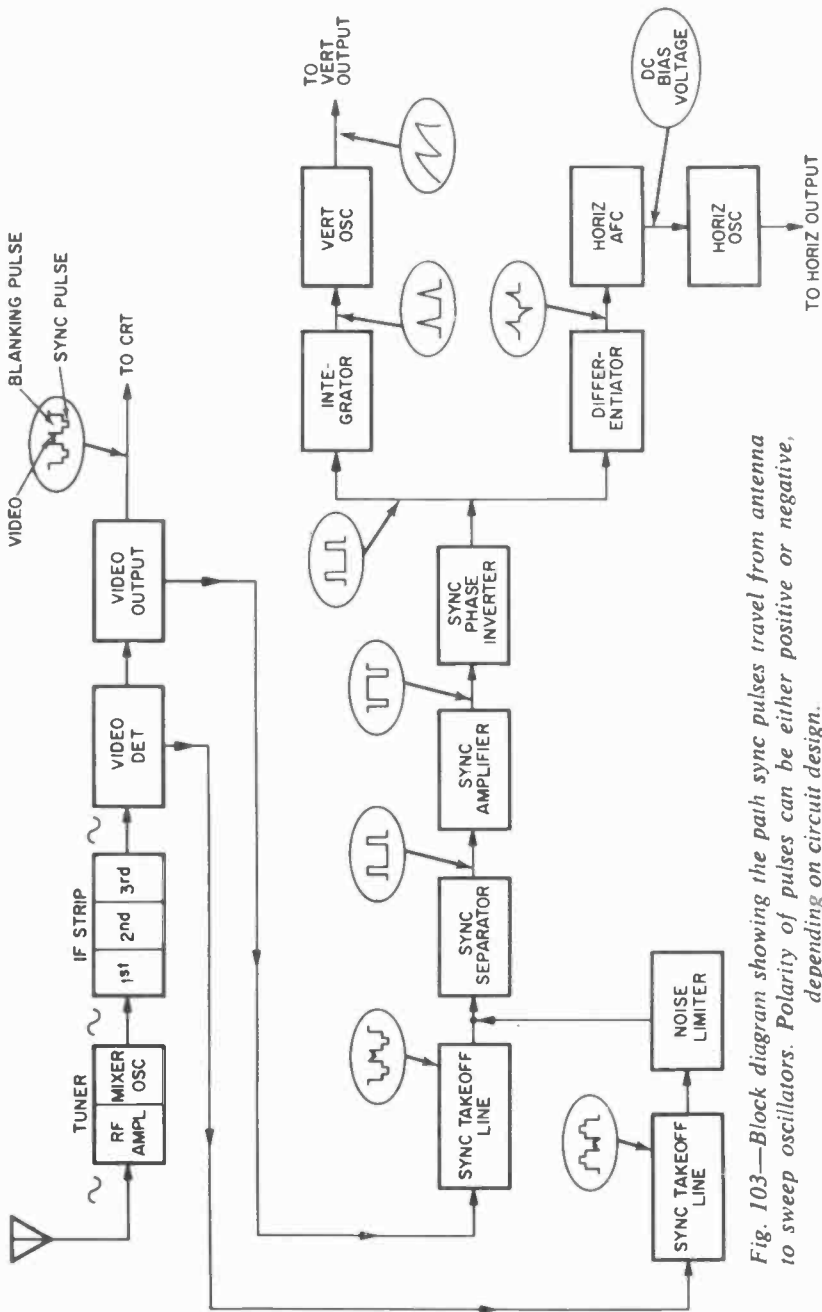
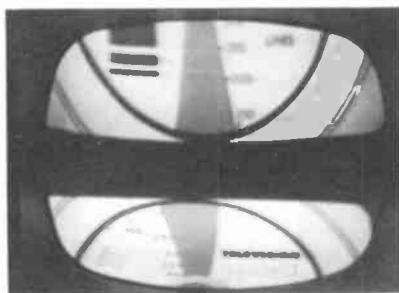


Fig. 103—Block diagram showing the path sync pulses travel from antenna to sweep oscillators. Polarity of pulses can be either positive or negative, depending on circuit design.

vary from a little to a lot. The picture has flopper that can drive a viewer berserk.

Something is sporadically throwing the vertical oscillator off frequency. This could be a high-level noise burst, video in the sync or the oscillator itself developing sporadic troubles (Fig. 104).



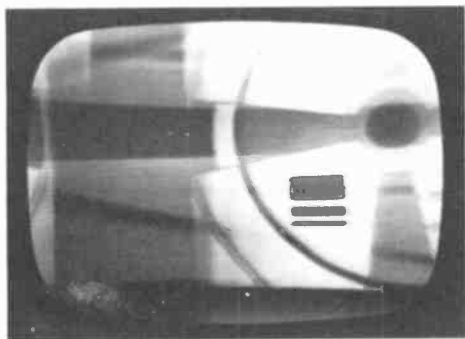
*Fig. 104—Intermittent vertical flopper.*

The troublemaking component could possibly be in any one of the sync stages or in the vertical oscillator circuit. You must start from the beginning of the sync circuitry and work through with a vtm and scope as described throughout the book.

### **Loss of horizontal sync**

This symptom (Fig. 105) is quite different from the screenful of lines produced by an off-frequency oscillator. In this case the horizontal oscillator is running at its prescribed 15,750 Hz; however, the picture is out of phase. The picture is whole but slipping sideways.

This symptom occurs when the horizontal sync pulse is impaired



*Fig. 105—Loss of horizontal sync, causing sidewise flopper or phasing.*

and does not lock the picture into place. The first service move is to adjust the horizontal hold control and determine how great the sync loss is. Is there some bit of lock-in power or none at all? What circuitry could impair only the horizontal sync pulse yet leave the vertical sync alone? If there is no lock-in at all, the suspect circuits would be the sync output, differentiator network, horizontal phase detector and input to the horizontal oscillator (Chapters 15 and 16).

While these circuits are the prime suspects, should there be a degree of lock-in, a second possibility could be that the horizontal sync pulse is impaired while it is traveling along with the vertical. This could occur in the sync takeoff line, the sync amplifier noise canceller or sync separator. The horizontal pulse could possibly be distorted in these circuits yet the vertical pulse passes through unscathed. See Chapters 4 through 11 for information on the TV you're working on.

## **Horizontal lines**

The familiar horizontal-line symptoms (Fig. 106) have many variations. There can be three broad slanting lines with the picture almost discernible, 30 lines of jumbled video, 300 lines, or more or less or in between.

Try adjusting the horizontal hold control. You might be able to lock in a particular line pattern. This means there is a degree of horizontal sync pulse getting through to the oscillator. You might not be able to lock in any line pattern. This does not necessarily mean that there is no sync getting through, although this is a possibility.

The main thing, if you see lines, is that your horizontal oscillator is running off frequency. This could indicate trouble in the horizontal oscillator circuit (Chapter 16), or the horizontal phase detector (Chapter 15).

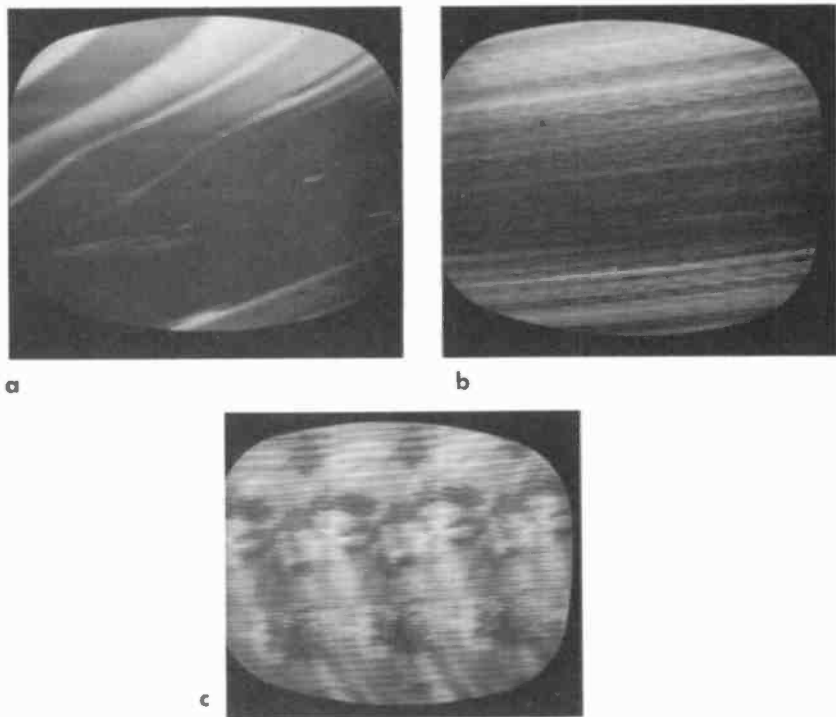
If the lines are numerous and you can lock in a line pattern, the horizontal oscillator itself is suspect. If the lines are not lockable and are accompanied with a high-pitched tweeting or whistling, the phase detector and differentiator should be first in line for checking.

## **Christmas tree**

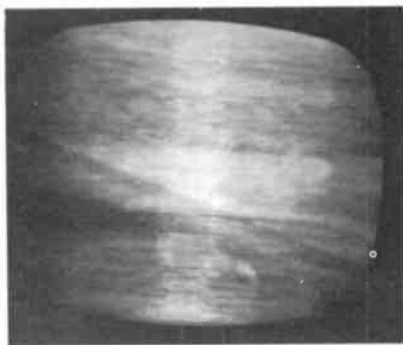
Christmas-tree symptoms get their name from the appearance of the TV screen during a certain type of trouble. A white pine-tree-shaped line structure appears. Most of the time it doesn't look like a tree but a line jumbled with an accompanying tweeting noise. It's ac-

tually the horizontal oscillator running below its prescribed 15,750 Hz. (See Fig. 107.)

Try adjusting the horizontal hold control during a seizure. If you



*Fig. 106—Horizontal line patterns: (a) few lines; (b) many lines; (c) way off response.*



*Fig. 107—"Christmas-tree" pattern.*

can almost adjust the picture in, that is, the picture goes to two or three broad horizontal lines before getting another attack, the trouble will be found in or around the horizontal waveform coil in the oscillator, as described in Chapter 16.

Another manifestation of exactly the same trouble is an intermittent version where the seizure does not occur until the TV receiver has been on for a length of time. Then the seizure occurs and stays, or it appears for a while and then goes away for a time.

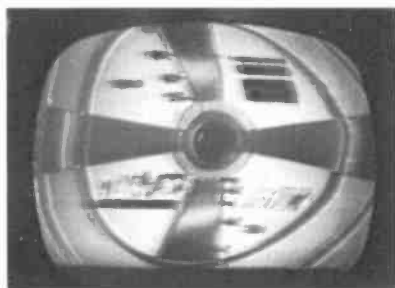
On the other hand, if you are not able to adjust the picture almost in, and the frequency is so far below 15,750 Hz that the raster tends to black out, the trouble is in the phase detector and oscillator (Chapters 15 and 16).

### Bending, pulling and S-curves

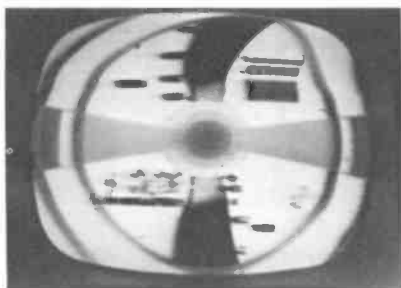
Fig. 108 shows various degrees of bending. They are tough to diagnose, because almost any circuit in the TV receiver can cause some variation of this trouble. You must carefully analyze the screen version and draw intelligent conclusions or else go on a wild-goose chase.

The sync circuits are prime suspects for certain of these symptoms. Tube defects such as heater-to-cathode leakage and changes in characteristics can cause all of them. The first step in troubleshooting here is to replace all the rf, i.f., video, sync, agc and sweep tubes and leave them in until the end of the repair. At that time, you can remove them and reinstall the original tubes. Meanwhile, you won't be thrown off by some odd tube defect.

The next step is to analyze the picture distortion. A bent picture with no black-and-white hum bars indicates the bending is being caused by the circuits after the sync takeoff point. With your scope and vtm, trace through the sync takeoff line, sync input circuits, sync separator, sync output, differentiator, afc, horizontal oscillator, integra-

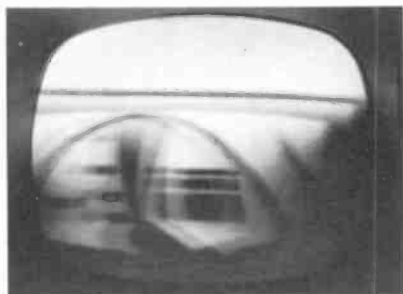


a

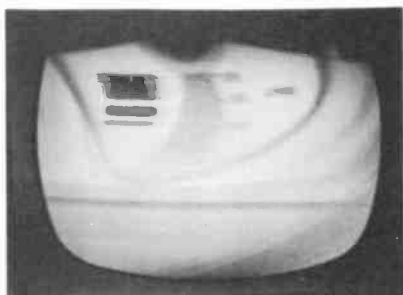


b

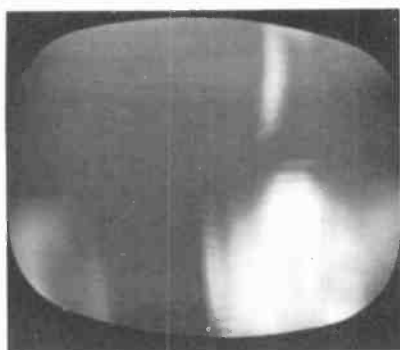




c



d



e

*Fig. 108—Degrees of bending. Page 16: (a) bending alone; (b) pulling and loss of video frequency response. This page: (c) S-curve and jitters; (d) hum bars and loss of sync; (e) jitter, loss of sync, hum bars, and loss of frequency response.*

tor and vertical oscillator as described in Chapters 4 through 16.

If there are also black-and-white hum bars, trace the circuit as described in Chapter 17. If the trouble is not in there, it's not in the sync circuitry and other circuits must be investigated.

## Chapter 2

# Test Equipment for Sync Troubles

WHEN troubleshooting sync and associated circuits, you can't (unfortunately) test voltages and waveforms with your natural senses directly. Your eyes, ears and feeling ability are not adequately equipped. They must have an interpreter between them and the circuit's goings-on. This is the role of test equipment.

Just what are you looking for in the circuit? The trouble, of course. You get scented on the trail by deviations from the norm. Therefore, first off, you must know what is normal in these circuits.

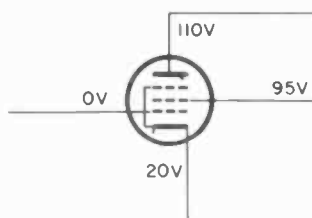
Normal what? In general, three things at each test point. Let's go through them as they appear on the schematic diagram.

### **Dc levels**

Tubes without any TV signal passing through them are warmed by their heaters, but operate with dc levels at all active elements such as cathode, control grid, screen and plate. Therefore, the first test information we are interested in is how many volts of dc are at each particular test point? How does the meter reading compare with what the schematic calls for? (see Fig. 201).

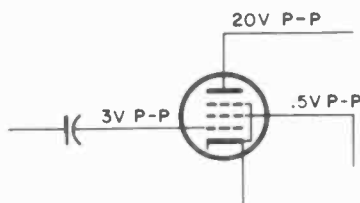
## Peak-to-peak voltage

The second voltage, then, at these test points is the peak-to-peak (p-p) reading of the signal as it enters and passes through the circuitry. The composite TV signal is a nonsinusoidal waveform that is amplified,



*Fig. 201—The first of three views of tube voltages: dc levels under no-signal conditions.*

attenuated, clipped, sheared and shaped as it passes through the sync circuitry. This processing must be done perfectly for the sync to lock in. Any excess gain or loss of the peak-to-peak value causes sync problems. Therefore this value at each test point provides service information. Any attenuation or excess gain is a clue to be followed up with further investigation (see Fig. 202).



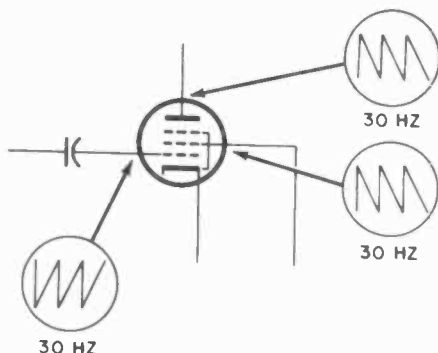
*Fig. 202—A second view of tube voltages: peak-to-peak signal values, as measured by vvm or scope.*

## Scope waveforms

This third entity is actually just a clearer picture of the peak-to-peak reading. This is the scope picture of the waveform at the test point. Even though the p-p of the signal might read correct, the actual waveform could be distorted or, during processing, not be shaped properly. The scope trace reveals all. Just compare the scope pattern you get with what the schematic of the TV receiver says should be at that point. A deviation from the norm could be an indication of trouble

and bears further investigation (Fig. 203).

Let's go through the test equipment you need to read these three things practically.



*Fig. 203—A third view of tube voltages: the scope pattern shows signal waveform as well as peak-to-peak voltage. A schematic usually gives normal voltages and waveforms and indicates the scope sweep frequency to be used for each waveform.*

## Vtvm

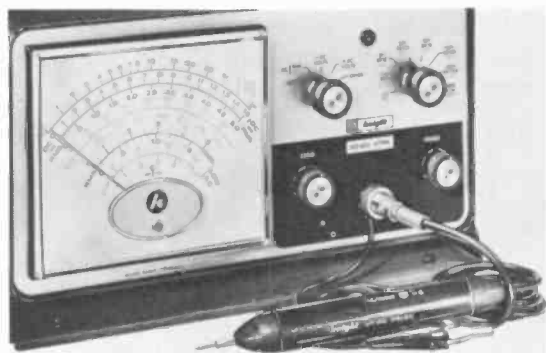
Don't even bother using a vom for serious sync servicing. While it will give you accurate plate voltages where high B+ is applied, when you try to read bias voltages or anything critical, the vom may load down the circuit so much that inaccuracy is the result.

A vtvm with its high impedance takes the readings with the least amount of loading and thus the best accuracy. In the sync circuits, there are many dc levels that can be as low as 0.2 volt. You must read these voltages exactly, for even a slight deviation can be a valid clue.

For peak-to-peak readings you can use any vtvm. From a practical point of view, however, if you have a vtvm that reads peak-to-peak nonsinusoidal waveforms directly, without any extra probes or attachments, you'll get a lot of use out of it, even if it does load the circuit down a bit. If, to read p-p values, you must connect a special probe or use mathematical formulas to get your reading, even though you know perfectly well how to do it, you're not going to bother except as a last resort. Maybe some of you might, but you'll still tend to shy away from the procedure.

Therefore, my advice is, treat yourself to a vtvm with a peak-to-peak scale that reads directly (Fig. 204). You'll get so much use out of it

that you'll wonder why you didn't get it sooner. The p-p scale is not confined to sync servicing. Sweep, video and agc circuits need it too. This vtm technique at your fingertips will open up a new vein of troubleshooting for you. Needless to say, after the preceding sales talk, I'll be dwelling heavily on p-p measurement techniques throughout the book.



*Fig. 204—A vtm with direct-reading peak-to-peak scales. On most such meters the junction selector is set to ac; the range selector is set to the desired peak-to-peak range.*

One word of caution about a p-p video reading: The schematic waveforms were measured peak-to-peak with a high level of brightness. Dark pictures will not give accurate readings. Have you ever been using a scope when the picture has suddenly gone dark or a night scene has come on? What happened? Your scope trace dropped drastically in amplitude. Then, when the bright scene returned the scope trace jumped back to normal.

The same thing happens on the vtm peak-to-peak scale, since the p-p is the amplitude of the waveform. Therefore, should you get a low p-p reading, make sure there is a good bright picture on the TV screen before drawing conclusions that you have a valid clue.

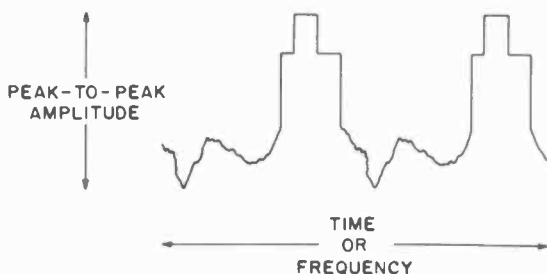
## Scope

The scope gives you an actual picture of the waveforms. The picture has two dimensions. The height is the amplitude and the width is the frequency. You'll be interested in only two frequencies during sync repairs: 30 Hz and 7,875 Hz. With 30 Hz you view vertical sync and with 7,875 Hz you can see the horizontal sync (Fig. 205).

In general, checking with both sweep frequencies at all test points

will reveal any distortion, and distortion is a clue to trouble. In this book, you'll find the waveshapes to expect at various points along the sync trail. Also, I'll show a lot of the ways the waveshapes can get messed up.

On the schematic diagrams, the specific waveshape for a specific test point is usually shown when it is useful. For the most part, you do not have to use both sweep frequencies first time around—just the one frequency specified in the diagram. On particularly tough repairs, though, you'll find occasion to view both 30 and 7,875 Hz whether the schematic indicates it or not.



*Fig. 205—Scope picture dimensions. Peak-to-peak amplitude (voltage) is the vertical parameter. Time or frequency can be read from the horizontal dimension.*

Any decent scope will provide good sync pictures. Naturally, the better the scope, the more accurate will be the reproduction. However, a cheap scope will do the job easily as long as you have the know-how.

About p-p readings on the scope: from a theoretical point of view the technique is ideal. What could be better than getting a peak-to-peak voltage reading and seeing the waveform simultaneously? However, in the average service shop, taking time to calibrate the trace and reading it for accurate p-p readings is impractical. Time is money, and constant calibrating takes time and throws you off your train of thought. Technicians, including me, are not going to do it consistently. If you have a scope with a p-p meter on it, fine. But how many of us do? Therefore, I use the scope for a look-see at the waveform to note distortion. I watch the p-p amplitude for drastic changes. For exact p-p readings I use the vtm.

I have found that my vtm with the p-p scale performs most of the sync duties normally thought of as being done with the scope. With a little practice you can learn to use yours efficiently too.

That doesn't mean I do not use the scope; I do. However, I check sync trouble out with the p-p scale on the vtvm first. If I can't lick it with the vtvm alone, then I go for the scope. The p-p scale, plus my imagination, usually do the trick, but not all the time.

### Low-capacitance probe

When you do need help from the scope, a good low-capacitance probe is a must. While there are a few test points in the sync circuit where a direct probe might do (see Fig. 206), it's best from a practical viewpoint to use the low-capacitance probe (Fig. 207) throughout the repair.

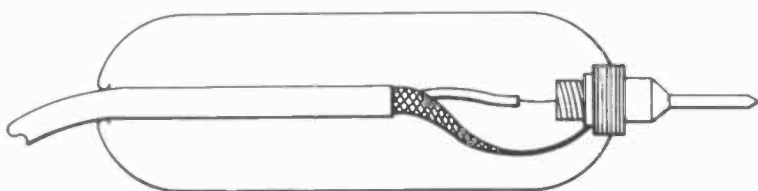


Fig. 206—A direct probe. Because this probe puts no isolating components between the circuit under test and the scope, it is not much use in sync servicing.

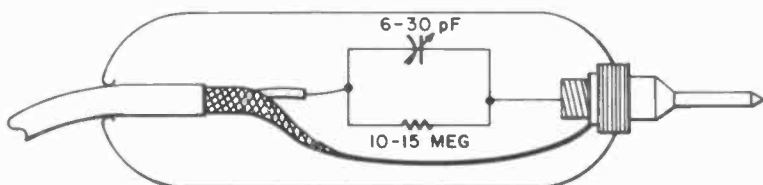


Fig. 207—A low-capacitance probe, which will not load down sync circuits. It should be used at all times except when a detector probe (Fig. 208) is needed. This probe attenuates the signal, but usually not disastrously.

### Detector probe

The low-capacitance probe is useful in the sync and video circuits, starting at the output of the video detector. Before the detector, the low-capacitance probe is useless. It won't detect the intermediate or radio frequencies. A detector or demodulator probe will. Therefore, once you decide that it is necessary to see what the sync pulse looks like before the detector, simply attach a detector probe (Fig. 208) to your scope. Then touch down on the detector input or any test point

in the i.f or rf. The detector will strip the TV signal out of the radio and intermediate frequencies and inject it into the scope for viewing. Keep in mind, though, that the closer you get to the antenna terminals, the less amplification of the signal has taken place. That means the scope picture will shrink drastically as you go from, say, the third i.f to the second to the first, etc.

You'll have to turn the gain way up on the scope. If your scope is not exceptional, you might not get enough signal in circuits preceding the detector.

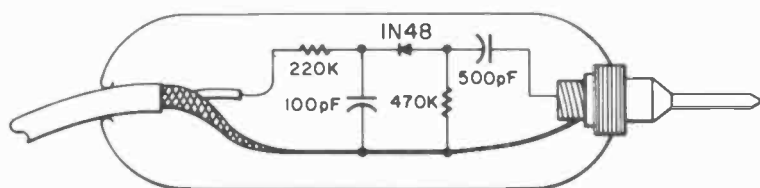


Fig. 208—A detector probe, which demodulates (detects) AM carriers of all frequencies up into the video range. It is useful to see what the sync pulse looks like in the rf and i.f. stages, before demodulation in the set.

### Bias box

Another piece of equipment I find useful in troubleshooting sync problems is the bias box. I own a high-impedance one that can go from  $-20$  to  $+20$  volts upon proper application (Fig. 209).



Fig. 209—A high-impedance bias box is useful to clamp agc lines and restore normal voltages for test.

It is invaluable during some kinds of trouble. If the rf, i.f., agc or video circuits are off, sync symptoms can result. Due to the interaction of all these circuits, many false clues can arise. These can throw you



way off the track, wasting hours. For instance, if the agc circuit fails to provide full negative bias to the first i.f. tube, the tube can conduct heavily, causing a decrease in the first i.f. plate voltage (Fig. 210).

Then you come along and find this lowered plate voltage. It looks like a valid lead, yet you'll end up finding no bad parts as you search out the plate circuit.

If, on the other hand, when you find these symptoms with the agc-video overtones, you clamp the bias box into the agc line, you'll restore the agc bias on the i.f.'s. Then the tube will conduct normally and all the circuits will operate with correct dc levels. Now if you discover low plate voltage, it will be a valid lead with defective components nearby. I find the bias box invaluable in inserting these critical voltages between  $-20$  and  $+20$ , at various points. You'll see the bias box in action in some of the case histories throughout the book.

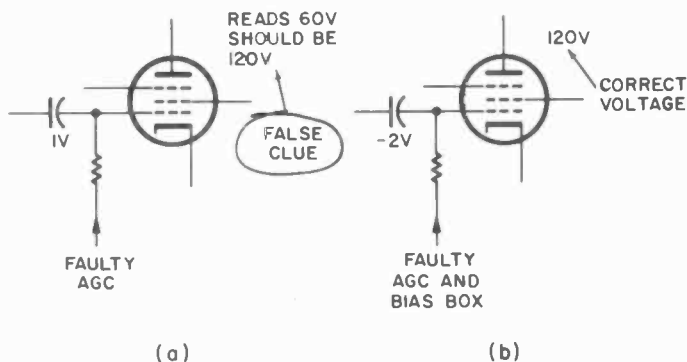


Fig. 210—Using the bias box. In (a) there is 1 volt on the control grid; the tube runs wide open, causing a drop in plate voltage. This can give you a false clue. In (b) the bias box is installed, providing a suitable control-bias of  $-2$  volts. The plate voltage returns to normal, eliminating the false lead.

It is not my intention to explain further the workings of these various pieces of test equipment. I'll leave that up to the manuals you receive with them. I simply want to point out their usefulness during a sync-repair job. There are other pieces of equipment that can be brought into play also. In fact, most of your equipment plus all the techniques you know will be useful. Signal generators, flying-spot scanners and other gear all get a play in the case histories.

These then, are the three types of readings and the equipment I use to get these readings: dc level, p-p voltage and waveform, read with the vtvm with its p-p scale and the scope with its two probes. I'll be drumming on these readings all through the book.

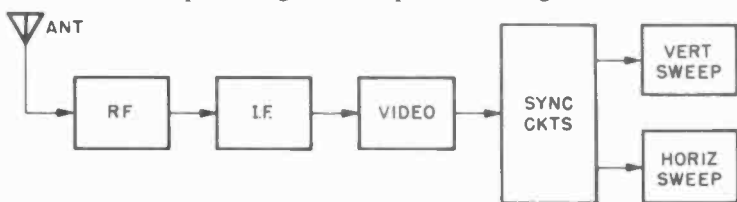
## Chapter 3

# Sync Trouble Briefing Session

LET'S assume a TV is on the bench with sync trouble. You've checked the tubes with no luck. Now you must troubleshoot the receiver to pinpoint the defective component and replace it. What is your approach? What is your point of view? What do you reach for first? What bits of theory do you bring into play to expedite the repair? I don't know yours, but I do know mine. Let me brief you on my troubleshooting procedures.

I find sync servicing probably the most time-consuming and head-scratching of all TV troubles. The reasons?

First of all, instead of the source of trouble being confined to the sync circuits, the problem can originate in the tuner, i.f. strip, video detector, video amplifier, agc or sweep circuits (Fig. 301).



