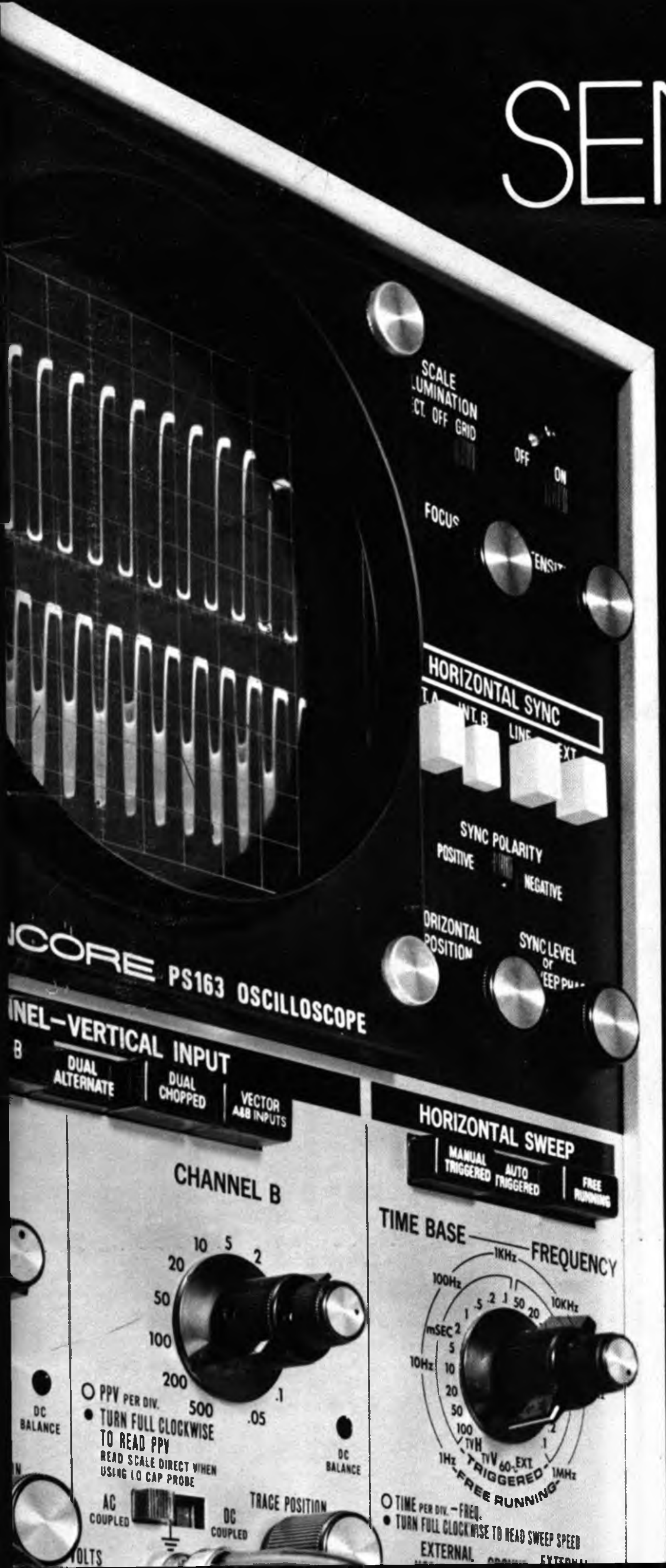
SENCORE

SCOPE SCHOOL



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INTRODUCTION

The Electronic Industry's Association has a familiar expression, "You're already paying for the equipment you don't have," and this is particularly true when it comes to oscilloscopes. Many technicians have told us they paid for their scope the first month they owned it. Others tell us their scope has been collecting dust from the day they brought it in. And still other technicians have told us, "If they really knew how to operate a scope they'd have one on their bench in a day."

That's what we're here for today. To cover the basics of the Sencore Scopes, and introduce key applications.

Understand one thing. We cannot take three hours and teach you what vo-tech schools and universities teach in a semester. We will, however, familiarize you with the theory and operation of Sencore Scopes so you can put this useful tool to work . . . . in whatever application you may have.

We are going to start at the very beginning, as if none of you have ever seen a scope before, and take you right through the entire scope.

We have divided this school into three sections: theory, operation and application.

It's going to be an information packed three hours, so let's begin with the theory of scope operation.

FIRST A LITTLE REVIEW....
5 IMPORTANT CONCEPTS

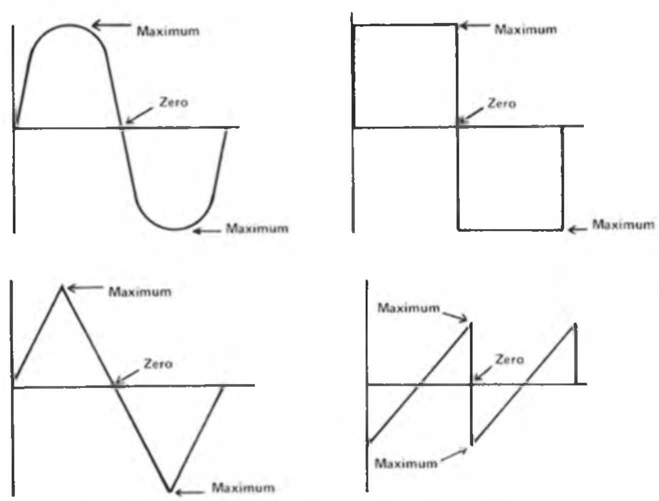
1. DC . . . DIRECT CURRENT

A constant value current flow in one direction.

2. AC . . . ALTERNATING CURRENT

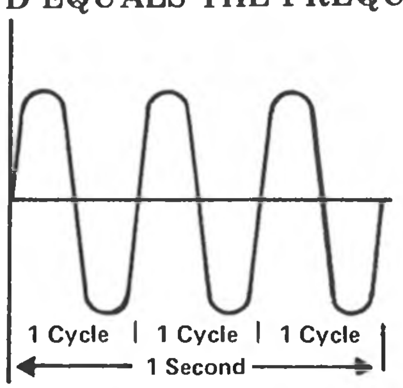
Defined as a flow of electricity which reaches maximum in one direction, decreases to zero, then reverses itself and reaches maximum in the other direction.

IMPORTANT: THE CYCLE IS REPEATED CONTINUOUSLY.



TYPICAL AC SIGNALS

THE NUMBER OF CYCLES PER SECOND EQUALS THE FREQUENCY.



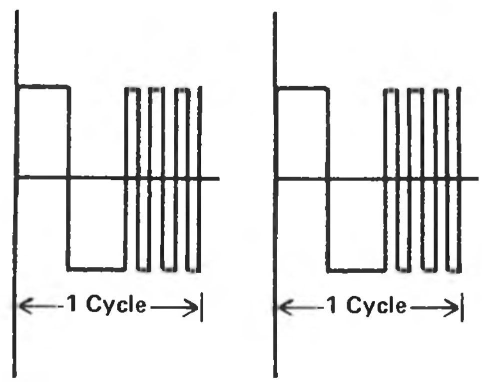
3 Cycles per second = 3Hz.

3. WAVEFORM . . .

Is a graphic representation of an electron flow, showing the amplitude changes over a period of time.

4. COMPLEX WAVEFORM . . .

A waveform that contains two or more frequencies.



A COMPLEX WAVEFORM DOES REPEAT ITSELF.

5. SCIENTIFIC NOTATION

$\frac{1}{10^x} = 10^{-x}$ Example: $\frac{1}{10^3} = 10^{-3} = .001$

$\frac{10^a}{10^b} = 10^{(a-b)}$

Example: $\frac{10^3}{10^6} = 10^{(3-6)} = 10^{-3}$

$10^a \times 10^b = 10^{(a+b)}$

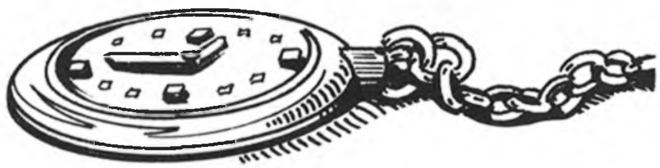
Example: $10^3 \times 10^6 = 10^{(3+6)} = 10^9$

SECTION 1...THEORY

WHY DO WE NEED A SCOPE?

We need a scope to analyze amplitude measurements with respect to time.

Everything in nature has some relationship to time.



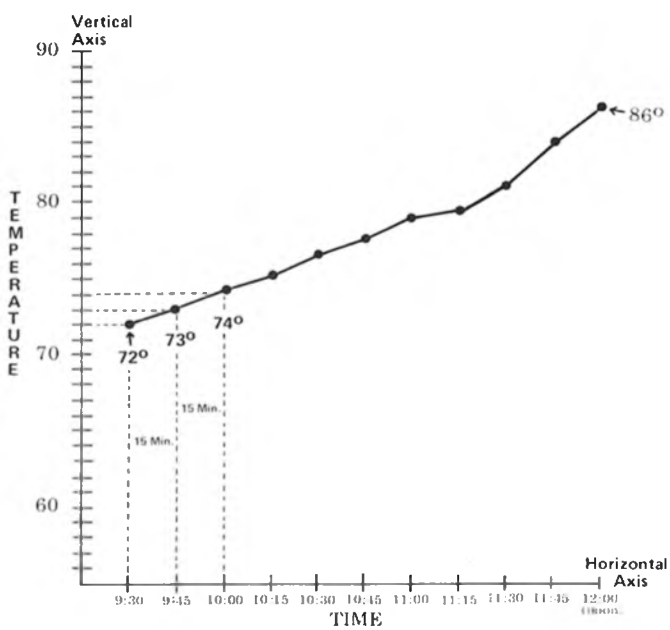
Example . . . . the time and temperature, at a bank

9:30 / 72°

However . . . . this is the temperature, at just one moment in time.

Now if we want to know if it's getting colder, warmer,

We need to know how the temperature is changing over a period of time.



So we stand under the bank sign with a piece of graph paper and mark the vertical axis scale in temperature, and the horizontal axis in 15 minute intervals of time. Then every 15 minutes we mark the temperature at that particular time.

This shows us what happened to the temperature over the entire morning.

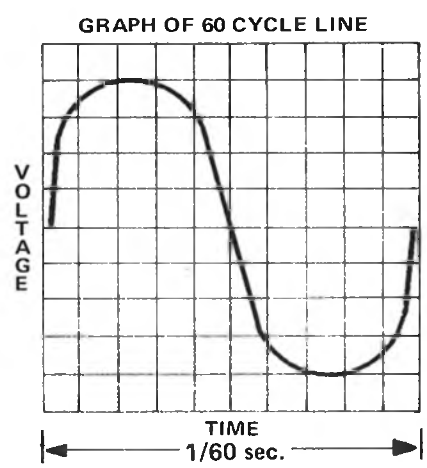
Our graph shows us the temperature is increasing and it's getting warmer.

By measuring temperature over a period of time, we can "analyze" the weather.

Now — if we want to analyze an electronic circuit, we must do the same thing — measure the output of the circuit over a period of time.

HERE'S WHY . . .

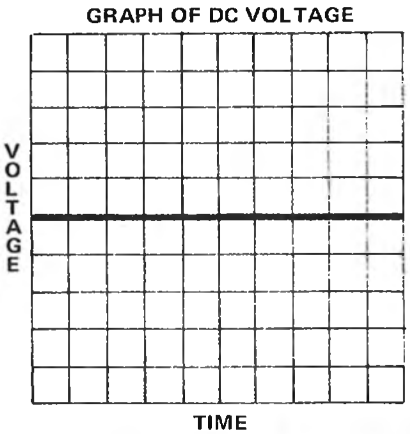
ALL ELECTRONIC SIGNALS HAVE A RELATIONSHIP TO TIME.



In our temperature example the time relationship was 3 hours. In electronics, the time relationship is fractions of a second.

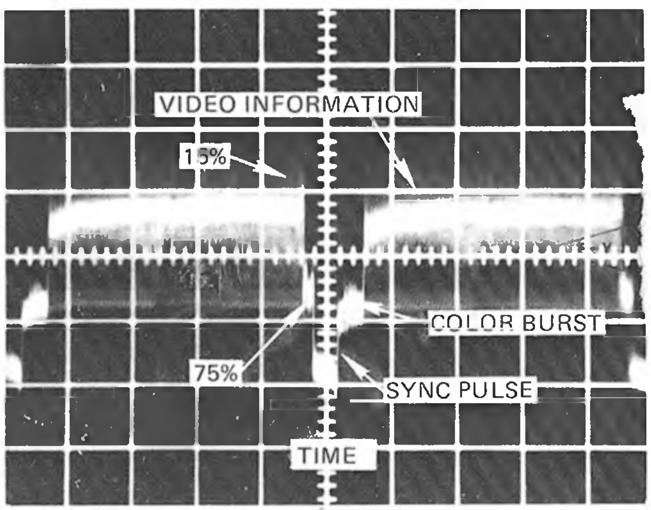
For 60 cycle AC line, the voltage must make one complete cycle in 1/60 of a second.

THIS IS A TIME RELATIONSHIP !



For any DC signal, the voltage must remain the same at any given instant of time.

THIS IS A TIME RELATIONSHIP !



This complex composite video waveform has several time relationships. First, it must rise from the 15% level to the 75% level in a given amount of time. Next the sync pulse must be present. Then the color burst. Then it drops down to the video information. Then the next cycle must start $\frac{1}{15733}$ of a second later.

THIS IS A COMPLEX TIME RELATIONSHIP!

YOU SEE . . . . ALL ELECTRONIC SIGNALS ARE A FUNCTION OF TIME.

When we plot electronic signals over a period of time — we get a "waveform." (It shows us the form of the wave over a period of time.)

HOW DO WE PLOT A WAVEFORM?

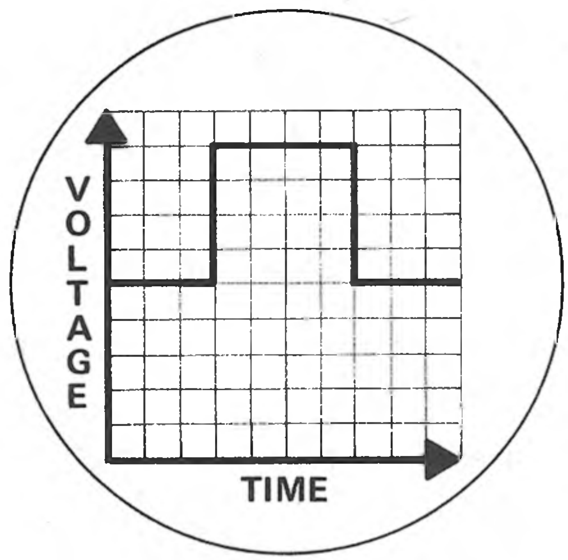
Can we use graph paper and a pencil and plot the different voltages over a period of time?

You could if the signal moved slow enough — like one/half a cycle a second.

But electronic waveforms move much faster — like a million cycles a second. How do we plot this action over a period of time?

BY USING AN OSCILLOSCOPE.

An oscilloscope is simply a very fast electronic graph that plots voltage changes of a waveform over a period of time.



INSTEAD OF GRAPH PAPER AND A PENCIL . . .

A scope uses an electron beam to plot the changing voltages of a waveform on the face of a phosphor coated cathode ray tube (CRT).

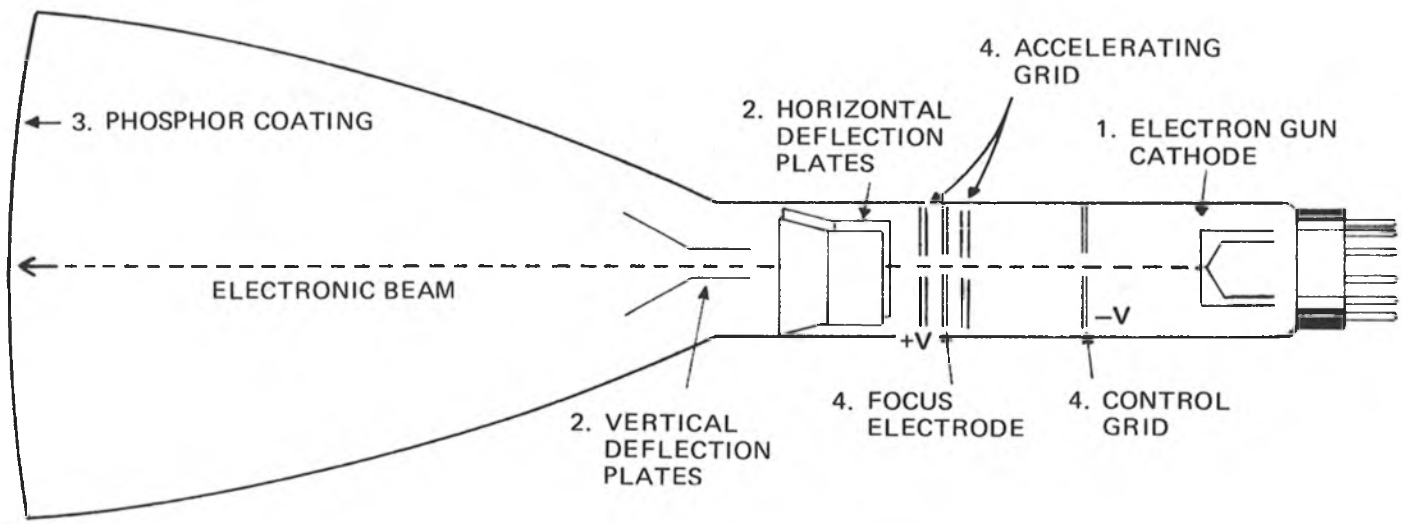
The phosphor coating of the CRT face actually "lights up" when struck by the electron beam. Let's see how this electron beam is generated, then see how we can control it to plot the output of a circuit.

THE CRT

The heart of a scope is the CRT.

The CRT of a single trace scope consists of 4 key elements.

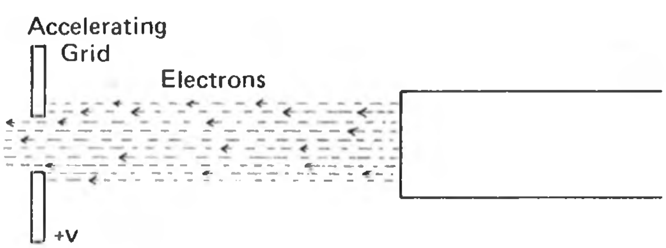
1. An electron gun that emits a continuous electron beam.
2. 2 vertical and 2 horizontal deflection plates to move the electron beam.
3. A phosphor coated glass that illuminates when struck by the electron beam.
4. The control grid, focus electrode and accelerating grids.



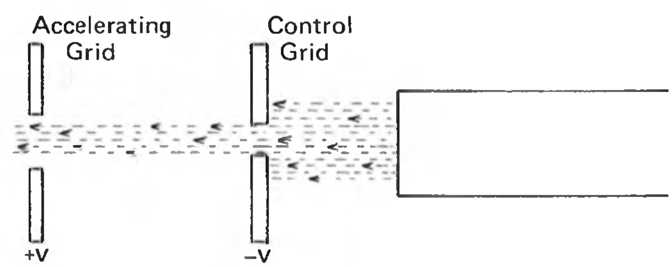
HERE'S HOW A CRT WORKS–

1. When the scope is turned on — the filament heats the electron gun which begins emitting electrons, just like a typical receiving tube.

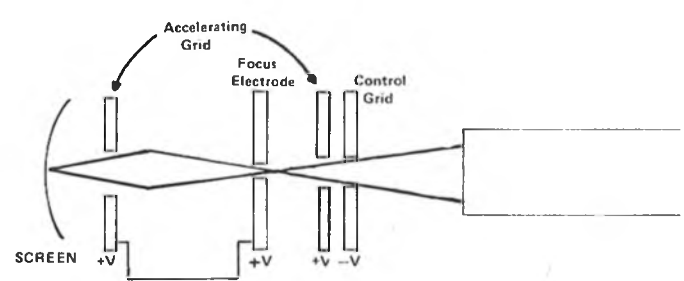
2. The positive accelerating grid voltage attracts the electron beam.



3. However, the negative voltage on the control grid repels the electron beam. The amount of voltage on the control grid determines how many electrons may pass through the control grid. This establishes the strength of the electron beam — and thus the intensity of the beam.



4. The voltage on the focus electrode forces the electrons into one compact beam, as pictured below.



SELECTING BEAM INTENSITY

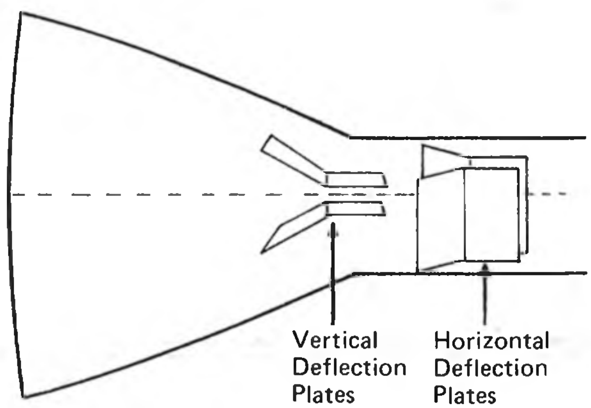
If you want a dim beam, increase the negative voltage on the control grid, and few electrons will pass.

If you want a bright beam, set the control grid to "zero" volts, and all the electrons will pass.

Once the beam intensity is selected, the beam is focused and accelerated toward the CRT face.

CONTROLLING BEAM MOVEMENT

Now that we have the electron beam at the CRT face, we need to move the beam by means of the horizontal and vertical deflection plates, as pictured here. First we'll look at the horizontal plates.



HORIZONTAL DEFLECTION PLATES

Here's what it looks like when we look straight down the neck of the CRT.

A voltage is applied to the horizontal deflection plates.

The physics principle that "opposite charges attract, and like charges repel" now takes over.

If the right plate is positive, as in Figure A, the right plate attracts the electron beam and moves it to the right.

Horizontal Deflection Plates

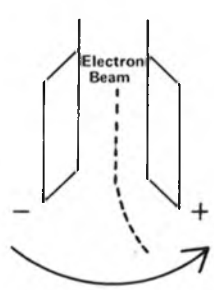


FIG. A

If the left plate is positive, as in Figure B, the beam is attracted to the left.

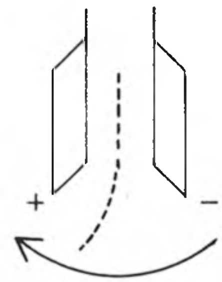


FIG. B

By changing the voltage value on the horizontal deflection plates, we can position the electron beam anywhere on the horizontal axis.

VERTICAL DEFLECTION PLATES

Now let's move the beam up and down.

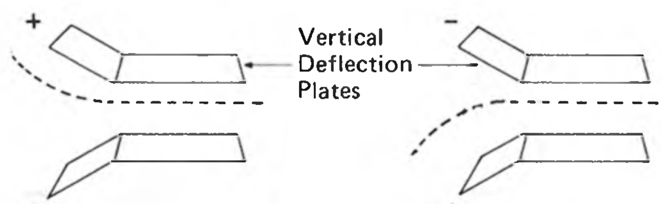


FIG. A FIG. B

If the top vertical deflection plate is positive, the beam is attracted and moves up, as on Fig. A.

If the bottom plate is positive, the beam moves down, as in Fig. B.

Therefore, the position of the electron beams depends on the voltage on the deflection plates. By changing the voltage value on the vertical deflection plates, we can position the electron beam anywhere in the vertical axis.