*Fig. 301—Block diagram showing the general sync pathway. Sync trouble can occur anywhere along here.*

Second, there are many types of sync circuits with a tremendous number of variations, and TV design engineers do their mightiest to

employ them all. This, of necessity, makes troubleshooting procedures numerous and confusing (Fig. 302).

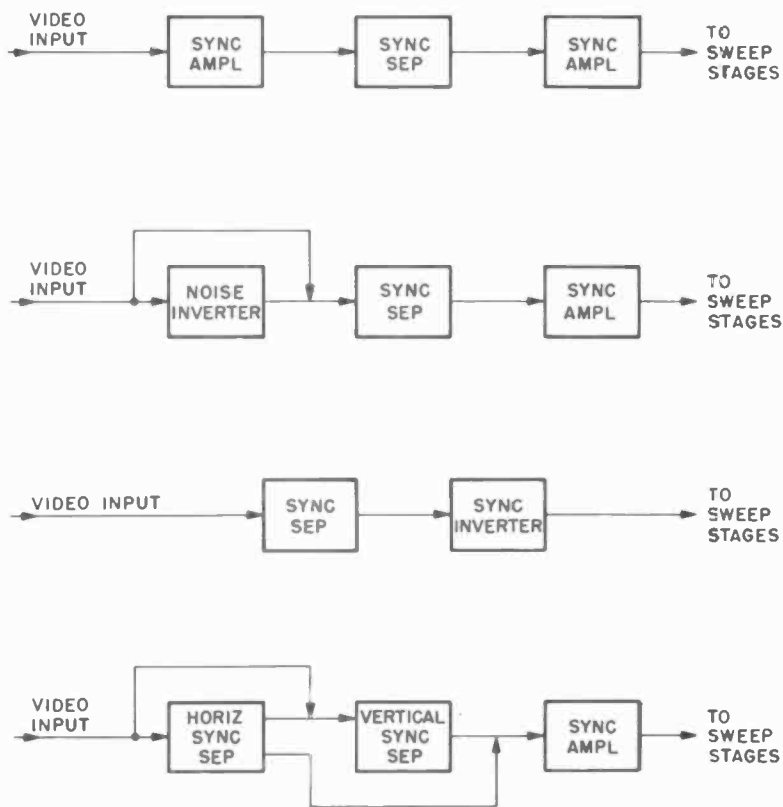


Fig. 302—Block diagrams of typical sync sections, representing a few of the numerous types you may encounter.

Third, there is much theory to wade through in briefing yourself.

Notwithstanding, here is an excellent general procedure you can follow: (1) preliminary examination, (2) blanking-bar analysis, (3) peak-to-peak and waveform examination, (4) voltage and resistance measurements (Fig. 303).

### Preliminary examination

Pinpointing the troublemaker is done by deduction, not mechanical dexterity. Therefore, the first step in starting a sync repair is to stop, look and listen. Observe the troublesome picture closely. Is it pure

sync trouble? Is the brightness, contrast, sound, focus, frequency response in pix, agc or any other circuit performance affected at all? Is the trouble occurring on all channels or just one? Is the trouble vertical or horizontal? Does adjustment of the vertical and horizontal hold, frequency and linearity controls affect the trouble or do they act strangely? Does adjustment of the contrast, brightness, volume or fine tuning affect the trouble? If so, how? The answers to these questions plus some deductions are going to help lead you to the troublemaking component. They are the beginnings of the eventual isolation. Let's see how.

Pure sync trouble is, as its name implies, a loss of synchronization

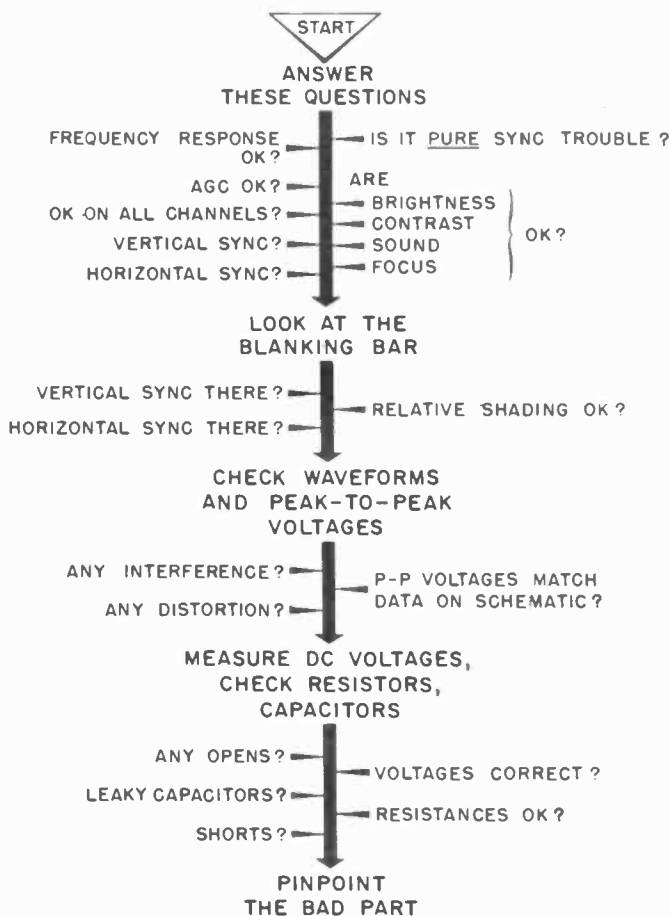


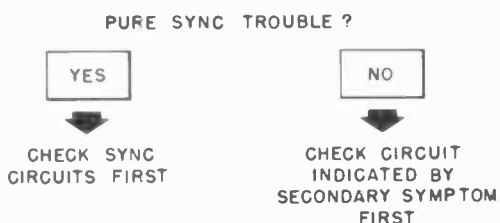
Fig. 303—A general troubleshooting procedure for sync problems.

with no other secondary symptoms. Sound, contrast, brightness, etc., are perfect. The picture simply exhibits sync symptoms. This indicates that the offender is in the sync circuitry itself.

Should there be a secondary symptom such as poor contrast, poor brightness and retrace blanking, smeared picture, agc overtones, wrong lock-in point on a hold control, crackling, humming or buzzing, this changes the indications. The second symptom combined with the sync symptom complicates the problem. Instead of a single circuit to worry about, you have the second or third as indicated by the additional symptoms.

You must consider three possibilities when there's more than just sync symptoms: (1) There is more than one bad component, each causing a separate symptom. (2) The sync trouble is somehow also causing the secondary symptoms. (3) The secondary symptoms are really the primary symptoms and the other trouble is causing the sync trouble too.

In most cases, experience shows the third possibility is the true one. When, in addition to sync symptoms, a secondary symptom also shows, the troublemaker will be found in the circuit indicated by the secondary symptom (Fig. 304). For example, if you have a sync problem and the picture is smeared, too, you'll most likely find the defective component somewhere in the video detector or video amplifier. Or, if you have a sync condition and the brightness is not turning off when you turn down the brightness control, chances are good the brightness circuit is causing all the troubles. Even though the sync symptom is more prominent than the secondary symptom, the secondary turns out to be the primary after all.



*Fig. 304—Presence or absence of a secondary trouble tells you what to check first.*

When a sync trouble occurs on one channel rather than on all channels, it indicates that, again, the sync trouble is not a result of sync-circuit malfunction. The antenna and tuner are probably causing the

trouble. And so it goes.

Examination of the action of the hold controls provides a lot of service information. If the vertical hold is working and the horizontal is messed up, the vertical sync sections are temporarily exonerated and suspicion falls on the horizontal sync circuits.

Should the horizontal hold be working and the vertical not, suspicion falls on the vertical sync section and not on the horizontal. If either the vertical or horizontal hold exhibits a wrong lock-in point or one-way control, the sync circuits per se are cleared and suspicion falls on the input of the particular oscillator or the oscillator itself.

The contrast-control setting in the video circuit provides a bit of useful information. As you advance the contrast control, the sync condition can get better or worse. If the trouble gets worse, it means you are strengthening the trouble with the contrast action. This means the trouble is in the video circuits or before. However, if the trouble remains constant or clears somewhat, you are strengthening the good signal before it gets to the sync circuits, and the trouble is probably after the video circuits and the sync circuits. (See Fig. 305.)

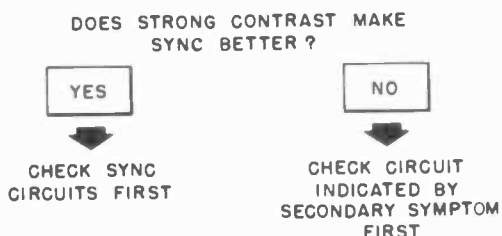


Fig. 305—The effect of the contrast control may point to the trouble area.

Thus goes the preliminary examination according to the actual situation. It is you versus an invisible defect somewhere in the TV. Somewhere in the instrument lies a bad part. You have now begun to ferret out the offender in logical style.

## Blanking-bar analysis

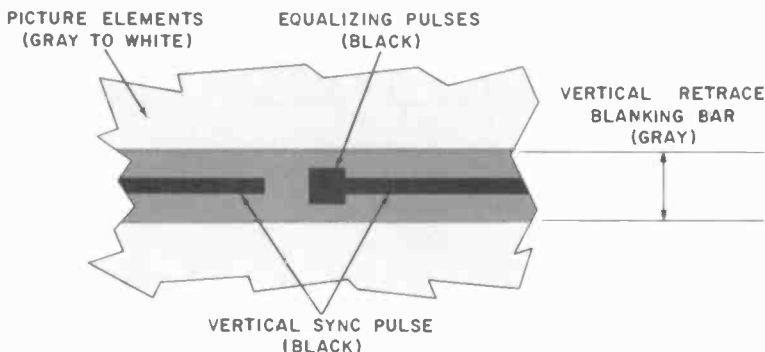
Spend a minute or two to stop, look or listen and thus get some indications of where the troublesome components might reside. The next step is some more observation. This new look-see is to verify what you've found and learn even more about the trouble and its cause.

Stop the moving CRT picture as best you can with the vertical and horizontal hold controls and try to get one of the blanking bars into

view. Either the horizontal or vertical bar will do. It doesn't have to sit still for more than a fleeting glance to provide you with the bit of service information you are looking for. You want to observe the relative blackness of the vertical or horizontal sync pulses that lie in the blanking bar.

To observe the sync pulse, turn the contrast down somewhat and turn the brightness up until the blanking bar becomes gray instead of its normal black. At that time, the sync pulses will, or should, appear black. Adjust the contrast and brightness till the sync pulse is just made black.

Under normal conditions the relative shades should come up this way: the sync pulses black, the blanking bar gray, and the picture elements from white to gray (Fig. 306). In fact, it might be a good idea to observe the blanking bars on normally operating TV's first so you can get an idea of what the relative shades should look like.



*Fig. 306—The vertical-retrace blanking bar. For blanking-bar examination, adjust the picture until the sync is just black.*

Once this is done, the blanking-bar shadings will give you a valuable bit of service information. During a sync seizure, should the shadings be as prescribed, the trouble source is indicated as being in the sync circuits themselves or after the sync circuits. If the shadings do not appear correct, the troublemaker is in the circuits before the sync circuits—the rf, i.f. or video stages. How come? Let's examine the composite video signal from a sync servicing point of view.

The purpose of the sync signal is to lock the vertical and horizontal oscillators precisely in step with the video information. That way, the video is framed on the screen without any rolling or flopping. Should a component conk out and the sync signals not arrive with perfect waveform or not at the exact time, the picture will not lock in properly

if cathode-fed; minus, if grid-fed) cuts off the cathode ray, no electrons hit the phosphor and the screen remains dark. If moderate amounts of signal are doing the modulating, some electrons hit the phosphor and a gray spot appears on the screen. Thus, as the varying signal voltage is applied, the screen shows light, gray and dark spots.

With the contrast and brightness levels adjusted for blanking-bar observation, the white represents 0% to 15% amplitude, the gray 15% to 75% amplitude and black 75% to 100%.

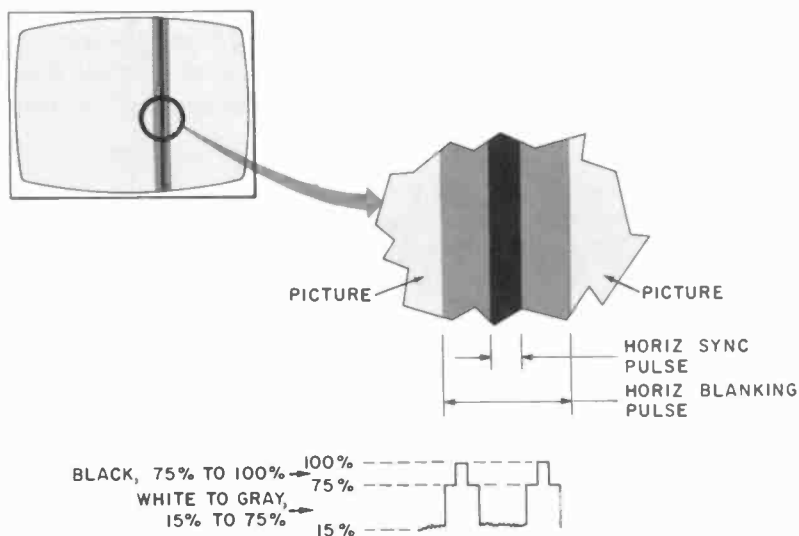


Fig. 309—The horizontal-retrace blanking bar.

Looking at the composite TV signal (Fig. 309) you'll note the picture information varies from 15% to 75%. The blanking level is at 75% and the sync pulse goes to 100%.

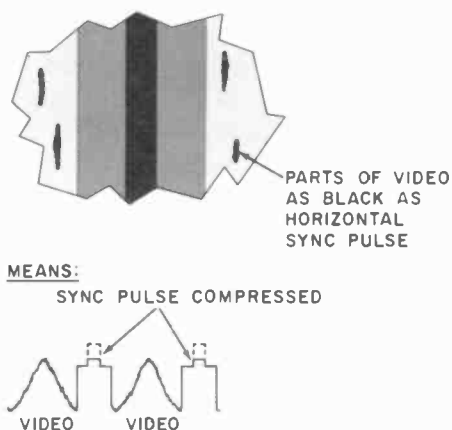
To check these amplitudes, simply observe a blanking bar. The vertical is usually handiest but the horizontal, if available, provides the same useful information.

The video information should vary from white to gray. The blanking bar proper should be gray. The sync pulse should be black. No bit of the picture should be any darker than the gray of the blanking bar.

If there is video information as black as the sync pulse (Fig. 310), it means the relative amplitude of the pulse has been compressed and is no longer higher in amplitude than the video. This means the sync separator won't be able to separate the sync from the video, and will cause sync trouble.



If the sync pulse is gone from the blanking bar, this means it is depressed to the same level as the blanking bar and will not even get into the sync separator.



*Fig. 310—If the CRT shows video that is as black as the sync pulse, the sync pulse has been compressed. The trouble is before the sync circuits.*

As you can see, examination of the sync pulse in the blanking bar provides valuable service information and is a necessary test step on every sync repair. The first two steps, preliminary examination and blanking-bar examination, provide you with your first leads. Also, the complete checkout is quick. You can complete both steps in a minute or two, as long as you know what you are looking for.

## Scope examination

While the scope is useful in other circuits, it is particularly so in troubleshooting sync symptoms. As pointed out before, the CRT gives you information at the halfway point of the signal path. Should the relative blackness of the sync be incorrect, you know the trouble is pre-sync takeoff. The scope permits a further look at the waveforms in the video at all test points. Should the blanking-bar analysis give these circuits a clean bill of health, then it's time to grab the scope and examine the circuits after the sync takeoff.

What are you looking for in these circuits? Scope patterns other than the norm. That means you should be quite familiar with what you normally find at these scope test points. Then, when something other than the normal pattern turns up, you'll be aware of the fact

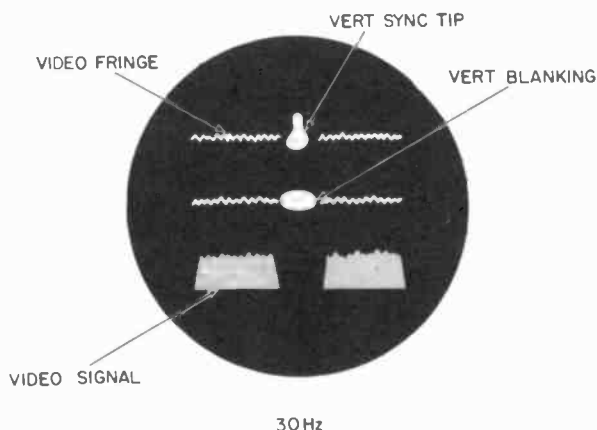
and immediately begin figuring out why. Let's see what should be on the various test points.

The first step in preparing for the scope examination is to disable the vertical oscillator. In lots of circuits, feedback from the vertical oscillator can affect the scope picture and provide you with false leads. To disable, simply pull out the vertical oscillator tube. (Be sure to turn down the brightness control so you won't burn a trace on the phosphor due to the lack of vertical sweep.) Should the TV filaments be series-wired or part of the tube used in another vital circuit, you will have to leave the tube in place. In these cases, tack-solder a resistor of less than 1,000 ohms from grid to ground or grid to cathode in the oscillator.

Then attach a .05  $\mu$ F, 600-volt capacitor on the end of the low-capacitance probe of your scope, to further isolate the scope from any dc distribution points. Set the horizontal sweep to 30 Hz. Touch the sync takeoff point. You should get a good composite video signal picture on the scope face.

Then switch the scope sweep to 7,875 Hz. There will still be a good composite video waveform on the scope face but of a slightly different nature.

At 30 Hz you are seeing the video, blanking and sync pulses of one complete frame, 525 lines all superimposed on top of one another. Note the wriggling mass of video that looks like something living. The large bright dot in the center is the vertical blanking bar. The center top dot is the vertical sync tip (Fig. 311).



*Fig. 311—Normal scope presentation of the composite video signal with a 30-Hz scope sweep.*

At 7,875 Hz you are viewing only two separate lines of the picture. The video is still wriggling but is not as heavily concentrated since it is two lines and not 525. The horizontal blanking level is quite apparent and the sync tips themselves show up nicely (Fig. 312).

These waveforms at the sync takeoff point are a scope representation of what you are seeing on the CRT face during blanking-bar examination. They control picture, blanking and sweep.

At precisely the same time the horizontal oscillator causes a line to be traced by the deflection yoke, the wriggling video is fed to the CRT gun. The trace is modulated to light spots and dark spots.

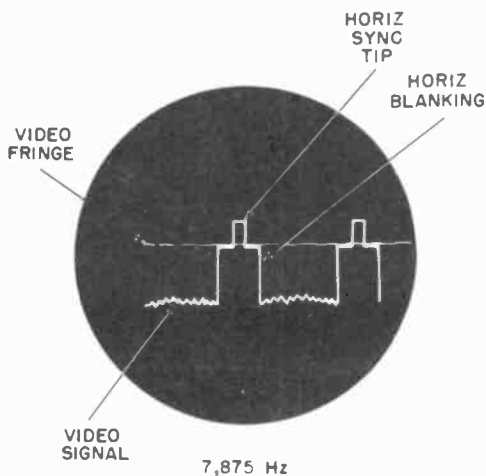


Fig. 312—Normal scope presentation of the video signal with a 7,875-Hz scope sweep.

At the end of the line, blanking level cuts off the gun. Then the sync pulse triggers the oscillator for a retrace.

As the oscillator begins the next line, the blanking level ends and video is once more fed to the CRT gun. This is what you see on the screen when you examine the blanking bar.

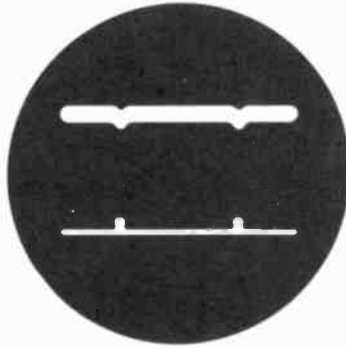
The next major test point is the input of any sync amplifier stages. At this point you should get approximately the same scope pictures. They could be attenuated slightly if they have to pass through any large resistors or small capacitors. However, the signal waveforms will probably be improved, smoothed and seemingly cleaned up a bit.

If there is a sync amplifier before the separator, its plate output is the next stop. At this point there should be an amplified picture of the same thing; however, it will be inverted 180°. Also the composite sig-

nal might be further cleaned of any hash that entered the amplifier tube. Additional sync amplifiers simply do the exact same thing.

The composite picture will remain on the scope on into the input of the sync separator or clipper. The inverting usually ends up with a positive-going sync pulse.

The output of the separator exhibits the first major change. The video signal will disappear. All that should show is amplified sync pulses. Their size and shape will vary but they should be alone and clean. The output will be about the same peak-to-peak value as the grid input, and negative-going (Figs. 313 and 314).



30Hz

*Fig. 313—Normal scope picture at the output of the sync separator with 30-Hz scope sweep.*



7,875 Hz

*Fig. 314—Normal scope picture at the output of the sync separator with 7,875-Hz scope sweep.*

Should any amplifier stage follow the separator, the pulse at its input will be about the same size and shape as the separator output. This stage then amplifies, limits, inverts and, in general, further cleans up the sync pulse. If there are any bits of video information still clinging to the sync pulse after separation, they never make it through this stage.

After the general sync amplifying and separating is completed, the horizontal and vertical pulses must be separated.

These pulses are siphoned off into two paths. One is the vertical integrator. This is a resistor and capacitor filter network that has a long time constant. The long duration of the sync pulse charges it, and any high-frequency components in the sync pulse are drowned in the long charge time. In that way, the horizontal high-frequency 15,750-Hz component is disposed of and the low-frequency 60-Hz vertical sync continues on. As you touch down on the test points through the vertical integrator with the scope probe, you'll see the 60-Hz spikes gradually clean up and form for presentation to the vertical oscillator circuit.

Some of the sync pulse also goes into the horizontal differentiator. The differentiator is also a capacitor and resistor combination but it has a short time constant. The leading edges of the sync pulses with their higher frequency are the only waveforms that pass through this network. The scope, set at 7,875 Hz, will permit you to follow this path and be sure the sync is not lost or messed up somewhere along the line.

## **Other patterns**

As you scope the sync, look out for patterns other than the norm. Loss or distortion of the normal scope pattern indicates the trouble-making component is nearby.

When you do discover a scope pattern other than the norm, be sure to check your findings against schematic scope waveforms and peak-to-peak voltage values. In lots of circuits, the normal scope patterns might not appear normal, although, for that particular TV, they are correct. These false leads can waste a lot of time.

## **Voltage and resistance checks**

Once you have analyzed the vertical or horizontal blanking bar and checked through the indicated circuitry with a scope you'll end up with a good idea where the defective component is. It's then time

to pinpoint it, and this you should do with the vtvm.

The schematic diagram and associated service literature of the particular TV provide you with the voltages and resistances of the circuits as they should be with no trouble in the TV. The technique described is to test for these voltages and resistances at indicated test points. If any of the readings do not match those called for, the incorrect reading could lead you to the troublemaker.

This is the vtvm technique in essence:

In stages such as sync amplifiers, the plate and screen voltages are typically those of a normal amplifier: B+ of 125 volts or better (Fig. 315). The grid bias on a sync amplifier, though, is usually more negative than on a regular amplifier and can be  $-3$  or  $-4$  volts, or even more. This is because the amplifier is usually designed to help in eliminating noise pulses which ride in above the sync-pulse amplitude. They are clipped with the higher bias.

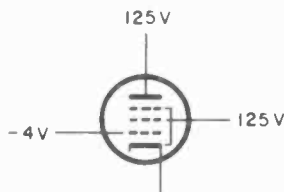


Fig. 315—The typical sync input amplifier has normal pentode voltages.

In the sync separator stage itself, the bias also runs very high. It can go as high as  $-10$  volts. The plate voltage is set low, around 50. The high bias and low plate voltage keep the tube cut off most of the time (Fig. 316). In that way, when the positive composite video signal is impressed on the grid it pushes the bias voltage from the high nega-

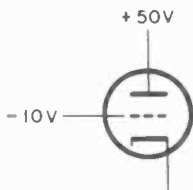


Fig. 316—The typical sync separator has a relatively low plate voltage and a relatively high control-grid bias.

tive level toward zero—tube conduction. That's how the sync pulses pass through and the video is left behind. The video with its positive voltage of from 0% to 75% lowers the bias but not enough to cause

conduction. Therefore the video modulates nothing and cannot appear in the output. The blanking voltage with its 75% level also is not enough to turn on the cathode flow.

However, the sync-pulse amplitude as it approaches 100% pushes the bias voltage into the conduction region. The tube conducts, the sync pulse modulates the electron stream and *only* the sync pulse appears in the plate output circuit. Thus the sync is separated or clipped from the rest of the composite TV signal.

Should you discover the plate voltage is way above or below 50 volts, the sync clipping will almost surely be defective. A bad component will be found in that circuit.

If you find the grid bias is not negative enough, you'll be getting some composite signal into the sync separator output and have video in the sync—not a good situation. Find out why that bias is incorrect and you'll have the repair practically completed.

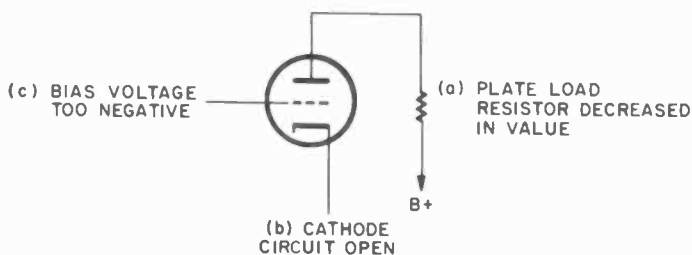
Any other amplifiers in the sync stages to boost the sync-pulse level will have normal B+ voltages of 125 or better. The bias on these amplifiers is normal, not high as in the previous sync stages. Check for these voltages as indicated in the schematic diagrams.

Once an incorrect voltage is uncovered, the last step in troubleshooting is to locate the component causing the incorrect reading. This is done by analyzing the schematic and deducing what components could cause this incorrect reading. The case histories throughout the book will demonstrate this what's-doing-it aspect; however, let's run through typical reasons.

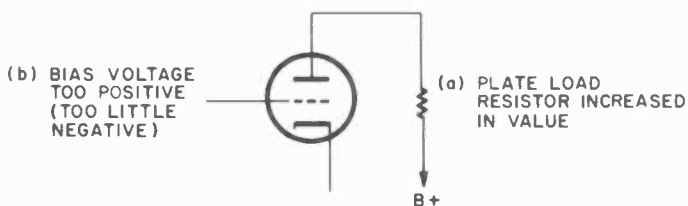
Suppose plate voltage is too high. This can happen if: (a) the plate load resistors decrease in value, permitting more B+ voltage to get through; or (b) an open circuit develops in the cathode circuit and the cathode current is not reaching the plate—with no cathode flow the full B+ is read at the plate since there is no voltage drop; or (c) excessive negative bias voltage cuts off electron flow. No current and the full B+ are read at the plate since there is no voltage drop. (See Fig. 317).

Suppose the plate voltage appears too low. This can happen if: (a) the plate load resistors increase in value and increase the voltage drop; (b) the bias voltage becomes more positive than usual and causes too much cathode current to flow, dropping the plate voltage to a low value (Fig. 318).

A high cathode voltage could be due to an increase in the value of the cathode resistor, which causes too much cathode bias to be developed. If the cathode voltage is lower than usual or nonexistent, a shorted cathode resistor or bypass capacitor could be at fault.



*Fig. 317—If plate voltage is too high, possible causes are: (a) reduced plate load resistor value; (b) open cathode circuit; (c) too much bias.*



*Fig. 318—If plate voltage is too low, possible causes are: (a) increased load resistance value; (b) too little bias.*

Your vtvm voltage readings will point out suspects for final analysis. Once you have some prime component suspects, fundamental resistance, capacitance and substitution checks can be run. Then when you find the actual troublemaker, replace it.

Let's dig deeper now and analyze the stages that can cause sync defects stage by stage, component by component and see what happens from actual case histories. We can start with sync takeoff circuits.



## Chapter 4

# Sync Takeoff Troubles

THE sync takeoff network is relatively simple and rarely contains more than five or six components, all capacitors and resistors. Because of its simplicity, it is quite often ignored as a trouble source.

Also, defects here cause subtle and indefinite symptoms. A set owner will even put up with these subtle symptoms and, after you complete a different repair, you'll discover this as a second trouble you have to clear up.

The sync takeoff network unfortunately is a common offender too. It has B+ voltage and high peak-to-peak signal voltages. This electrical stress exacts its usual wear and tear.

The result of not paying too much attention to the sync takeoff ends in your expending much troubleshooting effort before zeroing in on one of these components. To avoid this extra effort, all you have to do is be aware of the workings of the network.

The sync takeoff point will be found in different locations in different TV's. A popular point is the output of the video amplifier. The actual spot will be after the plate load. At that point there's a resistor somewhere between 5,000 and 50,000 ohms (R1 in Fig. 401).

The resistor isolates the video output circuit to keep it from being loaded down by the sync input circuit. It prevents the sync input from taking too much signal. The sync takeoff is only supposed to take a sampling.

The value of the resistor is determined by figuring out how little peak-to-peak video output the sync-circuit input needs. The resistor then drops the difference between what the video is putting out and what the sync circuit needs. For instance, the video output might be 65 volts peak to peak. The sync input needs 45 volts to work. The isolation resistor used is 15,000 ohms, and it drops 20 volts.