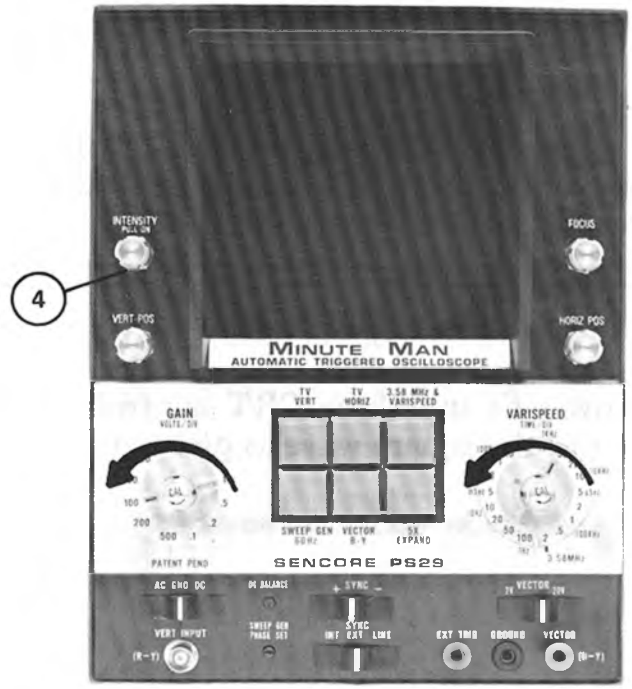
Once the beam is directed, it passes on to the CRT face, where it illuminates the phosphor coating.

NOW LET'S TRY IT ON THE SCOPE

First your instructor should have you count off.

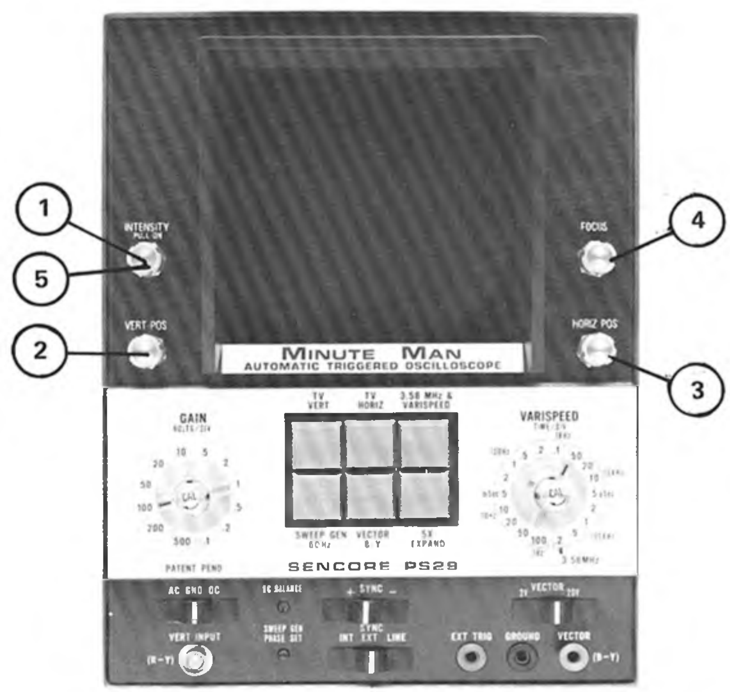
To set up the PS29 for this section of scope school, do the following:
(If using a PS163, go to Page 33 .)

NOTE: For all sections of the scope school, the two "Cal" controls must be set clockwise in the locked position.



1. Turn all other knobs fully counter clockwise.
2. Push vector button. (We are using the vector functions simply for display. Do not confuse this demonstration with any type of vector mode operation.)
3. Push 4 switches on bottom of scope to the far left.
4. Now turn the Minute Man on by pulling the Intensity Control. This starts the electron beam, but there should be no trace.
5. The probe should not be connected to any signal source at this time.

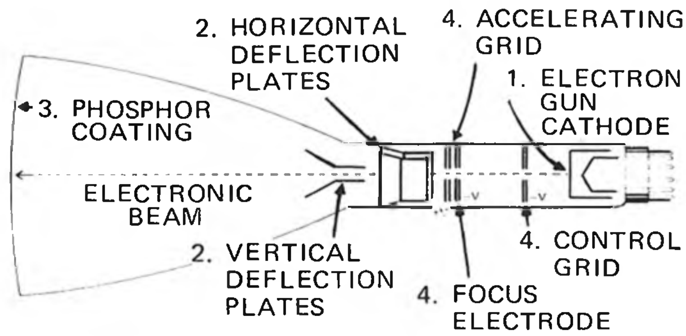
Here are the steps you should always follow if you have no trace on the Minute Man.



1. Turn the "Intensity" control fully clockwise.
2. Adjust the "Vert Pos" control until you can see the beam light on either side of the screen. (This changes the voltage on the vertical plate which bends the electron beam up and down.)
3. Adjust the "Horiz Pos" control until the trace is centered. (This changes the voltage on the horizontal plates, bending the beam from side to side.)
4. Adjust the "Focus" control until the trace becomes as small as possible. (This changes the voltage on the focus electrode, which will focus the beam.)

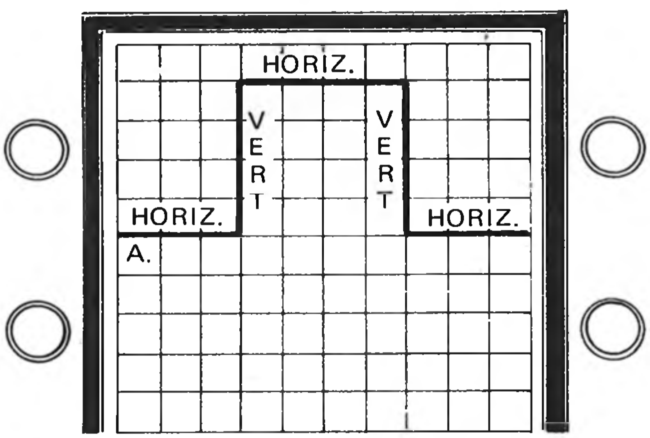
5. Turn the "Intensity" control down for minimum brightness. (This minimum intensity setting will prevent the beam from burning the CRT phosphor.

6. If necessary, re-adjust the vertical and horizontal position controls until the trace is perfectly centered.



(All Sencore Scopes)

Now let's use these CRT controls to trace out the square wave as pictured.



1. Adjust the vertical and horizontal position controls so the beam is at the far left of the CRT face. (Point "A" of our drawing.)
   (If using a PS163,
   A. Push vector A & B inputs
   B. Use two vertical "trace button" controls.)

2. Now, using the controls noted on the the square wave pictured, trace out the same square wave on your scope.

You have just manually changed the voltages on the horizontal and vertical deflection plates to sweep the electron beam across the CRT face at a frequency of about 1/10Hz. (Depending on how long it took you to trace the square wave.)

An oscilloscope changes the horizontal and vertical deflection plate voltages, as you just did, but the voltage changes are made automatically, at the rate of the incoming signal so we can display wave-forms at much higher frequencies.

Take a minute now to familiarize yourself with these controls.

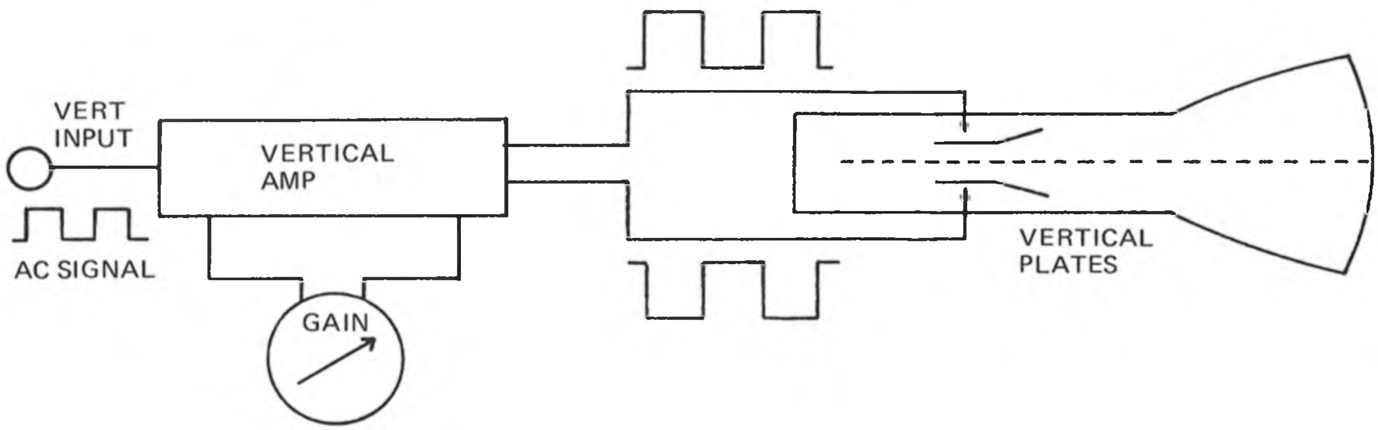
Then we'll see how these voltage changes are made automatically.

THE TOTAL SYSTEM THEORY

Now we have a trace that we can manually adjust. Other components are needed, however, to complete this system and make it automatic.

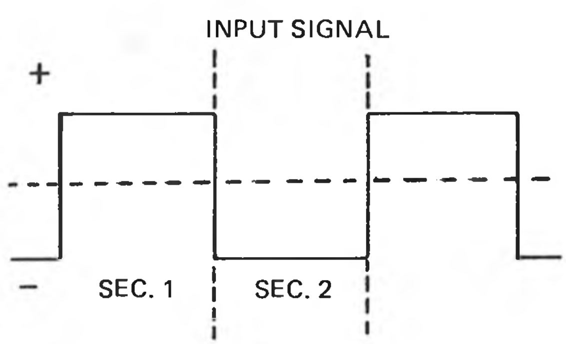
THE VERTICAL SECTION

A vertical amplifier. This amplifies the incoming signal to provide sufficient signal level for beam movement. This amplifier is calibrated and controlled by the front panel "GAIN" control. This is your voltage setting.

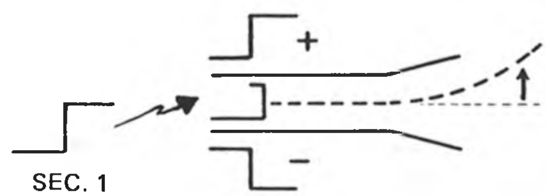


Example . . .

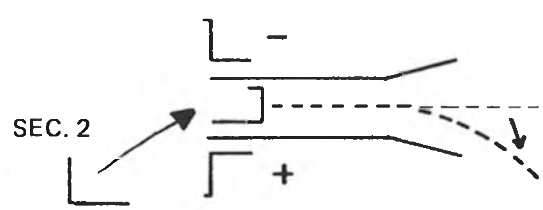
Let's divide this 1Hz AC signal into 2 sections and demonstrate the effect on the scope beam.



The first half second, section 1 of the input signal charges the top plate positively and the bottom plate negatively.



The negative electron beam is attracted to the top plate and repelled by the bottom plate — bending the beam up.



Section 2 of the input signal charges the top plate negative and the bottom plate positive. The beam is attracted to the bottom and bends that way.

The plates charge at the frequency of the signal. If the input was a 1KHz square wave, the plates would change positive, then negative, 1000 times a second. The beam would then move up and down 1000 times a second.

The Tech-Rep will demonstrate this on a 1Hz signal.

The beam is actually bending up and down at the rate of 1 cycle per second.

Now let's measure a high frequency signal.

PS29 MINUTE MAN SET-UP

1. Push the vector button
2. Center the dot trace
3. Set the varispeed control fully counter-clockwise.
4. Connect the probe to the 10KHz test point on the demonstrator.
5. Adjust the gain control as required to get about 4 divisions of deflection.

   You should get a straight vertical line.

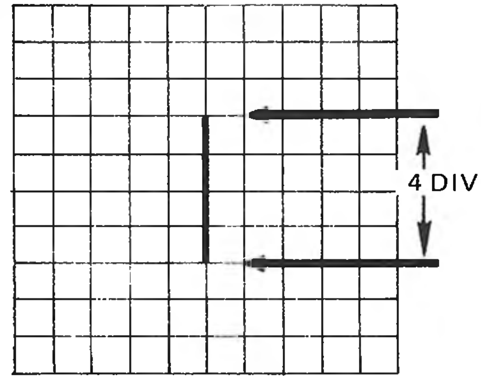
PS163 SET-UP

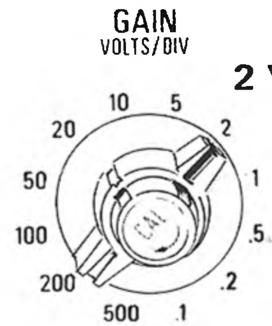
1. Simply use set-up from previous demonstration, with "vector" button depressed.
2. Connect probe to 10KHz test points.
3. Adjust gain control for 4 divisions of deflection.

If this demonstrator signal is AC, why does it look like it's standing still? It is moving, but it is moving up and down at 10KHz or cycles per second. Therefore, we have a blurred image that looks like it's standing still.

Now here is one of the most important features of a scope.

MEASURING PEAK - TO - PEAK VOLTAGE





2 Volts / Div.

EXAMPLE . . .

Count the number of divisions the signal deflects. This example is deflecting 4 divisions total.

Now check your gain setting. This example setting is 2 volts per division.

Now multiply these two numbers.

(Number of divisions) X (Volts per division) = V P-P.

OUR EXAMPLE:

(4 div.) X (2 volts/div.) = 8 volts P-P.

Measuring peak-to-peak voltage is a major benefit of a scope.

Now measure the peak-to-peak voltage of the waveform on your scope.

SUMMARY AND FEATURES OF THE VERTICAL SECTION

The vertical input is connected to the vertical deflection plates, through the vertical amplifier.

The vertical deflection plates change at the rate of the incoming signal, which moves the beam "up and down" at the same rate of the incoming signal.

The gain control adjusts the gain of the vertical amplifier and thus determines the vertical deflection of the waveform.

Because the "gain" control is calibrated in "volts per division," you can make peak-to-peak measurements directly from the scope.

IMPORTANT NOTE:

All Sencore scopes will measure 5000V peak-to-peak using the supplied probe — others go to only 600V. This is a Sencore exclusive that:

1. Gives you almost 10X the measuring capabilities.
2. Protects you against costly downtime.

THIS IS OUR VERTICAL SECTION

So far — we have seen that a scope will measure the peak-to-peak voltage of any signal.

AN OBVIOUS QUESTION THEN BECOMES . . .

WHY NOT JUST USE A PEAK-TO-PEAK METER?

Because meters only give us one dimension of measurement . . . the voltage.

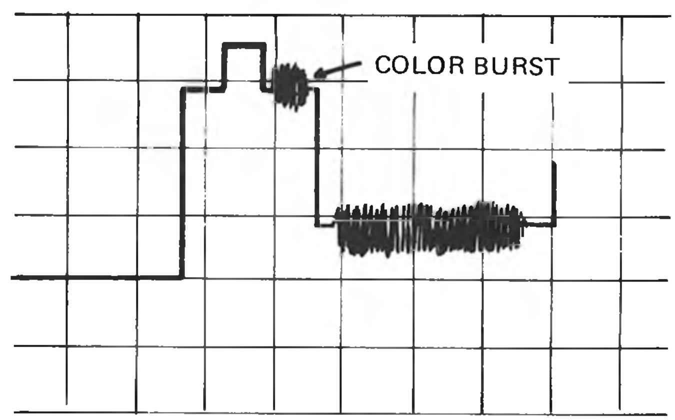
It does not give us a specific time relationship which is required in many applications.

EXAMPLES:

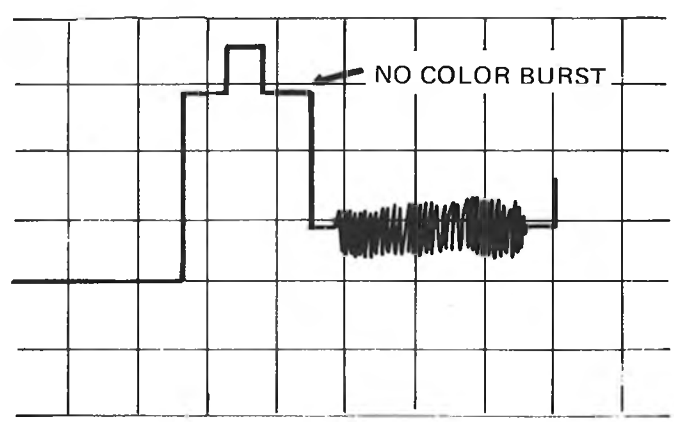
In TV, the color burst can be missing from the composite video waveform.

A meter will readout the same on both signals.

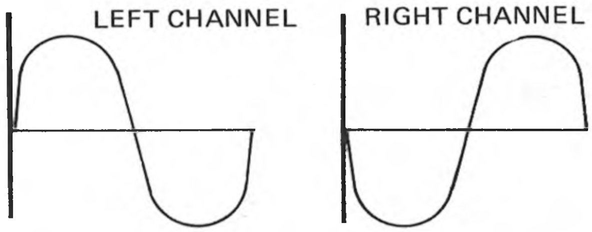
A scope will show you that the color burst is not present on the waveform . . .



METER WILL READ THE SAME



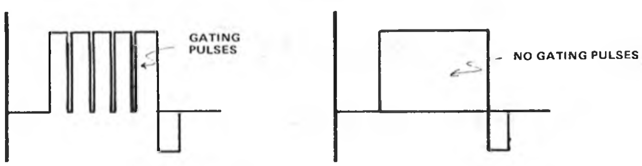
In Stereo applications . . .



THESE TWO SIGNALS
ARE OUT OF PHASE

Meter: Will measure both signals the same.
Scope: Will show you that these signals are the reverse of each other for the same time period.

In digital circuits . . .



Meter: Same measurements.
Scope: Will show you that gating pulses are not present.

So you see — the time display capabilities of a scope are very important.

So let's look at the 2nd dimension a scope displays.

TIME

The horizontal or time control is known as the sweep control.

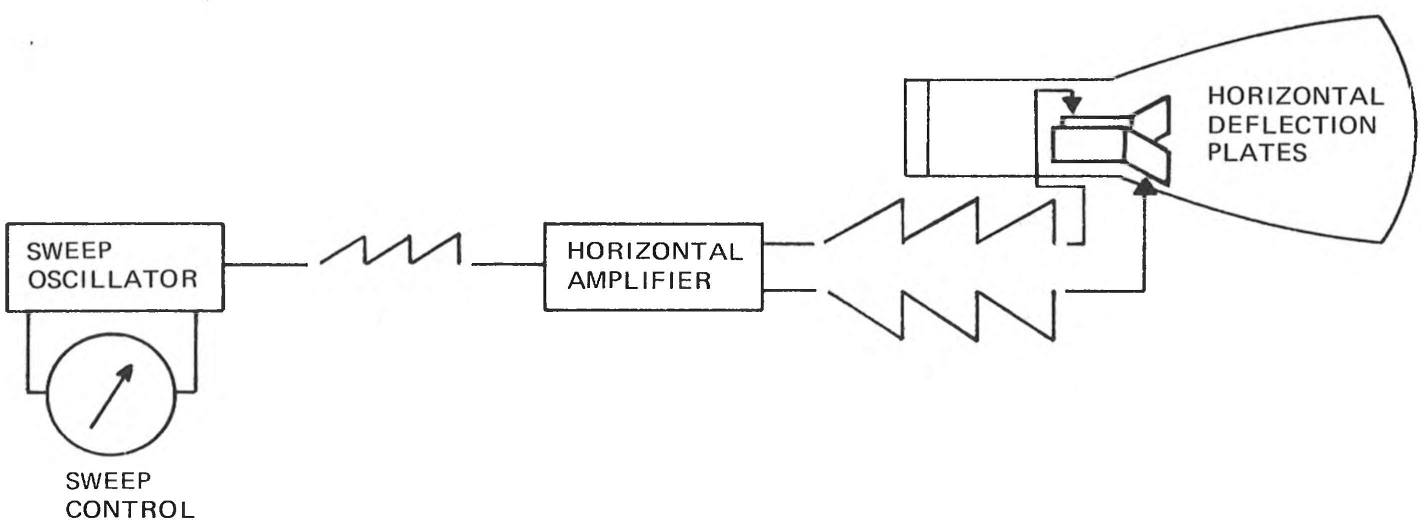
First, let's look at the circuitry behind it.

The vertical deflection plates changed at the rate of the input signal. On the other hand, the horizontal sweep section is independent of the input signal, and gives us consistent pre-set sweep.

THE THREE MAJOR ELEMENTS:

The sweep oscillator, the horizontal amplifier, and the horizontal deflection plates. The block diagram looks like this:

BLOCK DIAGRAM FOR RECURRENT SWEEP SCOPE



Here's how it works . . .

The sweep oscillator generates a fixed frequency signal. The front panel sweep control selects the frequency at which the horizontal oscillator runs.

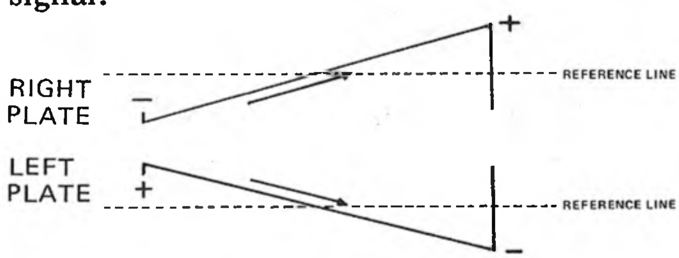
The oscillator generates a ramp waveform.

SWEEP OSCILLATOR OUTPUT

The "Horizontal Amplifier" provides sufficient signal strength to deflect the electron beam.

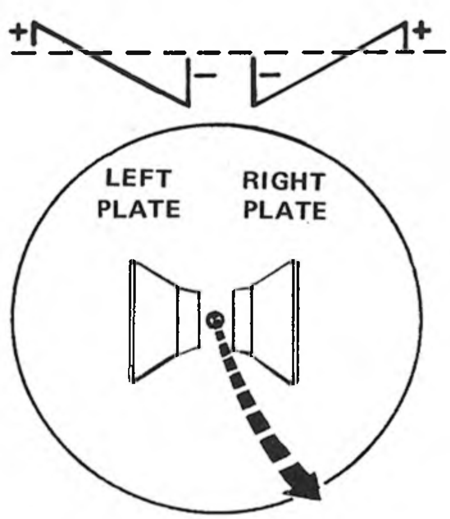
This signal is then fed on to the horizontal deflection plates.

Let's look at one cycle of the ramp signal.



At the beginning of the ramp, the left plate is positive, the right plate is negative. The beam is attracted to the left side.

As the ramp increases, the right plate becomes more positive, attracting the electron beam.



As the ramp crosses the reference line, both plates are neutral — the beam is centered.

As the ramp voltage continues to increase, the right plate becomes more positive and the beam continues to move all the way to the right side of the scope.

WHEN THE ELECTRON BEAM REACHES THE RIGHT SIDE, TWO THINGS HAPPEN:

1. The trace returns to the left side of the CRT very quickly due to the fast voltage drop.

2. The CRT is blanked during retrace, just like in a TV receiver, so you can't see the retrace lines.

Then the sweep starts all over again.

Let's try it on the scope.

1. Disconnect the probe from the test point.

2. Turn the varispeed control fully counter-clockwise to the 1Hz position.
3. PS29: Push the 3.58MHz varispeed button.
   PS163: Push the channel A, vertical input.

You should now have a single dot moving across the screen at the rate of 1 cycle per sec, from left to right.

There is no input signal, so there is no vertical deflection.

Now let's double the rate of the sweep oscillator signal by switching up to the 50mSec/Div. position on the varispeed control.

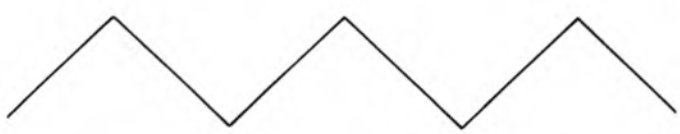
Our horizontal oscillator is now doubled in frequency, which doubles the speed of the trace.

We are now getting two full sweeps of the scope face per second.

This is how the horizontal section sweeps the electronic beam.

NOW THE TECH - REP IS GOING TO DEMONSTRATE HOW THE HORIZONTAL AND VERTICAL WORK TOGETHER USING A ONE Hz TRIANGULAR WAVE.

1. The beam is sweeping horizontally across the scope face at the rate of one cycle a second.
2. The beam is deflecting up, then down, as the input voltage varies.
3. When you put them together you get a triangular wave.



TRIANGULAR WAVE

MEASURING FREQUENCY
(All Sencore Scopes)

1. Move the probe to the 100KHz test point on the demo.
2. Push the 3.58MHz/Varispeed button. (Skip this step if using the PS163.)
3. Adjust "vertical gain" control for approximately 6 divisions of deflection.
4. Adjust the "varispeed," or timebase control until you have one full cycle on the scope screen.

The timebase control should be at the 1uSec/div. or 100KHz setting.

Notice that Sencore's timebase controls are calibrated in both time/div. and frequency.

Most scopes have only time/div. This makes it easier to determine the frequency of a signal.

The scope is now sweeping at 100 thousand cycles per second, which is the rate of the input signal.

HERE'S HOW YOU DETERMINE FREQUENCY.

There are several ways to measure frequency using an oscilloscope.

This first method is one of the fastest.

1. Set the Sweep control on PS29 or PS163 to a frequency calibrated sweep setting, that shows one complete cycle, or more, on the CRT.
(i.e. 1Hz, 10Hz, 100Hz, etc.)
2. Count the number of cycles in 10cm.
3. Multiply the number of cycles in 10cm by the sweep frequency as shown on the scope.

Example:

1. Connect the probe to the 100KHz test point.
2. Select the 100KHz sweep speed.
3. Count the number of cycles in 10cm. (In this case there is one.)
4. Multiply (1 cycle)X(100KHz) = 100KHz.

1. Now — keep the probe on the 100KHz test point.
2. Move the sweep setting to the next frequency calibrated sweep speed, (10KHz.)

3. Count the number of cycles in 10cm (should be 10.)

4. (10 cycles) X (10KHz) = 100KHz.

Next we'll show you a more complicated method — but also more accurate.

Count the number of divisions one cycle of the signal covers.

Multiply the number of divisions by the time per division on the varispeed setting.

Divide this into 1.

Here is the Frequency Formula . . .

$$\text{Frequency} = \frac{1}{(\text{No. of div. for 1 cycle})X(\text{time per div.})}$$

This time/frequency conversion guide will prove helpful in calculating frequency.

TIME FREQUENCY CONVERSION TABLE

Time/Div. Setting	Scope Sweep Rate
1uS	100KHz
2uS	50KHz
5uS	20KHz
10uS	10KHz

DECIMAL EQUIVALENT	SCIENTIFIC NOTATION
.000000001 sec	10^{-9} = 1 nanosec. = 1ns
.000001 sec	10^{-6} = 1 microsec. = 1us
.001 sec	10^{-3} = 1 millisecond = 1mS

Using our time/frequency guide, we can drop the numbers in place for our example.

First we'll use scientific notation:

Number of divisions = 10

Time per division = 1uSec. = 10^{-6} sec.

So the equation looks like this . . .

$$\frac{1}{(\text{10 div. for 1 cycle})X(1(10^{-6})\text{ sec/div.})} = \text{Frequency}$$

$$\frac{1}{(10\,(10^{-6})} = \frac{1}{10^{-5}} = 10^{5} = 100\,(10^{3}) = 100\text{KHz}$$

You can also work this problem using decimal notation.

$$\frac{1}{(\text{10 div. per cycle})X(.000001\text{ sec/div.})} = \text{Frequency} =$$

$$\frac{1}{.00001} = 100{,}000. = 100{,}000\text{Hz} = 100\text{KHz}$$

NOW —

1. Move the probe to the 10KHz test point.

2. Set the scope for a one cycle display.

3. Now calculate the frequency using any procedure above.

   It should equal 10,000.

TIMEBASE OR "VARISPEED" CONTROL.

How do you set up the "Varispeed" control for a particular frequency?

Usually, you simply connect to your test point and adjust the varispeed control until the proper number of waveforms appear.

However, this can be misleading if the waveform doesn't look like it's supposed to, because we never know for sure whether it's us, the scope, or actually the waveform. So we need to know the proper settings.

HERE'S HOW —

1. Our goal is to display 2 complete cycles of a waveform.

2. Here's your General Rule. To display 2 cycles of a waveform, the sweep frequency of the scope should be ½ the signal frequency.

EXAMPLE: 2KHz waveform

Sweep frequency should be 1KHz. So we want 1KHz sweep on the scope.

How do we know what setting is 1KHz on the varispeed control?

3. Use this formula —

$$\text{Time/Div. setting} = \frac{1}{10\ (\text{sweep frequency})}$$

For our example, the formula looks like this . . . .

$$\text{Time/Div. setting} = \frac{1}{10(1\text{KHz})} = \frac{1}{10\ (10^{-3})} =$$

$$\frac{1}{10^{4}} = 10^{-4} = .1\ (10^{-3}) = .1\ \text{millisec/div.}$$

This may look confusing . . . but, Sencore Scopes help you out by listing the frequency as well as the time/div., so you can dial right to your desired frequency.

This is another Sencore exclusive.

For practice, calculate the "Varispeed" control setting for a 100KHz signal. Then check it by doing it on the scope.

Now that we know how to display and measure frequency, our next big question is . . . .

What is Frequency Response?

Frequency Response is normally called bandwidth.

Bandwidth is normally expressed as the range of frequencies over which the vertical amplifiers of a scope will operate without distorting.

EXAMPLE: DC to 10MHz

Basically, a scope with this bandwidth will display any signal from DC to 10MHz, without distorting the waveform.

If you tried to measure a signal that was faster than 10MHz, the trace would be distorted, in some way, and be useless for analyzing.

What frequency response should a scope have?

Depends on the applications.

Here are some examples:	Suggested Bandwidth:
RADIO WORK	DC to 40,000 Hertz
TV SERVICE	30Hz to 8MHz
DESIGN	DC to 100MHz

Here are 2 important specifications for your scope . . . .

1. A scope must have a wide enough <u>true bandwidth</u> for your application so the waveforms will not distort . . . .

PLUS

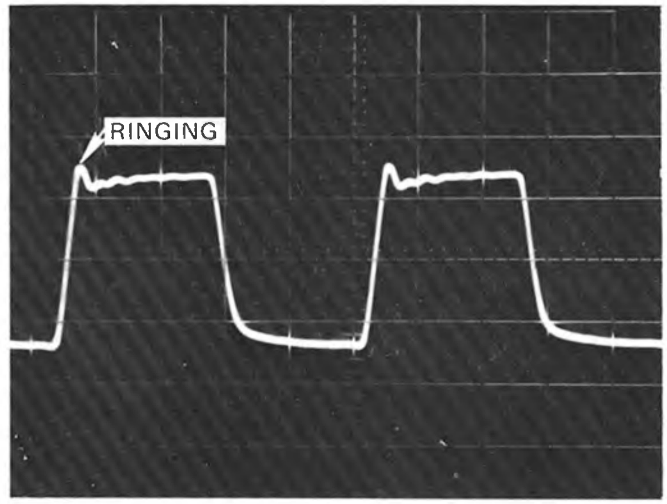
The scope must also . . . .

2. Have a fast enough sweep speed.

WHAT DO WE MEAN, TRUE BANDWIDTH?

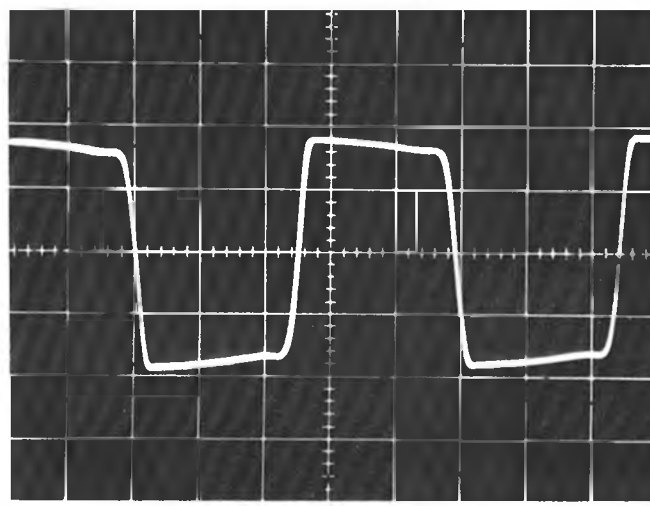
True bandwidth is the frequency response a scope has without peaking coils.

Peaking coils will extend a scope's bandwidth, but will also distort the waveform with ringing or overshoot.



This is what ringing or overshoot looks like as produced by a competitive scope that uses peaking coils.

Many times the circuit under test is ringing. If you're scope uses peaking coils, you'll never know if the ringing is coming from the circuit or the scope!



This is a similar 1MHz waveform on the PS29. Notice . . . no ringing or overshoot. The PS29 does not use peaking coils.

Now try it yourself.

Without any help from us —

1. Connect the probe to the 100KHz test point on the demo.

2. Now dial in two waveforms on the scope.

Notice the clean waveforms without overshoot or ringing.

Before buying any scope, always check to see peaking coils are NOT used —

Now that we have a true bandwidth —

The second important question is —

IS THE SWEEP SPEED FAST ENOUGH?

Again, this depends on the frequencies you are going to measure —

However,

For best observations of a waveform, most people prefer from 2 to 5 cycles of the waveform displayed.

NOTE: All service literature shows 2 complete cycles.

EXAMPLE:

WAVEFORM FREQUENCY

4KHz
8KHz
3.58MHz

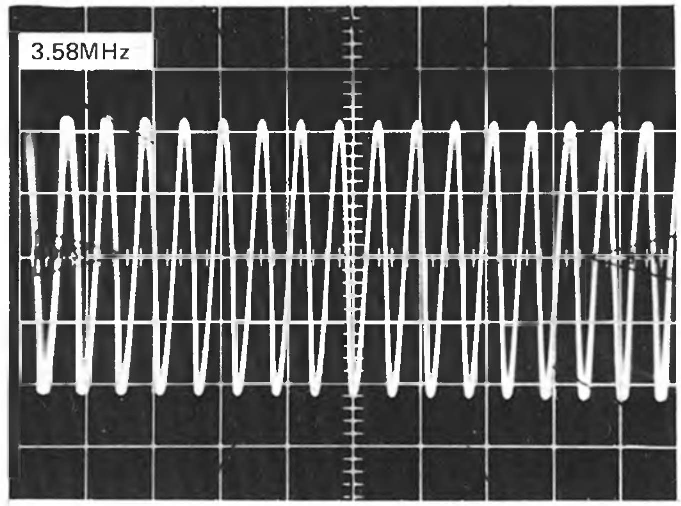
SCOPE SWEEP FREQUENCY	SCOPE SETTING FOR TWO CYCLES
2KHz	50uS
4KHz	25uS
1.79MHz	.05uS

What if the sweep frequency is not fast enough?

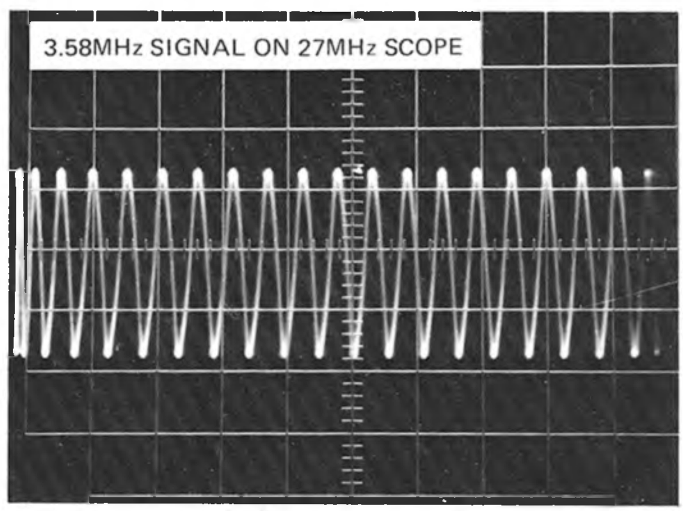
Your scope becomes pretty useless.

This is a 3.58MHz color oscillator set at the fastest sweep rate on an imported triggered scope.

There are too many cycles to analyze.

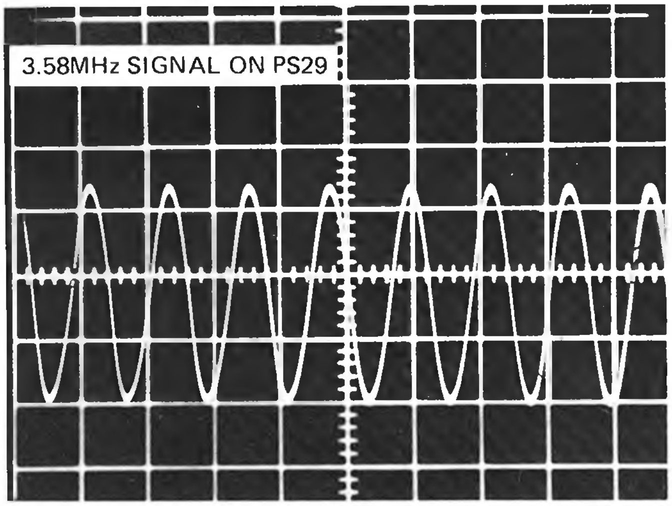


ALSO BEWARE OF WIDE BANDWIDTH CLAIMS . . . .



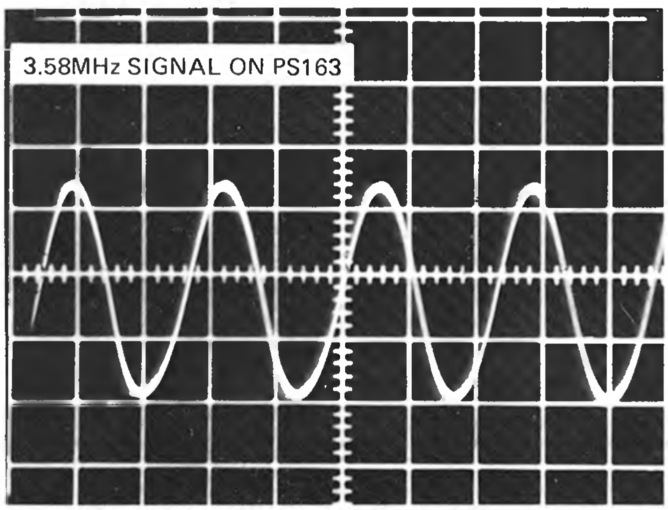
This competitive scope claims 27MHz bandwidth. This is a 3.58MHz signal at the fastest sweep setting on the sweep control.

It is virtually useless. All that bandwidth doesn't mean a thing without a fast enough sweep rate.



Here's the same 3.58MHz signal on the PS29.

Now this is useful.



And here is the same signal on a PS163.

If you want to display 2 cycles of a 3.58MHz waveform, the scope sweep setting should be at least 1.79MHz or .05uSec/div.

Using the 5X expand, the PS29 will sweep up to 2.5MHz a second.

The PS163 will sweep up to 5MHz a second.

What do you do with a scope on your bench that sweeps at only 100KHz, or even 200KHz?

It's going to be pretty useless — that's for sure.

NOW TRY IT YOURSELF

1. Connect the probe to the 3.58MHz test point on the demo.

2. Push the "Varispeed" button. (Skip this step on the PS163.)

3. Select the correct sweep speed (should be 3.58MHz).

   If you want to see only 2 cycles . . . .

1. — Push the 5X button on the Minute Man. Adjust "Cal" sweep control.
   — Pull the "Horizontal Position" control on the PS163. Adjust "Cal" sweep control.

This increases the sweep speed by 5 times for an expanded look.

Now unlock the 5X expand. Reset "Cal" control fully clockwise.

2. Now step the sweep control down to 1uSec per div. or 100KHz.

This is what you'll see on most OTHER service scopes.

Can you troubleshoot with this?

You can rely on Sencore Scopes to supply you with true bandwidth and fast enough sweep speeds to get the job done every time.

TRIGGERING

Let's go back for a minute.

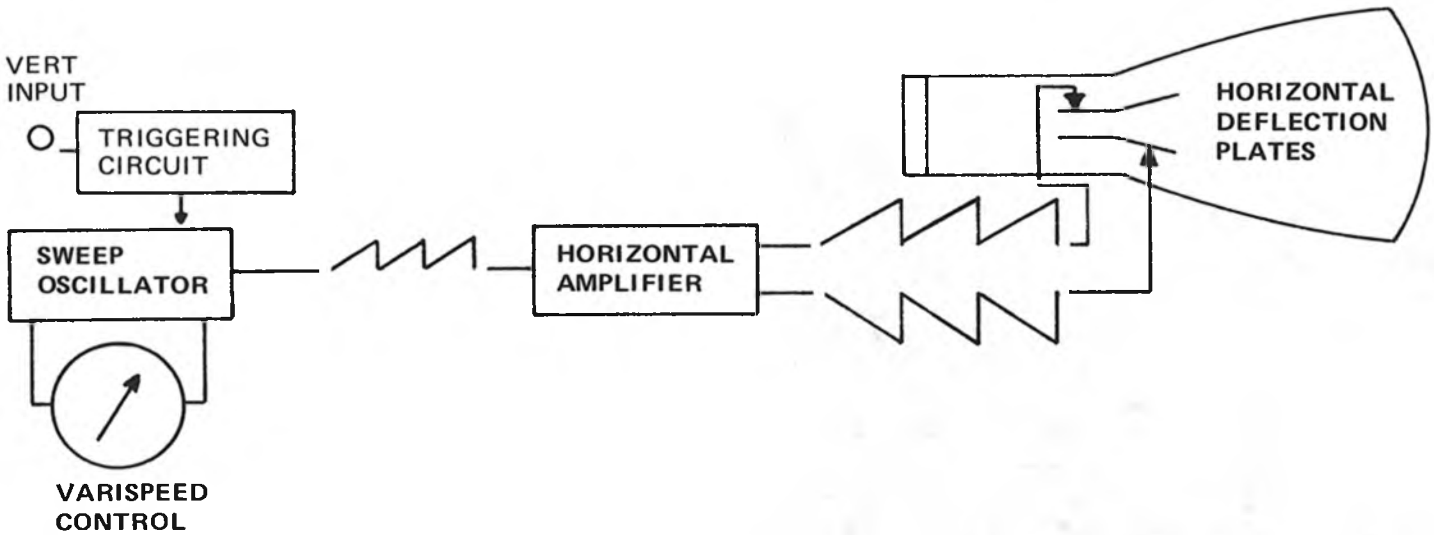
The sweep circuit that we described before was for semi-triggered scope, like the Sencore PS148.

The key difference between a semi-triggered and an automatic triggered scope is in the "sweep oscillator."

The sweep oscillator for a semi-triggered scope will run continuously.

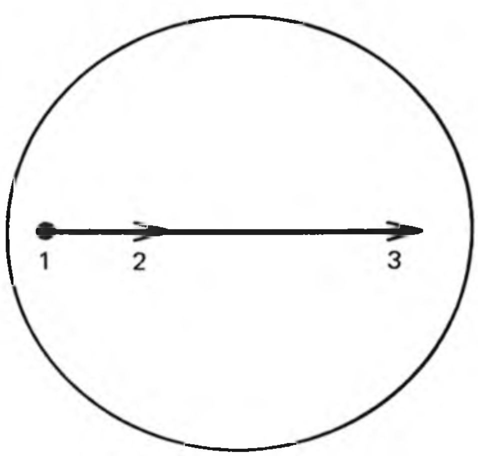
If you want to sync a signal in, you must adjust the sweep frequency of the scope until it locks in with the input frequency.

Our Tech-Rep will demonstrate this now on the PS148.



AUTO - TRIGGERING

The Auto-Triggering block diagram has one added element that makes all the difference . . . the "Trigger Circuit."



1. The Trigger Circuit holds the sweep oscillator off until a signal is received from the vertical input. The electron beam is stationary.
2. When a signal arrives from the vertical input, the sweep oscillator sweeps the electron beam one time across the CRT face.
3. The beam then returns to the left side of the CRT face and waits for the next input pulse.

BENEFITS OF GENERAL LINE AUTO-TRIGGERED SCOPES

— extremely stable triggering
— exacting frequency measurements are possible

DISADVANTAGES OF GENERAL LINE AUTO-TRIGGERED SCOPES

— sometimes complex to operate due to sync level controls, triggering modes, etc.

But Sencore has eliminated all the disadvantages of triggered scopes in the PS29 Minute Man.

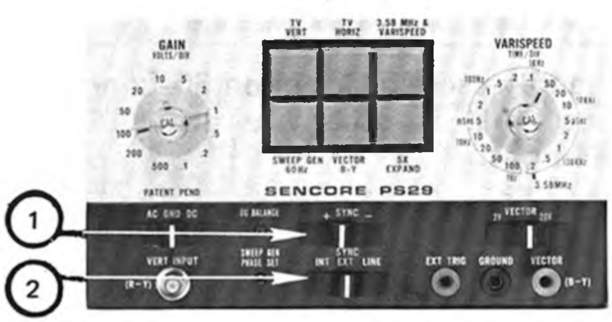
The Minute Man is completely pre-set and pre-synced. There are only two controls you need to know.

SYNC POLARITY AND SYNC SOURCE

The PS29 Minute Man and the PS163 are automatic triggered scopes. This means . . . .

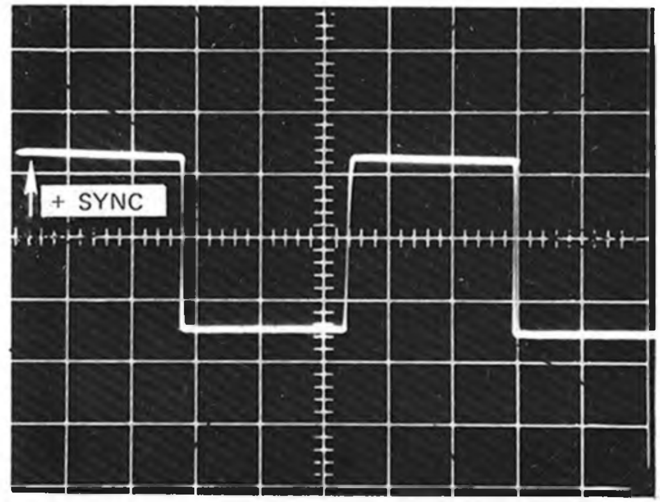
1. With the sync source switch on the internal position,
2. And the sync polarity switch in the + position,

The scope holds the electron beam on the left side of the CRT until the first positive signal enters the input.

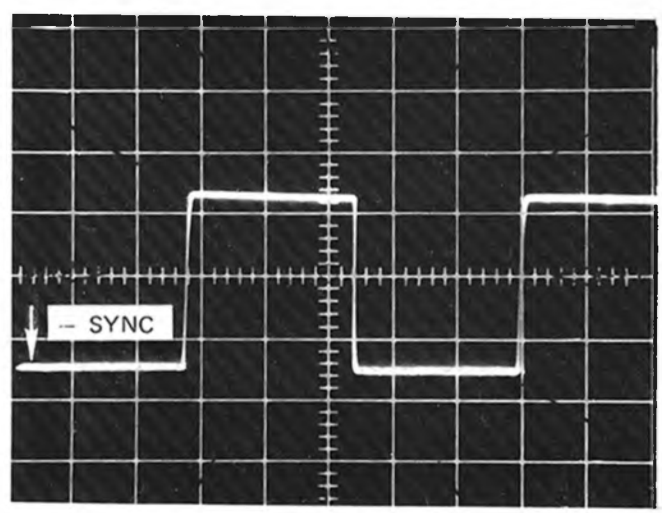


To demonstrate this, do the following—

1. Connect the probe to the 100KHz test point on the demonstrator and display two cycles on the scope.
2. The waveform should look as shown here.