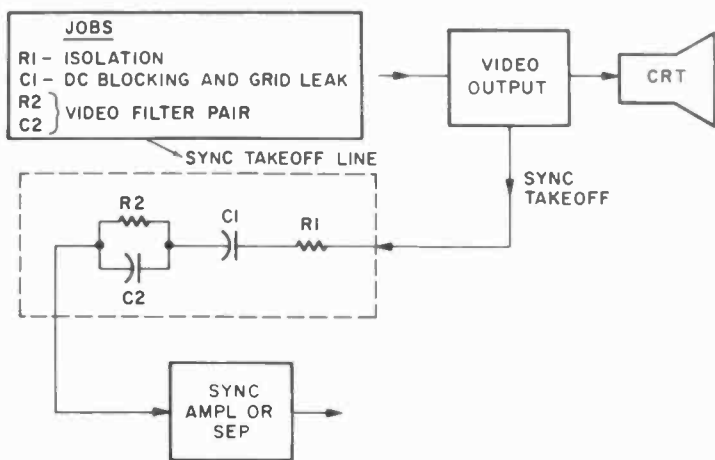


Fig. 401—The sync takeoff line. Trouble may occur in any of the components.

This reminds me of a set I serviced for a finicky customer. His complaint: The picture was not as stable as it should be on the strong channels. This meant 3, 6 and 10 from Philadelphia. However, channels 2, 4, 5, 7, 9, 11 and 13 from the New York area were holding better than usual.

I checked tubes to no avail and pulled the chassis for the bench. On the bench, I began my sync troubleshooting procedure. I examined the picture closely. In addition to the instability on strong channels, I noticed a secondary symptom. The picture was smeared somewhat and there was a slight ringing of the images—that is, there was a slight ghost-like condition, which was circuit-caused. The frequency response of the video section was being narrowed somehow.

I turned up the brightness, turned down the contrast somewhat and adjusted the vertical hold till I could view the blanking bar. I examined it closely. The relative blackness of the vertical sync pulse was excellent. That meant the trouble was after the sync takeoff point, and the video section was cleared of causing the trouble. Yet the secondary

symptoms indicated the video circuits were being affected.

I turned on the scope, set it for 30 Hz, attached a low-capacitance probe and touched it to the sync takeoff point between a 5,000-ohm 5-watt resistor and a 6.5-ohm peaking coil. (Fig. 402.)

A nice pattern appeared. I noted the peak-to-peak amplitude on the scope. Then I went past the 10,000-ohm isolation resistor and touched down again. The exact pattern reappeared with the same peak-to-peak value. Jumping back and forth I compared the peak-to-peak values on either side of the resistor with their height on the scope face. The peak-to-peak didn't change. But it should have. It should have been attenuated somewhat by the resistor.

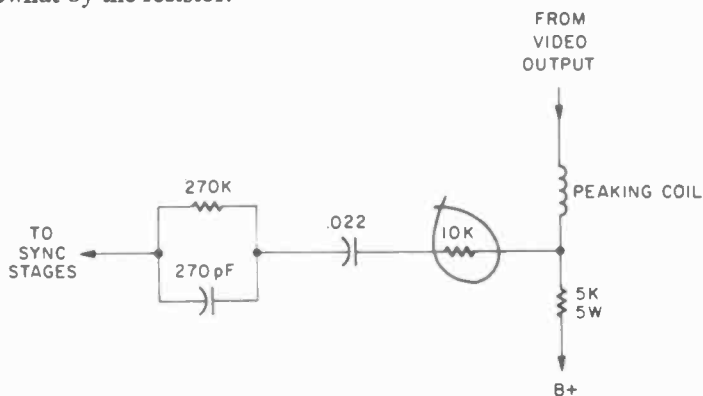


Fig. 402—The 10,000-ohm isolation resistor had dropped to 30 ohms, causing sync symptoms.

I grabbed the vtm and verified the peak-to-peak readings: 48 volts on either side. I switched to the resistance scale and turned off the TV. I read the supposed 10,000 ohms. The meter said 30!

I replaced the shorted resistor and turned the TV back on. With the new 10,000-ohm isolation resistor in there, the video circuit was no longer loaded down and its frequency response returned to normal. The smear and ringing disappeared.

I checked the strong channels. They locked in perfectly. The resistor was once more restricting the video signal so it wouldn't overwhelm the sync circuits, put video into the sync output and make the picture unstable on the strong stations.

I checked the weak channels. They were not as stable as they had been while the shorted resistor was still in the TV, but they were good enough to watch.

In addition to the isolation resistor, a blocking capacitor must be

placed in series with the resistor to keep the B+ of the video output from getting into the sync input. You'll find typical values ranging from 100 picofarads (micromicrofarads) to  $.05 \mu\text{F}$  at 400 to 600 volts.

If you take scope waveforms of the video as it passes through the blocking capacitor of a normally operating TV, you'll find little change in peak-to-peak values or pattern. There will be some slight attenuation with the smaller-value capacitors, varying from none to a little bit, according to the actual size of the capacitor. The smaller the value of the capacitor, the more attenuation will result.

The reason for putting a capacitor in the takeoff network is simply to block dc. The signal theoretically passes through as if the capacitor weren't there. For our sync takeoff purposes, though, just consider it as a regular dc blocking capacitor.

Another chassis arrived on the bench with some locking on strong stations but not enough. Also the picture had a definite weave.

On weak stations, there was no sync at all. Adjusting the hold controls was not enough to keep the picture stable.

I examined the blanking bar. It appeared normal even on the weak channels. That meant sync-circuit troubles.

With the scope on 30-Hz sweep I began checking waveforms at the sync takeoff point. I watched the peak-to-peak value on the scope. At the takeoff, it was about 50 volts. The scope pattern was normal.

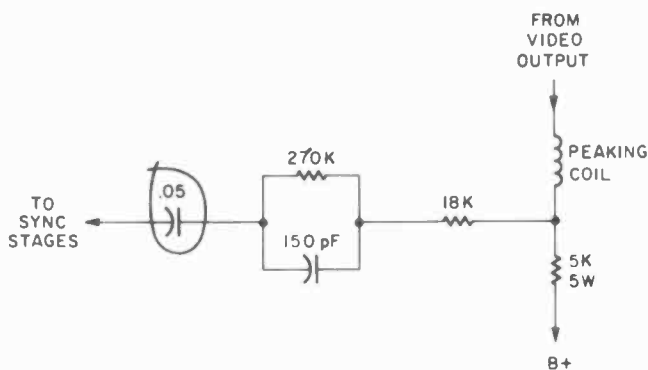


Fig. 403—An open  $.05\text{-}\mu\text{F}$  capacitor stopped the video dead in its tracks, causing poor sync.

I went to the other side of the 18,000-ohm isolation resistor. The picture remained good and the peak-to-peak dropped to about 40 volts, which was normal according to the schematic. I then went across a 150-pF and 27,000-ohm video filter pair. The picture cleared up a bit,

the top of the sync pulse flattened a bit and the peak-to-peak stayed about the same.

Next I hopped across the  $.05\text{-}\mu\text{F}$  blocking capacitor. The peak-to-peak dropped almost to nothing, and the video pattern jumbled badly.

Across a capacitor as large as  $.05$ , there should be no appreciable loss of the peak-to-peak value or video pattern. It is there strictly to keep dc out of the sync input. The ac signal should pass through it as if it's not even there.

I turned off the TV, disconnected one end of the capacitor and tested it with a capacitance checker. The  $.05$  was effectively open. I installed a new one and turned on the TV. The trouble had cleared (Fig. 403).

The reason the picture did hold a bit with a strong signal was that stray capacitance managed to get a little bit of composite video into the sync input. The picture had a weave since the video and 60-Hz hum were not being separated from the sync pulses due to the minute amplitude.

Another part of the takoff network to consider is the little R-C video filter that might be found. It is there to help clean up the video pulse. It helps maintain the steepness of the sync-pulse leading edges and flatten the tops of the pulses (Fig. 404).

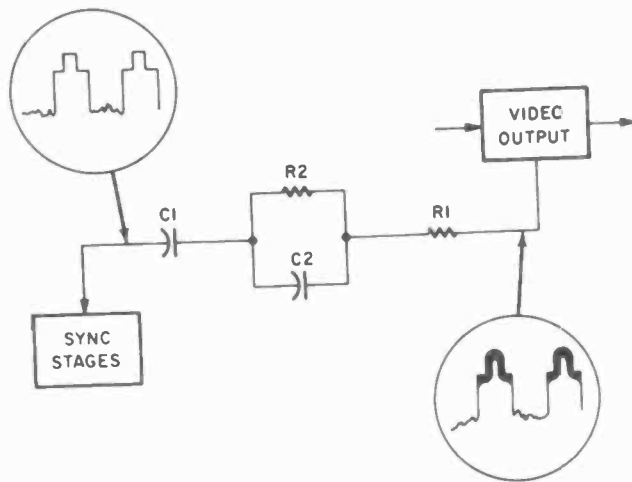


Fig. 404—The video filter ( $R2$  and  $C2$ ) cleans up haziness, sharpens leading edges, and flattens the tops of the pulses.

The filter is in series with the other components, and popular values for the capacitors run around  $220\text{ pF}$  and for the resistors between

will compensate for the omission. As you noticed in the last case history, the peak-to-peak value of the signal was under 10 volts. The other cases showed peak-to-peak of about 50 volts.

While it is popular to take a high peak-to-peak, a lower one can be used if there is enough amplification in the sync stages. When a designer does decide to use a lower peak-to-peak sync takeoff, that means he can take off from the video detector or the grid of the video amplifier. With these takeoff points, the blocking capacitor can be dispensed with, since there is no B+ to block.

Fig. 406 is an example of a direct-coupled sync takeoff from the grid of the video amplifier. The only component in the line is a 4.7K isolation resistor and then the line goes directly into the grid of the sync amplifier. (Note it is a sync amplifier, not a separator with the lower voltages.) An even simpler example is where the sync takeoff is in the plate of a diode that acts as a dc restorer. There are no components in the takeoff line—just a wire to the grid of the first sync amplifier (Fig. 407).

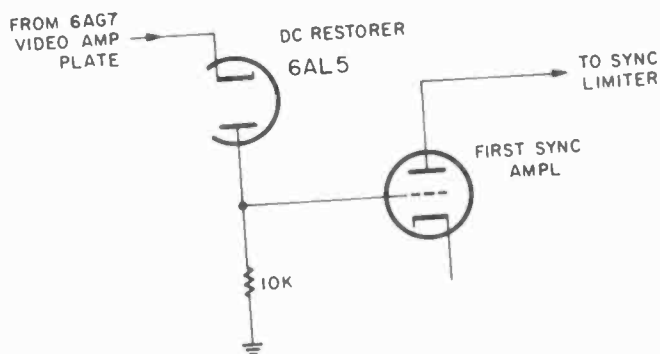


Fig. 407—Another direct-coupled sync takeoff.

No matter where the sync takeoff point is, from the video detector to the video amplifier output, its job is simply to sample the composite TV signal and couple it into the sync circuits. This can be through an isolation resistor, blocking capacitor or video filter networks of various sizes of components.

To test the takeoff network, it's easiest to track the composite signal through the network, carefully observing its peak-to-peak values and pattern. The schematic usually provides the information as to what should be where during normal operation. Deviation from the norm indicates trouble.

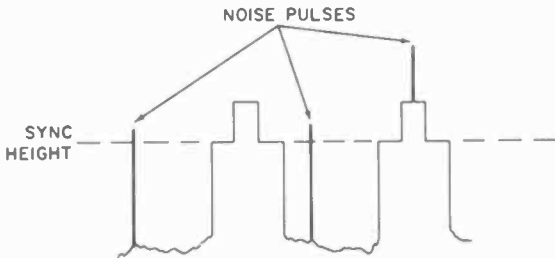
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## Chapter 5

# Sync Input Circuit Troubles

IN A great many TVs still around, you'll find sync amplifiers and noise inverters in the signal path, in front of the sync separator. A sync amplifier must perform two duties: (1) Amplify the composite TV signal for the sync separator. (2) Try to remove any noise pulses in the composite TV signal that are higher in amplitude than the sync pulses (Fig. 501).



*Fig. 501—One of the jobs of a sync input circuit is to eliminate noise pulses that might "fool" the horizontal and vertical oscillators.*

A noise-inverter circuit, if it's there, performs the second job.

Why should some TV chassis have sync amplifiers and/or noise inverters while others dispense with them?

As far as the sync amplifier is concerned, it's all according to where the sync takeoff point is. If it is in the final video output where p-p

voltages range around 60 a sync amplifier is not needed since 60 volts peak to peak is enough for the separator to operate with. Should the sync takeoff be at another point, such as the output of a first video amplifier, where the p-p is 8 volts, or the video-detector output where it is 2.5 volts, then additional amplification is needed. The result: A sync amplifier is placed in the signal line to increase the 8 or the 2.5 to about 40 volts peak to peak for separator action.

Then, to get as much use as possible from this sync amplifier, the circuit is designed to perform noise-cancellation duties, too.

Now about noise inversion circuits, if the TV chassis does not need a sync amplifier (although it would be useful to cancel noise bursts), a separate noise inverter circuit may be installed. Anyway, if either a sync amplifier or a noise inverter is in the TV, troubles in either circuit result in sync symptoms on the screen. Let's examine them, see why and discuss what we can do about them.

### Sync amplifier

While you'll occasionally come across a sync amplifier that is fed a high p-p voltage, typically its p-p grid input voltage is low. Its No. 1 job is to amplify the low p-p to a high value. The lower p-p volt-

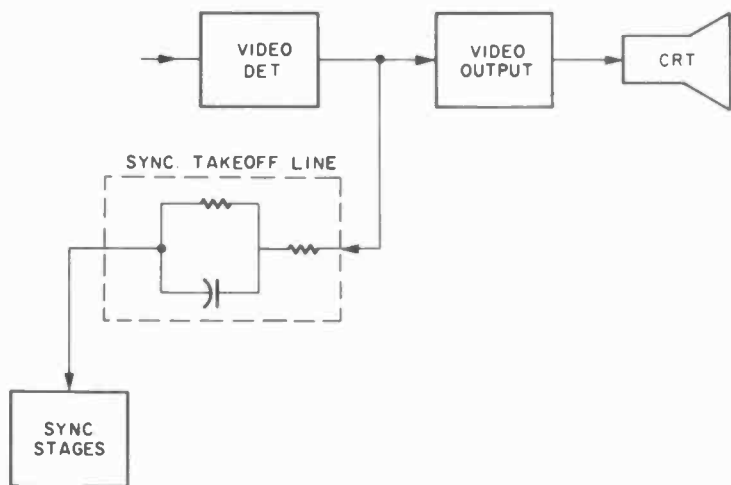


Fig. 502—A direct-coupled sync takeoff line. Note that there is no blocking capacitor, since the takeoff point does not carry a B+ voltage.

age comes from a takeoff point that is usually devoid of B+ voltages. Because of this, the blocking capacitor in the takeoff line is quite often



missing. No B+ to block, no capacitor (Fig. 502).

As a result of the direct coupling, the dc voltage at the control grid is the same as the dc voltage of the takeoff point—somewhere around zero. Because of this direct coupling, biasing of the tube is left to the cathode rather than the grid.

The bias is usually developed by a cathode bias resistor of around 330 ohms. The bias resistor may be bypassed with a capacitor or it may not. When it's not bypassed, the incoming video signal will be developed across it exactly opposite in polarity to the way it is developed in the plate. This tiny negative signal can then be handily tapped off and used for agc or noise inversion in the sync separator. Any leads you may see connected to the top of the cathode resistor are for that kind of tap-off.

A pentode is usually used as a sync amplifier, though you'll find triodes used too. Plate voltages are normally 125 or higher, and screen voltages the same or slightly lower. The plate load resistor will normally range around 22,000 ohms. The sync amplifier is just a simple amplifier except for one item: the bias. It's a bit more negative than most, and here's why.

Let's say 2.5 volts p-p is fed to the control grid. The dc grid bias is set to pass the signal and no more. There is no room to spare. The signal input is negative-going. The sync pulse is just negative enough to permit the tube to conduct. A more negative signal cuts off the tube. Any noise pulses that ride above the sync amplitude will cut off the tube, stop the electron flow and, in effect, be chopped off at that point.

If the bias were less negative, the noise pulses would still be of a greater amplitude than the TV sync signals. That's why the negative bias is slightly higher than that found in normal amplifiers.

In addition, the tube amplifies the sync signal nicely. It takes the 2.5 volts p-p and swells it up without distortion to 40. The 40 volts p-p is developed across the 22K plate load resistor and taken off for use in the next stage, the separator.

While these types of circuits are not found in newer TVs, they will find their way to your service bench week in and week out.

Just recently I saw an older model that had almost exactly this circuit. It had sync troubles too. There was no sync, either vertical or horizontal. I switched tubes to no avail. It was using a heptode converter as a sync separator and the pentode half of a triode-pentode as a sync amplifier. The sync takeoff point was in the grid of the video output that had 0 volts dc through a 4.7K isolation resistor (Fig. 503).

I examined the symptoms carefully. In addition to the loss of sync, there were agc overtones. I shot a fast glance at the moving blanking

bar. The relative shadings seemed to be there in good condition as it whirled past. I was led into the sync circuitry itself.

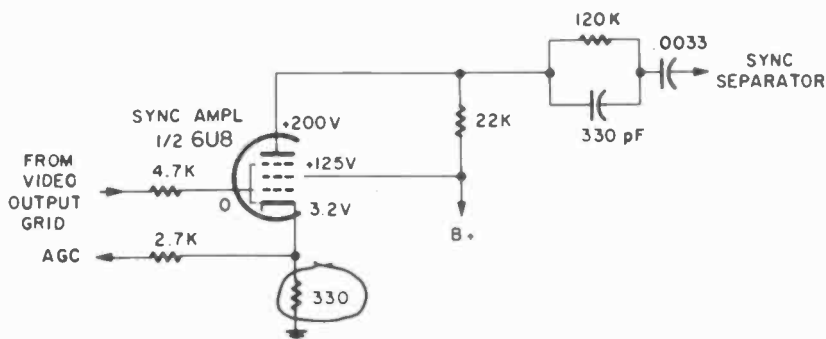


Fig. 503—The cathode resistor increased in value, cutting off the tube.

With the scope set at 30 Hz, I touched down on the sync takeoff point. The pattern was good and the p-p was 3 volts, as it should be. On the other side of the 4.7K isolation resistor the signal dropped to 2.5 volts p-p and the pattern remained good. Then I checked the plate. The video pattern was gone!

I switched the vtvm scale to dc volts and read the plate: 250 volts. It was supposed to have 200, according to the schematic. I read the other side of the plate load resistor—the same 250 volts. No drop across the resistor. Could it be shorted? It looked shiny. I didn't think a short was likely.

Then it struck me. The pentode section had sharp cutoff characteristics. If the tube was cut off, the plate load would cause no voltage drop. This seemed a more logical approach. (I ran a quick in-circuit resistance test on the plate load resistor anyway and it seemed good, as expected.)

I checked the control-grid dc voltage. It read 0 volts as it should. I checked the cathode. It read 12 volts. That put -12 effectively on the control grid. That would cut off the electron stream and no current would flow in the plate circuit. No current flow, no voltage drop and the full B+ would appear on the plate.

Why the high cathode voltage? I looked at the cathode resistor. It wasn't shiny; in fact, it was charred. I measured it. It read about 5,000 ohms instead of 330, as it should. I noted that an agc leg originated at the top of the resistor. This tied in with the symptoms. I replaced the resistor. Everything returned to normal.

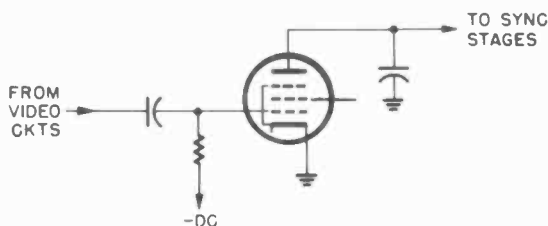
## Older sync amplifiers

There is also an older type of sync amplifier that you'll come across if you get occasional old 10- or 12-inch TV's in for repair. These sync amps do the same jobs of noise suppression and sync amplification, though in more classical fashion.

They use a remote-cutoff pentode instead of sharp-cutoff. Any noise pulses above the negative-going sync pulse will be attenuated since they're near the cutoff point.

Bias is provided for the tube from a combination of grid-leak bias with an assist from the negative end of the power supply.

In the plate circuit you'll find a capacitor to ground to bypass high frequencies (Fig. 504). The B+ going to the screen and plate is well filtered.



*Fig. 504—Older types of sync amplifier use a remote-cutoff pentode with a plate bypass capacitor and power-supply bias.*

Despite these circuit changes, sync amplifier troubles can be "shot" with the same techniques as for the later model circuits.

## Noise inverters

Another type of circuit you'll sometimes find after the sync takeoff line are noise-inversion circuits. Their purpose, as the name implies, is to remove noise pulses from the video signal that might be higher in amplitude than the sync pulse. Yes, this is the same duty as the sync amplifier's No. 2 job. As a result, you probably won't find both a noise inverter and a sync amplifier in the same TV.

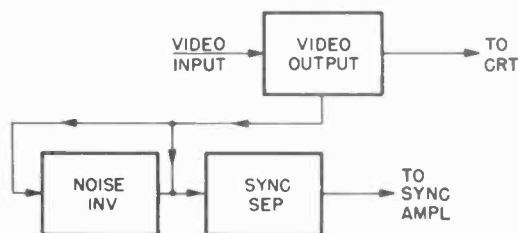
Most TV's now have the noise-elimination circuitry installed right in the sync-separator stage, but there are still plenty of chassis around and an occasional new one that have a separate circuit.

While the noise inverter is connected to the sync takeoff line, it is not between the takeoff and the separator. That is, the TV signal does not have to pass through it on its way to the separator.

The inverter sits alongside the separator, takes a sampling of the

signal and then the inverter output is fed back into the takeoff line to perform its function (Fig. 505).

The noise inverter has no load resistor as such. It develops its special output across the components in the sync takeoff line. It takes B+ for its plate through this line from the video output stage.



*Fig. 505—The noise inverter sits alongside the sync separator.*

There is another blocking capacitor around 1,000 pF, hooked onto the takeoff point for the inverter (Fig. 506). This capacitor goes to the grid of the inverter. This forms an individual sync takeoff line expressly for the noise inverter. Note this is an additional sync takeoff. When there is a noise inverter, a TV chassis has two sync-pulse takeoffs—one for the sync amplifier and one for the noise inverter. There are variations but this is basically what you'll find.

There is usually no isolation resistor in the noise inverter's takeoff line. The inverter does not load the video output. Here's why. The noise inverter tube sits idle. There is no conduction as long as only the composite TV signal is fed to the tube. The cathode of an inverter usually has a high cathode bias of around 25 volts. This is produced with a high cathode resistor of between 2,000 and 10,000 ohms. The grid voltage is slightly negative, and is developed grid-leak fashion with the capacitor and a grid-leak resistor in the megohm range. As in the sync amplifier, the cathode is not bypassed and the cathode bias can be used for agc.

With this high cathode-to-grid bias, the tube will not conduct at all as long as a regular composite TV signal is coming in the grid. It just sits there with a cool plate and heaters lit. This is all well and good, since it won't upset the video coming through the sync takeoff line that is also the inverter's plate load. But if there is a noise burst higher in amplitude than sync pulse, then the tube conducts for the duration of the noise pulse.

This noise pulse, amplified and inverted 180°, is developed across the takeoff line, at the same time but opposite in polarity to the noise

in the composite TV signal. The two noise pulses cancel each other. Most of the noise never gets any further than right here.

Troubles in a noise inverter like this can cause sync troubles such as vertical instability. The horizontal may seem unaffected. For example, in one typical chassis the picture would roll every few minutes. Adjustment of the vertical hold control would make it settle down a bit, but not satisfactorily. There were no other symptoms. I examined the vertical blanking bar. It looked perfect.

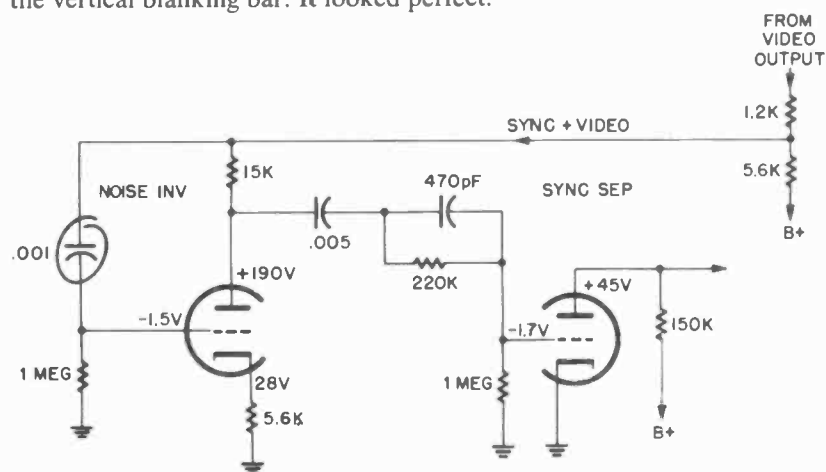


Fig. 506—A leaky blocking capacitor was allowing some dc to bleed through to the control grid. The tube was conducting erratically.

I watched the rolling to try to find a reason for the erratic activity. Then I noticed the rolling occurred as a scene changed. It rolled more on certain scenes than others. That means the changing of the video level was causing the rolling.

I started with scope readings at the sync takeoff point between a 1.2K and a 5.6K resistor in the video output (Fig. 506). Patterns and p-p levels looked good till I crossed the other end of the 15K isolation resistor. Then the video looked a bit jumbled. There was a noise inverter triode section sitting next to the sync separator. The plate of the triode was tied directly to the scope test point I had just looked at.

I moved over to the 1,000-pF blocking capacitor in the noise inverter's input. The pattern looked good there and the p-p was about the correct value.

I still had to eliminate the noise inverter as the trouble source. I took my high-impedance bias box, attached it to the control grid of the inverter triode, turned the bias up to  $-20$  and observed the picture.

The trouble cleared.

Since I had cut off the inverter triode (as it should be) and the trouble cleared, the trouble was in this circuit and the tube was not being cut off as it should be.

I removed the bias box and began taking dc voltage readings. The cathode voltage of 28 was on the nose. The grid bias of  $-1.5$  was not there—instead a varying positive 8 to 12 volts.

I disconnected the blocking capacitor at the grid end and took a dc voltage reading at the now open end of the capacitor. The meter revealed some dc leaking through. I replaced the capacitor and the trouble cleared.

The leaking capacitor was upsetting the cutoff of the tube. Instead of only random bursts of cancelling noise, some amplified video was developing across the 15K resistor. This reduced the input to the sync separator and the separator stopped separating, causing video to get into the sync pulses and producing the symptoms.

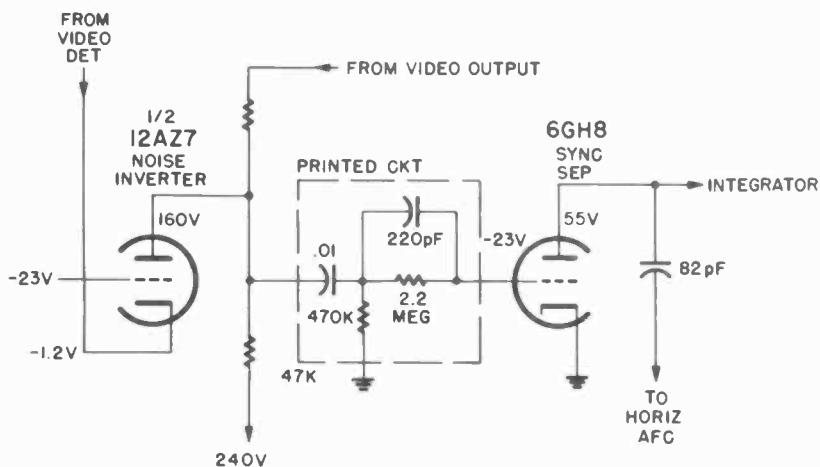


Fig. 507—A late model (1966) Dumont uses noise inverter and sync separator in series. A small printed-component separator is used instead of conventional components.

You'll find many variations of sync amplifiers and noise-canceling circuits. Fig. 507 shows one example. Some noise inverters will have their input to the plate of the tube, others at the cathode.

Some chassis have combined these functions in multi-element tubes with tricky circuits. No matter what the variation, the same or similar troubleshooting techniques are used. A working knowledge of these techniques will stand you in good stead.

## Chapter 6

# The Simplest Sync Separator

THE sync separator most popular among TV manufacturers is quite simple. It uses the least number of parts and space and is the least expensive to build. From a servicing point of view, the job is easy as long as one has a good understanding of the way the circuit works. Understanding this simple circuit makes it easier to figure out the more complex types.

The separator tube is usually a triode, although a pentode can be, and occasionally is, used. Both types work and fail in the same manner.

The input to the triode separator must be a high peak-to-peak composite TV signal. The takeoff feeds the signal into the control grid through a blocking capacitor with a value around 1,000 pF (Fig. 601). If the signal is passed through a sync amplifier first, the capacitor will be somewhere around .05  $\mu$ F.

The capacitor works with a grid-leak resistor in the megohm range to provide a long (R-C) time constant. The plate voltage is set relatively low and can be found to be anywhere from 10 to 75 volts. The cathode is quite often grounded. The plate load resistor can be found in values from 5 to 10K.