3. Notice, the leading edge is positive.
4. Now switch the "Sync Polarity" control to "negative."
5. The waveform should now look like this . . . .

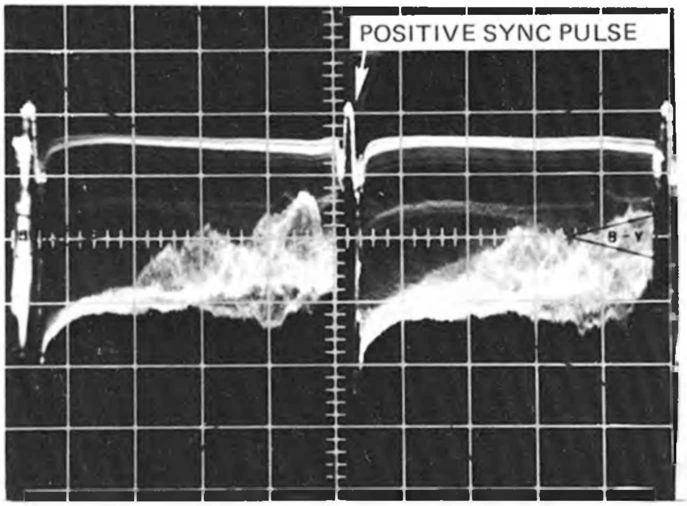


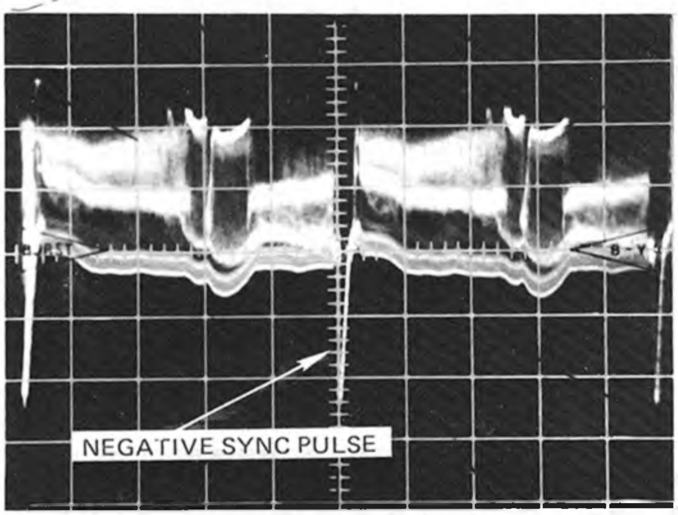
with a negative leading edge.

When do you use the "Sync Polarity" control?

Keep it in positive for most waveforms.

However, for complex waveforms, like the composite video waveform, you may have to switch.





How do you know if you are on the wrong sync polarity?

It won't sync in.

EXAMPLE:

1. Connect the probe to the simulated composite sync pulse on the demo.

2. Set the Sync Polarity switch to — polarity.

MINUTE MAN . . .
Push the TVV button

PS163 . . .
Select TVV on the timebase.

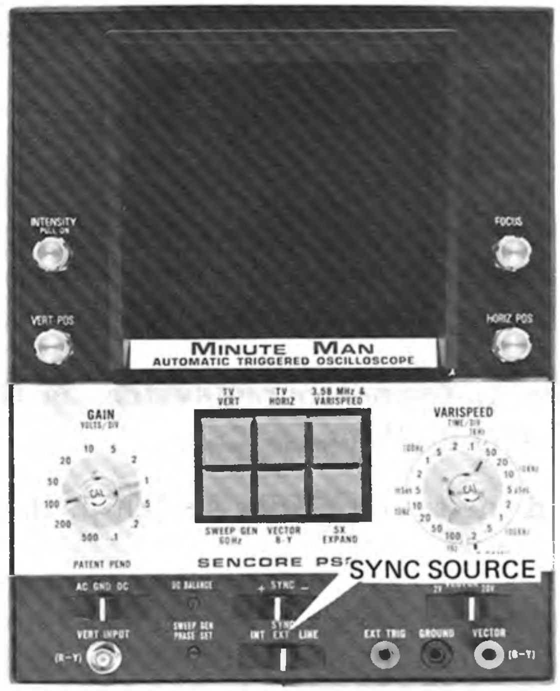
NOTICE — IT DOES NOT SYNC

Now switch to + polarity.

This signal has a positive sync pulse so . . .

IT SYNCS IN !

SYNC SOURCE CONTROL



Both the PS29 Minute Man and the PS163 have 3 sync sources.

INTERNAL: The Internal position activates the Auto-Triggering Circuit used for almost all displays. (The PS163 has an internal for A and B, depending on which input you want to trigger on.)

EXTERNAL: Requires external sync source that is connected through front panel jack.

LINE: Sweeps the horizontal @ a 60Hz rate.

Primarily used to lock in on 60Hz noise or hum, that is otherwise difficult to troubleshoot.

SWEEP SECTION SUMMARY AND KEY FEATURES

The varispeed or timebase control, selects the rate of speed the electron beam sweeps the CRT face.

The Minute Man will sweep the electron beam across the scope from 1 cycle a second (Hz) to 3.58MHz a second.

The PS163 will sweep up to 5MHz a second.

These high sweep rates allow you to measure any signal from 1 cycle per second (Hz) to 10MHz with a minimum number of cycles showing for accurate analyzing.

Sencore scopes do not use peaking coils — eliminating ringing effects — for true waveform reproduction.

Automatic-triggering, as used in the Minute Man and PS163, is the most stable triggering possible, and guarantees rock solid displays, even down to 2/10 of a volt.

The Minute Man and PS163's time base control is calibrated in frequency as well as time/div for faster measurements without calculations.

The Minute Man is both AC and DC coupled for greater measuring capabilities.

This is the conclusion of our general scope theory and operation.

Now we're ready to talk about the PS29 Minute Man's SIX VIDEO PUSHBUTTONS.

All test equipment is designed to . . .

1. Help you do a better job and . . .

2. Do it faster

This next section of the PS29 Minute Man will save hours of time off TV and video circuit troubleshooting.

THE SIX VIDEO PUSHBUTTONS

The Minute Man's 6 Video pushbuttons prepare you to display the key video waveforms with no more than a push of a button.

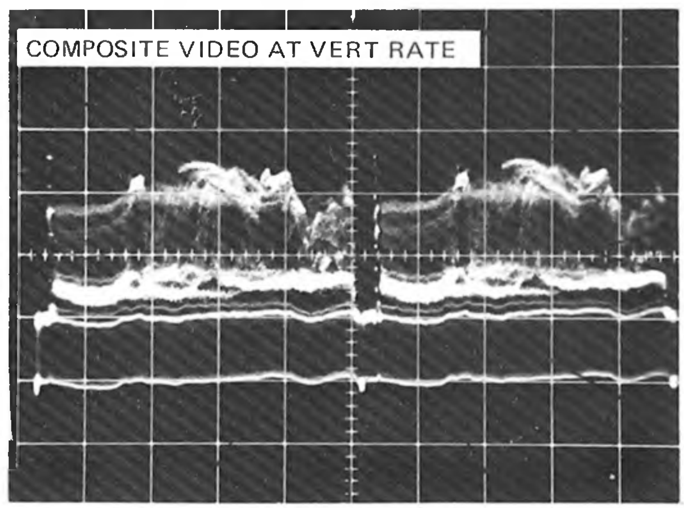
KEY WAVEFORM NO. 1
(For both PS163 and PS29)

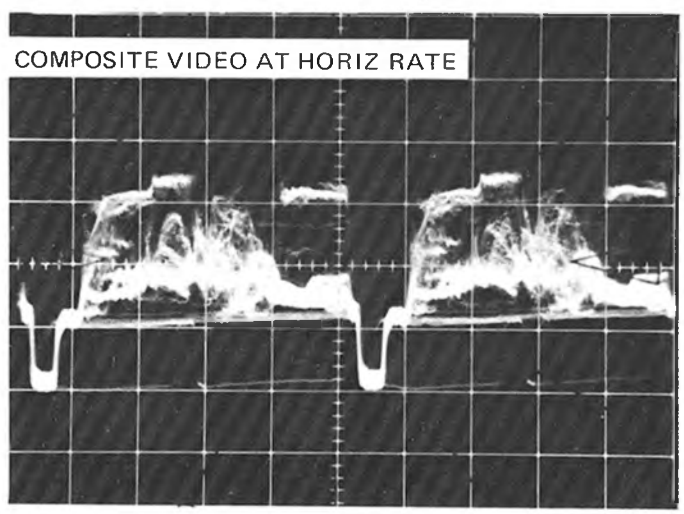
The composite video waveform will give information about several sections of a receiver at one time. (See key waveform no. 1 under Television Troubleshooting for full details.)

The composite video is a complex Waveform, consisting of two basic frequencies . . .

The TV Horizontal Sweep rate at 15,733Hz and the TV Vertical Sweep rate at 60Hz.

Here is the waveform at both frequencies . . .

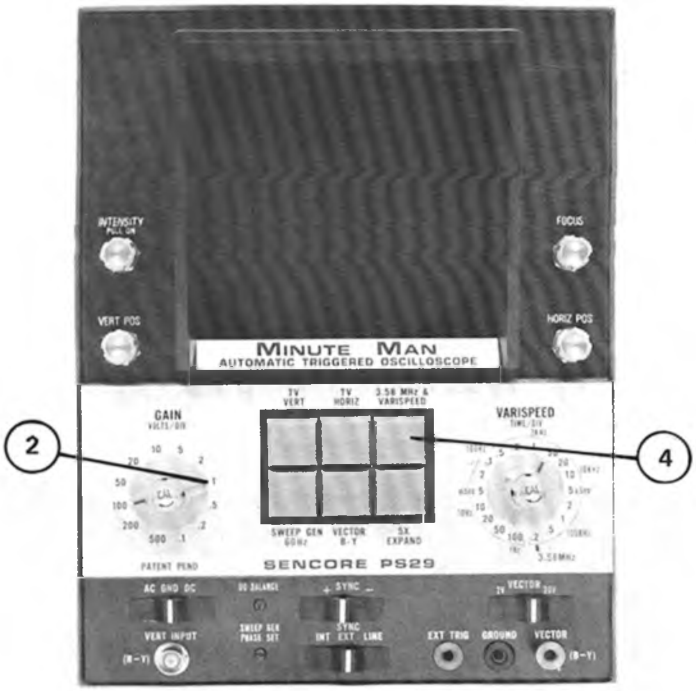




This is a very difficult waveform to display, even for an automatic triggered scope because it has two different frequencies, plus different amplitude in these signals.

First let's see how we would display this waveform with a regular scope.

Let's double check our scope set up first.



2. GAIN control at 1 volt/div.

3. TRACE is centered.

4. Push the 3.58MHz button.

Connect the probe to the composite video sync pulse (this is a common waveform picked up at the output of the sync separator of a TV set.) (Make sure to connect the ground plug to the demo common.)

Now turn your varispeed control until two waveforms lock onto the screen at the vertical rate.

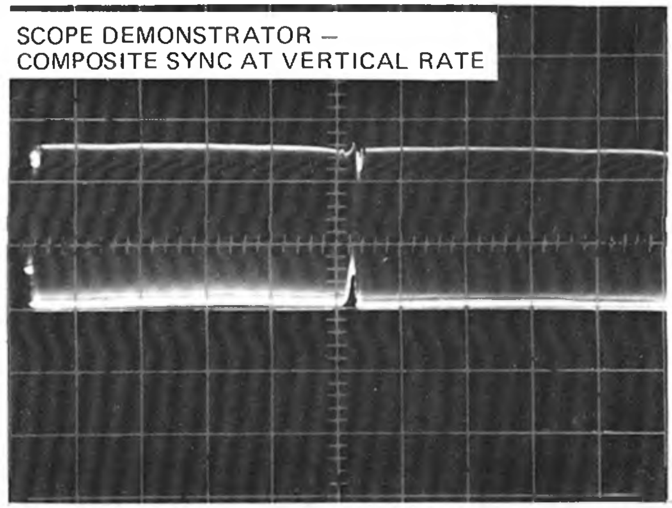
In most cases, it won't lock in.

This is the problem you'll experience, even with an automatic triggered scope.

Because of the different frequencies, the scope doesn't know what to sync on.

BUT THE MINUTE MAN ELIMINATES THIS PROBLEM . . .

PS29:
PUSH THE TV VERT BUTTON—
PS163: SELECT TVV POSITION.



IF NECESSARY . . .
— ADJUST VERT GAIN

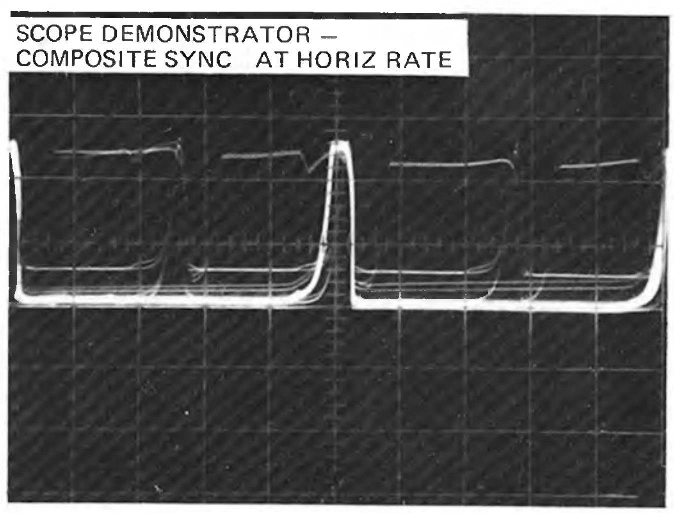
Two cycles of the composite sync signal — just like you see in the service literature.

Without
— calculating the sweep speed
— adjusting the varispeed control

All sync levels and sweep settings are pre-set.

What if you want to look at the horizontal component of this signal?
PS29:
JUST PUSH THE TV HORIZ. BUTTON—
PS163: SELECT TVH POSITION.

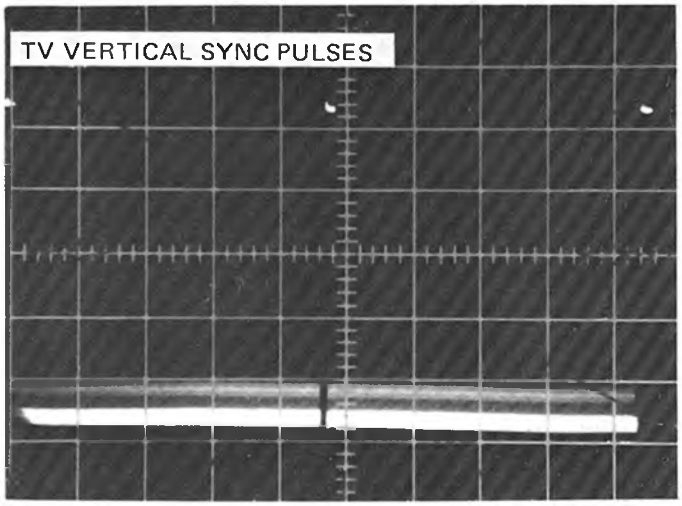
If necessary . . . adjust Vert Gain.



Bang — 2 cycles of TV Horizontal sync signals. Rock solid.

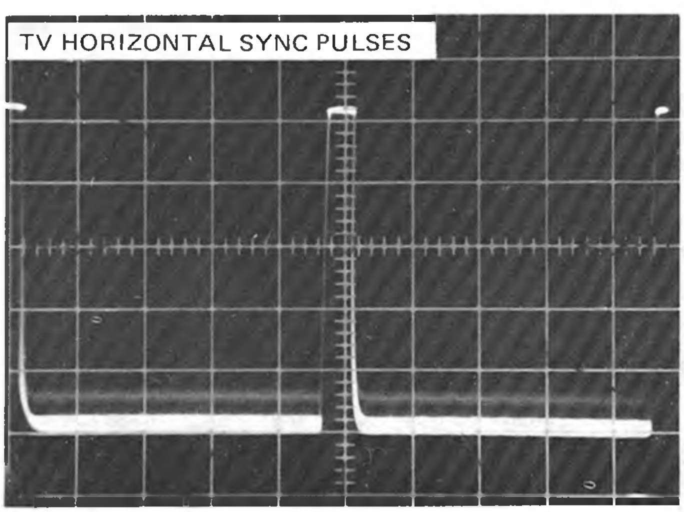
What if you want to see just the vertical sync pulses?

1. Connect the probe to the simulated TV Vert. 60Hz test point.
2. PS29: Just push TV Vert.
   PS163: Select TVV Position.



How about the simulated TV Horizontal sync pulse?

1. Connect the probe to the TVH, 15733 test point.
2. PS29: Just push TVH.
   PS163: Select TVH Position.
3. If necessary, adjust the "GAIN" control for sufficient amplitude (between 4 to 6 divisions.)

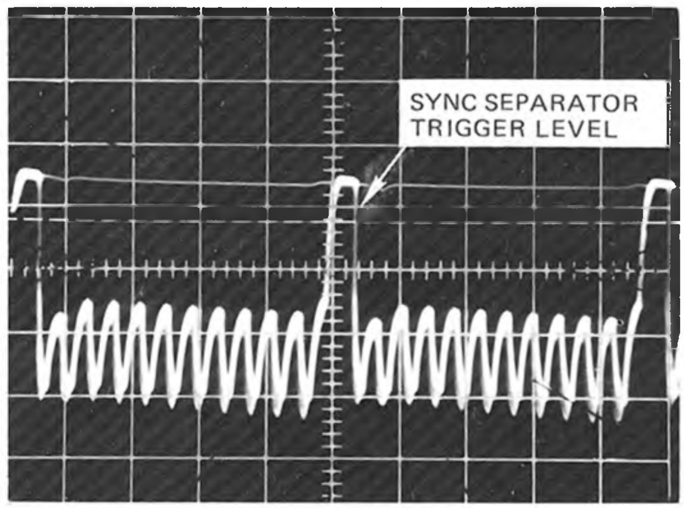


Now if we were troubleshooting, we'd simply compare the 2 cycles on the scope to the 2 cycles in the service literature.

But, how can the Minute Man buttons lock in the composite sync pulse when a regular automatic triggered scope can't?

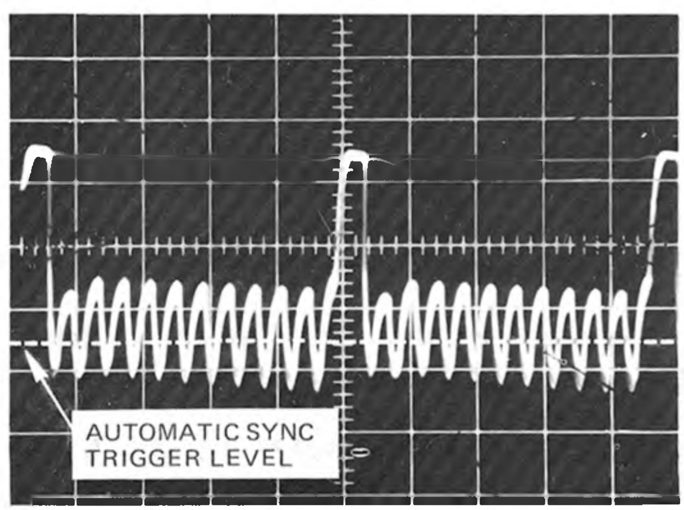
Because . . .
Both the TV Vert and TV Horiz buttons strip the sync pulses off the top of a composite signal and separate vertical from horizontal.

Then feeds these sync pulses into the triggering circuit.



This way — the trigger circuit sees only one frequency of sync pulses without any other noise.

Without a sync separator, the scope will trigger on any signal larger than 2/10 division high which could be any of these signals.



The scope is then triggering on every signal, which makes for an "unstable" waveform.

Sync separators guarantee rock solid waveforms — and you have them in the Minute Man with the push of a button.

The PS163 offers these same TVV and TVH positions, backed by sync separators, on the timebase control.

THE 5X EXPAND BUTTON (PS29 and PS163)

Scope set-up.

1. Probe on composite sync test point.

2. Push TV Vertical

3. Exactly center the middle sync pulse.

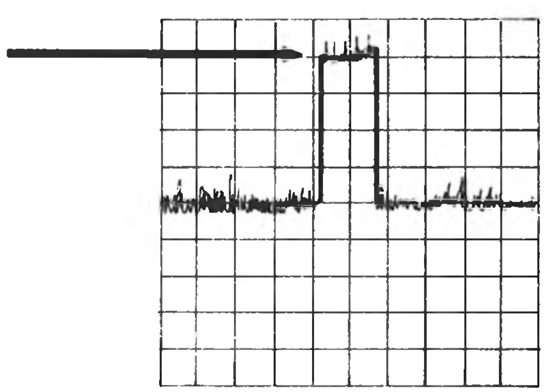
OK - notice how thin the sync pulses are?

Some times there will be information on a pulse like this that we want to see.

So, we push the 5X button on the PS29. (Pull the "Horizontal Position" control on the PS163.)

The waveform is expanded by 5 times.

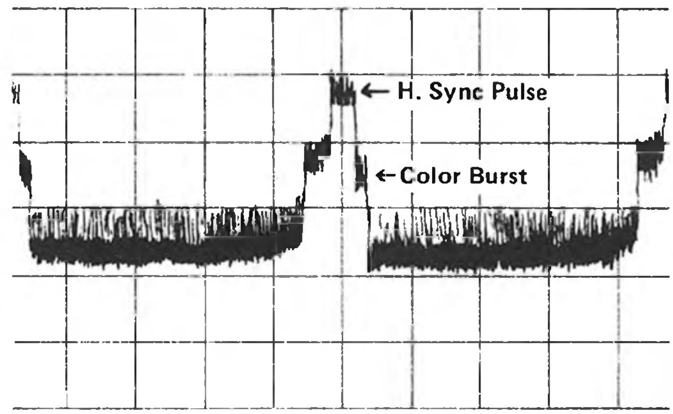
Now, look closely at the top of the sync pulse! It actually has 5 small pulses on it.



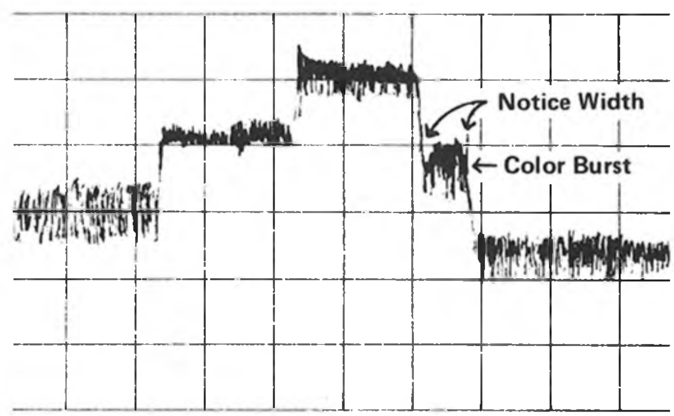
Notice that when you pushed the 5X button, the sync pulse stayed right in the middle. Most scopes must be repositioned when you push 5X. Not the Minute Man.

PRACTICAL APPLICATION OF 5X EXPAND

The color burst is on the back porch of the Horizontal sync pulse.



Composite Video
TVH Rate



Composite Video
TVH Rate With 5X Expand

It has 9 pulses. You need to expand the composite signal to see if the pulses are there.

THE 3.58MHz BUTTON (PS29)

Scope set up.

1. All switches to left.

2. GAIN control at 1 volt/div.

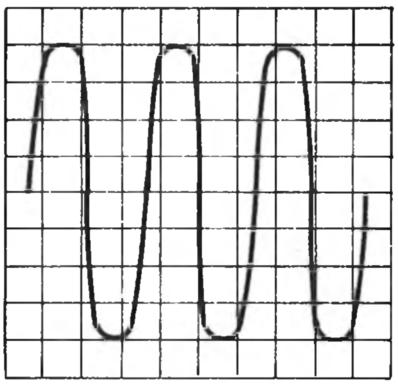
3. VARISPEED control full clockwise at 3.58MHz.

A third signal often used in troubleshooting is the 3.58MHz color oscillator waveform.

Let's get it on the scope.

1. Connect the probe to the 3.58MHz test point.

2. Just push the varispeed button.



This is the color oscillator. The Minute Man will expand this waveform so you can really troubleshoot.

THE VECTOR BUTTON

Scope set up.

1. Connect the probe to the R-Y vector jack.

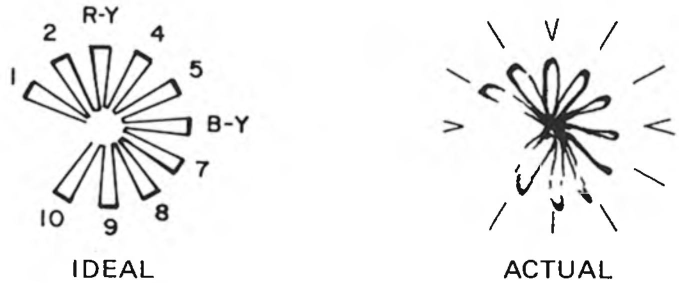
2. Connect the blue lead from scope vector input to the B-Y vector jack.

3. Push the VECTOR button. Notice the vector grid automatically lights up.

4. Unlock 5X expand button, if locked.

5. Push VECTOR switch to 2V.

You now have a simulated TV vector pattern on the scope.



This petal pattern can be extremely valuable in troubleshooting color problems. Of the scopes that have a vector option, most require —

— back end hook-up

— special adjustments

— a high level signal because they have only one sensitivity level

With the Minute Man you have —

— only 1 extra lead hook-up

— 1 button to push

— four sensitivity levels for use with virtually any signal level (2V, 2V with 5X, 20V, 20V with 5X.)

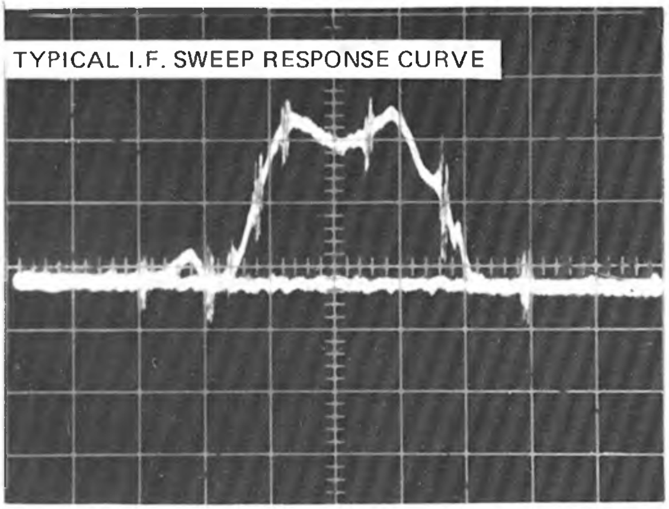
Use of the vector pattern is discussed in the TV troubleshooting section.

THE SWEEP AND MARKER BUTTON

Sweep alignment requires an oscilloscope.

TV RESPONSE CURVE OF IF SECTION

Our goal is to display the response curve as shown here.



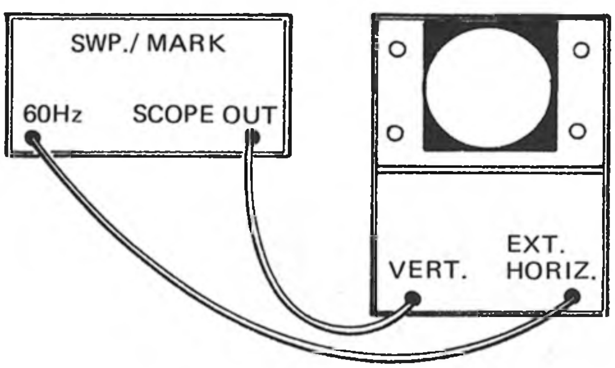
All typical sweep and marker generators sweep at the rate of 60Hz.

We want one complete cycle of the response curve, so the scope should be sweeping at 60Hz also.

Usually this requires 2 hook-ups with a scope.

1. Between "60Hz output" of sweep and marker to "Ext Horizontal sweep" of scope.

2. Between SWP/MARKER "scope output" to scope "Vertical Input."



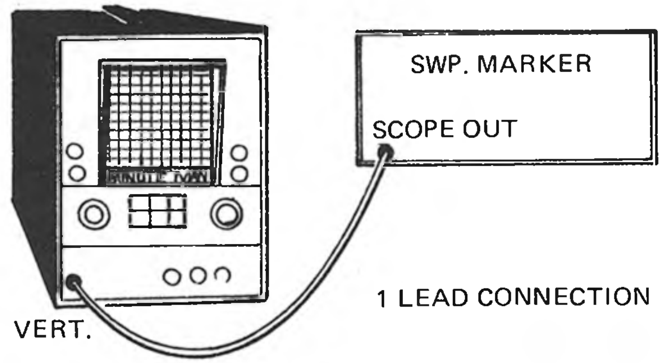
CONVENTIONAL SCOPE–SWEEP/ MARKER HOOK–UP

The Minute Man makes this much easier and more accurate.

1. Simply push the SWP GEN button.

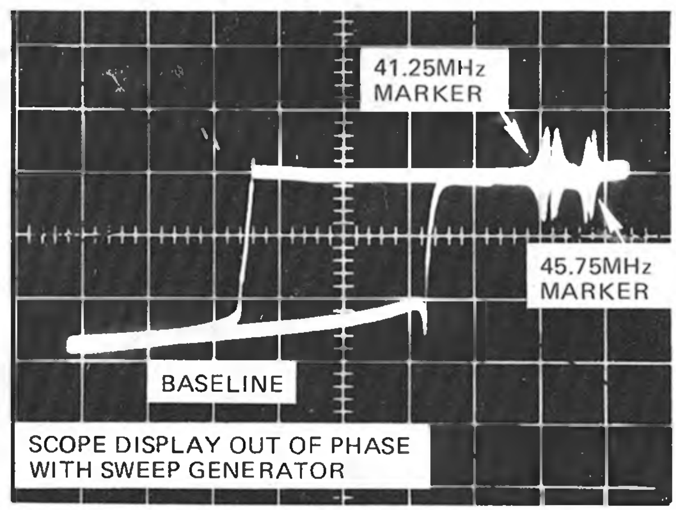
This automatically sweeps the scope at 60Hz — eliminates a cable hook-up too.

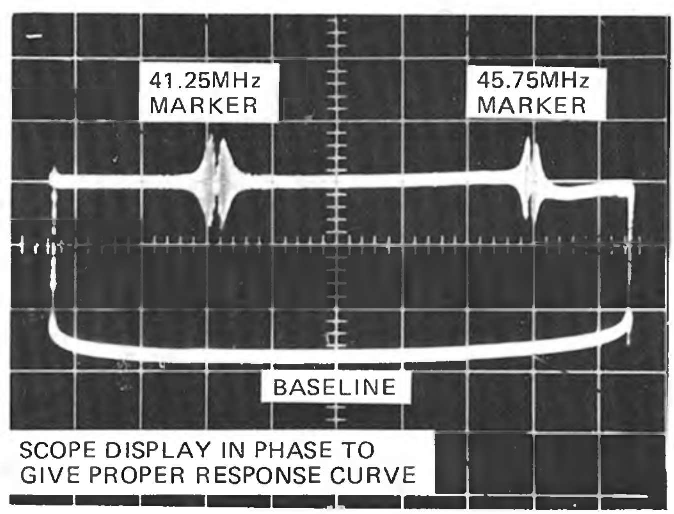
2. Then just connect the single cable from the sweep and marker to the scope vertical input.



SWEEP GEN PHASE SET . . .

This control adjusts the Minute Man's 60Hz sweep so it can be right in phase with whatever sweep and marker you use.





The Minute Man makes sweep and marker work simple and accurate.

VIDEO PUSHBUTTONS SUMMARY

The Minute Man's 6 video pushbuttons eliminate the need for numerous controls by pre-setting the sweep speed and sync levels so you just push a button for 2 complete cycles of the key video waveforms.

This saves time and increases your accuracy by . . .

— eliminating guesswork — you always know the scope is set up properly.

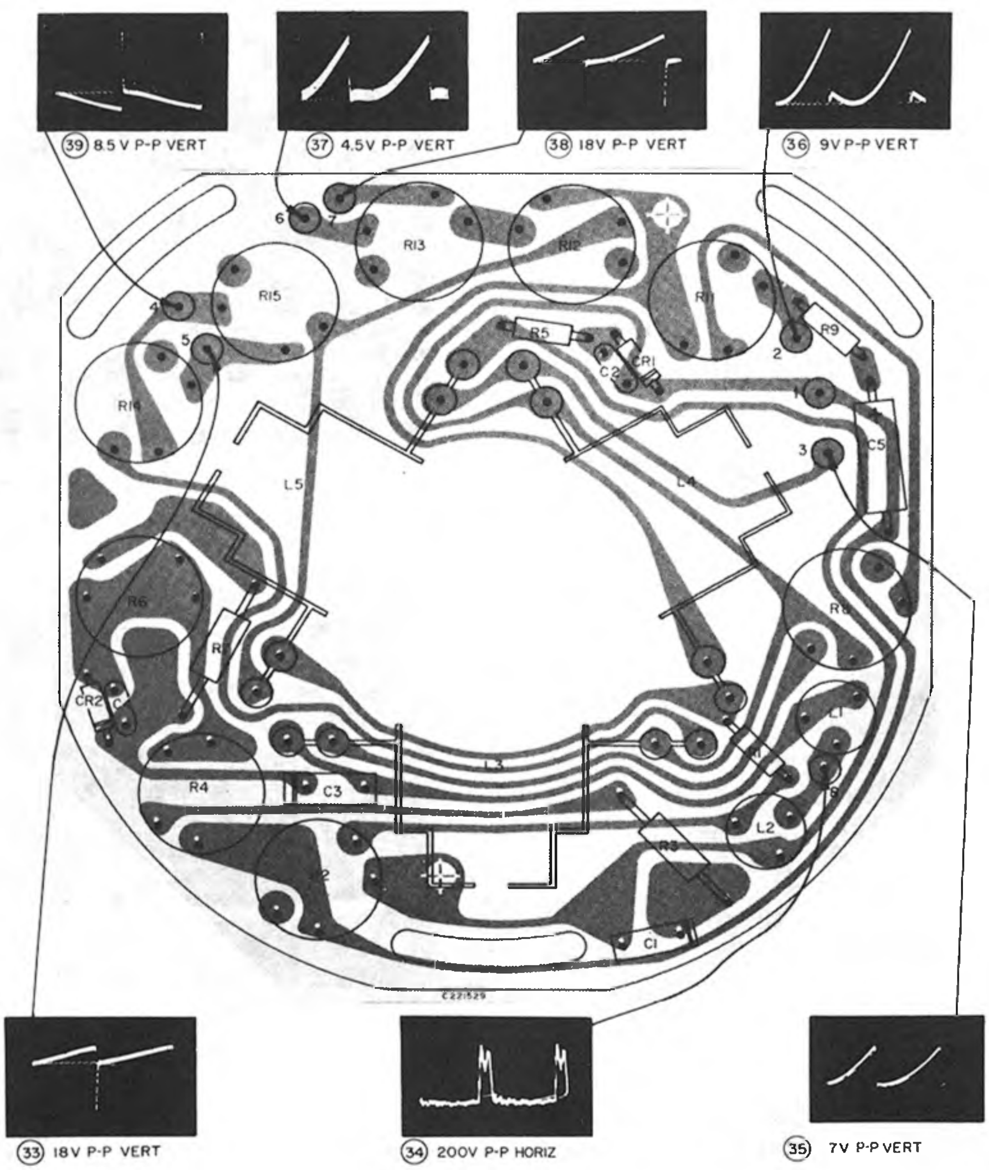
— eliminating time used to set extra controls.

— displays "rock solid" video waveforms with sync separators

It's your pre-set, pre-synced video troubleshooter.

This is a page out of "Servicing RCA for 1975." All boards are photographed with test points labelled and waveforms for each test point pictured.

NOTICE: All waveforms are either vertical or horizontal rate. To lock any one of these signals in you simply connect your probe and push one button. That's fast!



THE PS163 DUAL TRACE OSCILLOSCOPE

What is a dual trace scope?

A dual trace scope is basically two single trace scopes combined to display two different waveforms at the same time.

This is an over simplification, but from a functional standpoint, this is what a dual trace is used for. What is the major benefit of dual trace? Dual trace allows you to accurately compare two signals for time and phase relationships, plus compare amplitudes.

WHERE IS A DUAL TRACE SCOPE REQUIRED?

Many circuits . . .

— keyed AGC circuit to compare timing of the flyback pulse to the horizontal sync pulse

— Burst amplifier to compare timing of the flyback gating pulse to the transmitted burst signal.

— Horizontal sync section to compare timing of horizontal sync signal to the reference signal.

— Color phase and color killer circuits to measure phase relationships.

AUDIO

— input and output levels of any given amplifier.

— Phase relationship of Left and Right channels instereo receiver.

— amplitude comparisons of like Left and Right stages in a stereo receiver.

LOGIC

— time comparisons of gating pulses

— amplitude comparisons for "On-Off" switching circuits.

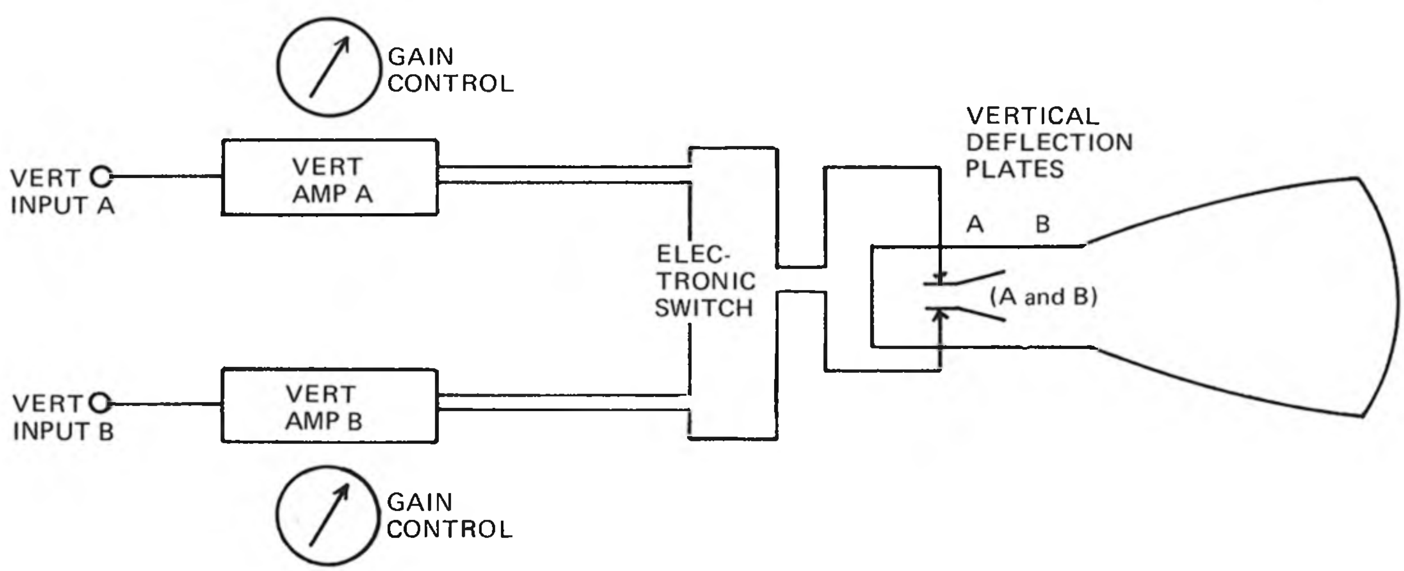
HOW DOES A DUAL TRACE SCOPE FUNCTION?

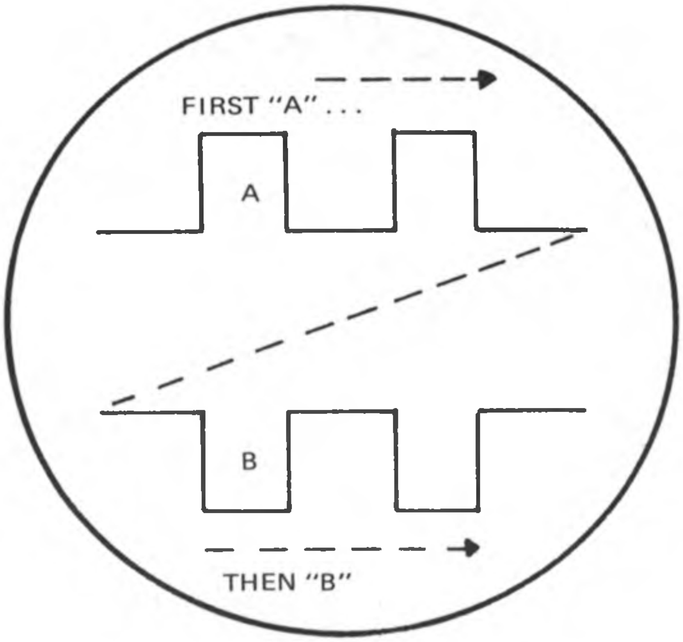
A dual trace is very similar to a single trace, with just a few additions.

1. A second vertical amp is required.

2. Now a switch is added that switches the CRT between the two amplifiers at a very fast rate.

Here is what it would look like . . .





As we look at two signals, A and B, as shown, the electron beam . . .

— sweeps one complete trace across the CRT on channel A.

— then switches down to B for one complete trace.

The beam then returns to the left side of the CRT and waits for the next input pulse.

The CRT control, sweep control and gain control are very similar to a single trace. Let's look at these controls now.

PS163 CRT CONTROL FAMILIARITY

To set up for this section of scope school, do the following:

1. Rotate all "Cal" controls fully counter clockwise.
2. Depress channel "A", vertical input.
3. Select AC coupling.
4. Depress "Auto-Triggered"
5. Depress "Int A" on horizontal sync control.
6. Rotate "Timebase" control to the 100mSec/Div position.
7. Turn the intensity control fully clockwise.
8. Turn scope on.
9. Adjust the vertical "Trace position" and "Horizontal position" control until trace is centered on screen.
10. Adjust focus control until trace is as small as possible.
11. Turn intensity control down until trace disappears. Then increase intensity until trace just reappears. (This will prevent the beam from burning the CRT phosphor.)
12. Your trace should be centered, vertically and horizontally, and sweep from left to right.

Take a minute now to familiarize yourself with these controls.

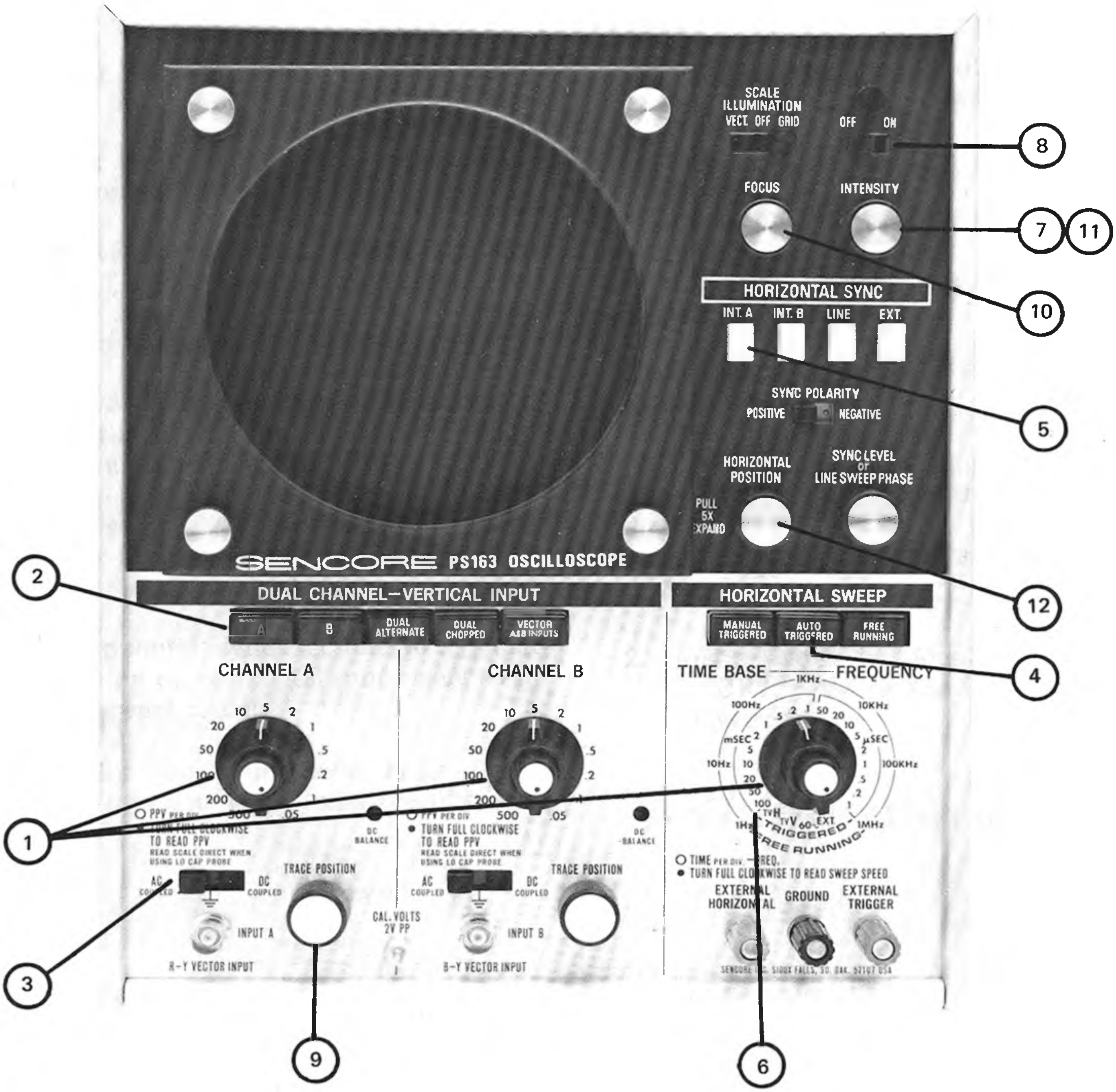
When you finish set all controls so trace is centered. (Return to page 8 following along with the PS29 section.)

THE PS163 FIVE DISPLAY MODES

To set up for this demonstration, use the set-up just completed with a centered trace.

CHANNEL A AND B

1. Connect both probes to the scope and put both probes on different 1MHz test points.
2. Select Vertical Input A.
3. Select Horizontal sync A.
4. Select "Time Base" position for display of 2 - 5 cycles.