When the signal is applied to the grid, here's what happens: As the high-amplitude positive sync tip turns on the electron stream, it causes grid current to flow. This charges the blocking capacitor and places a negative charge or bias on the grid. Then, when the sync tip's time is up

and the lower-amplitude video arrives at the grid, the tube turns off and the grid-leak combination begins to drain off some of the capacitor's charge through the resistor. However, the time constant of the R-C combination is so long that the next sync tip arrives before much of the charge can leak off. This keeps the grid at a high negative bias, proportional to the strength of the p-p video signal, all during operation.

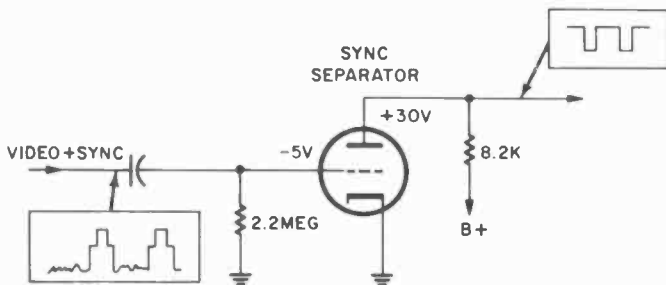


Fig. 601—A typical triode sync separator. The tube stays at cutoff except during the high positive sync pulses.

With this bias and the low, low plate voltage, the tube can go to cut-off quite easily. Thus, when the video signal and the blanking-pedestal portions of the sync pulse, with their lower amplitude, arrive at the grid, they can't turn the tube on. Only the higher-amplitude sync pulse extending above the pedestal can do so. As a result, only the sync pulses appear in the output.

A really high-amplitude noise burst on the extreme positive peaks of the sync pulse can cause the grid to draw additional current. When this happens, plate-current limiting takes place and these extreme positive pulses of noise are limited or clipped off. They do not appear in the plate output. This is a form of noise suppression, but it is not very efficient.

In fact, the separation action of these triode separators is not perfect. Cheap is cheap, and there are flaws. These triode separators do not possess as much noise-limiting ability as would be desired, and actual separation is not perfect. Yet they are quite satisfactory because of new advances in tuners that eliminate a lot of noise before it can get into the rest of the TV circuitry. Also, TV stations have stronger and purer transmissions now. These improvements have permitted set manufacturers to reduce some of the noise-eliminating ability of sync separators (Fig. 602).

About the separation quality: In these stages not all of the video is always clipped out of the sync. You'll find some video fringes leaving



the separator for subsequent travel into the oscillator stages. The differentiator and integrator are supposed to further separate the video from the sync. Under most conditions they do, but there will be instances of horizontal sync instability and some weaving in conditions of low signal strength and high noise conditions that a more complex sync separator would clear up. There's not much you can do in the sync stages in these cases. Antenna work might help, but not sync servicing.

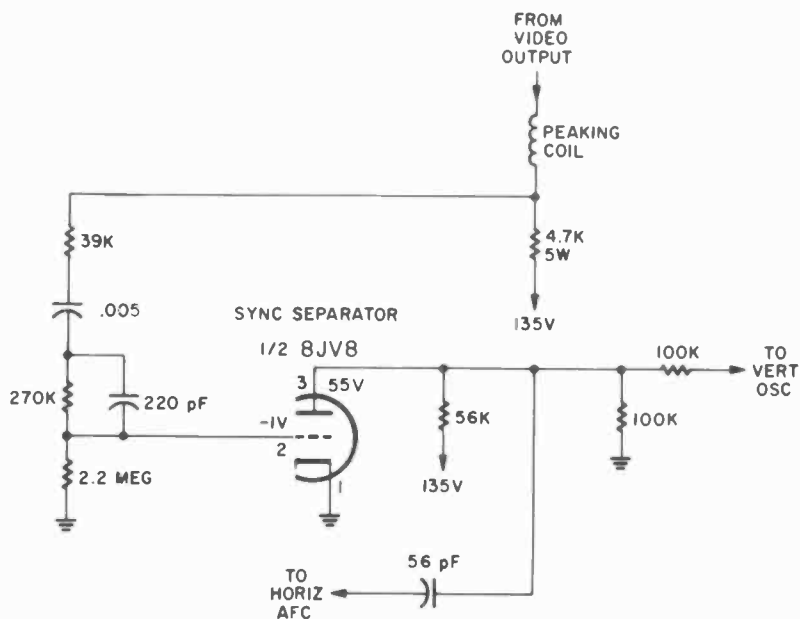


Fig. 602—A late model (1966) Silvertone uses a triode sync separator. The only thing new is the tube type.

Be on the lookout for video fringes in the sync signal in this simple separator. It is often quite normal for these TVs to have some video in the separator output. Don't let this be a false lead.

Because of the critical nature of the separators, slight changes in components cause troubles that wouldn't occur in more complex circuitry. If a capacitor or resistor changes value to a small degree, it can cause bending or instability. A slight change in the grid input capacitor, grid-leak resistor or plate load resistor can cause sync troubles as it shifts what is clipped. This puts video into the sync or compresses the sync pulse. Even the tube, although giving a good emission test and performing well in another type of circuit, could cause sync problems. The

tube must perform exactly as prescribed.

A typical subtle sync trouble for a similar circuit (Fig. 603) was in a 24-inch Emerson chassis where the picture was good, yet exhibited gradually worsening vertical instability the longer it played. After about 10 minutes, it required a hold-control readjustment every few seconds.

I let it play for about half an hour before I made any checks. Then I examined the operation of the various controls. They all worked fine except the vertical hold. It was critical and locked in only at one fine setting.

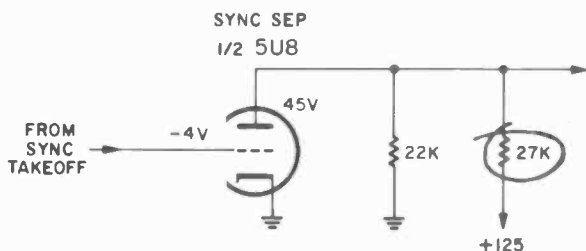


Fig. 603—The load resistor had increased, dropping the plate voltage to 10 volts and causing unstable sync.

I touched the scope probe to the sync takeoff point. Good video. I came across the takeoff line into the triode separator grid. The video cleared up and the sync pulses shaped into a better square wave. Then I tried the plate of the separator. There was a small, clean sync spike no larger than that at the input grid. I looked at the schematic. There was supposed to be a large amplified spike tinged with video (the triode separator also amplifies the spike as it separates it from the video). This was a good lead. The trouble seemed near at hand.

I switched the vtvm to +DC and took a reading at the plate. It was supposed to read 45 volts, but it read only 10.

I checked the control grid. There should have been -4 volts and it was there, right on the nose. That meant the grid input was good.

I went back to the plate circuit and checked the B+ end of the 27K plate load resistor: 125 volts. At the plate end there is a 22K resistor as a voltage divider to ground.

I turned off the TV and resistance-checked both resistors in circuit. The 22K read 22K. The 27K read 1 megohm. I replaced the 27K with a new one and the trouble cleared.

The lowered plate voltage increased the sync-clipping action by making the tube cut off more readily. However, it reduced the tube's amplifying ability. The horizontal still worked well, since it is not as

dependent on spike amplitude as the vertical (Chapters 15 and 16). The vertical sync ability was reduced drastically as the 27K resistor got hotter and kept increasing in value, making the B+ and the sync spike smaller and smaller.

If the shunt resistor had increased in value, exactly the opposite situation would have occurred. The plate voltage would have increased. The amplification of the tube would have increased, and the separation would have decreased. Some of the video would have entered the sync, causing a weave in the picture.

If that shunt resistor had decreased in value, the effect would have been the same as the case described. The voltage-divider action under that condition would have drained off more dc voltage than prescribed, lowering the plate voltage and the sync spike.

If the 27K resistor had decreased in value, the effect would have been similar to having the 22K increase in value. The plate voltage would have increased, causing too much amplification and too little separation.

increased and, since the grid operates expressly for noise pulses, the larger amplitude makes the grid work better at noise cancellation. However, if you increase the signal at the grid too much, some of the signal will become strong enough to modulate the electron stream, appear in the plate output and bend the picture.

In strong-signal areas where relative noise is weaker, you turn the control to make the grid more positive, thus, reducing the ability of this grid to cancel noise. It is satisfactory, though, because with the stronger signal, there is less noise in the signal. The adjustment is set to prevent sync troubles due to noise and should be set with this, and only this, in mind.

Some of the controls affect contrast, agc, etc., or else exhibit subtle or little change. You must be wide awake when you are working in these circuits. Breakdown of the components in this circuit causes sync troubles, but the clues that appear are tough to spot.

A case in point was a Westinghouse H853 chassis that arrived on the bench with sync troubles. The customer was complaining that his distant stations were not coming in properly. All the distant stations had the bends. The three local channels also had some bends, but the pictures were better.

The first thing I tried on his TV was our antenna. The same symptoms persisted, so his antenna was okay.

I took my flying-spot scanner and injected a test pattern into the rf input. With full strength, the pattern had slight bends; as I reduced signal strength, the bending increased.

I jumped the tuner and injected the pattern into the first if. The same symptoms persisted, so the tuner was exonerated.

I removed the scanner and returned the antenna to its terminal on the TV. Then I examined the vertical blanking bar. Perfect relative shadings. This pointed me to the sync circuits themselves.

I installed the low-capacitance probe, set up for 30 cycles and touched down on pin 7 of the 6CS6 sync separator, the No. 3 grid (Fig. 702). A nice composite TV pattern emerged, 22 volts p-p as it should be. Then I looked at pin 1, the No. 1 grid. A fair-to-middling pattern showed with a peak-to-peak voltage of about 0.5 as prescribed; maybe a shade low but still within tolerance. I switched to 7,875 Hz and looked at the plate, since this was the waveform on the schematic. It showed 18 volts p-p as listed. However, the schematic showed a clean horizontal spike. This one wasn't clean; it had quite a bit of video clinging to the spikes.

I grabbed the vtvm and began taking voltage readings. The plate

was 35, correct; the screen 40, okay; pin 7 was  $-17$ , about right. Pin 1 was off, but not by much. Instead of reading 0.6 volt dc, it was zero.

I thought at 0 volts the operating characteristics of the 6CS6 would be shifted. This grid, with its more positive bias, could cause the video input to modulate the electron stream. If it did, some video would get onto the sync spikes. That could cause the weave—especially on weaker channels that caused a less negative grid bias than the stronger channels.

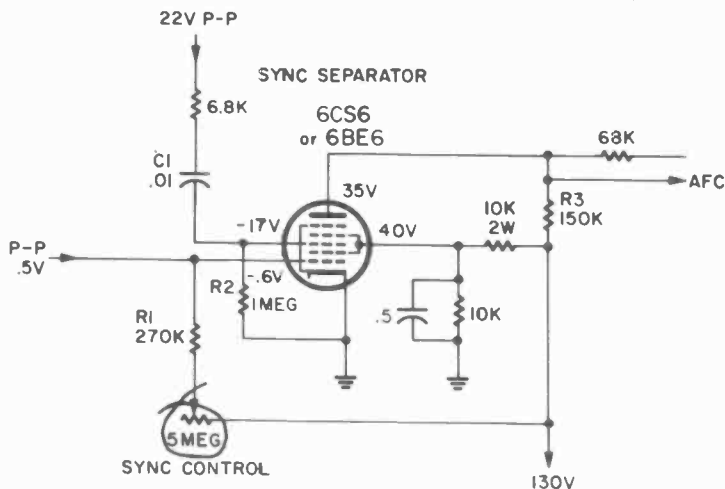


Fig. 702—A shorted potentiometer caused a bend in the picture.

I began checking components in the No. 1 grid circuit. The 270K resistor read on the nose. The 5-meg sync-control potentiometer read 200 ohms. I varied it. It was hard to turn and the resistance didn't change, so, it must have been shorted internally. It was at its strongest position at all times. This permitted some of the B+ on the other side to leak through the 270K and keep the grid bias set for extremely powerful amounts of signal strength only. Any weakness of signal permitted video to get into the sync and cause the bends.

A new potentiometer cleared the trouble and I was able to adjust for weaker signals (or stronger noise) once more.

This was a tricky pinpointing job. The only leads were the bit of video in the plate circuit and bias that was a shade lower than normal on No. 1 grid. These hard-to-spot indications can easily be overlooked unless you have a good understanding of the activity in this pentagrid sync separator.

Other components cause troubles, too. C1 usually has B+ on the video side. If it begins to leak, some of this B+ is going to come

through, lowering the negative bias or even turning it positive, depending on the amount of leakage. A shorted C1 will put the B+ right on pin 7. If C1 opens or changes in value, the peak-to-peak voltage will be reduced or completely lost, depending on how much capacitance C1 loses. Whatever happens to C1, sync trouble will occur.

R1 rarely goes bad. If it increases in value, there will be few noticeable symptoms in the picture. Should R1 short, the peak-to-peak voltage won't develop as designed, and the high negative bias will drop—depending on the decrease.

There is usually no blocking capacitor into pin 1; the takeoff point is ordinarily in the detector output or video input. R2, on the other hand, is the grid-leak resistor, across which the low peak-to-peak voltage develops. If it decreases in value, the bias is going to approach zero, according to the amount of decrease. This will shift the operating characteristics of the tube, causing bends, weaves and overloading of the picture as in the case history given. If R2 increases in value, there probably will be little or no change in the picture, unless the resistor opens up altogether. Then the picture overloads.

R3, the plate load resistor, quite often decreases in value. When it does, the plate voltage is increased and the video is amplified, rather than getting its sync clipped off. If R3 increases in value, the plate voltage is lowered and excessive clipping takes place. With the video getting into the sync, the picture will bend. With excessive sync clipping, the picture will tend to roll vertically.

Fig. 701 is a typical sync separator, but there can be other circuit variations. If you consider any plate or control variation with respect to the typical, it should not be too difficult to reason out the trouble suspects.

## Chapter 8

# “Siamese Pentode” Sync Troubles

WITH the advent of a rash of new tube types, a new sync-separator design has come into popular use the last few years. Its use is based on tubes such as the 3BU8, 6BU8, 6HS8, etc. These are sharp-cutoff Siamese-twin pentodes. The name Siamese twin is used because the two pentodes have a common cathode, control grid and screen grid. They have separate suppressor grids and plates.

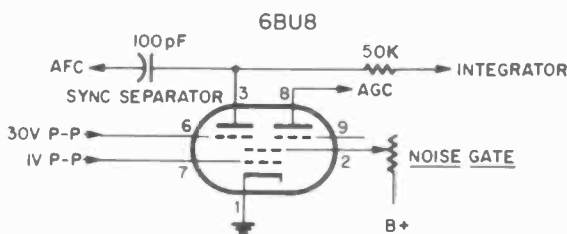


Fig. 801—A sharp-cutoff “Siamese-twin” pentode used as a sync separator and an agc keyer.

In addition to separation, these tubes can also perform noise cancellation and agc keying duties.

Your first glance at the typical circuit (Fig. 801) shows something

new One grid number three (pin 6) is not acting like a suppressor. The sync takeoff line feeds right into it as if it were a control grid. In fact, it acts just like a control grid. There are 30 volts p-p of TV signal issuing into it. The adjoining element above is the plate (pin 3). It carries 75 volts p-p of horizontal and vertical sync. This is an amplified and clipped version of the suppressor input. The plate output splits off into two paths, one through a tiny 100-pF capacitor to the horizontal afc, and the other to the integrator through a 50K isolation resistor.

This suppressor and plate are effectively a triode sync separator, even down to the detail of not completely getting the video out of the sync. The subsequent integrator and afc circuit complete the separation.

The other plate (pin 8) and suppressor (pin 9) are also acting in triode fashion and are doing agc keyer duty.

Meanwhile, beneath the two suppressors sit a single screen, a single control grid and a single cathode. The screen-grid circuit contains B+ and usually a megohm potentiometer called a noise gate to vary this B+ slightly. The screen-grid voltage sets the conduction level of both sides of the tube. Increased screen voltage increases conduction, and decreased screen voltage decreases conduction. For the sync section, this sets the clipping level of the separator action.

The control grid, like the heptode control grid, performs the noise-cancellation job for both the sync separator and the agc keyer. Both suppressors receive goodly amounts of positive video from the output of the video amplifier. The control grid simultaneously receives a TV signal from the video detector, about 1 volt p-p or less and negative-going. The small peak-to-peak voltage has little power over the electron stream, except when a large noise pulse higher in amplitude than the sync pulse comes in. The same pulse appears on both suppressors at the same time. A negative noise pulse on the control grid cuts off the entire tube. Therefore, no noise can get into the plate outputs.

With this tube we must forget about suppressors as such. If you think of the suppressor-plate combination as two triodes setting atop a special electron-stream-shaping network, your thinking during the repair will be clarified.

In a Zenith portable 16C20 chassis I had in for repair, the symptoms were overloaded video and bad horizontal pull. The pull was so severe that the blanking bar sat almost in the center of the screen.

After routine tube replacement proved fruitless, I examined the horizontal blanking bar that was so available. It checked okay, which meant the trouble was after sync takeoff. Since both agc and sync



separation reside in the same 6BU8 tube as Siamese twins, this was the circuit I first examined.

The schematic (Fig. 802) revealed that the sync side should have 65 volts on the plate (pin 8). On the suppressor (pin 9), there should be  $-15$ . The  $-15$  was developed grid-leak style by a 3,300-pF capacitor and a 6.8-meg resistor. The 6.8-meg does not go to ground, but to the screen. The high resistance blocks the B+ from the suppressor.

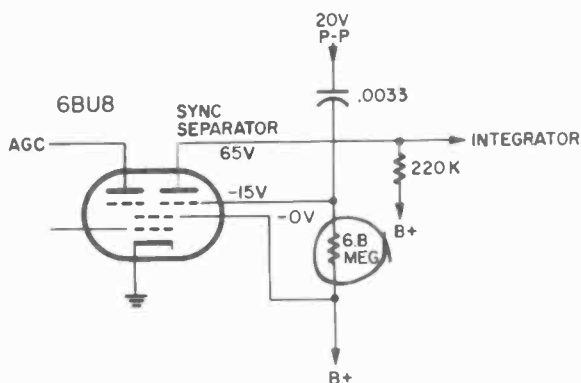


Fig. 802—The 6.8-meg resistor had dropped to 100,000 ohms, allowing some of the screen B+ to get onto the suppressor and kill the bias.

I took the scope and touched down on the plate (pin 8). The spikes were distorted and had video in them. Peak-to-peak, they were about 50 volts, instead of 35 as prescribed.

I grabbed my vtvm and began dc voltage readings. The plate was down to 40 volts instead of 65. I read the suppressor; it had  $+5$  instead of  $-15$ .

The first likely suspect was the 3,300-pF blocking capacitor. I disconnected it. It checked out perfect, so I reconnected it.

Next suspect, the blocking resistor—the 6.8-meg resistor from the screen. I disconnected it. It read 100K. It had shorted down a bit, allowing some B+ to leak through, and leaving the suppressor sensitive to bias. With the positive voltage the tube conducted strongly, and amplified the video instead of clipping the sync. This was increasing the peak-to-peak plate voltage, decreasing the dc plate voltage, putting lots of video into the sync and causing the symptoms. The trouble had agc overtones, since the agc was the sync Siamese twin. A new 6.8-meg resistor restored all.

## Chapter 9

# Separate Horizontal and Vertical Separators

SOME TVs have separate horizontal and vertical sync separators. When first looking at this circuit, you might think that this is where the two sync frequencies part company, but it's not. They are promptly rejoined in the plate output for further amplification together in one sync output tube (Fig. 901).

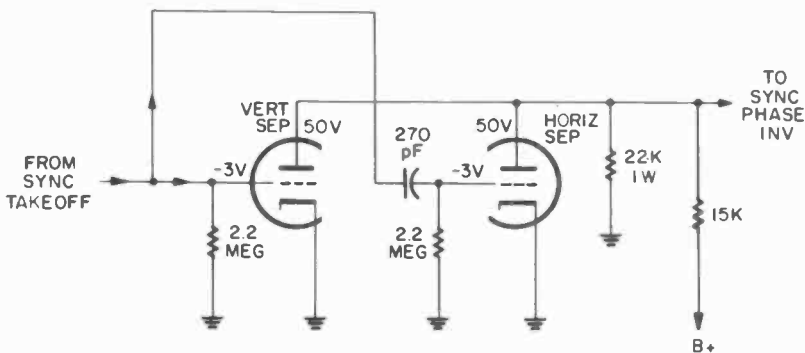
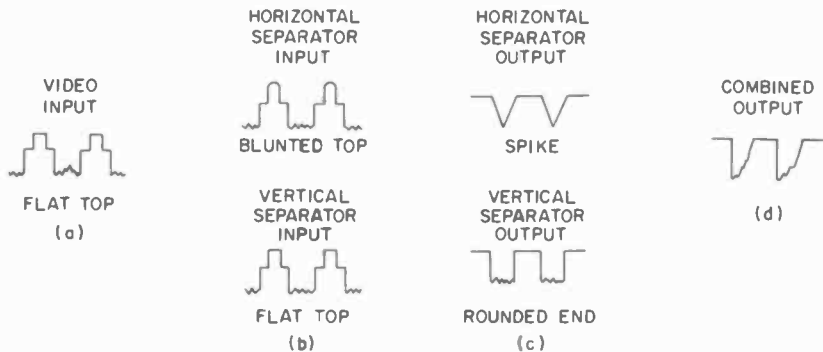


Fig. 901—A circuit with separate vertical and horizontal sync separators. The 270-pf capacitor blunts the top of the waveform applied to the horizontal separator.

Why have them part company at all? For wave-shaping reasons. In separate separators, the horizontal waveshape can be concentrated on

without concern for the vertical's special needs, and vice versa.

In the horizontal separators, either a resistor around 10K or a capacitor around 270 pF is placed in series with the grid input. This additional component following the takeoff line weakens and rounds off the top of the square sync tip (Fig. 902b, upper waveform). This reshaped video enters the triode separator. Separation takes place, and a sharper horizontal spike appears in the plate output than if the sync tip were still square and broad upon grid entrance (Fig. 902c).



*Fig. 902—Waveforms for separate vertical and horizontal sync separators. Part (a) shows the video signal. The blunted input to the horizontal separator (b) permits the horizontal output spike to be more pointed (c). The combined output (d) has a sharp leading edge and good pulse duration.*

In the vertical separator, the normal cleaned-up video is inserted into the grid, with the sync tip as flat as possible. (Fig. 902b, lower waveform). The vertical sync output is an amplified sync spike, but with a much flatter top than the horizontal output (Fig. 902c).

Since the vertical sync depends on the duration of the pulse, duration is preserved and amplified in the vertical separator. Since horizontal sync depends on the steepness of the leading edge of the pulse, this characteristic is what concerns horizontal separator. The two outputs are then combined and the net result is a sync spike with a steep leading edge and a good pulse duration (Fig. 902d).

The input of each separator is about 10 volts p-p, positive-going. Their combined amplifier output is about 30 volts p-p, negative-going. The output is then fed into a sync phase inverter (to be covered later).

The separators are usually both triodes with grid-leak bias. The bias is highly negative. They will have either a common plate output resistor of about 15K or a common grid input into the next stage through coupling capacitors. Low plate voltages are supplied either through voltage-

dropping resistors in series with the plate load (between the B+ line and the load) or with voltage dividers in parallel with the plate load.

In a CBS 921 chassis I was working on, the symptom was unstable horizontal hold, or a picture that tended to slip sideways—not going off into lines, but slipping. The vertical hold control was locking at one end, and the vertical hold had more than its usual range.

I examined the blanking bar—it was perfect. I picked up my scope probe and set the scope for 30 Hz. Starting at the sync takeoff point (between the video amplifier and the video output tube), I contacted a video waveform of about 8 volts p-p (Fig. 903). I came across the 12K isolation resistor and the .022- $\mu$ F blocking capacitor uneventfully. As I passed over the video filter (the 470K resistor and 390-pF capacitor), the peak-to-peak voltage dropped drastically. I opened the 390-pF unit and ran a capacitance check. It had reduced in value to about 4 pF—practically open.

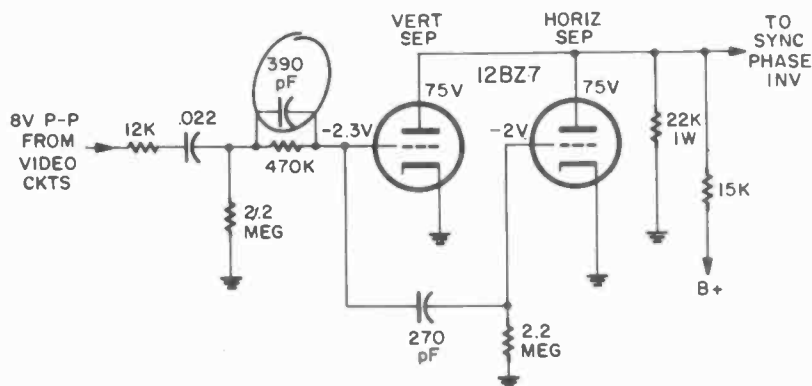


Fig. 903—The 390-pF capacitor in the video filter opened, causing the instability.

Before I replaced it, out of curiosity I wanted to see what had happened at the plates. I took a scope reading of the two plates of the 12BH7. There was amplified video at both instead of clipped sync.

This meant that video was getting into the horizontal and vertical sync circuits. The integrator was cleaning out the video fairly well and this resulted in more vertical sync than it usually received, locking the vertical hold more firmly than usual. The video was getting in the horizontal afc circuit harming its action causing the unstable situation.

I installed a new 390-pF capacitor. The 10-volt p-p restored the two separators' high bias, which made them sync clippers once more and not just plain amplifiers. The horizontal and vertical trouble cleared up.

## Chapter 10

# Other Types Of Separation—Sync Limiting

A TWO-STAGE sync separator effectively chops off the video in the first stage and the top of the sync pulses in the second. You could call this sync limiting. Through a routine sync takeoff line, a positive-going sync signal is fed grid-leak fashion into a sync separator. The plate B+ is low, as in other sync separators. The peak-to-peak signal is from 10 to 30 volts. The separator chops off the video, and the plate output is an amplified sync pulse with all video about gone.

The plate output is directly coupled into the cathode of the next stage, which puts the same B+ on the cathode as is on the preceding plate. The sync pulse, because of inversion in the first stage, is now negative-going.

The grid bias on the second stage is highly negative. The bias voltage is B+ that passes through a voltage divider and places the cathode-grid relationship at a -10- to -20-volt figure. Sync clipping again takes place, only this time the tops of the sync pulses are clipped off. This eliminates all pulse peaks, and places all the sync pulses at the same level, which makes for stable sync. The uniform pulses then proceed to a sync amplifier and on to their appointed jobs in the sweep oscillator (Fig. 1001).

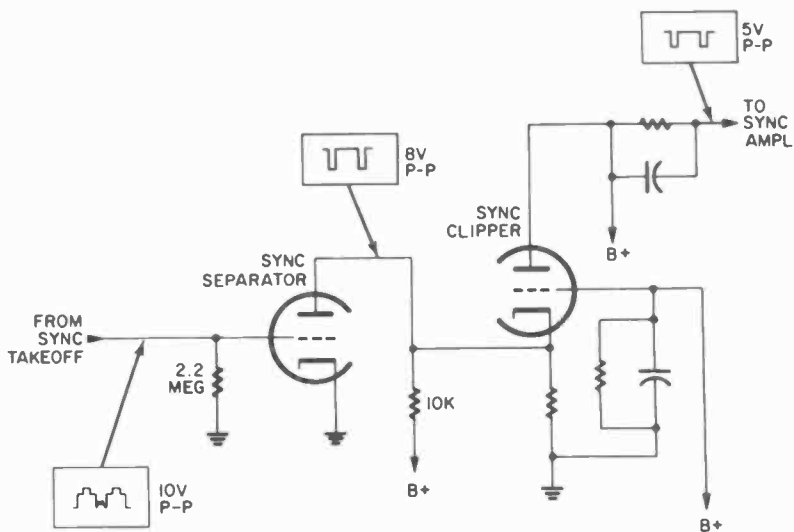


Fig. 1001—Sync limiting. The first stage clips off the video; the second clips the top of the sync pulse.

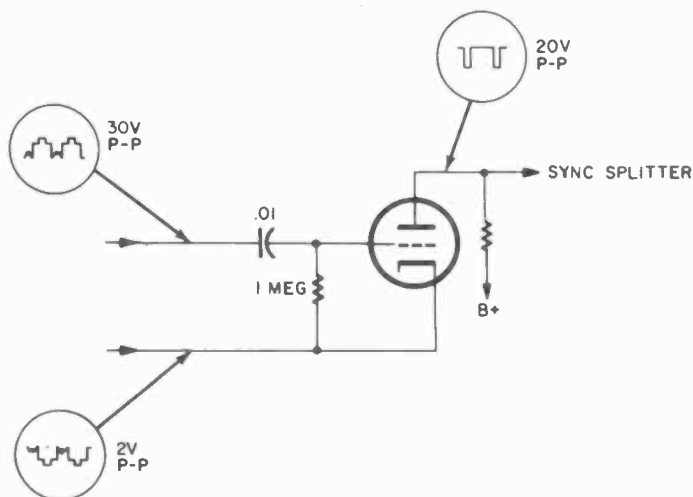


Fig. 1002—Sync keying. The simultaneous sync peaks at cathode and plate cause conduction. Otherwise, the tube is cut off.

## Sync keying

A sync keyer is not used very often, but you will find some of them around. Again a routine sync takeoff line picks off a high-amplitude signal from the video output and feeds it grid-leak style into the control grid of the sync keyer, which is a triode. The positive-going sync peaks tend to push the bias in the positive direction and make the tube conduct only during the sync pulses.

At the same time, a direct-coupled line goes from the cathode of the video output tube to the cathode of the sync keyer. This negative-going sync pulse at the cathode tends to reduce the cathode bias and thus tries to make the tube conduct.

The overall bias of the tube is set at cutoff. That way, the tube is normally cut off.

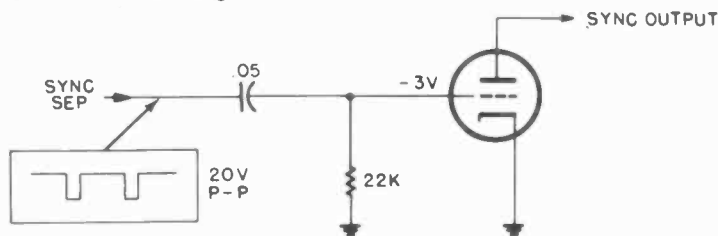
However, when the positive sync peaks arrive at the grid simultaneously with the negative sync peaks at the cathode, the tube conducts. Since the tube conducts in bursts only during the keyed period of time, a pulse appears in the plate output at exactly the right time (Fig. 1002). Subsequent circuitry covered in the next chapter takes it from there.

## Chapter 11

# Sync Output Circuit Troubles

**THERE** are three jobs a sync output stage must perform: (1) More amplification of the sync pulses. (2) More noise reduction. (3) Phase inversion and splitting. Therefore, when trouble strikes in this stage one of these three jobs is not being performed.

The sync signal, by the time it arrives at a sync output stage, has already been amplified, noise-cancelled and switched from positive to negative, and vice versa. The sync output stage in a TV does these things once more, as a finishing touch.



*Fig. 1101—A sync output circuit. The resistor and capacitor can cause sync trouble.*

A typical circuit will use a triode section such as one half of a 6SN7 or 12AU7 (Fig. 1101). The grid input might employ either a fixed or grid-leak bias. Nevertheless, it is usually capacitance-coupled from the separator stage through a  $.05\text{-}\mu\text{F}$  coupler. A 22K resistor from grid to



ground provides a leakage path for the grid current. About 15 to 20 volts peak-to-peak of sync pulse comes through the capacitor from the separator. Fifteen or 20 volts p-p is enough, since the output tube is there to bring the voltage higher for sync application to the integrator and differentiator.

The peak-to-peak voltage is negative-going as it leaves the separator. The sync tips thus drive the tube into cutoff rather than conduction. This clips out any noise pulses that might be riding atop the sync. It also flattens the top of the pulse without hurting the steepness of the leading edge. This is exactly the way the integrator and differentiator like the pulse.

The bias on the grid runs around a normal  $-2$  or  $-3$  volts. Should the  $.05\text{-}\mu\text{F}$  capacitor spring a leak, some of the low  $B+$  from the separator will upset the bias on the grid. How much depends on how low the leakage resistance becomes. A low resistance makes the tube conduct heavily, rather than cut off. The sync pulses are lost in plate saturation, producing a loss of horizontal and vertical sync. The amount of loss will be in direct proportion to the amount of leakage (Fig. 1102).

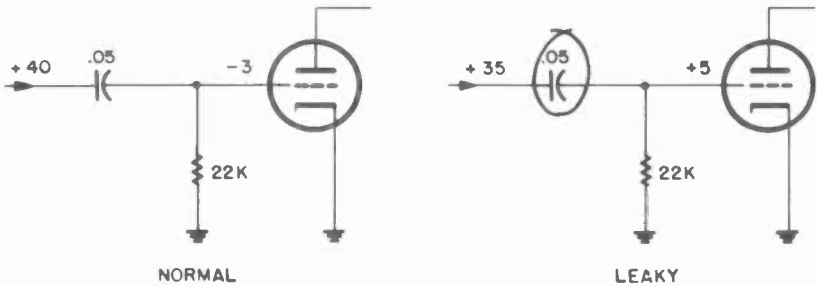


Fig. 1102—If the  $.05\text{-}\mu\text{F}$  capacitor should leak, some of the  $B+$  will pass through, making the bias more positive.

If the  $.05\text{-}\mu\text{F}$  capacitor loses capacitance, the peak-to-peak voltage will be attenuated. Depending on the amount of capacitance loss, the symptoms will vary. The picture first becomes bent and then develops unstable vertical sync. As the loss becomes greater, the horizontal and vertical lock-in become more and more critical. You'll never lose sync altogether with this condition because stray capacitance and pickup will convey some of the sync voltage around the capacitor even if the capacitor opens completely (Fig. 1103).

When the  $22\text{K}$  resistor begins to decrease in value, both syncs become unstable in proportion to the amount of resistance loss. This is because the grid bias is decreased and the peak-to-peak voltage is decreased,

since it has fewer ohms to develop across. The lowered amount of grid input and the lessened ability of the tube to amplify reduce the drive into the subsequent sync circuitry, reducing lock-in power (Fig. 1104).

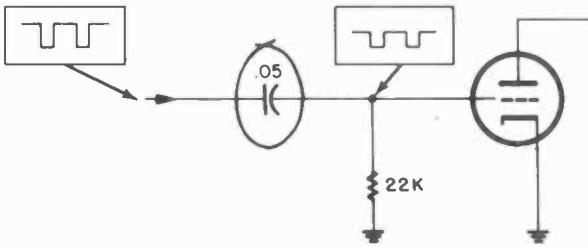


Fig. 1103—If the .05- $\mu$ F capacitor loses capacitance, the peak-to-peak voltage will be attenuated.

In addition to acting as an amplifier and noise canceler, some sync output stages act as a phase inverter and phase splitter. This is usually when the afc circuit needs a push-pull input. When this is necessary, a load resistor of 2,000 or 3,000 ohms is installed in the cathode. Across this resistor is developed about 10 volts p-p, negative-going. This is then fed through a 500-pF coupling capacitor into one end of the afc (Fig. 1105).

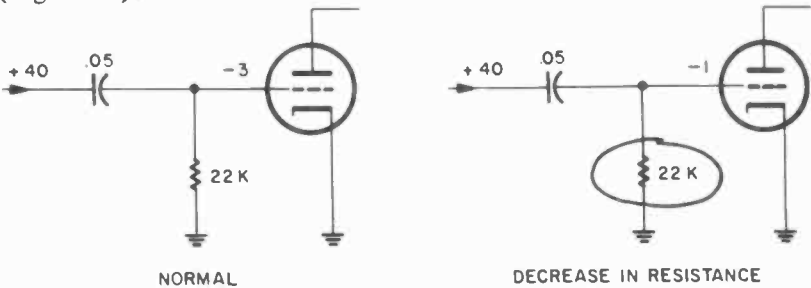


Fig. 1104—If the 22,000-ohm resistor decreases in value, the peak-to-peak voltage developed across it lowers and the grid bias drops.

Meanwhile, in the plate circuit there is another load resistor of about the same value. Across it about the same peak-to-peak voltage is developed, but it's positive-going. Another 500-pF capacitor feeds this pulse into the other end of the afc.

The plate output is about 25 volts p-p. So a 6,000- to 10,000-ohm resistor is installed in series between the plate and the afc load to drop the voltage so only 10 volts p-p develop across this afc load.

The afc push-pull is critical. Any leakage or capacitance loss in the

500-pF capacitors will cause loss of horizontal sync. Any resistance change in the cathode or plate load resistors or the blocking resistor will also cause loss of horizontal sync.

In the plate is another leg, with or without a series blocking resistor, that goes directly to the vertical integrator. The 25-volt p-p plate signal passes through this leg into the integrator. If there is a series resistor in the leg and it increases in resistance, the signal will be attenuated and the symptom on the screen will be unstable to no vertical sync, depending on the amount of increase the resistor exhibits.

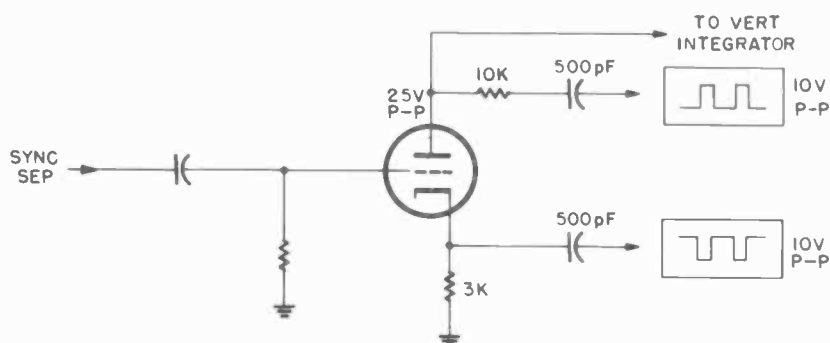


Fig. 1105—Push-pull output to afc. When a sync output stage acts as a splitter, a load resistor is installed in the cathode.

Any other components that might be placed in the circuit can also cause trouble. For instance, if the grid has fixed bias controlled by a megohm dropping resistor from B+, a loss or gain in value in this resistor can raise or lower the grid bias. If it raises the bias positively by decreasing in value somewhat, a complete loss of sync can result as plate saturation ruins the action of the tube and eliminates the sync pulse. If it makes the bias more negative by increasing in value, the picture will bend and vertical sync becomes unstable. The bias change causes excess clipping of the negative-going sync pulse. As long as you understand the sync output tube, you can reason out what is happening. A typical example of trouble in this type of circuit occurred in a department-store-special TV. It was using a 12AU7 dual triode, one section for sync separation and the other for sync amplification, noise cancelling and phase splitting.

The symptoms were no vertical or horizontal sync. A fast preliminary examination and blanking-bar analysis indicated trouble in the sync circuitry. I grabbed the scope and began traveling down the sync path, component by component. As I came across the .05- $\mu$ F coupler into the sync output (Fig. 1106), the waveform distorted and the p-p height on

the scope dropped. There was much less than the normal 20 volts p-p.

I took the vtvm and touched it to the same test point, the grid of the sync output tube. Instead of the normal 5 volts dc, there were 35 volts.

Where could the 35 volts be coming from? Across the capacitor at the separator plate is the plate B+ of 40 volts. The capacitor must have sprung a leak. I gave it an in-circuit resistance check. The meter said 200 ohms. I looked over the circuit. It had to be the capacitor—nothing was in shunt. I clipped the capacitor out of the circuit and measured it bare on the bench. So far, so good—it was shorted.

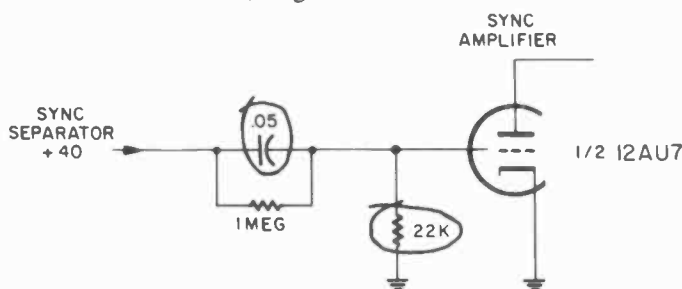


Fig. 1106—The shorted  $.05\text{-}\mu\text{F}$  capacitor ruined the 22,000-ohm resistor by permitting B+ to drain through it to ground.

I replaced the capacitor. The dc voltage at the grid dropped to around normal. I looked at the CRT screen. Now the picture was rolling. I tried to stop it; the vertical control had a center point, but was unstable. I checked the horizontal; it was locking in a little better, but not as solidly as it should.

I took a scope picture. The peak-to-peak voltage looked about normal. I jumped back across the  $.05\text{-}\mu\text{F}$  replacement capacitor. The voltage was a shade higher in amplitude on the separator side. The peak-to-peak voltage shouldn't change as it passes through a capacitor as large as  $.05\text{-}\mu\text{F}$ . I read the grid bias. It read 3 volts dc instead of 5. There was a 1-meg resistor that came from 40 volts dc to set the grid bias at 5 volts; if it had increased in value, it could have caused the bias loss. I read it. It read a little less than 1.2 meg, which was within tolerance. I decided to replace it anyway. Before I did, I read the only other component in the grid circuit—the 22K resistor from grid to ground. It read about 10K. So, the 35 volts that had been across this resistor to ground while the capacitor was shorted had damaged it. I replaced it. Sure enough, the sync returned to normal. I tested the old 12AU7 before putting it back in the circuit. It was bad too. The high grid bias had damaged it also. The TV has been playing ever since.

## Chapter 12

# Vertical Integrator Troubles

MOST vertical integrators at first glance look like a single component. This is because the capacitors and resistors in it are usually all contained in a molded plastic printed-circuit unit with pigtail leads (Fig. 1201).

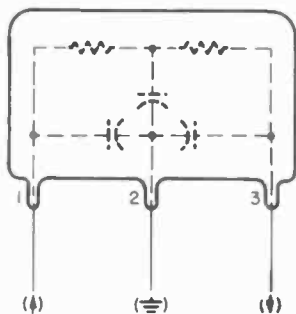


Fig. 1201—A typical molded integrator low-pass filter.

Inside the little package may be (1) resistors in series that isolate and pass the 60-cycle vertical spike from the sync stage; (2) capacitors in shunt that bypass the higher-frequency horizontal pulses; (3) capacitors in series that block dc; and (4) resistors in shunt that act as voltage dividers to set dc levels. Different combinations are found in the various networks you may encounter.

The network, in all its variations, is a form of low-pass filter. It is different from other low-pass filters in that it is designed to handle pulse waveforms, while other filters are built to pass sine waves and other low-frequency waveforms.

Specifically, the vertical integrator passes the vertical pulse, rejects the horizontal pulse and reshapes the vertical spike to a sawtooth waveform that the vertical oscillator must have for lock-in.

The first series resistor and shunt capacitor in the integrator have a long time constant with respect to the duration of the pulses that come in. Values around 100K for the resistor and 10,000 pF for the capacitor are common. That way, almost any variation of the sync output square wave, such as a pointed spike, is reshaped into a sawtooth.

The peak-to-peak input is usually about 25 volts. As the spike passes through the series resistor and charges the shunt capacitor, it loses a few volts of its peak-to-peak voltage.

The integration network varies in the number of components according to the ability of the sync stages. A very efficient sync system requires only one series resistor, a shunt capacitor and perhaps a blocking capacitor (Fig. 1202). A less efficient sync system necessitates a more complex integrator, such as one with three series resistors, three shunt capacitors and a blocking capacitor (Fig. 1203). This removes video fringes, improves leading edges and reduces overamplitudes.

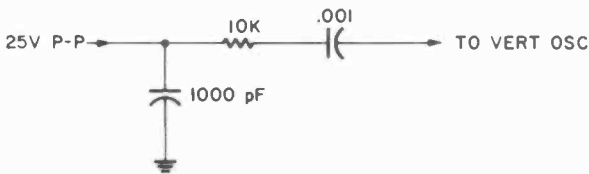


Fig. 1202—The simplest integrator.

Second, the complexity of the integrator is governed by the type of vertical oscillator it feeds. Various oscillators dictate certain components in the integrator.

From a troubleshooting point of view, it is not necessary to know the original designer's motives, but what happens when each component fails.

or sweep problems. If there are horizontal symptoms too, the trouble

Failure of any integrator component usually causes *only* vertical sync is probably not in the integrator.

Leakage of any series capacitor permits dc from the sync output to

leak through to the oscillator. This leakage changes the control-grid bias and will change the oscillator frequency in direct proportion to the amount of leakage. A badly shorted blocking capacitor could kill the oscillator altogether, resulting in no vertical sweep.

Loss of capacitance in the series capacitor attenuates the peak-to-peak voltage according to the degree of capacitance loss. The condition will vary from vertical instability to no vertical sync, depending on the percentage of loss and the circuit. If the capacitor opens completely, you could still have some semblance of sync because stray capacitance might get some of the p-p sync signal into the oscillator anyway. It varies according to the layout of the wiring.

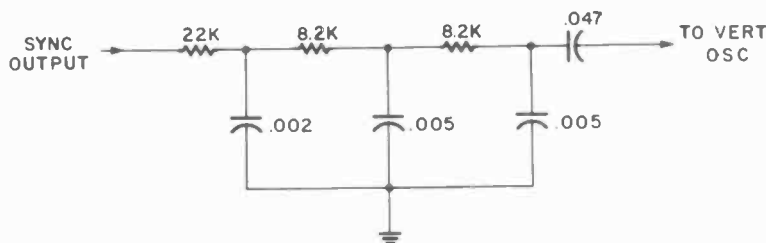


Fig. 1203—A more complex integrator.

If a series resistor opens up or increases in value, it will also attenuate peak-to-peak values and cause exactly the same symptom—loss of vertical sync—as does the capacitance loss in a series capacitor. The sync loss will occur in direct proportion to the resistance increase.

Shorted series resistors, on the other hand, might not cause any apparent symptoms except that the vertical-hold center range might shift, or the range of the hold control might cover more sweep than normal. However, a shorted series resistor could cause either the oscillator or the sync stage to act up. They won't be isolated from each other, so interaction of the sync signals and oscillator pulse might take place.

Leakage in shunt capacitors that are blocked off from the B+ in the sync output can cause distortion of the waveform, causing the timing of the vertical sync pulse to shift. This makes the picture lock in at the wrong place. The vertical blanking bar will appear on the screen with the picture on either side like slipped movie film. Usually, the blanking bar will appear about an inch off the bottom of the screen. You'll find that adjustment of the vertical-hold control will tend to lock the picture in properly, but it will be unstable. A more stable hold spot is found with the blanking bar showing.

If these capacitors open or lose capacitance, the integrator won't filter as well. This causes vertical instability as other signals, such as horizontal and video, get through to disturb the integrator.

Shunt capacitors that are not blocked off from the sync output B+ tend to leak B+ off to chassis, ground or a similar spot. This can cause burnout of any resistors unlucky enough to be in the pathway of the B+. Loss of B+ to the sync output also results, reducing the efficiency of the last stage. The trouble will vary, according to the amount of leakage. Small leakage causes vertical stability. High leakage will kill vertical sync. In some circuits, horizontal sync is affected too. This happens when the horizontal sync is taken off at a point where this dc level will affect it.

Change in resistance of shunt resistors messes up the voltage-dividing action these resistors provide. This shifts dc levels in and around the resistors that have gone sour. Vertical instability and a loss of vertical sync are usually the result. The sync voltage under these conditions will enter the vertical oscillator at an incorrect value. If the shunt resistor loses resistance, the sync voltage will be decreased. If the resistor gains in resistance, the voltage might be raised or lowered; at any rate, it will be incorrect and cause the vertical symptoms.

I recently experienced an interesting case of vertical integrator troubles in an old 12-inch Emerson table model. The noise-reducing ability of this old baby I hold in question. Also, horizontal and vertical instability, I find, are not unusual in high-noise-level areas. Our shop, which is on a main highway, is in such an area.

I examined the TV carefully. Blanking-bar shading was correct and both hold controls had good center points and seemed to perform normally, even though the customer complained, "It doesn't hold as good as it used to."

After close examination, I concluded sync was almost normal, yet it could be a bit more stable vertically. I exonerated the horizontal sync completely.

The scope was handy, so I began coming down the sync pathway. To my surprise, the scope picture was very clean. Little noise appeared in the green trace. As I passed from the sync-output plate into the vertical integrator, all seemed well. I went across the blocking capacitor. The called-for 40 volts p-p dropped drastically.

I tested the blocking capacitor. It was perfect in both resistance and capacitance. As the next step, with my vtvm, I took dc-level readings. All read well; however, I noticed that every time I touched a test point on the side of the series capacitor that was blocked off from B+, the



picture locked in solid. The only thing was that the blanking bar was locking in about an inch from the bottom of the picture.

I thought, "What am I doing with the vtvm to cause this?" I was inserting a high resistance from the test point to ground. The addition of the shunt resistance (the vtvm), working with another component no longer of correct value, was upsetting the timing of the waveshape and was triggering the oscillator at an incorrect time. Leaking shunt capacitors could be the cause. I turned the TV off and began examining them.

The third capacitor, a  $.005\text{-}\mu\text{F}$  unit, had a 100,000-ohm leakage (Fig. 1204). The leakage was preventing proper vertical pulse re-shaping. The sawtooth was forming improperly, causing some instability. Adding the vtvm in shunt was just like putting a high-meg resistor in shunt. This knocked the timing of the pulse off slightly, causing the wrong lock-in position.

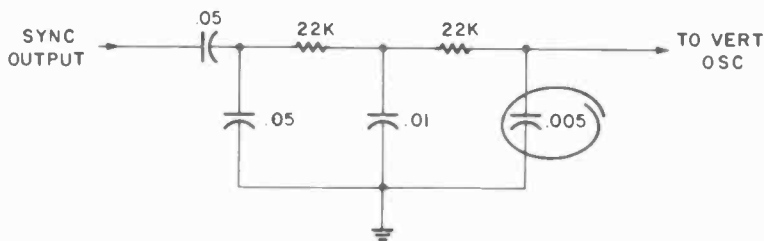


Fig. 1204—The last shunt capacitor developed a 100,000-ohm leakage, causing vertical instability.

I replaced the  $.005\text{-}\mu\text{F}$  capacitor and the picture locked in. In fact, I was surprised that it locked in so solidly. Since that case, I replace that particular capacitor every time I run into one, and I'm usually rewarded with a lock-in bonus.

## Chapter 13

# Vertical-Oscillator Sync Troubles

**THE** input to the vertical oscillator is the end of the line for the vertical sync pulse. It enters here and is seen no more.

The vertical oscillator runs free and independent around 60 Hz. The sync pulse removes this freedom and triggers the oscillator so that it runs in step with the studio camera. That way, the picture holds.

Vertical oscillators come in two general forms, the blocking oscillator and the multivibrator. There are many variations of these two types. Our concern in this book is with the sync troubles that occur due to defects in the oscillator. Therefore we won't concern ourselves with what happens when the oscillator stops running, or doesn't produce enough and causes vertical sweep problems. We will confine our discussion to what happens when the oscillator runs off-frequency and the picture loses sync.

### **Blocking oscillator troubles**

As the sync pulse leaves the integrator for a blocking oscillator, it must have a sharp leading edge and be positive-going. The sharp leading edge is applied just before the grid cuts off, and this makes for precise firing of the oscillator. The positive-going pulse makes the tube conduct and polarity inversion through the tube makes the signal negative. This is the way the polarity must be for the sawtooth-forming capacitor in the plate circuit to discharge.

The sync pulse comes in through a blocking capacitor of about  $.01\mu\text{F}$  and passes over a couple of megohm-size resistors in series to ground. One of the resistors is a potentiometer labeled vertical hold control. The two resistors in combination with the blocking capacitor are grid leaks, and the values of the three components decide the dc level of the oscillator's control grid. Since the dc level determines the frequency at which the oscillator runs, these three components are frequency-controlling components. Any deviation from their designed values can throw the oscillator frequency off. The center point of the vertical hold potentiometer is designed to make the oscillator run at 60 Hz (Fig. 1301).

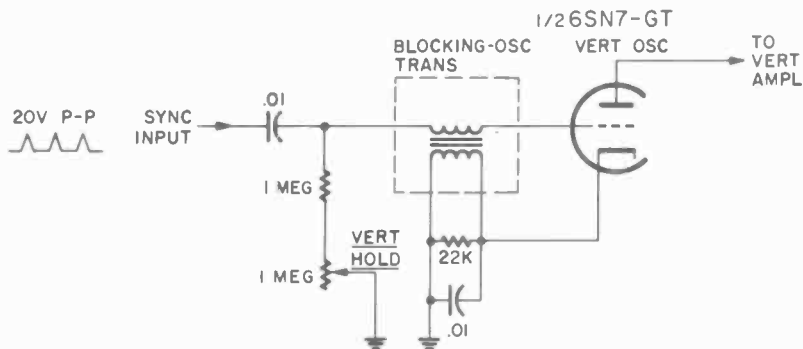


Fig. 1301—These are the frequency-controlling components in a cathode-coupled blocking oscillator.

Leakage of the blocking capacitor shifts the dc level of the control grid and throws the frequency off in proportion to the amount of leakage. Loss of capacitance in the blocker reduces the height of the sync pulse and can cause vertical instability in addition to the oscillator frequency change.

A change in ohmage of the two series resistors, either shorting down or increasing, changes the frequency. A slight change will move the center point of the hold potentiometer, while a large change will make the control lose its hold point altogether. When a loss of frequency occurs, these three frequency-controlling components are prime suspects. As we travel in to the blocking oscillator, we come to a vertical blocking-oscillator transformer. The primary of the transformer is in the plate circuit in plate-coupled blocking oscillators or in the cathode circuit in cathode-coupled blocking oscillators.

The transformer primary couples a portion of the plate- or cathode-

developed signal back to the grid circuit. This sustains oscillation. Essentially, the circuit operates as a sine-wave oscillator. When you first turn on the TV, the tube (a triode, such as a 6SN7) begins to conduct. The grid-leak controlling components build up a negative bias in the control grid in their designed time. As the negative voltage builds, it cuts off the tube. Then the grid voltage begins leaking off down the resistors to ground. The bias decreases, the voltage comes back across the cutoff point and the tube conducts once more. Some of the signal in the output is coupled back to the grid via the transformer. This recharges the capacitor. The bias increases, passes over the cutoff point and the tube cuts off again. After cutoff, some of the bias voltage again leaks off through the resistor and the tube comes back on. The conduction couples more signal back and the tube cuts off again. Over and over, at 60 Hz, the oscillator action continues in sine-wave fashion.

It can be seen that anything affecting the transformer feedback can upset the precise running of the oscillator. Should the transformer develop shorted windings, the oscillator frequency will be thrown off. The transformer is notorious for developing intermittently shorted windings, giving intermittent loss of vertical sync or shifting of the hold range. (If the transformer opens or shorts out completely, no vertical sweep is a possible result as the oscillator quits running.)

Defects in the plate and cathode circuit components usually cause, not sync troubles, but deflection problems. The only exception to this would be any resistors or capacitors in direct shunt with the primary of the transformer. Should they short out completely, they kill the vertical sweep, but leakage or resistance change could cause a shift in oscillator frequency.

A good example of sync trouble in the circuit occurs regularly in RCA chassis like the KCS 47's. I had one on the bench recently. The complaint: intermittent vertical sync trouble. I hooked the chassis up with all the appropriate hookup wires and the test CRT, then turned on the TV. The picture came in and locked flawlessly.

I checked the vertical hold control. It was locking solidly and had a center point not quite in the center. This could be normal, so I went to another job and let the chassis cook. About 15 minutes later, I glanced over and saw the picture rolling. I readjusted the hold control. It locked in fine, but the center point had shifted somewhat. I let it play some more as I worked on the other job.

About 10 minutes later, it began rolling again. I successfully reset it once more. I completed the other chassis, put it on checkout and turned

my attention to the intermittent. I checked all peak-to-peak and dc levels in the oscillator. Everything checked out, on the nose. As I put the meter lead down, the picture began rolling again. This threw all the dc levels off, but readjustment of the hold control reset them.

I looked over the schematic. Since the actual center point of the hold control was shifting, and the lock-in power remained nevertheless, the vertical sync pulse was probably okay. The vertical oscillator itself was shifting its frequency slightly. Not by much, or the sync pulse wouldn't have continued to provide lock-in.

This indicated that the oscillator frequency-controlling components were causing the problem. There were a .01- $\mu\text{F}$  coupler, an 820K resistor in series with the 1-meg vertical hold to ground and a plate-coupled blocking oscillator transformer.

I looked at the resistors. Both looked good and read perfect. I left them in the circuit. I detached one end of the .01 and gave it a test on my capacitance tester. It read .01- $\mu\text{F}$ , and showed no undue leakage.

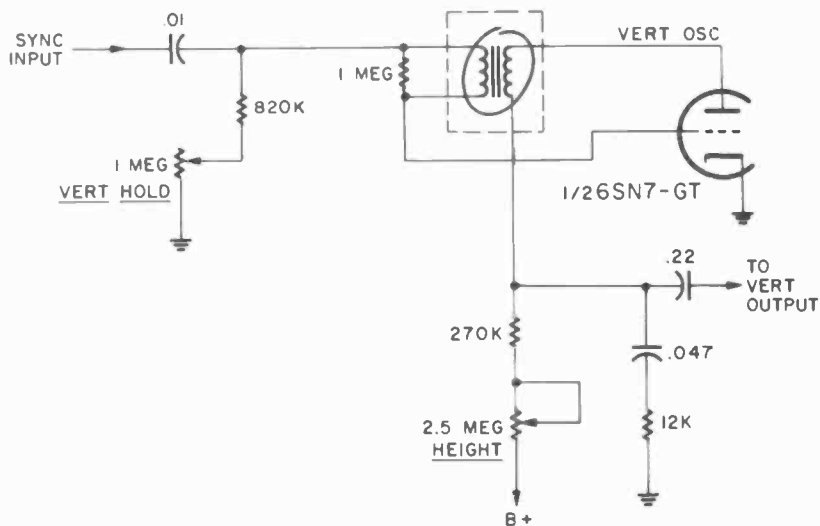


Fig. 1302—A shorted winding in the vertical blocking-oscillator transformer caused intermittent shifts of vertical frequency.