SCALE ILLUMINATION
VECT. OFF GRID
OFF ON
FOCUS
INTENSITY
HORIZONTAL SYNC
INT. A
INT. B
LINE
EXT.
SYNC POLARITY
POSITIVE
NEGATIVE
HORIZONTAL POSITION
SYNC LEVEL or LINE SWEEP PHASE
SENCORE PS163 OSCILLOSCOPE
DUAL CHANNEL—VERTICAL INPUT
B
DUAL ALTERNATE
DUAL CHOPPED
VECTOR A&B INPUTS
HORIZONTAL SWEEP
MANUAL TRIGGERED
FREE RUNNING
CHANNEL A
CHANNEL B
TIME BASE
FREQUENCY
1KHz
100Hz
10KHz
mSEC
μSEC
10Hz
100KHz
1Hz
1MHz
TRIGGERED
TURN FULL CLOCKWISE TO READ PPV
DC BALANCE
TRACE POSITION
AC COUPLED
DC COUPLED
INPUT A
INPUT B
R-Y VECTOR INPUT
B-Y VECTOR INPUT
CAL. VOLTS 2V PP
GROUND
EXTERNAL TRIGGER
1
2
3
4
5
6
7
8
9
10
11
12

NOTE

Now we are triggering on the 1MHz signal coming into channel A, just like a single trace scope.

Select horizontal sync B.

The trace continues to display, because the triggering circuit is being triggered by the 1MHz signal entering input B.

5. Now turn the gain control down so the waveform is only one division high and remove the B channel probe.

   The trace disappears because there is no triggering signal.

6. Select "Vertical Input" B.

7. Reconnect the probe.

   Now we're triggering and displaying on channel B, just like a single trace scope.

   The PS163 can trigger off of either channel A or B.

GENERAL RULE:

1. Trigger on the lower of the two frequencies

   or

2. Trigger on the signal that has the larger sync pulse

   or

3. Trigger on reference signal if measuring time relationships.

Example: input to delay line in TV receiver.

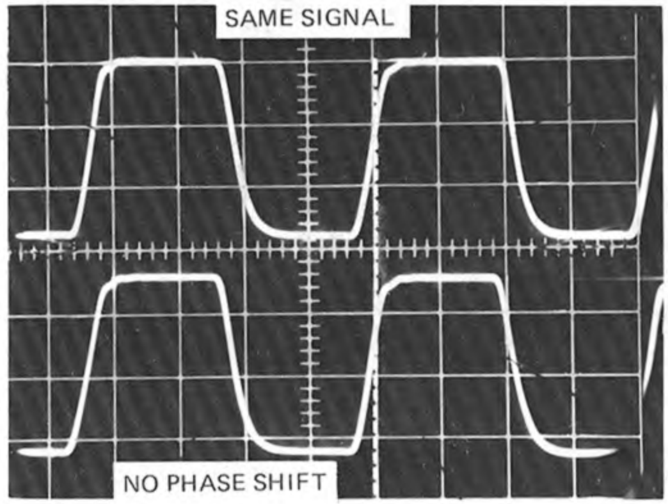
DUAL ALTERNATE

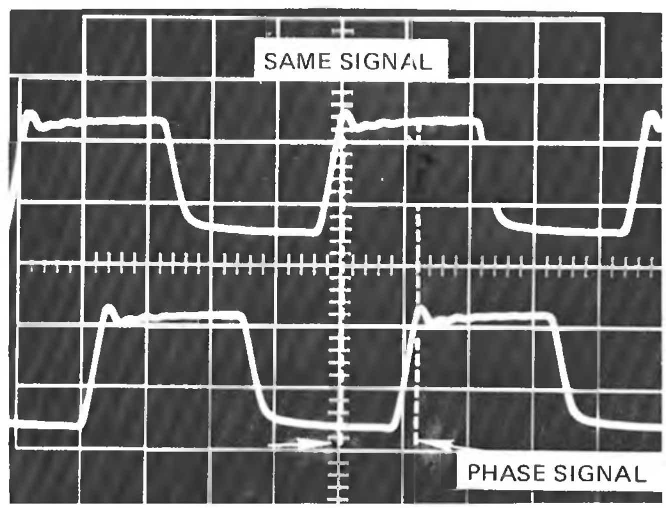
8. Select dual alternate. Now two waveforms appear. This is the standard dual trace mode used for almost all measurements.

9. Adjust the trace position control until both waveforms are super imposed, on top of each other.

   Notice - virtually no phase shift.

The PS163 has less than 1% phase shift between channels for accurate time and phase comparisons.





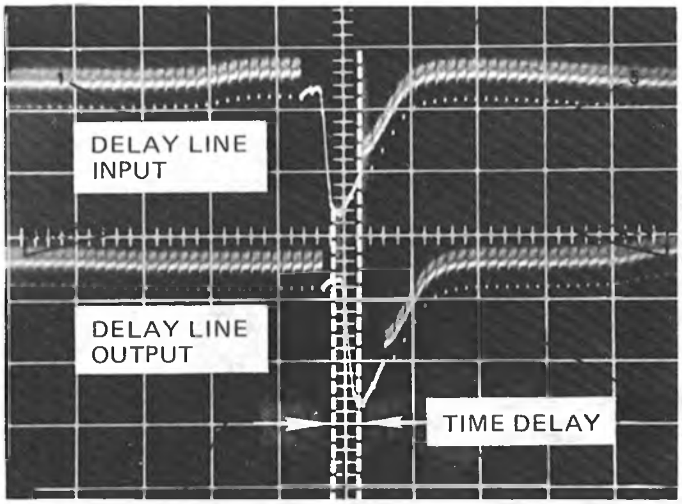
This competitive scope displayed a 50% phase shift between channels, making any time/phase measurement virtually useless.

MEASURING TIME DELAY AND PHASE SHIFT.

The major function of a dual trace scope is to measure time delay between two signals.

As previously mentioned, many signals in TV receivers, stereo and logic circuits, operate with a pre-determined phase shift between the two signals.

Example:



Delay line in TV must have time delay as shown.

Other circuits require no-phase shift, in which case we need to determine that these two signals are occuring concurrently.

Example:

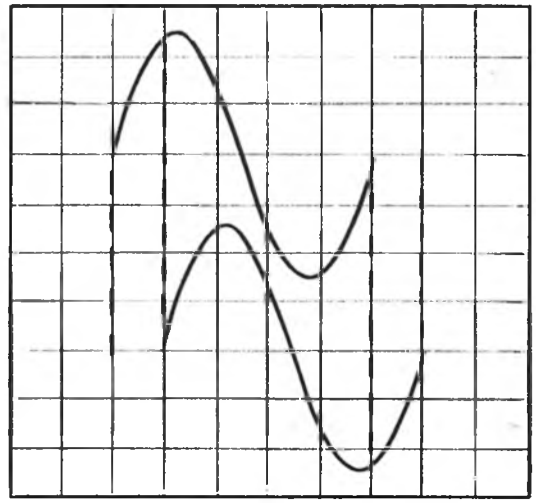
Horizontal sync pulse must be present at same time flyback pulse arrives at gated A.G.C.

HERE'S HOW YOU MEASURE TIME DELAY.

1. Measure the actual distance, in divisions; between the two signals peaks (either positive or negative. They must be the same peak however.
2. This distance is 1 division.
3. Now multiply the sweep setting by the number of divisions.

   Our sweep setting for this example is: 10uSec/div.

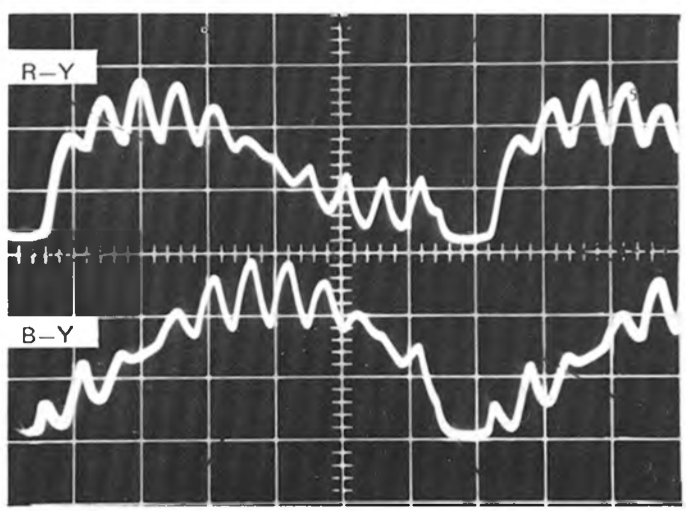
Time delay = (no. of div.)X(sweep setting)
Time delay = (1)X(10uSec)
Time delay = 10uSec



Let's look at this time relationship using the sine wave modulation of the R-Y and B-Y signals on your demo.

1. Connect channel A to the R-Y signal and channel B to the B-Y vector test point.
2. Select "Dual Alternate Display.
3. Select Auto-Triggered sweep.
4. Select either Int. A or Int. B, depending on which offers the best sync.
5. Dial in a sweep setting of 10uSec/div.

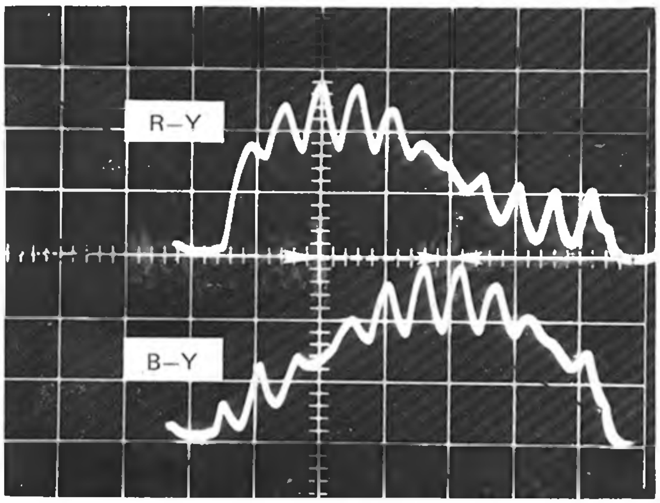
   Your display should look like this.



6. Adjust the "Horizontal Position" control to place the peak of the R-Y sine wave on the center vertical grid.

7. Move this trace to the top half of the screen.

8. Move the lower waveform so the peak of B-Y sine wave modulation is on the center horizontal grid, as pictured here.



9. Measure the distance from the center vertical grid to the B-Y sine wave peak.

It should equal 1.6 divisions.

Multiply (1.6) X 10uSec = 1.6uSec.

The time delay relationship is 1.6uSec.

DUAL CHOPPED

Dual chopped is used to display two low frequency signals less than 100Hz.

VECTOR A AND B INPUTS

1. Push "Vector" vertical display.
2. Connect channel A to R—Y test point, and channel B to B—Y test point.
3. Adjust the vertical gain controls for maximum display.

NOTICE — the horizontal control is now inoperative. You must use the two vertical position controls to center the trace.

4. Switch the vector grid on.

TRIGGER MODES

One of the greatest benefits of the PS163 is the versatility in the Horizontal Sweep modes.

The PS163 offers 3 basic sweep modes.

1. AUTO-TRIGGERED

— used for almost all applications

— automatically triggers on input signal from either channel A or B, depending on your "sync selection."

— displays solid-no-jitter waveforms

— allows accurate time comparisons

Select Auto - Trigger and display a 10KHz waveform.

2. MANUAL TRIGGERED

— used when precise level adjustment is necessary on a complete waveform.

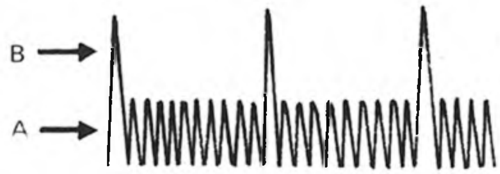
a. Push "Manual Triggered"

b. Connect probe to "composite TV sync" on demonstrator

c. Set timebase to 5mSec per division.

d. Adjust "sync level on line sweep

phase" control until signal syncs in. (It may be touchy!)



Ordinarily, the scope will trigger on any signal larger than A. Consequently, the trace triggers on every pulse, and will not sync.

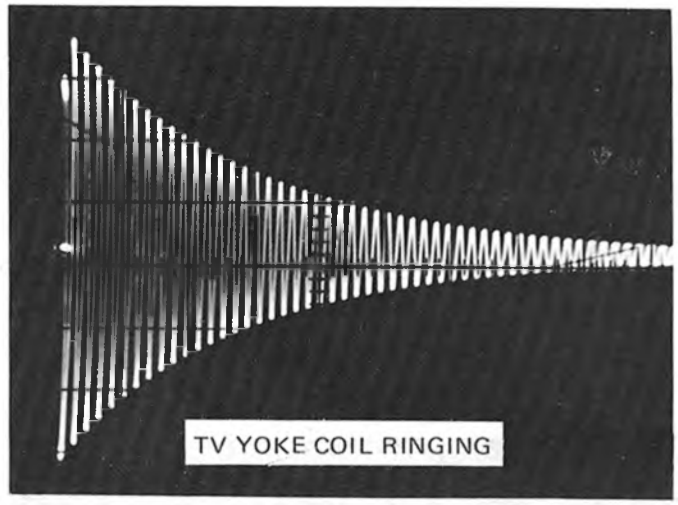
By adjusting the "sync level" control, you are changing the acceptable level of the triggering circuit.

3. FREE RUNNING

The PS163 is also a free running scope.

— used to display signals with virtually no sync pulse present at display frequency desired

— will display non-recurrent waveforms - like "Ringing" waveforms taken from a coil.



PS163 TRIGGER MODES

1. Put timebase control on 5mSec.
2. Probe the "composite sync" test point.
3. Push "Free Running" Horizontal sweep.
4. Now — adjust the vernier control until the waveform locks in.

With three basic sweep modes, the PS163 is one of the most useful oscilloscopes on the market for electronic design, manufacturing and service.

PS163 OVERVIEW

4 KEY OPERATING POINTS

— The PS163 has 5 vertical input modes for maximum single and dual trace capabilities.

— 1% accurate time/phase comparisons are available on the PS163, for the most accurate analyzing available in this price range.

— The PS163 has 4 selectable sync modes of A, B, Line and Ext., for maximum efficiency.

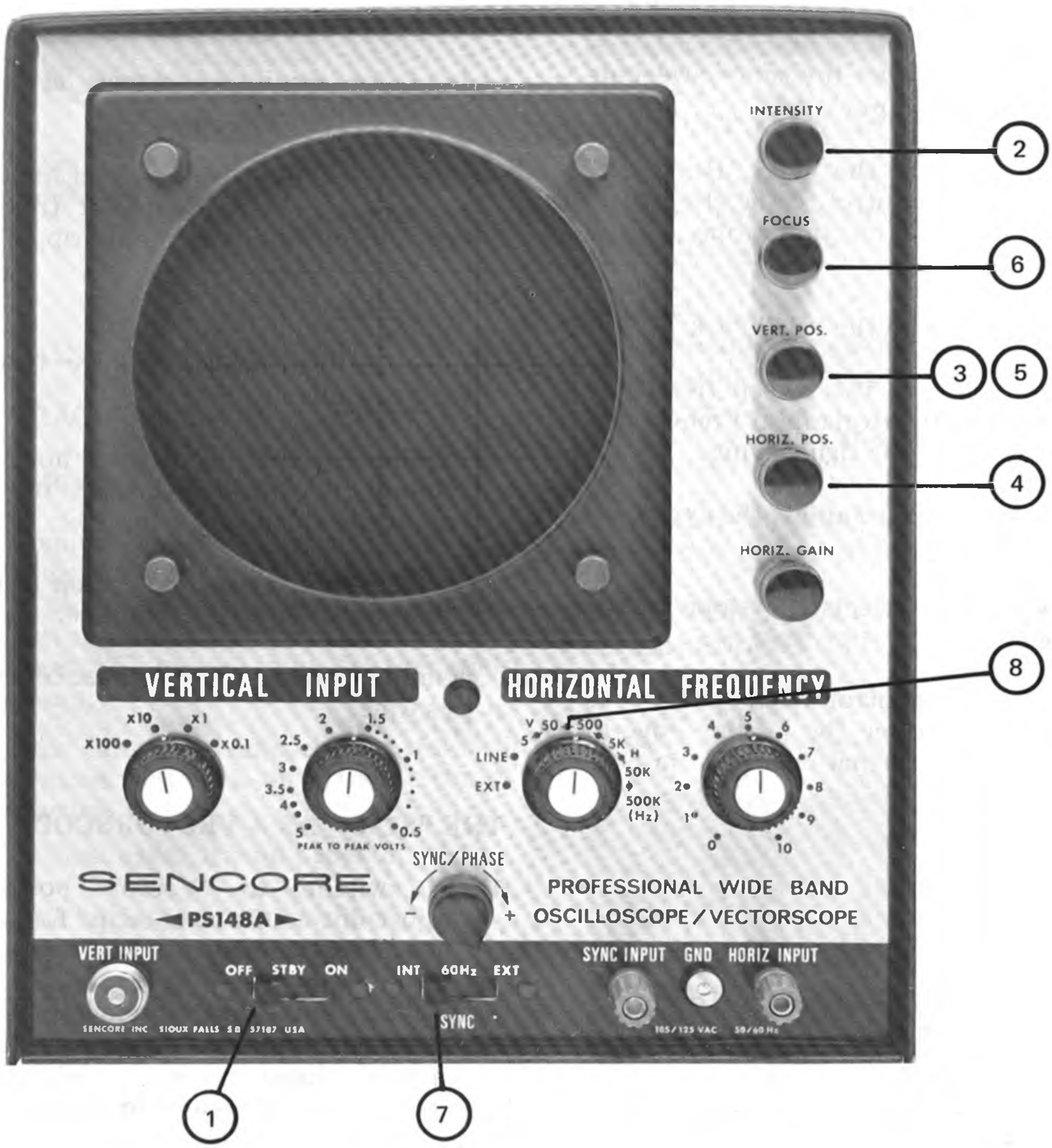
— 3 basic sweep modes equip you for almost any 10MHz scope application you'll encounter.

The PS163 Instruction Manual describes in detail the operation and application of these controls. Use this manual as a reference when ever a question arises.

PS148 FAMILIARIZATION

1. Turn on the PS148
2. Turn "Intensity" control fully clockwise
3. Rotate "Vert Pos" control until portion of trace appears.
4. Center trace using "Horiz Pos" control.
5. Recenter trace using "Vert Pos" if necessary
6. Focus trace using "Focus" control until trace is as small as possible.
7. Select "Int." sync.
8. Select 50Hz on "Horizontal Frequency".

The PS148 is now set-up. Take the time to familiarize yourself with these controls now.



APPLYING A SIGNAL TO THE PS148

1. Connect the probe, with the alligator clip attached, to the 10KHz test point on the demonstrator.

2. Adjust the "Vert Gain" control for approximately 2 divisions of deflection.

THE KEY TO OPERATING THE PS148

The PS148 is a sync-sweep scope.

It will trigger on virtually any signal, with or without a sync pulse.

The key is to get the scope sweeping in sync with the input signal.

3. Simply adjust the left "Horizontal Frequency" control to the closest frequency range on the scope to the input signal.

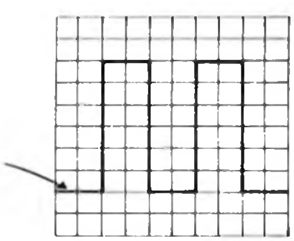
   This gets you in the "Ball Park."

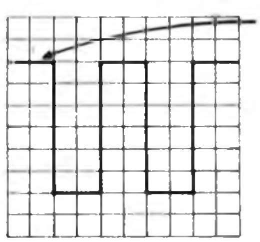
4. Now fine tune this sweep frequency with the right "Horizontal Frequency" control, until the signal syncs.

5. You may have to adjust the sync level control.

   This control selects the slope of the leading edge.

6. Rotate the control from positive to negative. Notice the leading edge of the displayed signal change from positive to negative.





7. SYNC SOURCE

   The PS148 has three selectable sync sources.

1. INTERNAL

— used for most all measurements

— sync is developed off pulse being measured

— requires fine tuning "Horizontal Freq." control

2. 60Hz (Line Frequency)

— used for displaying signals at Line Frequency

— more often used to sync and hum or background 60Hz. (Example: trouble-shooting 60Hz power supply ripple.)

3. EXTERNAL:

— used on signals where sync is not readily available

— requires external, front panel hook-up Example: Chroma Circuits of TV composite video of TV receiver.

This covers the basic operation of the PS148 as a wideband oscilloscope.

Familiarize yourself with these controls at this time.

THE PS148 AS A VECTORSCOPE

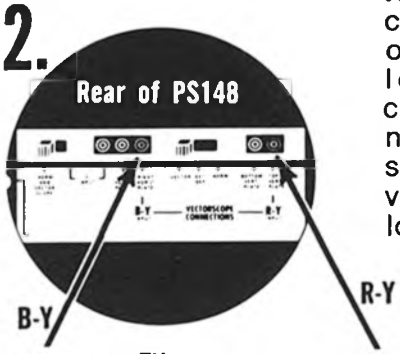
1. Set switches to "Vector" position. Adjust dot on front of scope for good focus, low intensity and near center.

2. NOTE: Vectorscope connections are on rear to prevent loading of color circuits. Keep connecting leads well separated to prevent additional loading.

1.

Set switches to VECTOR position. Adjust dot on front of scope for good focus, low intensity and near center.

2.



Note: Vectorscope connections are on rear to prevent loading of color circuits. Keep connecting leads well separated to prevent additional loading.

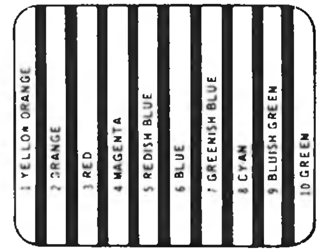
Connect to TV B-Y Demodulator output (or blue grid of color tube)

Connect to TV R-Y Demodulator output (or red grid of color tube)

COLOR TROUBLESHOOTING

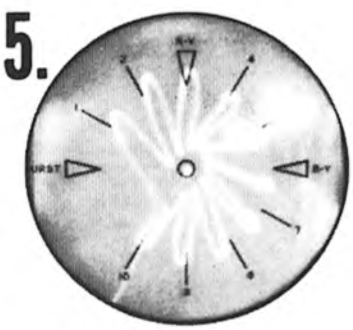
3. Connect scope ground lug to TV chassis ground.

4. **10 Bar Pattern**



Connect standard 10 bar color generator to antenna terminals and tune in best possible 10 bar pattern. If picture cannot be viewed, set generator controls to average settings.

5.



Pattern should now appear on Vectorscope. Adjust color TV color level and fine tuning for best viewable pattern. Rotate Hue Control and note "Cogwheel" effect.

PS148 SUMMARY

KEY OPERATING POINTS

The PS148 will sync on virtually any signal up to 5MHz, which covers all TV applications, using a free running horizontal sweep.

Any non-recurrent signal, such as a coil ringing waveform, can be displayed, using the PS148.

Accurate peak-to-peak measurements can be made with the PS148 using the calibrated vertical gain control.

The PS148 has three sweep modes of internal, external and line, for maximum versatility.

Doubling as a vectorscope, the PS148 is an extremely useful tool in all color TV troubleshooting.

5000V (DC + peak) protection guaranties a long life, versatile oscilloscope.

NOTE

GENERAL WAVEFORM TROUBLESHOOTING AND ANALYSIS

The main benefit of an oscilloscope is to be able to analyze the shape of a waveform to determine the cause of the malfunction. Following this page we have listed general symptoms of waveforms with common troubles experienced in a variety of circuits, under different conditions. Understand that these are not specific characteristics that will lead you directly to a given component in a circuit. By recognizing these general "trouble-signs," however, you will immediately know the type of trouble in a circuit. This can save hours of troubleshooting and analyzing time in the long run.

WAVEFORM ANALYSIS WITH AN OSCILLOSCOPE

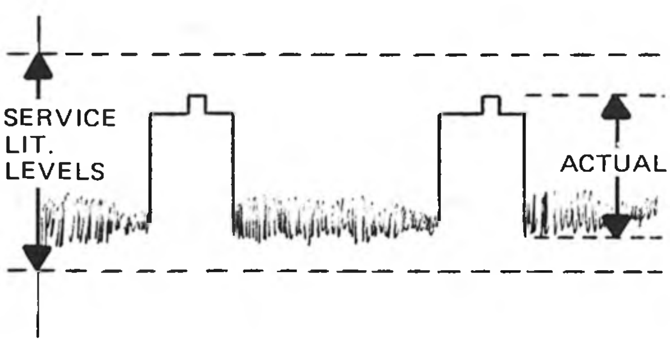
Three parameters must be considered for complete analysis of a waveform — amplitude, frequency and basic shape.