That left the vertical blocking-oscillator transformer. I rapped it smartly with my marking crayon. The picture began to roll immediately. I rapped it again. The rolling stopped. I could make it stop and go at will. Evidently the insulation on the transformer's windings had deteriorated and was causing intermittent shorting. I replaced the transformer

and the trouble ceased. The vertical hold also now locked in dead center (Fig. 1302).

## Multivibrators

The purpose of a vertical multivibrator is to produce a 60-Hz signal. Multivibrators come in two general forms—cathode-coupled and plate-feedback. You'll find many variations of each type. They come separate from vertical output stages and combined with vertical output stages. A working knowledge of general feedback methods enables you to see at a glance the type you're dealing with and enables you to puzzle out the various circuit innovations. I'm not going to dwell on vertical sweep problems these circuits can cause, but on vertical frequency troubles; it is frequency troubles that can make the picture fall out of sync.

The incoming sync signal to a multivibrator, unlike that to a vertical blocking-oscillator circuit, is designed to leave the integrator negative-going. The idea is to drive the multivibrator into cutoff at first rather than to conduction as in the vertical-blocking oscillator.

Then the output from the first half of the multivibrator, which is positive-going since it is inverted  $180^\circ$ , drives the second half into conduction. The output of the second half is thus negative-going. This output does two things: It feeds back an in-phase negative signal to the grid of the first half. It also feeds a negative signal to the sawtooth-forming capacitor, permitting it to discharge and form the sawtooth.

The frequency-controlling components in a multivibrator are similar to the ones in the vertical-blocking oscillator. They are the vertical hold control, the resistor in series with it and any capacitor in series or shunt that forms an R-C network with the hold resistors. Also, any resistors or capacitors in the feedback line can cause frequency problems. Other components, while remote possible suspects as causes of vertical rolling, usually cause sweep troubles rather than frequency ones.

The frequency of the multivibrator is determined by the length of time the developed bias takes to leak off the R-C network. The center setting of the hold control is the exact resistance necessary to make the oscillator run at 60 Hz as long as the other frequency-controlling members are not defective.

This R-C network will be found in the control-grid circuit of the second half of a plate-coupled multivibrator. In the cathode-coupled multivibrator, the R-C components are in the cathode leg. Just look to see where the vertical hold control is.

If the coupling capacitor, which is usually around a 4,700-pF, should leak, and if sweep is not affected, the oscillator will drift from 60 Hz according to the amount of leakage. Loss of capacitance here will change the R-C time constant and throw the frequency off. Change of resistance in either the hold control or series resistor will shift the hold center point according to the amount of change. A great change throws the center point off the hold range altogether.

Other frequency-controlling suspects in the various circuits include any components that could cause the dc level of the grid or cathode leg to shift. Feedback capacitors, series resistors and coupling capacitors that lead onto the grid or cathode circuit are to be suspected. Plate components, while remote suspects, usually are not frequency problem culprits, since their failure distorts the vertical spike, which affects sweep rather than frequency. The classic example of trouble in this R-C network and associated frequency-controlling components follows. The TV comes on fine. The vertical hold control is set dead center. After a bit, the picture begins to roll. Natural response is adjustment of the control, which you do. The picture relocks, but at a different hold setting.

A few minutes later the picture rolls again. Resetting the control stops the flopover. However, the lock-in point is now near the end of the hold range.

A few minutes later the picture again rolls. This time, adjustment of the control is futile. The point of adjustment is now off the range.

This is a familiar trouble to me. One such TV was one of those build-it-yourself kit types. The vertical oscillator was a cathode-coupled multivibrator. The vertical hold control was a 2.5-meg potentiometer that rose out of ground. In series with it was a 470K, ½-watt resistor. The two components were between the plate of one side and the control grid of the other side. The tube was a 6SN7 dual triode.

The plate of the one half was supposed to carry 100 volts. The control grid of the other half was to have -20 volts at its dc level. A 4,700-pF coupling capacitor kept the two dc levels apart.

I hung my vtvm probe on the plate and watched the meter needle. After about 3 minutes, the 100 volts faltered, then skidded to 97. I then touched the probe to the control grid. The -20 volts dropped to -10 in the same length of time.

The 4,700-pF was a prime suspect if it would leak under pressure. I disconnected the grid end, attached the probe to that open end and turned on the TV. At first, the needle stayed on zero. Then it began to creep a bit. In about 5 minutes, I had 10 volts dc reading on the meter. I replaced the capacitor and the trouble disappeared.

The dc levels in the multivibrator were being shifted, and this automatically changed its frequency. Readjusting the hold control compensated for the leakage until the leakage increased to a point where the range of the potentiometer would no longer compensate. A new, non-leaking capacitor stopped the unwanted changes (Fig. 1303).

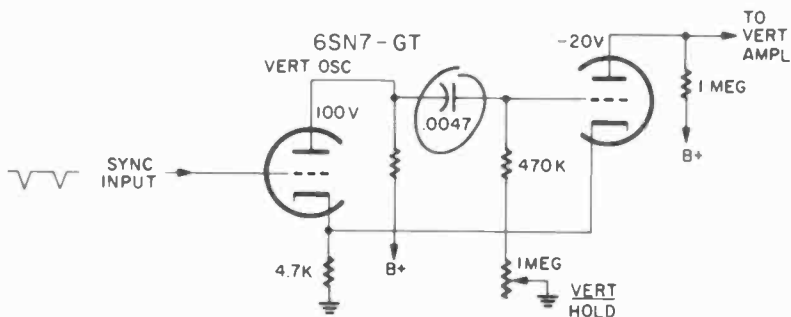


Fig. 1303—A 4,700-pF (.0047- $\mu$ F) coupling capacitor developed leakage in a cathode-coupled multivibrator.

## Multivibrator—output combinations

A popular variation of the multivibrator is a combination multivibrator and vertical output stage. The schematic usually is confusing because the output stage is thought of as being after the multivibrator, and is shown that way. Yet the first stage of the multivibrator is in the vertical output stage too. Thus the multivibrator's second half is shown before the first. This is less confusing than putting the output stage first, but it is nevertheless confusing.

The integrator output is inserted over the top of the second multivibrator stage's plate, through a .05- $\mu$ F capacitor with a high working voltage into the control grid of the first multivibrator stage, which is also the vertical output tube. A large resistor to ground works with the coupler, grid-leak style, to produce a bias of between -10 and -20 volts on the vertical-multivibrator-vertical-output tubes. The output tube is usually a beam-power type.

The plate output of this stage is fed through a blocking capacitor of about a .005- $\mu$ F with high working voltage back to the grid of the second multivibrator stage. The feedback is in phase with the action of the second half of the multivibrator and maintains its action. A tap-off in the feedback line of some resistors and capacitors in series is also fed into the first multivibrator output grid. This is out of phase with the incoming signal, which is negative-going, and is used to improve vertical



linearity. This integrator-type line shapes the feedback specially for this purpose (Fig. 1304).

Failure of any of the aforementioned components will affect vertical frequency. The blocking capacitor that attaches to the plate of the first multivibrator tube and the control grid of the second can leak. When it does, the frequency will shift. If the leakage is bad, vertical sweep will be affected too.

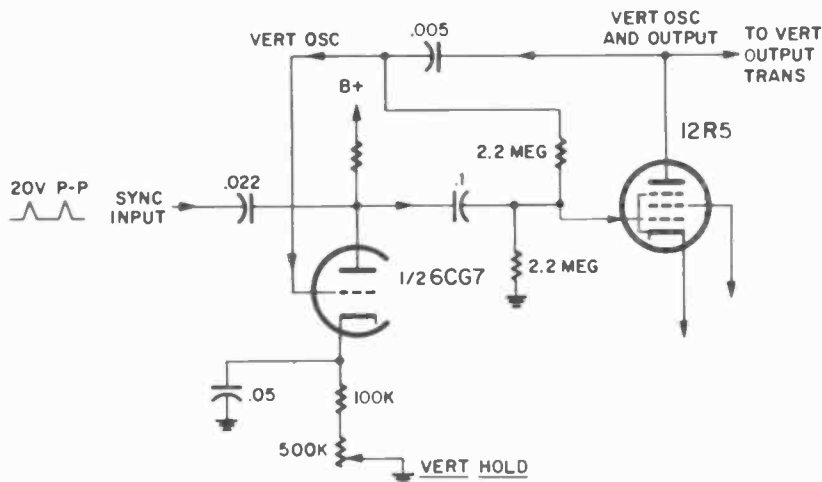


Fig. 1304—The frequency-controlling components in a combination multivibrator-vertical-output stage. Failure of any of these components could cause frequency troubles.

The resistor to ground in this same line does the same thing, should it change. Coming out of the plate of the beam power tube, the  $.005\mu\text{F}$  blocker can leak. When it does, the vertical hold range will shift as the feedback is attenuated, causing the grid dc level to change slightly. If the capacitor shorts out completely, it can kill sweep if it's connected directly to the control grid, or it may simply shift hold range if there is another blocking capacitor in series. Sometimes this second capacitor is there with resistors in series or in parallel.

These extra components are there doing a job like the integrator; that is, shaping the vertical spike. Leakage of this capacitor causes troubles similar to those caused by the other  $.005\mu\text{F}$  unit. In fact, it is not unusual to find both of these blockers in series leaking or shorted. When they both are shorted, vertical sweep trouble occurs. The resistor causes the same type of troubles as its ohmage changes.

A typical case of this trouble occurred in a Motorola portable TS423.

The complaint was intermittent loss of vertical sync. I tried the hold control. It was on the very end. On strong signals, the picture would roll. On weak signals, it just about held with some flopover. The trouble seemed to be in the vertical oscillator.

The vertical oscillator was a plate-coupled multivibrator consisting of a 12R5 as the first half and one part of a 6CG7 as the second. The sync pulse was coupled in over the top of the plate of the 6CG7 section through a .01- $\mu$ F capacitor into the grid of the 12R5 beam power output tube, which was also doing vertical output duty. (See Fig. 1305.)

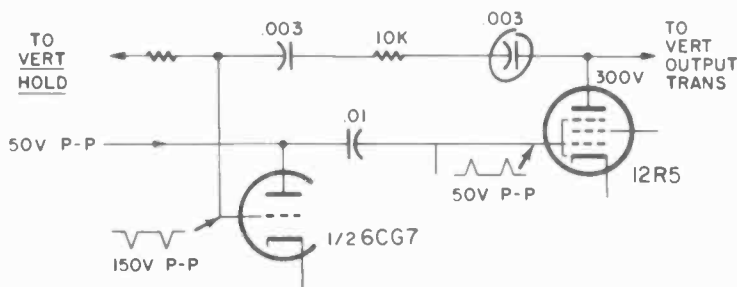


Fig. 1305—The shorted .003- $\mu$ F capacitor upset the p-p feedback, causing vertical instability.

Out of the plate of the 12R5 were two legs. One went to the vertical output transformer and the other coupled back to the control grid of the 6CG7. This was the feedback that sustained the oscillation.

I took a vtvm and read the peak-to-peak input at the grid of the 12R5. It was about 50 volts, as it should be. I didn't read it at the plate for fear of hurting the meter with the high vertical output pulses.

I did read it at the grid of the 6CG7. It read about 70 volts p-p. That was wrong; it should have been about 150. Apparently there was loss of p-p voltage in the feedback line. There was a .003- $\mu$ F capacitor in series with a 10K resistor and another .003- $\mu$ F capacitor.

I switched to dc and read the test point between the series components. There was 300 volts dc. There was supposed to be about zero.

The B+ could be coming from only one place, the plate of the 12R5. I checked the blocking capacitor between the plate and the test point. It read 3 ohms. Dead short. I replaced it. The vertical sync returned and the hold's center point returned to the center of the range.

I replaced the other .003 on general principles, since it had been under the strain of the 300-volt dc. It might or might not have sprung a leak, but I wasn't taking chances.

## Chapter 14

# Triode AFC Circuit Troubles

YOU don't trigger the horizontal oscillator as you do the vertical oscillator. The horizontal runs at 15,750 Hz, while the vertical chugs along at 60. Noise bursts are easily removed in the vertical integrator because their frequency is so much higher than 60 Hz. Noise bursts are not so easily removed in horizontal circuitry because their frequency is near 15,750 Hz.

Yet the horizontal sync pulse must somehow have an effect on the horizontal oscillator to keep it in sync without any interference from noise. Noise can also trigger the oscillator, causing all kinds of picture distortion.

How can the noise problem be overcome? By not feeding the sync pulse to the horizontal oscillator directly. Instead, the pulse is fed to an intermediary circuit, a frequency-comparer circuit known as afc (automatic frequency control). As the sync is fed to it, some feedback from the oscillator output is also fed through another input (Fig. 1401).

The two waveforms pass through the circuit together. The output of the afc is a small dc voltage. As long as the oscillator remains in frequency with the sync, the afc output remains constant. Should the frequency start to change, the two voltage waveforms won't compare and the afc correction voltage will change. The correction voltage is designed to change the frequency so that the oscillator is brought back to 15,750 Hz once more.

The waveform comparison takes place only during the instant the sync pulse compares itself with the feedback pulse from the oscillator. If some noise burst should ride into the afc input between sync pulses,

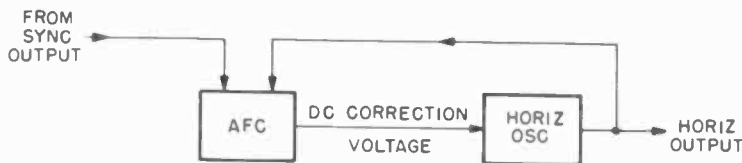


Fig. 1401—Block diagram showing afc satge. The afc compares the sync to the feedback to produce a dc correction voltage.

the noise will find no other waveform with which to compare itself: no comparison, no effect on the dc correction voltage. This is how noise bursts are keyed out of the picture.

### Triode afc circuits

The afc triode is usually a medium- $\mu$  type, such as a 6U8 or 6SN7 (Fig. 1402). Into the plate comes a pulse from the oscillator output. A favorite spot is from a tap or special winding in the flyback transformer. The pulse as it leaves the transformer usually has a very high peak-to-peak value, and a couple of 1-watt resistors in the 100K range are placed in series to reduce it. Then, also in series, a .005- $\mu$ F blocking capacitor is placed to keep the high dc level of the flyback circuit from getting into the afc region. The blocker carries a high working voltage.

These high voltages and the high working voltages of the components are necessary to handle the high pulse voltages and high dc from the flyback. You'll also find some resistors and capacitors going to ground from this feedback line. Their purpose is to take the spike-shaped pulse from the flyback and give it a sawtooth shape.

Since there is no B-plus on the plate, the electron stream is not attracted there. However, as the sawtooth-forming capacitor charges, the plate may draw a tiny current and develop a tiny bias—less than 1 volt. Anyway, the net result of this input is a sawtooth waveform of about 15 or 20 volts p-p on the plate with a 15,750-Hz frequency.

Meanwhile, the horizontal sync pulse is applied to the cathode or grid or both. The cathode receives a pulse of about 15 volts p-p from the sync output. It is usually applied to the cathode through a coupling capacitor of 1,000 pF or less. The pulse then meets an R-C network that gives it a good sawtooth shape. The R-C is usually a 1,000-pF capacitor and a 100K resistor in parallel from cathode to ground.

This loading of the cathode leg dissipates quite a bit of the peak-to-peak voltage. If you take a reading on the sync side of the coupling capacitor, you'll find 15 volts p-p. As you cross the capacitor, the voltage can drop in half. Be careful of this, because it might seem that the capacitor is bad. It's not; the loading of the cathode circuit is dropping the voltage.

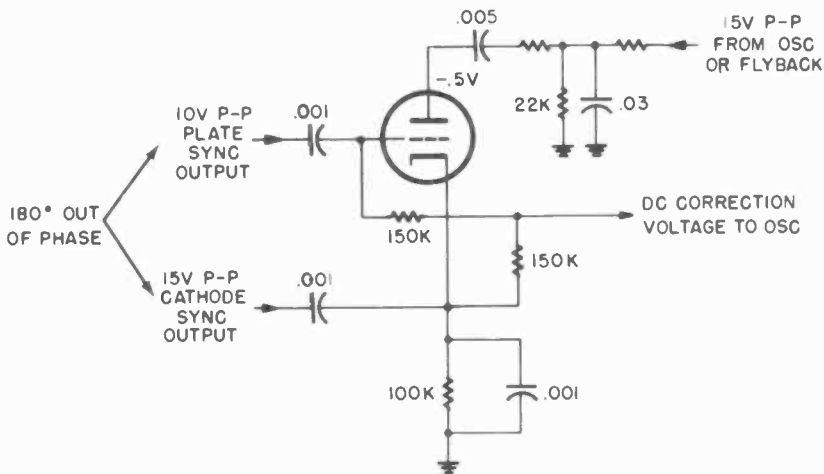


Fig. 1402—A typical afc stage. Three inputs produce a single dc output.

Into the grid, through another capacitor of about the same size, can come another sync pulse. This pulse, however, is  $180^\circ$  out of phase with the cathode input. The peak-to-peak voltage on the sync side will be around 10 to 12 volts. The loading of the grid circuit can drop the effective voltage. Don't be misled by an appreciable peak-to-peak drop across the capacitor; again, loading is causing the change.

Anyway, as you can see, there is a plate waveform, a cathode waveform and possibly a grid waveform, too. The cathode and grid are at 15,750 Hz for sure. The plate is around 15,750. The plate must be compared with the cathode. How is this done?

A couple of matched resistors around 150K each are tied between cathode and grid. The sync pulse coming into the cathode develops across the cathode resistors to ground, giving the cathode a bias of about +5 volts. This is the bottom of the matched pair.

The control grid draws a little current and forms a slight negative bias. That means across the two matched resistors in series is a voltage from about -2 to +5. A tap is made between the two resistors, and a

dc voltage is taken off. This voltage is sent to the oscillator and is designed to make the oscillator run at exactly 15,750 Hz.

As long as the feedback waveform peak occurs at precisely the same time as the sync peak in the cathode, the tiny bit of emission in the tube exhibits no change. If the oscillator runs fast or slow, the feedback peak will shift, the space emission will change, the cathode bias and grid bias will change, the dc correction voltage will change and the oscillator will be brought back into step with the sync.

As the pulse leaves the flyback, it first encounters some 1-watt resistors. If these short, more peak-to-peak voltage will get through to the plate. Unless they short down to zero, little happens to the horizontal sync. The negative voltage on the plate tends to increase and might shift the horizontal hold control range.

If the resistors increase in value, the peak-to-peak value will drop and can become ineffective. You'll lose horizontal phase and the picture will shift sideways, since there is no plate waveform to compare the cathode's waveform with.

If the coupling capacitor should leak, some of the flyback dc will get into the afc plate. This can make the horizontal hold very unstable, and the hold control will lock way off its normal lock-in point. If the capacitor opens, you'll lose horizontal phase because the flyback signal can't get through. Any resistors in shunt with the flyback feedback line are there to help make the spike a sawtooth. If they short, the sawtooth won't form properly. Also, a lot of the voltage is going to be shunted to ground. Depending on the degree of short, some of the amplitude will be lost. As a result, the picture flops sideways.

If the resistor increases in value, the sawtooth has more resistance to develop across and its voltage will increase. This makes the plate draw more grid-leak-type current and increases the negative bias, which reduces the amount of space current drawn as the pulse reaches its positive peak. This upsets the grid-cathode bias setup and changes the dc correction voltage. The picture becomes unstable and the horizontal hold control isn't as effective. Usually, the resistor gradually increases in value while the TV is on and gradually shifts the hold point, making constant readjustment of the control necessary.

Any capacitors in shunt with these resistors are also part of the sawtooth-forming network. When one of these capacitors begins to leak, not too much happens to the picture; the amplitude of the sawtooth decreases somewhat. As the capacitor shorts down further, more and more of the amplitude goes down the drain, and the picture begins flopping sideways with less and less control from the hold pot.

If a capacitor opens, the sawtooth is no longer formed and the full spike of about 200 volts p-p gets to the plate. The horizontal seems to hold, but goes into a Christmas-tree effect very easily.

The coupling capacitor that comes from the sync to the cathode can leak. When it does, the cathode voltage rises and some of the sync-output dc leaks through. The horizontal frequency will go off either slightly or widely, according to the amount of leakage. If this capacitor opens, you'll lose horizontal lock-in. The hold control will still control the frequency, but the picture won't lock in.

When something happens to the R-C network in the cathode, the cathode bias changes. If the network increases impedance or resistance, the bias increases. If the network decreases in resistance, the bias decreases. Either way, the control of the oscillator is lost and the picture either goes off into lines or flops over sideways.

When a sync pulse is fed to the grid  $180^\circ$  out of phase with the cathode pulse, it is sent in through a coupling capacitor. If the capacitor leaks, some of the dc from the sync circuit will bleed through to the grid. This puts a positive voltage there, upsetting the sensitive dc correction voltage. The oscillator will run way off frequency. If this coupling capacitor opens, there will be no symptoms on the screen. The horizontal frequency performs as before. Why install this capacitor in the first place? Theoretically, it stabilizes the afc circuit.

Now, about the two matched resistors that are center-tapped for the correction voltage. If they short, either individually or together, the range of the lock-in point in the horizontal hold is restricted. However, the hold works fine. You'll never be called upon to locate this trouble because the set owner won't notice it. If you are working around these circuits for some reason, give them a fast resistance check to be sure they are okay.

If these matched resistors increase in resistance, troubles occur. The top one causes horizontal instability as its resistance passes 500K. The bottom one, as it passes 500K, increases the cathode voltage and changes the correction voltage to a more positive value. This throws the oscillator way off frequency.

A typical example of trouble in this circuit occurred on a G-E 21C110 (Fig. 1403). The picture was way out of horizontal sync. Adjustment of the horizontal hold control was changing the number of lines, but did not bring the picture anywhere near back into sync.

The first step I tried after replacing tubes was to isolate the troublesome circuit. The afc triode was part of a 6U8; the pentode half of the tube was audio; the TV was parallel-wired. I pulled the 6U8 out of its

socket and turned on the TV. The lines reappeared on the screen.

I adjusted the horizontal hold control. Now I got a picture, but it wouldn't hold horizontally—just flopped sideways.

This meant the oscillator itself was okay. The dc correction voltage was throwing the oscillator off-frequency. I replaced the 6U8 with a new one, then I set my vtvm on its peak-to-peak scale and began to read. All the peak-to-peak values were correct. I switched to dc and began reading. The plate was zero, as it should be. The cathode was  $-8$  instead of  $+8$ ; the grid was  $-8$  instead of  $+0.4$ .

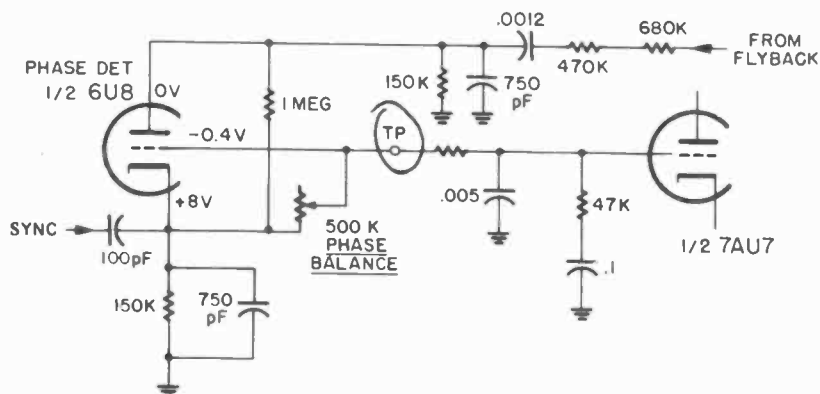


Fig. 1403—A test point had a 400,000-ohm short to ground, causing the horizontal sync loss.

Instead of matched resistors, a phase balance control of 500K was tied between cathode and grid. I checked it. It was okay. I checked the cathode input capacitor and the R-C network in the cathode—all okay.

Then I wondered what could cause the negative voltage in the cathode and grid. The peak-to-peak values were okay. Possibly the peak-to-peak voltage had some place to develop across in the grid circuit, causing a lot of grid current to flow.

I took a resistance reading from grid to ground. Sure enough, there was 400K to ground, where there should have been infinite resistance. I double-checked all the components by direct replacement, to no avail.

I looked at the chassis. Then I noticed this G-E had test points tied in the grid line. I disconnected the components from the test point and then read the test point. It read 400,000 ohms to ground.

I turned on the TV. The picture came on and looked fine. I left the test point disconnected and taped the components in mid-air into a neat spider joint. That was the repair.



## Chapter 15

# Diode AFC Circuit Troubles

IN our shop you are likely to hear a technician call for a “cockeyed” or perhaps a “looking-to-the-side” diode. All this means is that he wants a dual selenium diode. The “cockeyed” is a description of the type 1615 that has the arrows pointing at each other. The “looking-to-the-side” is the type 1616 that has the arrows in series (Fig. 1501).

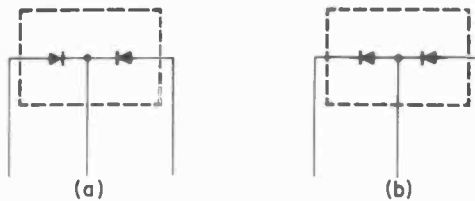


Fig. 1501—Afc diode types: (a) “cockeyed” diodes; (b) “looking-to-the-side” diodes.

These diodes are found in an increasingly popular type of afc circuit. The circuitry is very much, if not exactly, the same as that using a dual diode tube, such as the 6AL5.

In this circuit, the diodes are designed to conduct equally. As long as they do, there is a steady dc correction voltage that runs the oscillator at 15,750 Hz.

There are two inputs into the afc. One is a feedback voltage, saw-

tooth in nature, that comes from the oscillator output. Second, there is the horizontal sync input. As long as the two inputs are of the same frequency, and in phase, the dc correction voltage remains constant. If the oscillator speeds up or slows down, the sawtooth feedback won't match the sync input. This makes the diodes conduct unequally, which changes the correction voltage. The correction changes the oscillator frequency till it's back in step with the sync.

As in the triode, the feedback can be taken from the plate circuit of the oscillator anywhere in the horizontal output circuit, or from a winding in the flyback transformer.

Also, as in the triode, the horizontal sync pulse can be taken from either the plate or cathode of the sync output or from both. If taken from one, there is one sync input. If taken from both, there are two sync inputs  $180^\circ$  out of phase with each other.

Let's look at a few variations of this theme. A typical cockeyed-diode circuit (Fig. 1502) has a sync input of about 10 volts p-p entering the center tap at the two cathodes through a 100-pF capacitor. The spiked input from the horizontal output is passed through resistors in series and capacitors in shunt that drop the couple of hundred peak-to-peak volts down to about 10 and change the spike to a nice sawtooth. Then

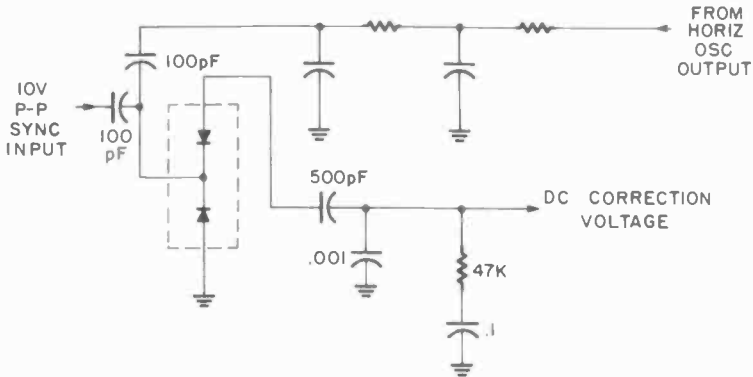


Fig. 1502—A typical cockeyed-diode afc circuit.

the sawtooth is coupled into the same cathode point through a 100-pF capacitor. A negative potential is developed at the cathodes, and the diodes conduct equally. Out of the higher of the rectifiers (nonground) comes the correction voltage. As long as the diodes conduct equally, the correction voltage simply runs the oscillator at 15,750 Hz. The diodes conduct equally as long as the sawtooth passes through zero volts at the same time the sync pulse hits its peak (Fig. 1503). Should

the oscillator shift in frequency, the diodes will conduct unequally. A correction pulse will develop and be fed to the oscillator, setting it back on course.

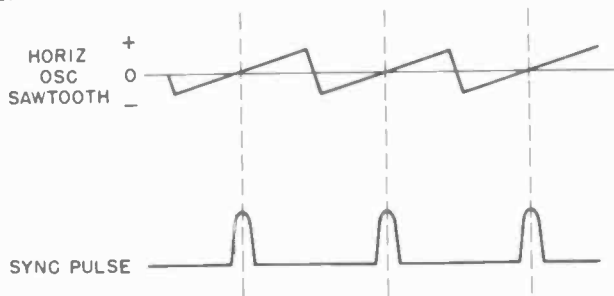


Fig. 1503—The diodes conduct equally as long as the sawtooth passes through zero as the sync pulse hits its peak.

Notice I said *correction pulse*, not correction dc. The pulse must be passed through a low-pass filter like an integrator. In the filter, the pulse is turned into the dc correction voltage. A typical filter consists of a coupling capacitor of about 500 pF in series, a 10,000-pF capacitor in shunt to ground and a 47K resistor and a 0.1- $\mu$ F capacitor in series to ground.

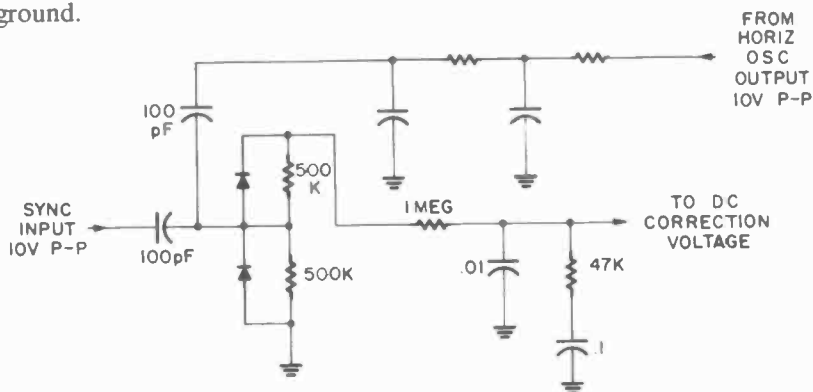


Fig. 1504—A typical looking-to-the-side diode afc circuit.

A typical “looking-to-the-side” afc circuit (Fig. 1504) has its sync input of about 10 volts p-p coming in through a 100-pF capacitor to the center point between the two diodes. The sawtooth feedback from the horizontal output, also about 10 volts p-p, comes in via a feedback line through another 100-pF capacitor to the same point. The two wave-

forms add together, and the combined peak-to-peak value makes the diodes conduct equally. Two matched resistors of around 500K are placed directly in parallel with the two diodes. This permits the ac waveform to flow in both directions, since the diode, by its very nature, permits current flow only in one direction. The back-and-forth action makes the input capacitors charge and leak, putting a slight negative bias (less than 1 volt) at the high end of the diodes. The bias is coupled into the oscillator grid via a megohm-sized resistor. A low-pass filter is also installed to turn any correction pulse to plain dc.

As long as the two input waveforms add up perfectly to the prescribed peak-to-peak value of around 20 volts, the diodes conduct equally. If the oscillator falls out of step, the peak-to-peak voltage will decrease and the diodes conduct unequally. This produces the dc correction voltage that, in turn, sets the oscillator back in step.

A third variation of the dual-diode afc circuit is basically this: Take the ground end of the diodes off ground, then couple the cathode sync output to one end of the diode and the plate sync output to its other end. Send the horizontal feedback into the center tap (Fig. 1505).

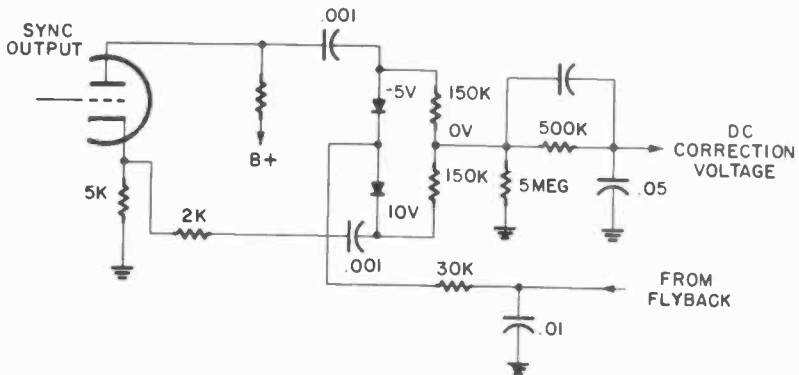


Fig. 1505—Variation of the looking-to-the-side circuit with two sync inputs  $180^\circ$  out of phase.

The rest of the components are about the same as the “looking to the side” circuit of the preceding figure. The charging and leaking of the input capacitors and shunt resistors put a negative bias on one end of the diodes, a positive bias on their other end and a near-zero voltage in the center. A tap off the center of the shunt resistors sent over a low-pass filter into the oscillator carries the correction voltages.

What happens when the components fail? Let’s start with the feedback line. Series resistors increasing in value cut off the feedback wave-

form to the diodes. This prevents the diodes from conducting. There is no constant voltage. The oscillator runs free with sideways flopping. If the resistor shorts, the feedback increases somewhat, but not too much change occurs in lock-in power. The lock-in range will be narrowed somewhat though.

A shorted capacitor to ground in the feedback line won't cause any trouble unless the short gets pretty bad. If it should go below 1000 ohms, it will drain off the feedback and diode conduction will decrease, although the conduction remains equal in both diodes. Loss of horizontal hold ability then occurs in proportion to the short.

Leaky capacitors in series in the feedback line will let some positive dc get through. This gets onto the oscillator grid and throws the oscillator frequency off, depending on the degree of leakage. If these capacitors open, conduction will stop because the feedback input will stop. The oscillator becomes free-wheeling without sync lock-in and the picture flops sideways.

In the sync input line or lines, the symptoms are the same, for one or both. A coupling capacitor from the sync output comes either from the cathode or plate circuit. If one leaks, it will let some positive dc through, according to the degree of leakage. This changes the bias developed by the diodes' conduction and throws the oscillator off in relation to the amount of dc that bleeds through. If one of these coupling capacitors opens, there may or may not be a reaction.

If there is only one sync input and the coupling capacitor opens, diode conduction effectively ceases, since there's no sync input, and the oscillator free-wheels. If there are two sync inputs and one of them opens, the remaining input could be enough to fire the diodes, and some semblance of horizontal sync may, or may not, remain in the picture. Anyway, these are good hot suspects when the oscillator is free-wheeling.

Now about the two shunt resistors. An ohmmeter test of them should always be made when working in or around this circuit. These two resistors should match as closely as possible to their designed value. When replacing them, pick two replacements that are closely matched.

If the shunt resistors have increased or decreased in value, they will upset the amount of conduction of the diodes in the afc circuit. Since the balance is only over a narrow range, the net result of their defect, in either direction is loss of horizontal sync. The degree of loss depends on how far from their designated value the resistors have gone.

The next components in line are the diodes themselves. They are the prime suspects. They may short, open, increase in forward resistance

and lose conduction ability. The symptoms vary from slight jitter, to slight loss of horizontal sync, to complete loss of horizontal sync, to the picture locking with the horizontal blanking bar in the center of the picture, to a Christmas-tree effect, to complete loss of raster.

If you have horizontal symptoms at all, you can quite often isolate the trouble to the afc circuit (or someplace else) by removing the dual diode.

Since there are no heaters, it doesn't matter if the TV is series-wired or not. For most troubles in the afc circuit, remove the diode, and all symptoms other than no horizontal sync should disappear. The oscillator will be free-wheeling. This is not a proof-positive test. For instance, if a coupling capacitor that is blocking dc from the oscillator grid shorts, removing the diode won't help; but in many cases, it's a good test.

To test the diode, direct replacement is the best bet. If you do not have a substitute diode, a test of forward and then back resistance is good. Forward resistance is good under 10K. Back resistance is good over 100K. Any deviation from these values justifies replacement.

I'll go into the low-pass filter oscillator input in the chapter on horizontal oscillators.

A typical afc problem occurred in a Westinghouse H853K chassis. This TV uses a dual diode, but it doesn't use a silicon rectifier; it uses a 6AL5. The cathodes are tied together. The sync input arrives via an 82-pF capacitor from the sync separator output with a peak-to-peak voltage of about 25. The feedback comes from the second plate of the oscillator through a feedback line consisting of a 27K resistor and a 390-pF capacitor in series into one plate of the diode. The other plate goes to ground. (See Fig. 1506.) As you can see, this is exactly the

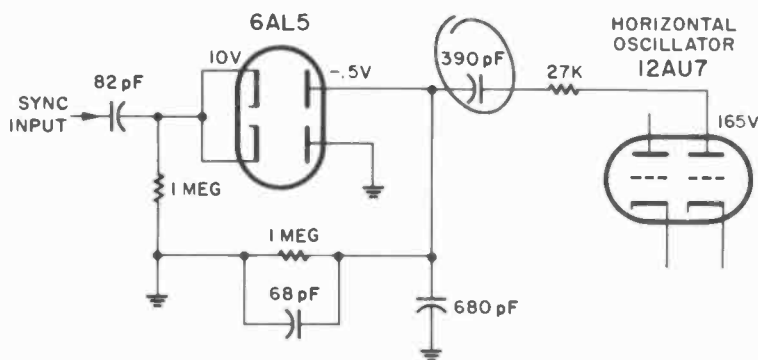


Fig. 1506—An open 390-pF capacitor in the feedback line was ruining the horizontal sync action.

same circuit as the cockeyed diode.

To digress for a moment, if a 6AL5 is used and the cathodes are in series rather than tied together, two matching shunt resistors will be in the circuit, exactly like the diode that looks to one side.

Back to this case—there was no horizontal sync. The picture just flopped sideways. I pulled the 6AL5. The picture did exactly the same thing. This seemed to indicate that all afc action was kaput.

I grabbed my vtvm, turned it to dc voltage and began my examination. The plate of the sync separator, a 6CS6, was 35 volts (as it should be). This was the sync side of the 82-pF coupler. I crossed over the coupler. At the cathode tie point, there was 10 volts dc. That meant the charging and leaking of the 82-pF capacitor and the 1-meg resistor to ground were doing nicely with the 15,750-Hz, 25-volts p-p sync input.

I read pin 7, the ungrounded plate. It read zero volts rather than  $-0.3$ . This wasn't a large discrepancy, so I checked the schematic and decided to read the feedback plate of the 12AU7 oscillator. It read 165, as it should. I actually didn't have a good clue yet. I switched to peak-to-peak readings, which I should have started with anyway.

On that same plate, pin 6, I took a reading. Instead of 110 volts p-p, there was only about 30. Uh-oh! I looked at the screen. False lead. There was a dark scene on the screen—I waited for a bright picture. The peak-to-peak rose to 110.

I crossed over the 27K series resistor in the feedback line. The 110 volts dropped to about 100, which was normal. I crossed over the 390-pF capacitor. Oops—the peak-to-peak dropped to 3 volts! It was supposed to come down to 25 not 3.

I turned off the TV. There were two possibilities. Either the 390-pF capacitor was open and not permitting passage of the signal, or there was a short in the plate leg to ground that was draining it off.

I took a resistance reading from pin 7 to ground. It read 2 megs, as it should. That left the capacitor. I replaced it without further fanfare.

I turned on the TV. The picture came on perfectly, with good substantial lock-in power.

In this case, dc and resistance readings were all but futile. The only way the bad capacitor could be located was with a peak-to-peak reading or a scope picture.

## Chapter 16

# Horizontal Oscillator Troubles

**NO RASTER** is the main symptom of a defective horizontal oscillator. This is because loss of the oscillator output results in loss of high voltage. However, when the oscillator simply goes a bit off frequency, the raster remains, but the picture is a mass of lines. We will be concerned with sync troubles in the oscillator rather than high-voltage loss, but keep in mind that some components can also cause high-voltage troubles, depending on the degree or type of defect.

For instance, a plate load resistor that increases somewhat in resistance can knock the frequency off. If the same resistor increases more in resistance, it can kill the raster.

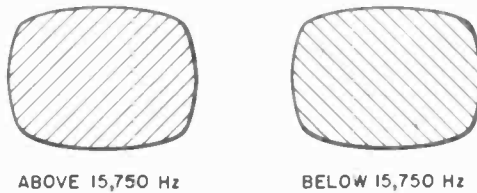
The frequency can go higher than 15,750 or drop below; it's useful to know which way the frequency went. If the lines are sloping uphill to the right, the oscillator has risen above 15,750 Hz. If the lines slope downhill to the right, the frequency has dropped. (See Fig. 1601.)

When the frequency drops considerably, the oscillator will run in the audio range and you'll hear the tweeting or squeaking. This is the Christmas-tree effect.

When the frequency goes way high, you might be able to lock in two, three, four or even more pictures side by side. There will be many lines, though, that make the picture unviewable. When trouble strikes, the first test is to eliminate the afc circuit. There are several ways of doing this, depending on the circuit. You can pull the afc tube or dual diode,



short the afc input to ground, or disconnect the afc input from the oscillator or disable the sync. If the trouble is in the afc, the picture will then flop sideways. If the trouble is the oscillator, the condition won't change.



*Fig. 1601—The slope of the CRT pattern tells whether the horizontal oscillator is above or below 15,750 Hz.*

The oscillators come in many forms: the old standby cathode-coupled multivibrator, the old Synchroguide, the newer Synchrophase and a few other sine-wave type oscillators. Let's examine some of the typical ones.

## Multivibrator

The cathode-coupled horizontal multivibrator (Fig. 1602) is almost exactly the same as the vertical except that its frequency is 15,750 instead of 60 Hz. Because of the need for a higher frequency, the values of capacitors and resistors will be different. Also, a coil that rings at 15,750 cycles is placed in series with the plate of the first half of the multivibrator. It stabilizes the oscillator action. It usually measures about 40 ohms. If it shorts out completely the oscillator still runs perfectly, but it will be unstable. If the coil develops shorted turns, the oscillator becomes very unstable because the coil will ring at a much different frequency and won't perform its stabilizing duties by ringing in time with 15,750. If the coil opens, either the raster will disappear completely or the oscillator will zing way, way off frequency. The plate B+ must pass through the coil and an open coil won't permit passage (unless there is a shunt resistor of low value across the coil).

The ringing coil usually has a capacitor of about .0047  $\mu$ F across it. This capacitor is part of the L-C circuit that performs at 15,750. If this capacitor shorts, the oscillator still runs just as if the coil shorted. If the capacitor leaks, which is quite common, the oscillator becomes unstable—as if the coil developed shorted turns. If the capacitor opens or changes in value, again instability results, since the L-C circuit is affected drastically.

side by side. Continuing adjustment, and rocking the 60K potentiometer back and forth, finally zinged the picture back into place.

After a few minutes, it rocketed off again. Since it was a parallel-wired heater string, I pulled out the 6AL5 afc tube. The picture acted as though I had done nothing. That meant the trouble was in the oscillator itself.

I knew the frequency was off, so I didn't have to bother with the scope. The best place to start was with dc voltage readings. With the picture back in place, I read the two plates. Pin 1 was about 90 volts, close enough to the prescribed 100. Pin 6 was 165, right on the nose. I then examined the control grids. Pin 7 was  $-18$ , close enough to  $-21$ , and pin 2 was under  $-1$  volt, as it should be.

A commercial came on. The picture took off once more. I took an insulated jumper lead and shorted out the 95-ohm stabilizer coil in the plate leg off pin 1, with the TV still on. As soon as I touched both ends of the jumper across the coil, the picture snapped back into sync. I removed the jumper lead. The picture still stayed in. I flicked the channel selector off and on to channel 10, the live station. The picture went off again. I retouched the jumper lead tips. On came the picture once again. I turned off the TV and tried to put the pieces together.

The picture was stable when first turned on. That meant the stabilizer coil was set properly. It developed instability after being on for a while.

Shorting out the coil and shunt capacitor restored a semblance of stability. That meant either the coil was developing shorted turns, or the capacitor was leaking or changing in capacitance.

The capacitor was a best first test. I again turned on the TV. The picture was stable. I took my solder gun and pressed the trigger. I then touched the tip to the 3900-pF and moved it slowly back and forth the length of the capacitor. The heat from the gun permeated the capacitor. The horizontal oscillator took off once more. Looked good. The heat from the gun was breaking down the capacitor. I installed a new one and turned on the TV. The picture came in. I flicked the channel and it remained in.

As a matter of interest, I took an ohmmeter test of this suspect capacitor. It read about 10 megs, meaning it was bad. Just then a commercial came on the TV. The picture didn't waver. The commercial went off; the picture stayed on. The TV was fixed.

## Synchroguide

Buried many times and then dug up again is the Synchroguide block-

ing oscillator circuit (Fig. 1604), which you'll recognize by the hold control. It is usually a coil instead of a potentiometer, and the adjusting screw can make several full turns. Set owners become confused, turn it past the lock-in point and never get the set back in horizontal sync. You arrive and the repair is simply to adjust the slug.

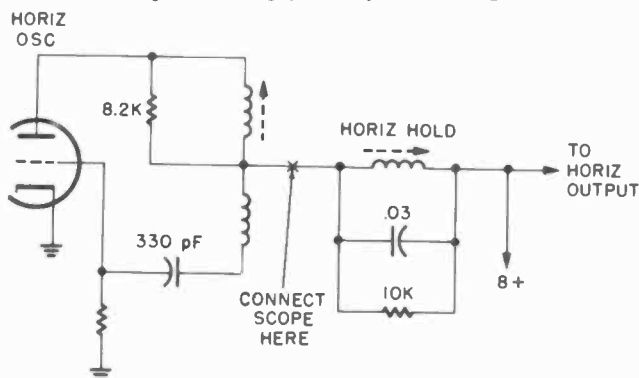


Fig. 1604—Synchroguide oscillator, showing scope test point.

Basically, the circuit is a plate-coupled blocking oscillator and is usually fed afc from a triode control tube. The frequency-controlling components are the frequency coil and its associated components. The coil is much smaller than its vertical-oscillator counterpart.

The coupling capacitor is usually around 330 pF. Its value is determined by the inductance of the coil. These two factors set the horizontal frequency. If the coupling capacitor loses its capacitance, the frequency shifts off. The more capacitance it loses, the more the frequency goes, with an accompanying loss of width. Should it leak a bit, the frequency also goes off. As the amount of leakage increases, the width decreases. Finally, the raster disappears.

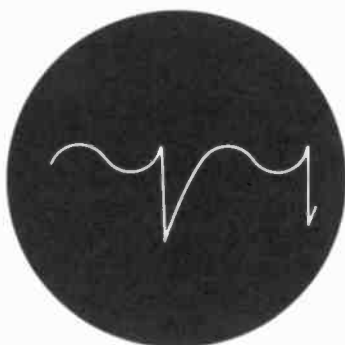
The coil itself is subject to failure. If it opens, the raster disappears. Should it develop shorts, it still rings, but at an undesirable frequency. The more shortage it develops, the more the oscillator's frequency will depart from 15,750 Hz.

I mentioned the horizontal hold control. It is usually installed in another ringing coil that is attached in series with the plate of the oscillator on the other side of the blocking-oscillator coil. This coil is a stabilizer and produces a sine-wave ringing. When this coil opens, not enough B+ gets to the plate, and the raster dies out. If the coil develops shorts, the oscillator will develop some instability. The more shorts, the more instability.

In shunt with the sine-wave coil, there may be capacitors and/or resistors. The capacitors will be around  $.03 \mu\text{F}$  and the resistors 10K or better. The capacitor is there to ring with the coil, and the resistor broadens the ringing point. Leaks, shorts or opens in either type of shunt component don't produce too much in the way of symptoms—just some subtle oscillator instability.

Misadjustment of the cores in these two coils produces various degrees of the Christmas-tree effect. Aging hurts the permeability of the cores and causes this instability. Usually backing off the core in the phasing end of the transformer cures the Christmas-tree effect.

If the cores are screwed way off by the customer, you'll have to perform a full-fledged horizontal alignment. It's best done with the scope. Simply hang your high-impedance probe at the tiepoint where the sine-wave coil attaches to the center point of the blocking-oscillator coil. Set the scope at 7,875 Hz. Turn on the TV, let it heat about 10 minutes, and set all potentiometers related to horizontal hold at their normal mid-range. Then adjust the two cores until you see the familiar double-peaked waveform about 100 volts p-p (Fig. 1605). Make sure the two peaks are exactly the same height. Next take off the probe,



15,750 Hz

*Fig. 1605—Scope picture for a properly adjusted Synchroguide oscillator. Adjust the two cores until you see the familiar double-peaked waveform.*

watch the picture and make any touchup adjustments necessary to compensate for scope loading. It shouldn't take more than a few minutes for the whole alignment procedure.

If no scope is handy, you can set it up another way. Turn on the TV and let it heat up. Then, short out the sine-wave stabilizing coil. Next, disable the afc by either pulling the tube or diode to disconnect

the afc input line, or disabling the sync separator. Make sure all horizontal-hold potentiometers are centered at their approximate mid-range. The picture at this point may or may not be way out of horizontal sync—it doesn't really matter. Now, adjust the blocking-oscillator coil until the oscillator is running at 15,750 Hz, and the picture is no longer a mass of lines, but flopping sideways. Then disconnect the short. The picture will probably go way off again. This time, adjust the sine-wave coil until the picture reappears, even if it won't hold.

Restore the afc input. While watching the picture, touch up the two coils until you feel the hold is stable. This method is not as sure-fire as the scope procedure, but with a little experience you can do a fairly accurate job this way.

The other frequency-controlling components are around the horizontal-hold potentiometers, if there are any. You'll find some in the triode control tube in the afc, usually in the plate circuit of the triode. All resistors and capacitors in series or shunt with these hold potentiometers are suspect during horizontal-frequency seizures. Shorted series resistors put too much B+ on the triode. Open or increased-value series resistors stop the B+ from getting to the plate, its destination. Shorted capacitors drain or leak through, changing B+ values.

On an RCA KCS47, I had a confusing repair. A knowledgeable set owner brought his TV to me and asked me to install a deflection yoke. I turned on the TV. The high voltage whined on and I looked at the screen. There was a raster about ½ inch wide with almost full height. The vertical bar was a bit jagged. I've seen yokes do exactly this. I installed an antenna. The picture was a long way out of horizontal sync.

Since this set has a plug-in yoke, I quickly dismantled the yoke assembly and installed the new yoke. I was in for a surprise. When I turned on the TV again, I had exactly the same condition.

In case my replacement yoke was also defective, I installed a second replacement yoke. The condition remained unchanged. As a hedge against the fact that I had a bad batch of replacement yokes, I took the TV's original yoke and installed it in another KCS47 that was on the bench. The old yoke produced a beautiful picture. Now I was comfortably sure the yoke was not causing the problem.

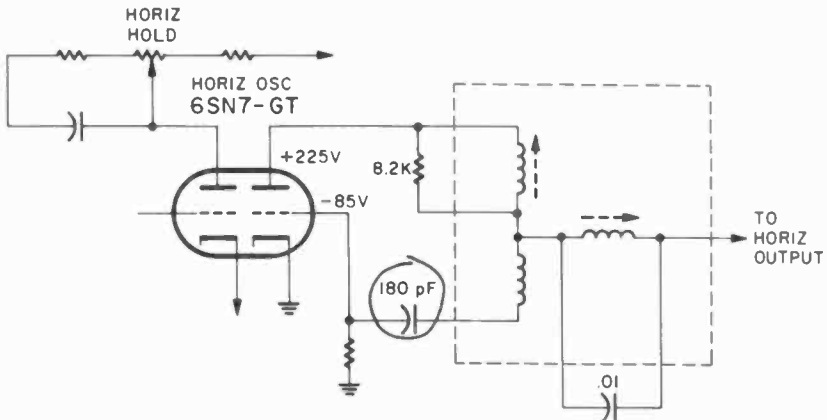
The next step was to find out where the loss of sweep and frequency were occurring. I took my flying-spot scanner, plugged a lead into the horizontal sweep output and inserted a pulse from the scanner into the horizontal output grid. A full raster emerged on the screen. This exonerated the horizontal output circuit. I jumped back to the oscillator plate and touched down with the pulse; a full raster again emerged. I

dropped down to the oscillator control grid, and this time there was no full raster—just the loss of width and frequency.

Since the output section was good, I thought the width problem was actually the secondary condition. The frequency trouble was the primary symptom. The scope wouldn't help me, since the condition of the picture was obvious on the TV screen.

I began taking voltage readings. The plate of the oscillator read about 40 volts instead of 225. The control grid read  $-5$  instead of about  $-85$ .

I began examining the frequency-controlling components between the grid and plate. They consisted of a 180-pF capacitor, the blocking-oscillator transformer, the sine-wave coil and a .01- $\mu$ F in shunt with the coil.



*Fig. 1606—A shorted 180-pF capacitor caused yoke-type symptoms in addition to throwing the horizontal frequency off.*

A resistance reading of the 180-pF capacitor showed that it measured about 100,000 ohms. I replaced it. The yoke-type symptoms disappeared. The customer didn't believe that was all I did. He thinks I repaired his yoke too (Fig. 1606).

## Synchrophase

The synchrophase is another form of blocking oscillator, this time cathode-coupled. It is quite common now and has some confusing features until you become familiar with them.

Number one, don't bother using a scope in this circuit; it tells you nothing. Even phase alignment has no need for the scope. The control

tube, one half of a dual triode (usually a 6CG7), is cathode-coupled into the oscillator. The total cathode load resistance is around 500K. The sensitive dc correction voltage develops across here. If the resistors increase or decrease in value, the amount of voltage will vary, making the oscillator unstable or causing it to die altogether, depending on the amount of deviation from the norm.

At the bottom of the load resistor is the horizontal hold control. It is usually around 40K. In series with the hold control and directly coupled to the grid of the oscillator is another resistor, around 56K. The correction voltage, as we know, is extremely critical. Slight changes of the hold-control setting have a great effect on the horizontal frequency. Therefore, you will usually find this hold control geared down with three ball bearings sticking out of the back of the potentiometer. When you turn the control, you must turn it many revolutions to move the wiping arm through its entire range. This tends to give the idea that the control is a coil; it isn't. It has stops, but they are many revolutions apart.

If you have to replace the potentiometer, be sure to attach it to the gear system, or the control will be more critical than the customer can handle. If either the potentiometer or the series resistors should increase or decrease in resistance, the frequency will flip way off.

Tied to the grid and running on into the cathode, you'll find the L-C blocking-oscillator network. The capacitor will be around 470 pF, and you'll find the coil has a nonadjustable core. This can be confusing, since the core is readily available in the chassis. However, when you insert your alignment tool, there is no slot or hex lead to turn it—just a flat, smooth surface. Leave it alone. Don't try to turn it; you can't.

Leakage in the capacitor will cause the frequency to go off in accordance with the amount of leakage. Shorting or opening kills the oscillator. Change in capacitance causes the frequency to change.

Opening of the coil kills the oscillator altogether. Shorted turns change the frequency.

In series with the cathode grid line, you'll find a tank circuit of about .01- $\mu$ F and an adjustable coil. Problems in this coil and capacitor have exactly the same result as problems in the blocking-oscillator coil. This tank circuit is our old friend, the stabilizer. It rings at 15,750 and helps keep the oscillator in line. This adjustable coil is the only coil adjustment you can make in the Synchronphase.

During Christmas-tree seizures of all kinds, here's a simple alignment setup. Short out the stabilizer coil with a jumper lead. Using the channel-selector flick test, set up the horizontal hold control to the

exact spot where the picture locks in. Then, disconnect the jumper lead. Adjust the stabilizer coil (usually a screwdriver adjustment near the blocking-oscillator coil) until the horizontal hold is as stable as possible. If you can't bring the horizontal hold in this easy way, a defective frequency-controlling component is indicated.

I serviced one such, an RCA KCS128 (Fig. 1607). The symptom was no horizontal sync. The vertical locked perfectly. I tried the horizontal hold control. I turned and turned and turned, but to no avail. However, one clue did show up. No matter how I twisted the hold control, there was absolutely no effect. The line pattern just remained.

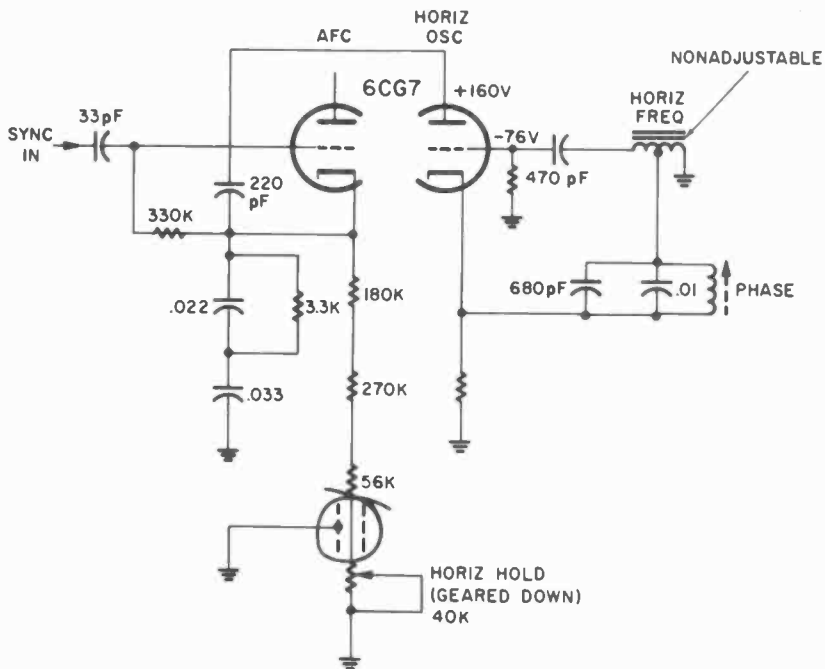


Fig. 1607—A typical RCA Synchronphase circuit. A shorted cable stopped the horizontal hold from working.

I began taking voltage readings. The plate of the oscillator was supposed to be 160 volts. It was 150. The grid of the oscillator was supposed to be  $-76$ ; it was  $-60$ . Not too far off, but it could bear inspection. The cathode was supposed to be 0.2 volts; it was about that, so now what?

Well, what were the frequency-controlling components, really? I



circled them on the schematic: the blocking-oscillator coil and the 470 pF next to it; the phase coil and its two shunt capacitors, the string of resistors in the cathode circuit; the cathode pulse filter (.022  $\mu$ F, .033  $\mu$ F, and 3,300 ohms); and the 220 pF and 330K next to it. I took a deep sigh. Since there were no voltage clues, I was going to have to test each component individually.