WAVEFORM AMPLITUDE

Generally, two symptoms can occur: low or excessive amplitude.

SYMPTOM:
Low amplitude

Example: If the video to the picture tube in a TV is too low, the picture will be washed out and have poor contrast. (Service literature will show the correct amplitudes.)



SUSPECTED CIRCUITRY:
Weak amplifying stage or excessive loading through leakage.

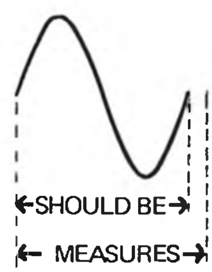
SYMPTOM:
Excessive amplitude

Excessive amplitude is seldom encountered without clipping or compression. Refer to these symptoms for this condition.

WAVEFORM FREQUENCY

SYMPTOM:
Off value frequency

Example: Reference 19KHz oscillator in stereo receiver measuring 18.5KHz.



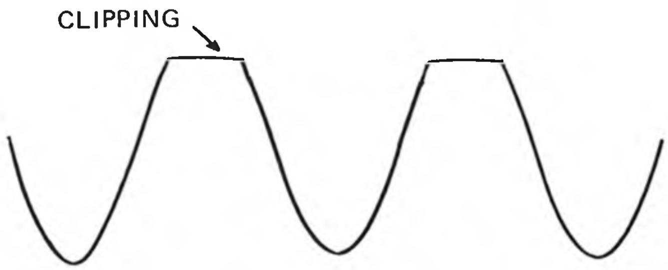
SUSPECTED CIRCUITRY:
Reference oscillator off frequency due to component failure.

WAVEFORM SHAPE

Waveform shaping is the most varied analyzing area. Following are several general shaping conditions that indicate circuit problems.

SYMPTOM:
Clipping

Example: Clipped sine wave in output of audio amplifier.



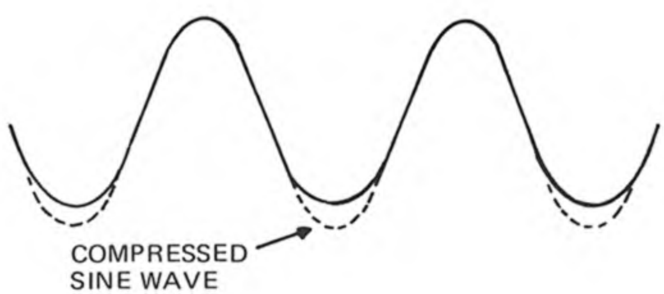
CAUSE: Incorrect bias in amplifier — causing input signal to swing below cutoff.

SUSPECTED CIRCUITRY:
Check bias of Amplifier Stage and compare to service literature.

SYMPTOM:
Compressed waveform:

Example: Compressed sine wave in output of Audio Amplifier stage.

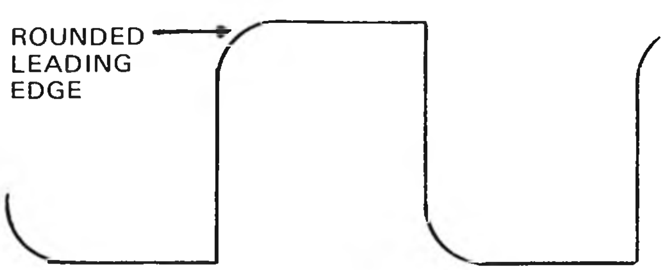
CAUSE: Insufficient bias.



SUSPECTED CIRCUITRY:
Leaky coupling capacitor.

SYMPTOM:
Rounding leading edge on square wave.

CAUSE: High frequency loss in amplifier.



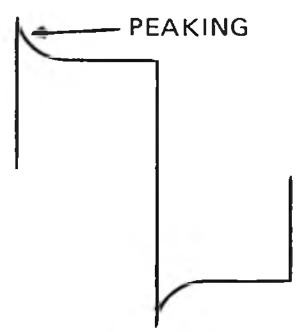
Example: 10KHz square wave at output of amplifier (10th harmonic not being passed, causing rounded edge.)

1KHz square wave measured at same point in same amplifier has all edges squared.

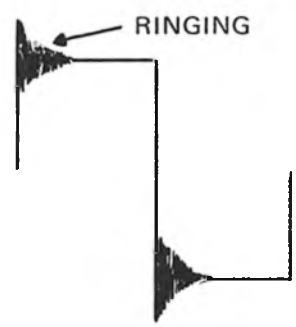
SUSPECTED CIRCUITRY:
Load impedance on output of amplifier has increased in value.

SYMPTOM:
Peaking or ringing

CAUSE: High frequencies amplified more than the lower frequencies. Improper compensation of an attenuator or failure of peaking circuit, if present, will cause this amplification.



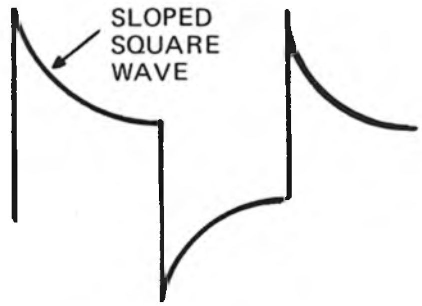
Ringing will occur when peaking coils are not damped properly.



SUSPECTED CIRCUITRY:
Component failure in peaking circuit.

SYMPTOM:
Sloping square wave

CAUSE: Low frequency loss. Condition caused by a coupling capacitor of too small a value. (Will show only on lower frequency signal.)



SUSPECTED CIRCUITRY:
Changing component value in coupling circuit.

SPECIAL NOTE: Always be aware that a combination of these problems can be present, but careful analysis with an oscilloscope will detect each of these symptoms.

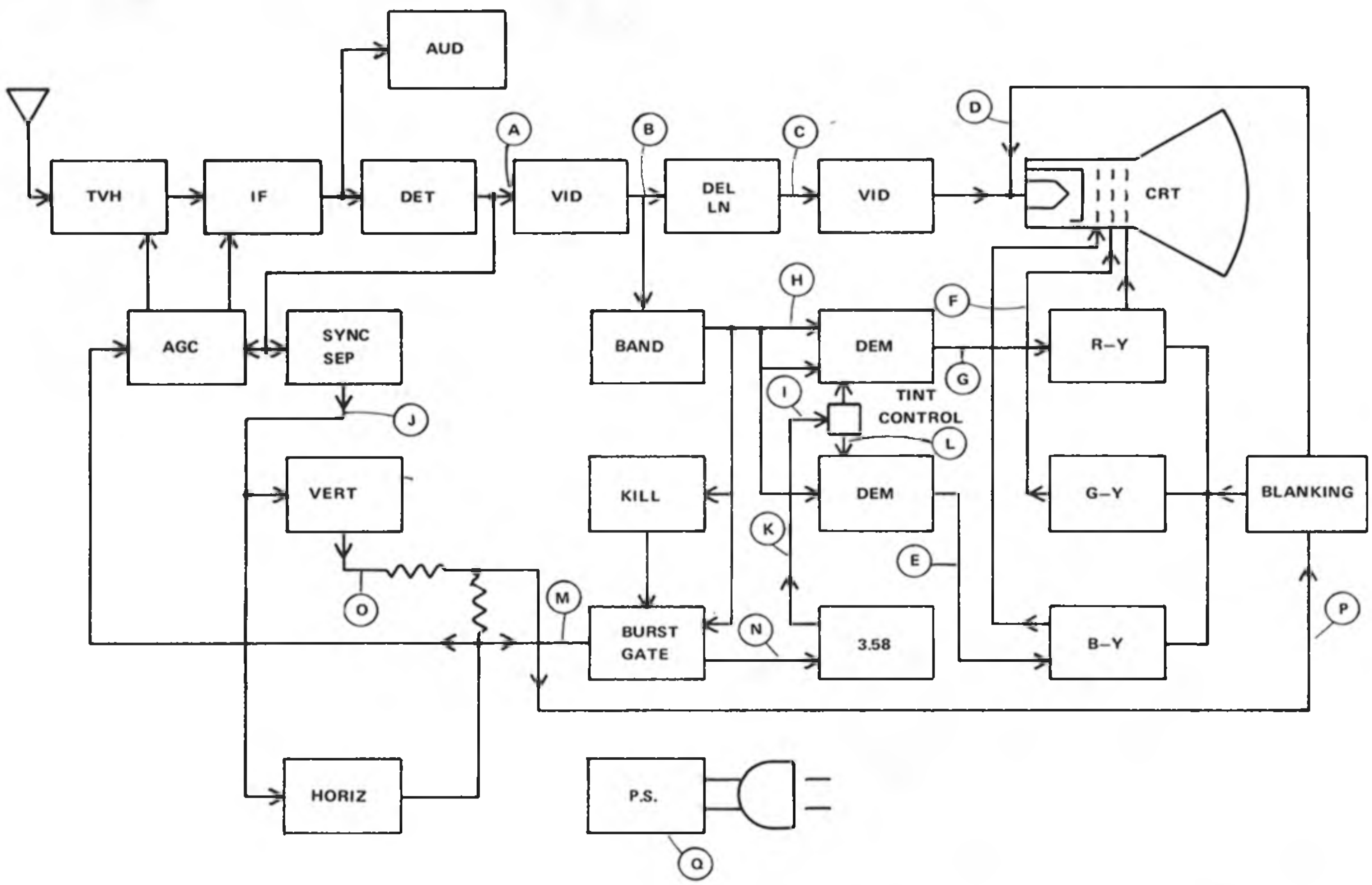
NOTE

TV WAVEFORM ANALYSIS

In TV servicing, there are certain key waveforms that greatly simplify trouble-shooting. If we know what these wave-forms represent, and what they should look like in a properly operating set, our job of finding the cause of the defect in our TV is greatly simplified.

The first problem encountered by a technician learning to use a scope for TV servicing is how to find these waveforms in the TV. Usually, the service literature for the chassis is a great aid in finding the proper test points. We will soon find, however, that all TV's have the same basic block diagram. By being familiar with this basic block diagram, the manufac-turer's service literature will be more efficient to use.

The following block diagram shows the key sections of a TV receiver. The key test points have been marked, and these same test points are used for producing the waveforms in this section.



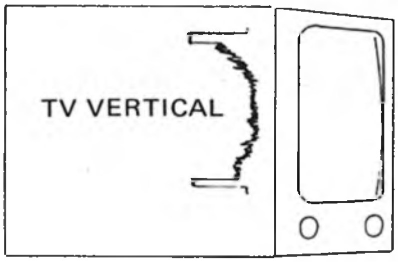
Once you have your new oscilloscope in operation it will be well worth your time to sit down with a properly operat-ing TV set and look at some good wave-forms. This will be the best education you can receive as to what the waveform actually looks like, and how to locate the test point and set your scope to display the waveform.

After this short practice session, you will be able to use the scope for trouble-shooting with the same speed and de-pendability as your meter — with the added information that only a scope can provide!

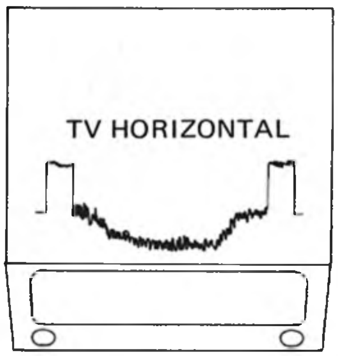
THE COMPLETE VIDEO SIGNAL

Most troubleshooting literature tells us that the composite video signal is the most important signal for troubleshooting. But, what exactly does this signal represent?

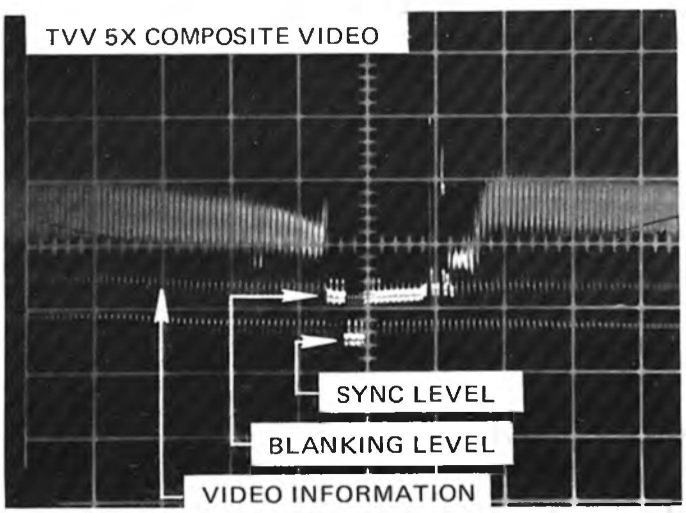
Let's imagine that we could look at the edge of a picture tube and "see" the signals used to make up our video display. If we did so, this is what we would see:



Likewise, a top view would give us this:

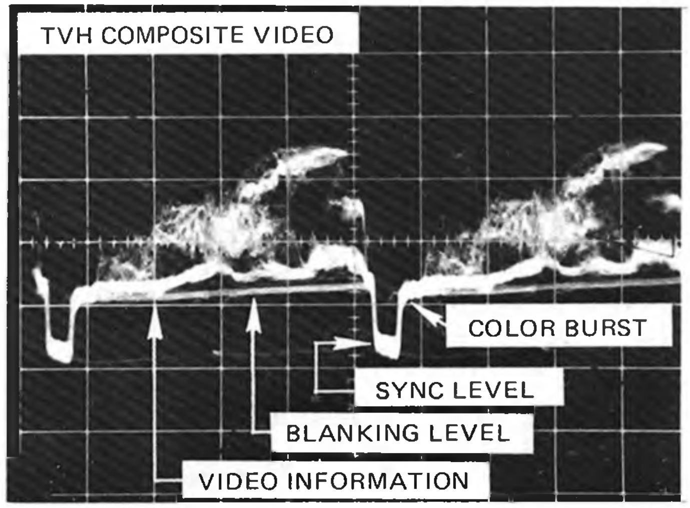


These are the waveforms we see in many schematics:



The "blanking level" represents the blackest picture possible. Any signal of lower amplitude makes up our sync information.

The "Color Burst" used to reference our color circuits and the sync pulses, lock our sweep circuits to the incoming signal.



Additional signals a triggered scope can show us include the blanking pulses, and serations in the vertical waveform. The blanking pulses tell the TV receiver to "blank" the CRT while the trace is moving from the end of one picture to the beginning of the next. The VITS signals are used only by the TV station to maintain its equipment, and the serations are the horizontal sync pulses during the vertical blanking time.

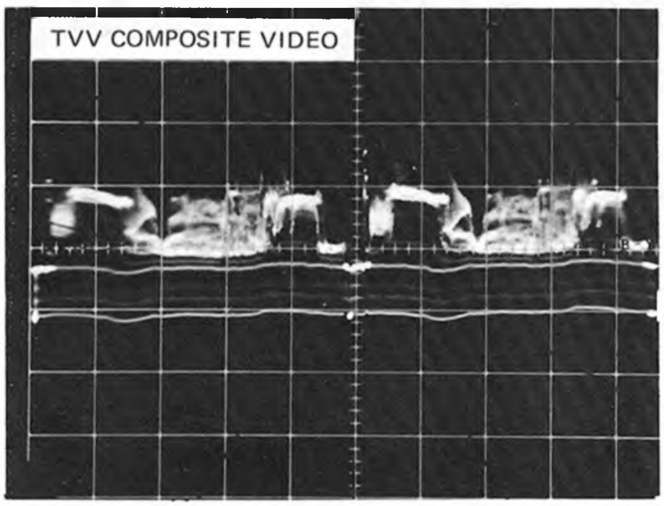
Most service literature shows you what a waveform should look like. However, you are looking at TV sets that have problems. So we have listed here one key video waveform and then typical problems encountered so you can recognize these conditions when they exist.

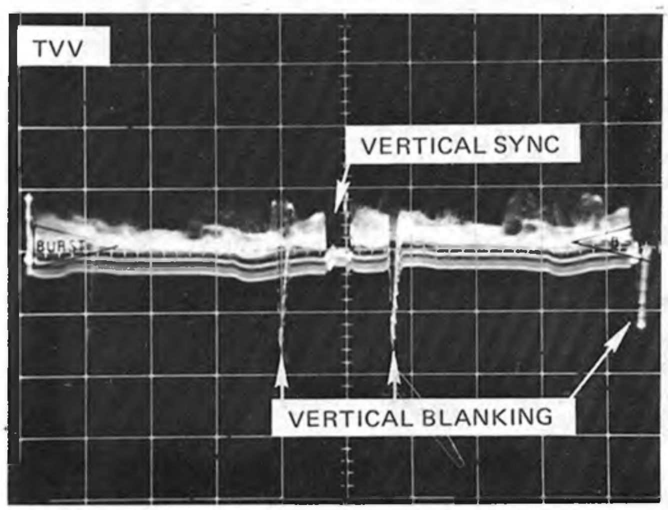
Each key waveform shows the proper signal for the test point, then several waveforms illustrating problems that may be encountered. Relate the receiver's problem to the general block diagram and the receiver schematic. Check the circuits indicated to locate the fault.

Following are the key waveforms with the block diagram test points and the initial set-ups for the Sencore PS163 and PS29. The PS148 set-up is not included, as it requires the adjustment of the sweep and sync controls for every waveform. You can lock in TVV at 60Hz and TVH at 15,750Hz on the PS148.

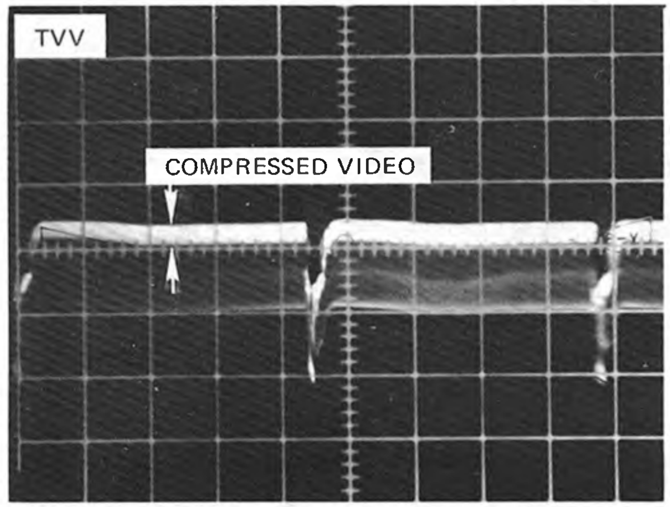
1. COMPOSITE VIDEO

PS163:	Time Base: TVV Sync: Ch A or B
PS29:	Button: TVV Sync: —, Int.
Test Point :	Video Detector, "A" Video amp, "B" Delay line "C"



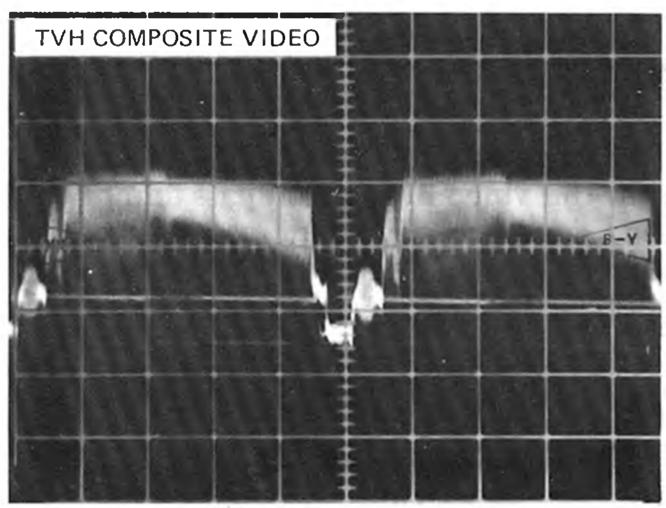


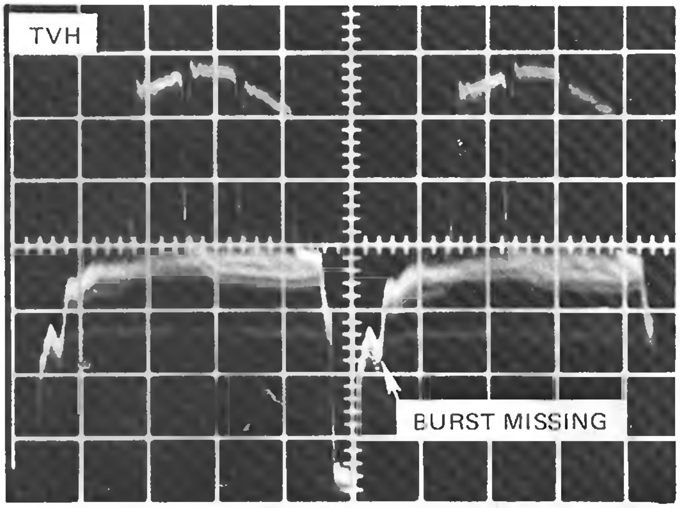
Symptoms:	Vertical roll or jitter
Cause:	Low sync amplitude
Check:	IF alignment, fine tuning, video amp



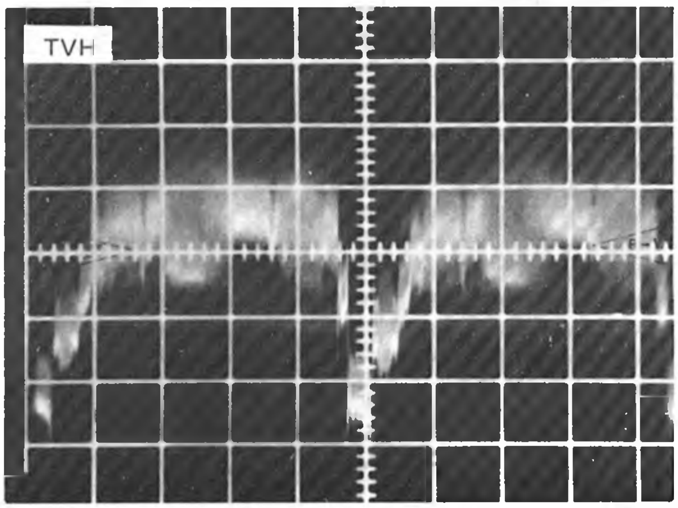
Symptom :	Poor contrast
Cause:	Compressed video
Check:	IF alignment, fine tuning, video amp

PS163:	Time Base: TVH Sync: Ch A or B
PS29:	Button: TVH Sync: —, Int.
Test Point:	Video detector "A" Video amp, "B" or delay line "C"





Symptom: Poor or intermittent color
Cause: Low burst
Check: Fine tuning, IF alignment

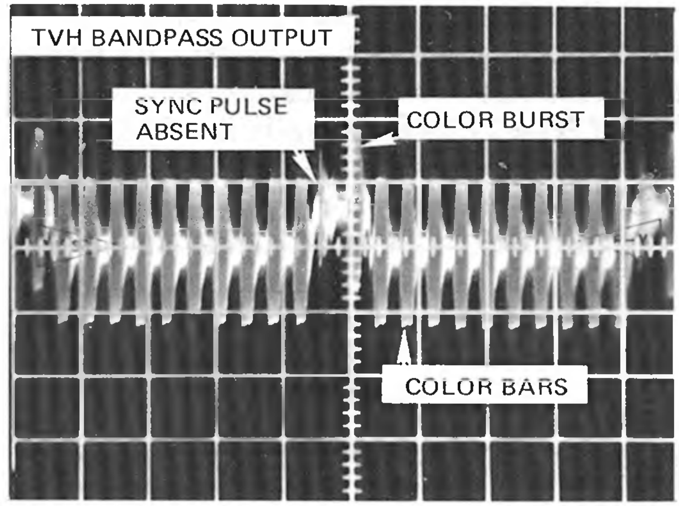


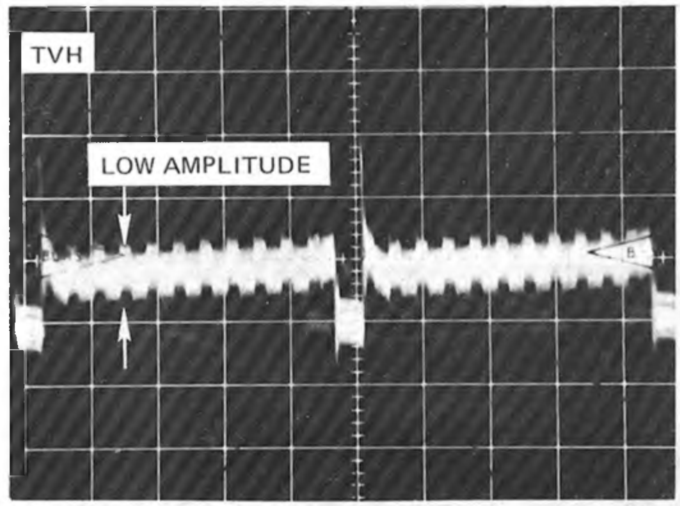
Symptom: Ringing (ghosts)
Cause: Ringing in IF or amp
Check: IF, fine tuning

2. BANDPASS AMPLIFIER

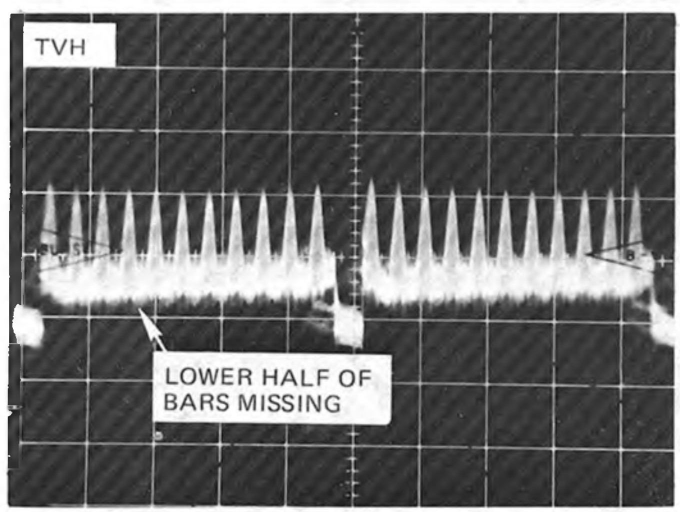
The color information is separated from the video in the bandpass amplifier. This signal is later fed into our color demodulator to provide color for our picture.