I began doing just that. I figured the easiest ones would be the ones I could test in-circuit. I began taking resistance readings. First I read the cathode (pin 8) to ground. It read under 100 ohms, as it should.

Next I read the grid (pin 7) to ground. It read 56K. I figured the potentiometer was at one extreme end, shorting out the resistance element, and went on.

I grasped the potentiometer and began to turn it to full resistance. I kept the probe on pin 7 and watched the meter needle. The needle didn't move. It should have increased to about 100K. I turned the control all the way both ways. The needle still pointed to 56,000 ohms. The potentiometer was shorted to ground.

I disconnected the ground end of the potentiometer and took another reading at the grid. It still read 56,000 ohms. It should have been much higher with the potentiometer disconnected from ground. I touched down on the low side of the 56K resistor. The needle dropped to zero ohms. Here was the short to ground. I looked to see how it could be shorted.

There was a shielded cable running from the resistor to the hold potentiometer. It must be shorted internally. I snipped it out of the circuit and installed a new cable. Sure enough, the short disappeared. I turned on the TV. It was still off frequency. I began slow rotation of the horizontal hold control. This time the line pattern began to change. The lines became thicker and thicker until the picture flopped into place.

The shorted cable effectually cut the hold control right out of the circuit. There was not enough resistance to develop the full correction voltage of  $-40$ . Only  $-35$  developed. That 5 volts was enough to flip the oscillator off frequency.

## Chapter 17

# Sync Troubles in Non-Sync Circuits

WHEN the blanking-bar examination reveals that the sync pulse is not blacker than picture elements during a sync seizure, the sync circuits themselves are exonerated. The trouble then lies in the rf, i.f., video or agc circuitry. This is the time to look particularly for secondary symptoms to clue you in.

If you have tunable ghosts or snow in with the sync trouble, the tuner becomes a likely suspect. Ringing, overloading or some loss of video and audio indicate the i.f. strip might bear investigating. A smear, poor frequency response, ringing or poor video while audio is good indicates video-circuit problems. Overloading, and better reception on weak channels than on strong ones, tell you that agc trouble is in with the sync trouble.

### **Rf—i.f. sync troubles**

The main misfortune that can befall sync pulses during passage through the rf—i.f. areas is that the pulse may not be properly amplified. This happens when the alignment of the rf-i.f. section is off and the full range of the picture carrier is not equally amplified. As in hi-fi, all frequencies ought to be amplified “flat.” If alignment is off, the low frequencies are amplified less than the highs. When this happens, the height of the sync pulse is said to be compressed. You’ll see the sync

pulse in the blanking bar, but not black enough to pass inspection.

How does this happen? The alignment can become incorrect when a strategic capacitor, resistor or coil becomes defective through shorts, opens or leaks. Another major reason for the alignment being off is that someone, customer or otherwise, may try turning the adjustments in the rf and i.f. stages.

Fortunately, the sync condition is not usually present by itself. It may be accompanied by sound bars in the picture, a buzzing in the sound and a weak picture.

When you have this type of trouble, it is time to look at the i.f. response curve and see where the picture carrier is actually sitting on the curve. It is supposed to be sitting at the 50% level of the slope.

Let's discuss the curve a bit. The i.f.'s job is to pass a certain range of frequencies, usually a band about 6 MHz wide. The actual frequency range is determined by the i.f. design—usually it's around 11, 22 or 44 MHz. Now the i.f.'s are supposed to amplify about 4 MHz worth in the center of the bandpass, flat at 100%. That means there will be a plateau at the 100% level. On either side of the plateau there will be a slope coming up from 0%. The picture carrier is designed to be set at 50% on the slope at the high-frequency end. Why at 50%? Why not on the plateau at 100%?

For these reasons: The TV picture signal needs to vary from 0 to 4 MHz to produce *fine* detail. Modulation process of the carrier wave sets up two sidebands, each 4 MHz wide. That means the carrier would need 8 MHz of bandwidth to be transmitted. That's too much space in the frequency spectrum. Only 6 MHz are allotted to each station.

The stations transmit what's known as vestigial sidebands. Since the complete 4 MHz of information are included in each sideband, the lower sideband is suppressed, leaving only a vestigial sideband of  $1\frac{1}{4}$  MHz.

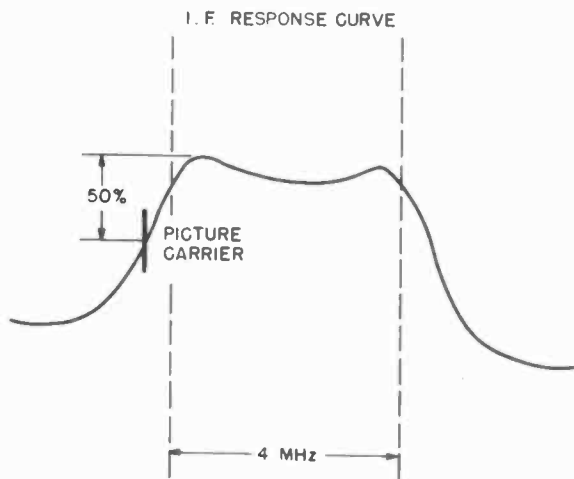
The only problem is that this means twice as much low-frequency signal is transmitted from 0 to  $1\frac{1}{4}$  MHz as is transmitted from the higher frequencies,  $1\frac{1}{4}$  to 4 MHz. This poses a reception problem for the receiver. It must take this unequal amount of signal and somehow amplify it so all the amplified result is of equal strength. It must either reduce the extra low frequencies or beef up the skimpier higher frequencies.

This is accomplished by setting the picture carrier at the 50% level on the response curve (Fig. 1701). That way, all frequencies will be amplified on either side of the 50% level. For instance, a low-frequency signal will pass through the i.f.'s. The higher sideband is amplified at a 61% level; the lower sideband counterpart is amplified at

39%. The two of these total the desired 100%.

Then, a high-frequency signal will pass through the i.f.'s. The higher sideband falls on the plateau of 100%. There is no lower sideband, since it was chopped off during vestigial-sideband transmission. The net result is another amplified signal at 100%. All signal from 0 to 4 MHz is amplified 100%. True video fidelity is maintained as long as the picture carrier falls 50% up on the high-frequency slope.

The sync problem comes in when the picture carrier doesn't fall at 50%. If the carrier falls below this, the low frequencies between 0 and 1¼ MHz, which contain sync pulses, are reduced according to how far the carrier drops below 50%. If it goes as low as 10%, sync control disappears.



*Fig. 1701—Correct placement of the picture carrier. The picture carrier must be at the 50% level on the slope of the response curve.*

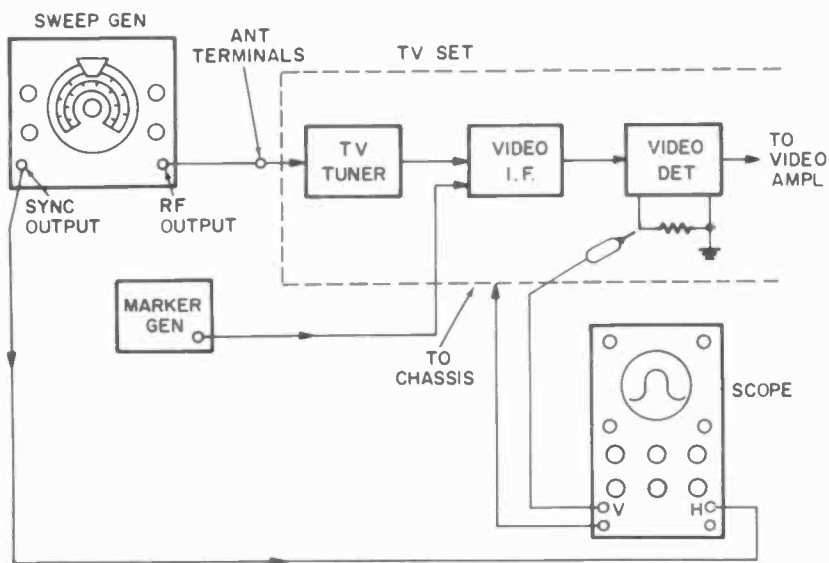
Any playing around with traps or coupling transformers can result in misalignment with sync ramifications. Also, shorted coupling capacitors, increased-value cathode resistors, shorted turns in small coil windings, or anything that alters the bandpass characteristics of the i.f. can cause this form of sync trouble. With increases in the number of do-it-yourselfers, this type of trouble is becoming more common. In the old days, there were few cases such as the one I had recently.

The TV was a department-store special with just the name of the store as the brand. Fortunately, the set owner had a booklet containing service and alignment instructions.

I turned on the TV. The sound came in with a good example of

intercarrier buzz. The picture drifted upward into view. I say drifted because it proceeded to drift right past where it should have locked in. The picture rolled up and down and the contrast was poor. The set owner said he had been unable to keep the picture still and that he hadn't been pleased with the way the sound and picture came in together. When the picture was best, the sound was poor, and vice versa. Armed with some do-it-yourself knowledge and the service manual, he had tried to adjust the sound to come in with the picture.

He pointed out the adjustments he had tried. He had twisted every core and potentiometer in the i.f. and audio circuits that had the words audio or sound attached to them. He didn't understand how this could have affected the sync.



*Fig. 1702—Procedure for obtaining the i.f. response curve: (1) Set the TV for the desired channel. (2) Inject a sweep 6 MHz wide into the antenna terminals at the frequency of the selected channel. (3) Attach a scope to the detector load resistor. (4) Set the scope sweep to be identical to the generator sweep. (5) Feed an accurate marker signal into the i.f.'s. (6) Observe the response curve and marker pip.*

The TV was left in my care. First off, I installed new pretested i.f. tubes. Then I examined carefully all the dc voltages in the rf amplifier, oscillator, mixer and the three i.f. circuits. They all matched the schematic callouts. Then I assembled my sweep generator, marker and scope (Fig. 1702). I inserted a channel-3 frequency about 6 MHz wide

into the antenna terminals. I turned the channel selector to channel 3 and turned on the set. Next, I hooked the scope across the load resistor of the detector and inserted the sweep from the generator into the horizontal terminals of the scope: I also adjusted the phase till I got only one trace on the scope. That way, both scope and generator were sweeping out identical traces. A response curve appeared on the scope. I turned on the marker at exactly the prescribed picture frequency and clipped it into the grid of the first i.f. A pip appeared on the response curve. It was way low on the slope, almost on the bottom.

I gingerly began rocking the various audio adjustments one by one. The response curve squiggled a bit. I returned each to its original position. Then I touched an adjacent-channel sound trap. The response curve jiggled and the pip rose a bit on the slope. I turned a trifle more. The pip seemed to get higher. I kept on turning. The pip settled at about 50% level. I stopped and turned on the TV. The picture came on with more contrast and the sync was holding fine.

I checked the blanking bar. The sync pulse looked normal now. Its relative blackness was blacker than any picture element. There was still some buzz in the sound. I touched up the quadrature coil by ear, and the buzz disappeared. By watching the TV screen, I touched up all the rest of the audio coils. The picture looked good. I called the set owner to come and pick up his TV.

He was pleased at his return-to-normal reception; however, he was still unhappy that the sound and picture were not exactly on top of each other, so I tried to explain that this is the way a TV is designed. Anyway, I doubt that he will try doing his own aligning in the future.

The sync will hold fairly strongly during other i.f. troubles, and right now we are interested only in sync problems. If you suspect rf or i.f. circuits as the source of your sync trouble, take a look at the response curve and pip. If the pip is 50% or higher, you can usually clear the rf-i.f. section as the trouble source. (Be sure your marker is right on the nose. An inaccurate pip can give you a false lead.)

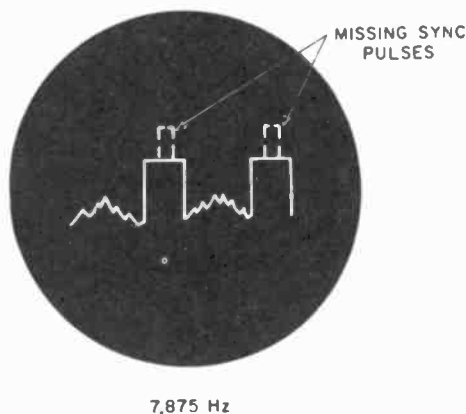
## Video sync troubles

A rough rule of thumb to help determine whether the nonsync trouble is in the rf-i.f. or the video is this: If the sync pulse is present, no matter what its relative blackness, the troublemaker is usually found in the rf-i.f. If the sync pulse is missing from the blanking bar, the trouble is probably in the video circuit.

Actually, what happens in the video circuit is that some defective

component alters the circuit to form a sync clipper. Then, as the video is processed through, the sync is chopped off the blanking-bar pedestal.

Because of this, it is quite easy to isolate the leg where the defect is. If there is no sync pulse on the CRT, take your scope and touch down with a low-capacitance probe on the grid or cathode (whichever is the video input) of the CRT. Verify the fact that the sync pulse is missing. On the scope picture, the composite video should be there minus the sync tip. Look closely at this chopped-down pedestal so you'll know for sure when you cross over the trouble spot and when the good pulse appears (Fig. 1703).



*Fig. 1703—The scope waveform in the video circuits points out the missing sync pulses.*

From the CRT, drop back to the plate of the video output, then to the grid, and then to the detector output. Don't forget the amplification that takes place in the video output.

When the sync pulse reappears on the pedestal, you know the trouble-maker is between that point and the one you touched before it.

### **I.f. testing too**

You can apply the following test procedure to the i.f. and rf, too, if your scope has enough gain. Be careful if the sync pulse is not completely chopped off but is merely compressed a bit.

When you pass over the detector, detach the low-capacitance probe and attach a detector probe. Next, touch down on the video-detector input, and then on the plate of the last i.f., to its grid, etc. You might have to turn the gain on the scope up high as you approach and

enter the first i.f. Should you want to go into the tuner, the scope gain will have to go even higher.

had no hooks. The symptoms indicated sync troubles, but with agc overtones. I had to be careful. Sync and agc were Siamese twins in this case, housed in the same 6BU8 tube.

My first step after tube changing was to install my bias box. I clipped into the agc line. Then I varied the bias. The hook straightened up nicely. The rolling stopped and the excessive contrast was restored to normal. This test pinned the blame directly on the agc circuit.

I looked at the schematic (Fig. 1705). The cathodes of the twins were common and tied to ground. The noise-inversion input was common to their common control grid. Their screen B+’s were common at their common screen. However, they had separate suppressors.

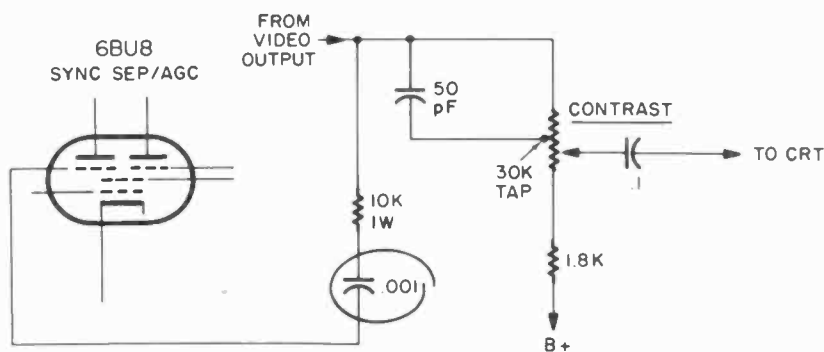


Fig. 1705—A leaky 1,000-pF (.001 $\mu$ F) capacitor in the agc input line was causing agc symptoms.

I followed the agc suppressor input back to its takeoff point in the video output near the contrast control. I switched my vtvm to peak-to-peak and began tracing the signal from there. At that point, there was 12 volts p-p, as it should be. I crossed over a 1,000-pF capacitor that was blocking dc from the video out to the agc input.

The peak-to-peak dropped drastically to about 4 volts. I quickly disconnected the capacitor and read its resistance. It read about 10 megohms. I replaced it.

That was it. The leaky capacitor was dropping the peak-to-peak voltage, lowering the bias voltage on the agc suppressor grid. The lowered bias dropped the agc to the rf and i.f., and they ran too strongly. This overwhelmed the contrast control and caused the sync input to be too great. The sync clipper didn't operate properly and let some video into the sync, causing the hook. Did you note that the peak-to-peak signal tracing used here was simply the technique used to troubleshoot the sync circuit itself?

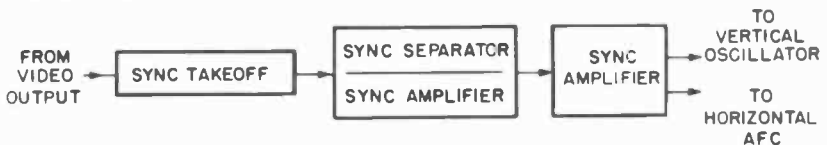


## Chapter 18

# Servicing Transistor Sync Circuits

THE latest generation of TV's—transistorized sets—are in the marketplace selling like hot cakes. Their appearance on service benches has become commonplace. In each solid-state TV there is a transistorized sync circuit. It differs from tube-type circuits, but it performs exactly the same job.

The same resistors, capacitors, coils, etc., are used. The only change is that the tubes and tube voltages has been replaced by transistors and transistor voltages. The composite TV signal still comes out of the video section through a sync takeoff line, passes through a sync separator and a sync amplifier, and is then applied to the vertical and horizontal oscillators (Fig. 1801).



*Fig. 1801—Block diagram of transistor sync circuits. The general circuit layout in a transistor TV parallels that of a vacuum-tube set.*

The first change in troubleshooting transistors is that you needn't test tubes, because there are none. However, don't start by testing transistors instead. The breakdown rate of transistors is not like that of tubes. Transistors go bad only about as often as capacitors or resis-

tors—not in 80% of set failures, as is the case with vacuum tubes. Without the heat and high B+ voltages, transistors are much more reliable than tubes. You must test a transistor with the idea that it is no more likely to be the troublemaker than the other components in the circuit. Also, when you do test a transistor, you must exercise more care than with other components because heat, static charges on meters, shorting one of the elements to the wrong spot or other rough handling can damage the transistor.

It's easy to service transistor sets correctly. Just be prepared with miniature tools, low-wattage irons, an ohmmeter that deflects from right to left (not left to right like some old ohmmeters), a transistor tester and some substitute transistors. It wouldn't hurt to read up on transistor testing either.

Transistors become defective because of opens, shorts, leakage, low gain, and changes in operating characteristics. The surest test of course is direct substitution; however, in-circuit resistance and gain tests are the easiest approach. When the in-circuit tests reveal no information, it is time enough to begin unsoldering.

### A typical sync circuit

Sync transistors are picked to have excellent switching characteristics so they can handle the various frequencies that are applied to them.

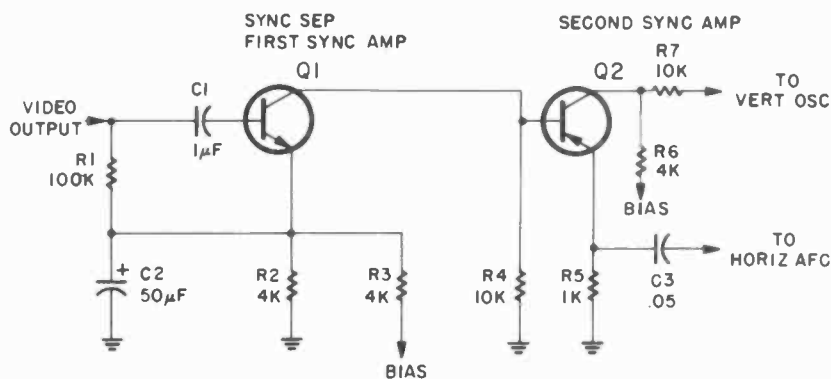


Fig. 1802—A typical transistor sync circuit. Good switching transistors and the correct value of input capacitor (C1) make a transistor sync separator.

A typical transistorized sync circuit is shown in Fig. 1802. Q1 gets its emitter bias through the voltage divider consisting of R2 and R3 bypassed by the 50- $\mu$ F filter C2. There is no fixed bias on the base.

C1 charges up from the incoming video signal, developing a reverse bias that is proportionate to the video amplitude. This reverse bias on the base cuts off the current flow in Q1. Q1's normal state is to sit there cut off.

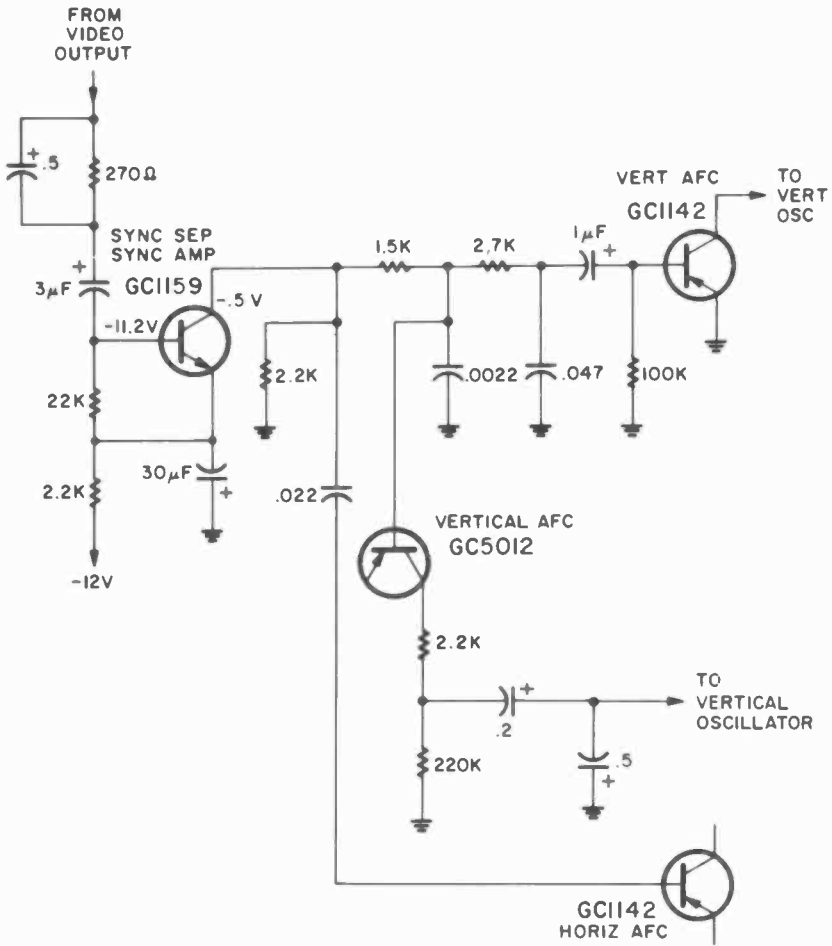


Fig. 1803—This unusual transistor sync circuit uses two transistors as a vertical afc, replacing the conventional integrator network. However, the sync separator remains the same as usual.

However, C1 discharges at the peaks of the incoming composite TV signal. These peaks, of course, are the sync pulses. Thus the sync pulses are separated from the TV signal, and only the sync pulses get into the transistor. Each pulse is amplified in the transistor and then

direct coupled into Q2, where it is further amplified. The sync pulse is developed across R5 and R6. The R6 output is applied to the vertical oscillator and the R5 output is coupled to the horizontal afc network through C3. There are many variations of this circuit. Some use more transistors, others use just a single transistor, but they are all basically the same (Fig. 1803).

## Transistor servicing

When you get a transistor TV in front of you on the bench, begin the same way you would with a tube set. First examine the symptoms and try to label them. Is the trouble a complete loss of sync? Loss of vertical sync? Loss of horizontal sync? The bends? Or what have you?

Try the various adjustments. Examine the quality of the blanking bar and sync pulses and determine what specific circuit you should start taking measurements in.

Next pull out the schematic, test the dc levels, the peak-to-peak readings and the scope waveforms. Bring into play the low-capacitance probe, the detector probe and the bias box. Track down any definite clues. The situation is very much the same as in the tube set, except there are no tubes to plug and unplug, voltages are much lower, and there are transistors to test.

Instead of plate and grid voltages, there are collector and base voltages. The average sync-separator plate voltages are between 50 and 100 volts; separator transistor voltages range between 5 and 10 volts. While control-grid voltages are about  $-3$  volts, base voltages read in the neighborhood of 0.3 volt. These smaller voltages mean you need a good vtvm—one with a 0.5-volt scale. Before starting to take these transistor readings, set the zero point exactly. During a voltage reading, a glance won't do. Read the needle closely. Any deviation from the voltages the schematic calls for bears further investigation.

Actually, current readings rather than dc voltage readings would be more indicative of trouble. However, set manufacturers seem to believe that you can't teach old dogs new tricks—not overnight, anyway. Technicians have been fixing TV's by means of voltage tests for so long that to switch them to current tests today would impose a hardship. Therefore, on most schematics you'll find voltage test points, not current readings. It would be a good idea if they provided both.

Should you want to develop the amperage test-point approach, do so. It will speed your transistor servicing not only in sync applications but in all transistor areas. No, you don't have to open the circuit and use

an ammeter to make the readings. Simply read a voltage drop across a resistor in the leg you are troubleshooting—that is, take a vtvm voltage reading on each side of the resistor and subtract one from the other. For instance, suppose one side of a resistor reads 4.3 volts and the other side reads 12.4 volts. The drop is 8.1 volts.

The current traveling through the resistor is  $E/R$ . Jot down the voltage drop and divide it by the resistance of the resistor. The result is the current. Old familiar  $I = E/R$ .

The resistor in the collector circuit in Fig. 1804 is 15K. The voltage drop across this resistor is  $34 - 9$ , or about 23 volts.  $E/R$  equals  $23/15,000$  or about 1.5 mA. This is your schematic current reading. Any great deviation indicates trouble nearby.

If figuring out the current looks like a lot of trouble, it's not. After you do it it's a snap. Current considerations will tell you what's going on in the transistor. This in turn will indicate certain components as trouble suspects, just as voltage considerations in a vacuum tube indicate trouble possibilities.

### Case of the Sylvania 19T33 portable

Let's go through a typical sync-separator repair, again referring to Fig. 1804 which is from a solid-state Sylvania 19T33 series. The portable TV had no sync at all. The vertical rolled slowly and the horizontal slid by in full frames, I tried the vertical-hold control. There was a center setting where the picture held still, but there was no vertical sync lock-in action.

I tried the horizontal-hold control. It too could stop the sideways motion near the center of its setting, but there was no lock-in. The sync pulse looked good in the blanking bar as it slid past.

There were no secondary symptoms—just a complete loss of sync. I pulled out the schematic on the set and loosened the chassis.

I set my vtvm on the 15-volt scale and took a voltage reading at the sync-separator collector. It read 9 volts as it should. Then I set the function switch on the 0.5-volt scale and read the base voltage. It read about 0.5 volts, which was normal. From a milliampere point of view, normal voltages meant normal current drain. No clues here.

I switched to peak-to-peak readings and read the base test point again. The schematic called for 1.8 volts p-p. There was nothing at the test point. I skipped up to the sync takeoff point in the video output, beneath an 8,200-ohm resistor. There were a few volts p-p there.

I followed the takeoff line to a .022- $\mu$ F capacitor and touched down.

The peak-to-peak voltage was there. I crossed over the capacitor and the voltage was still present. Then it suddenly disappeared. I glanced at the screen and sighed. A dark scene was being transmitted. A light scene came back on and the voltage returned, as is normal.

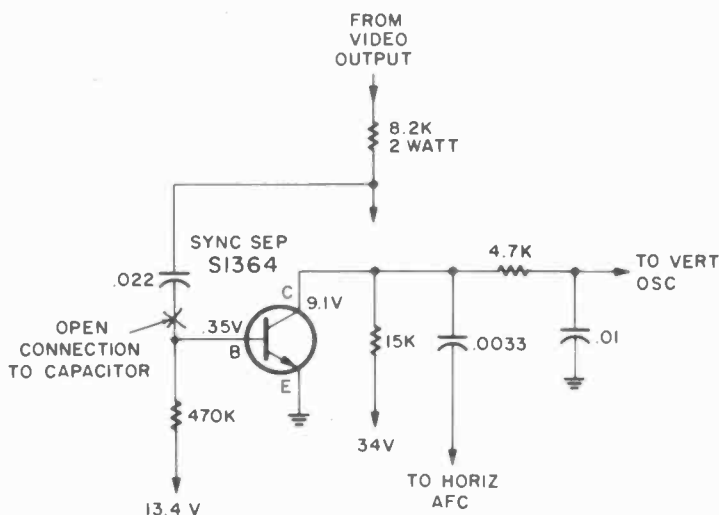


Fig. 1804—An open connection on the printed-circuit board halted the signal voltage before the base input.

I decided the peak-to-peak voltage was being lost between the capacitor output lead and the base connection of the transistor. I took a jumper wire and connected the two test points. Lo and behold, the sync returned to the screen. The picture locked fine. I took a low-wattage iron and worked over the printed-circuit board from connection to connection. Presto, the TV was repaired.

As a matter of interest, I read the base connection again; the peak-to-peak voltage was there. One of the two connections must have had a cold solder joint. Dc voltages and current had been correct on the transistor, since fixed bias was applied to both base and collector. Good old peak-to-peak technique had revealed the trouble spot.

To be sure, transistor sync circuits are harder to service than their tube counterparts; but they are not unduly rough. However, if you haven't already done so, pick up a book on transistor servicing and learn the latest tricks. Invest \$10 or so in new tools, and get a transistor tester and some replacement transistors. Do these things and you'll be ready to repair transistor sync troubles when they come your way.

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