PS163:	Timebase: TVH
	Sync: —, Ext.
PS29:	Button: TVH
	Sync: —, Ext.
Test Point :	Bandpass output "H"





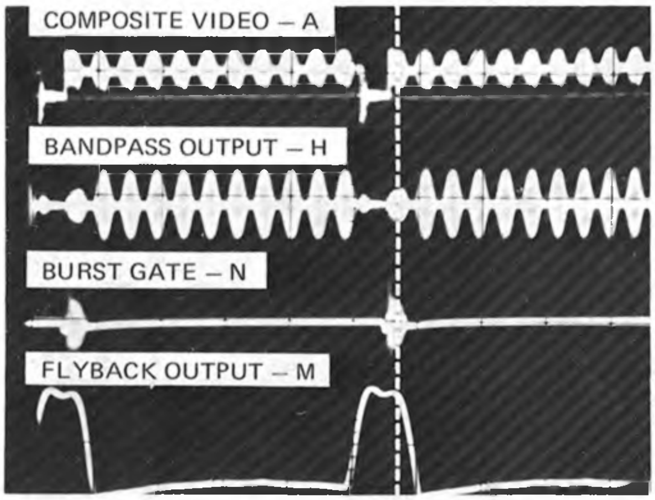
Symptom: Poor color
Cause: Low chroma amplitude
Check: Tuning, IF or chroma alignment

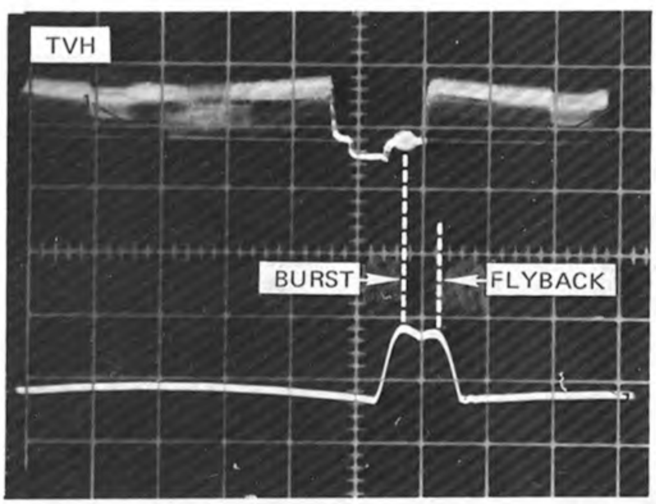


Symptom: Poor color detail
Cause: Low amplifier bandwidth
Check: Tuning, alignment

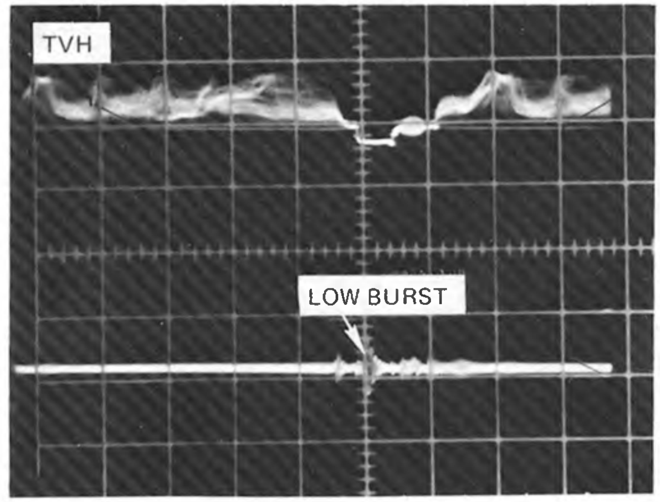
After being separated from the video signal, the chroma (color) information is processed by several stages to provide our color picture. First the burst is separated in the burst gate to sync our 3.58 oscillator to the same phase and frequency as the TV station.

This picture shows the time relationship between the chroma.





Symptom:	Rainbowing, changing flesh tones.
Cause:	Improper flyback timing
Check:	Flyback connections, Gate operation, Horiz hold, phase detector.

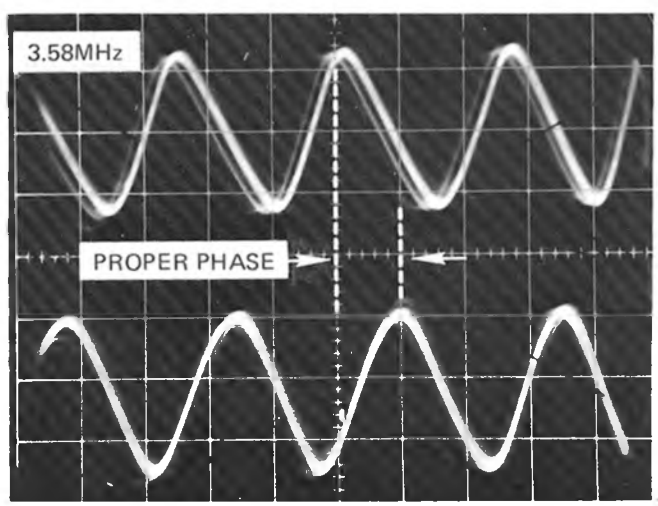


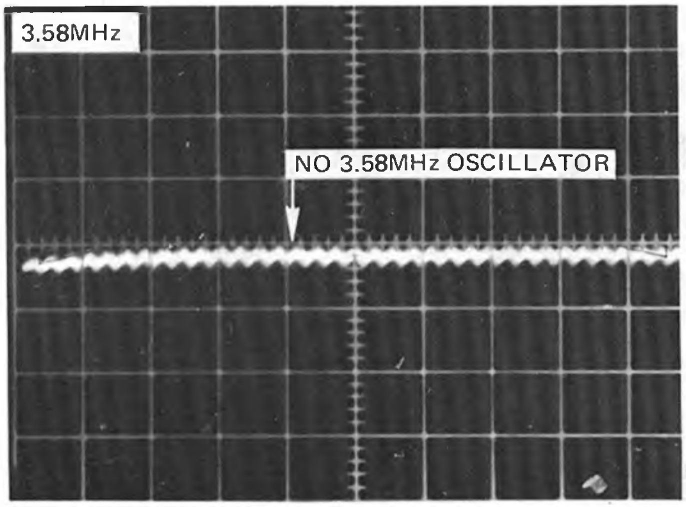
Symptom:	No color
Cause:	Low burst from bandpass amp
Check:	Bandpass amp, color killer

3. BURST OSCILLATOR

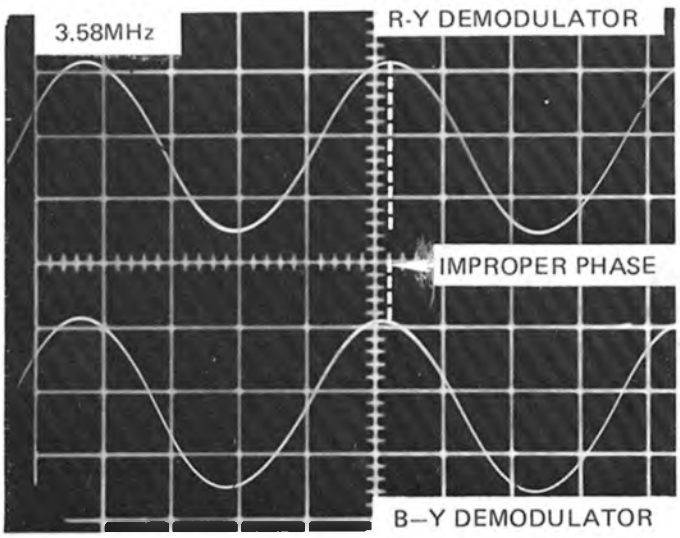
After the burst has been separated, it is used to control the burst oscillator which must be locked in phase to the station signal. The tint control changes the phase of this signal to produce the proper color range, and flesh tone.

PS163:	Timebase: .2uS (1MHz) Sync: Auto, Ch A or B, + or –
Test Point:	"K" R-Y Demodulator "L" B-Y Demodulator





Symptom: No color
Cause: Dead oscillator
Check: Crystal and oscillator Circuit



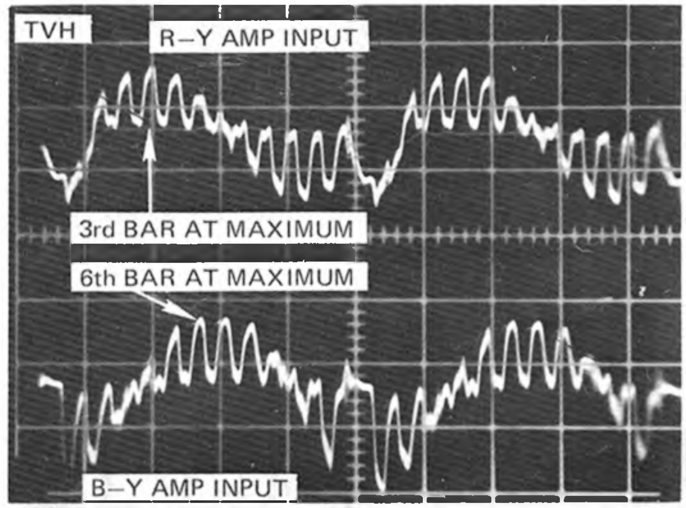
Symptom: Poor flesh tones
Cause: Improper phase shift
Check: Phase shift network, tint control

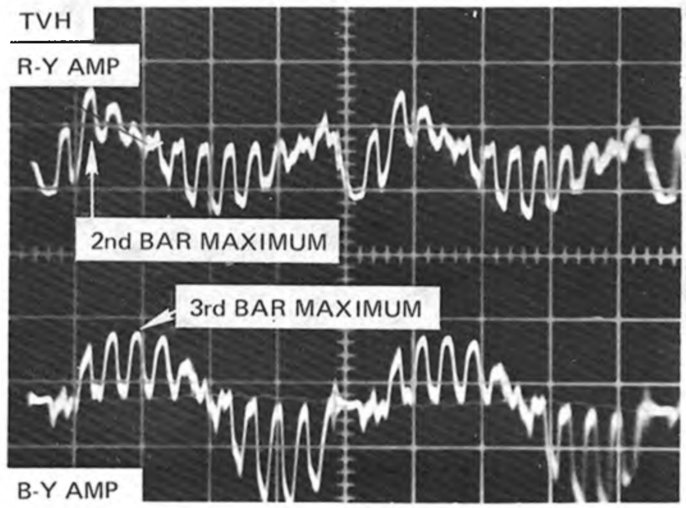
4. CHROMA OUTPUT (Dual trace only)

The 3.58MHz signal and the output of the chroma bandpass are then fed to the R-Y and B-Y demodulators where the final colors are separated.

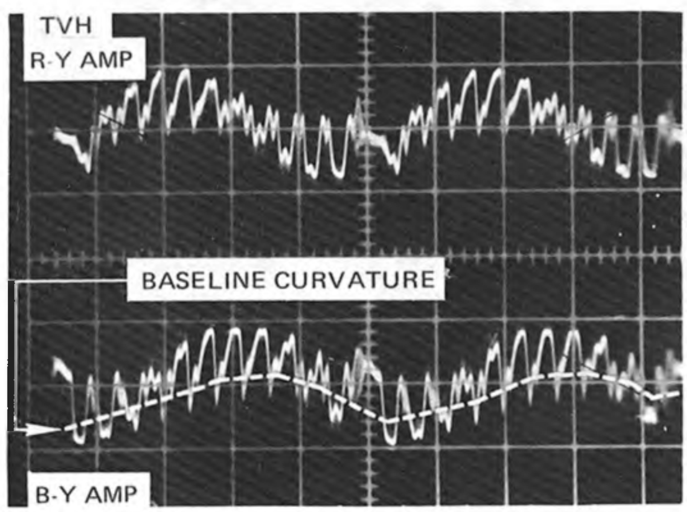
Test Points: "G" R-Y amp output
"E" B-Y amp output

PS163: Timebase: TVH
Sync: Ch A, negative or (if no sync) Ext. negative





Symptom: Poor flesh tones
Cause: Improper phase
Check: Tint



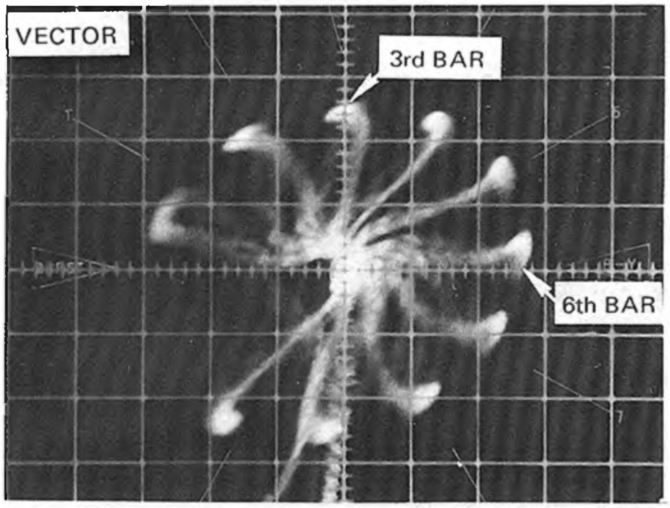
Symptom: Poor color saturation
Cause: Chroma signal not reaching "black" level (baseline)
Check: Demodulator alignment or components

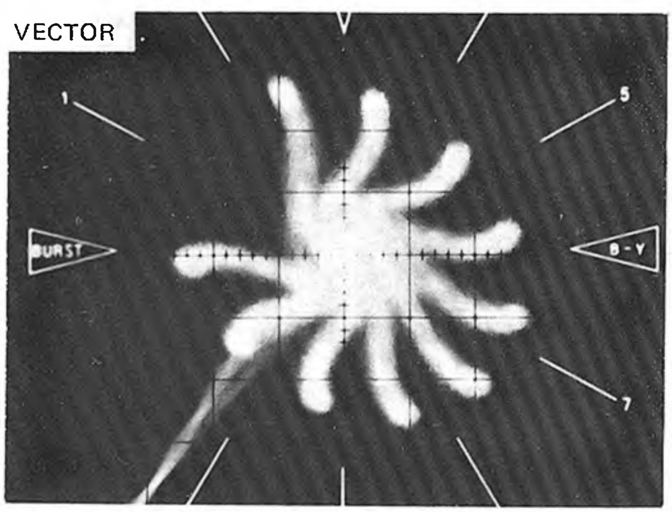
5. COLOR VECTOR PATTERN

The alignment and checking of the demodulators can best be done using the "vector" method of alignment.

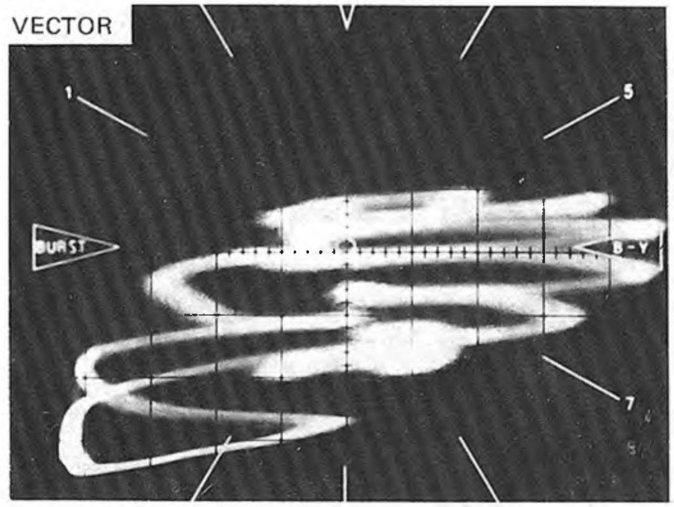
PS163: Mode: Vector
PS29: Mode: Vector

Test Point: "G": R-Y output
"E": B-Y output





Symptom: Tint control changes some colors more than others
Cause: Improper phase relationship
Check: Operation of tint control, alignment of demodulators



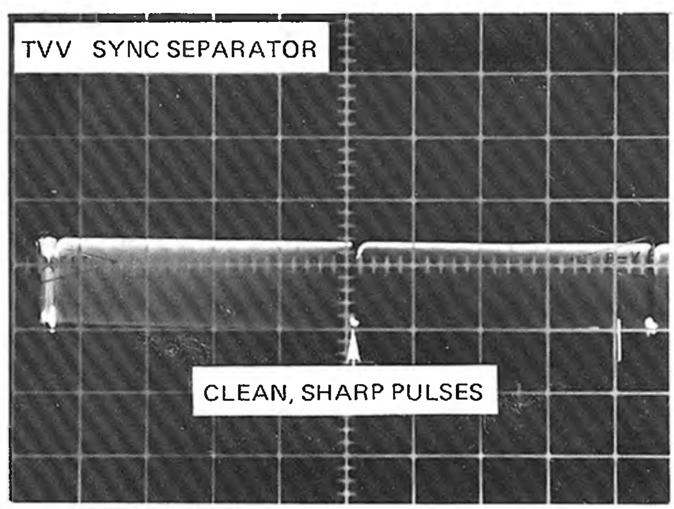
Symptom: Poor hues
Cause: Low red output
Check: R-Y amp, demodulator alignment

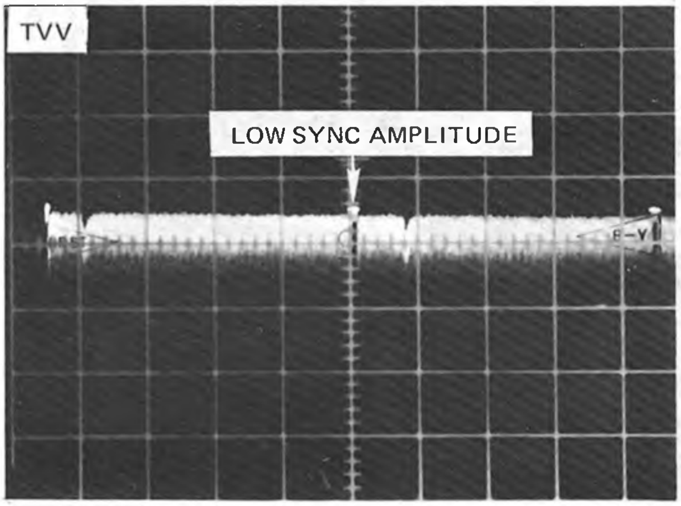
6. SYNC SEPARATOR

Another key waveform is the output of the sync separator. This circuit removes all video information so that pure sync information can be used to lock the horizontal and vertical oscillators.

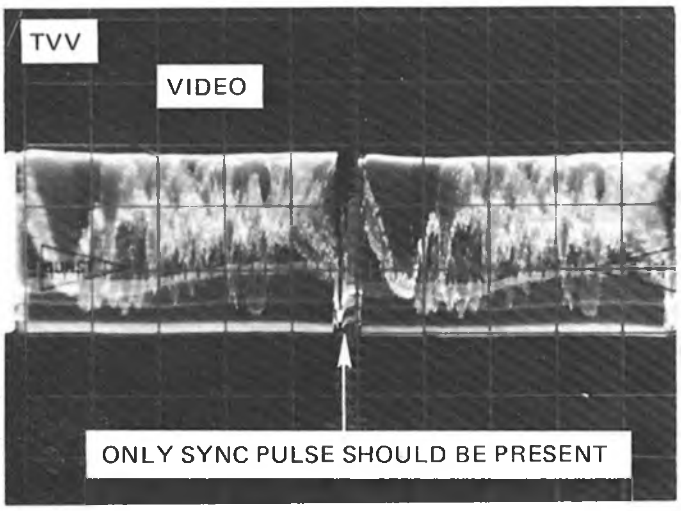
PS163: Timebase: TVV
Sync: Int. Ch A or B, —

Test Point: "J" Sync separator





Symptom: Picture rolls
Cause: Low sync level
Check: Composite video signal, Sync Sep., Bias or Sep. transistor



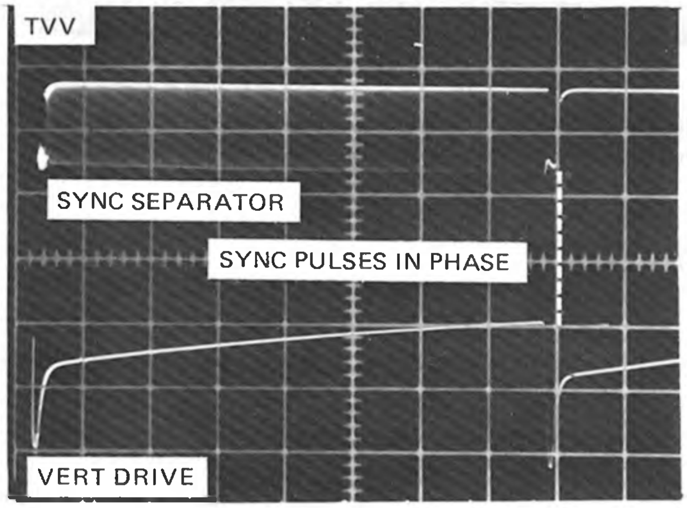
Symptom: Picture jitters
Cause: Video in sync
Check: Sync Sep.

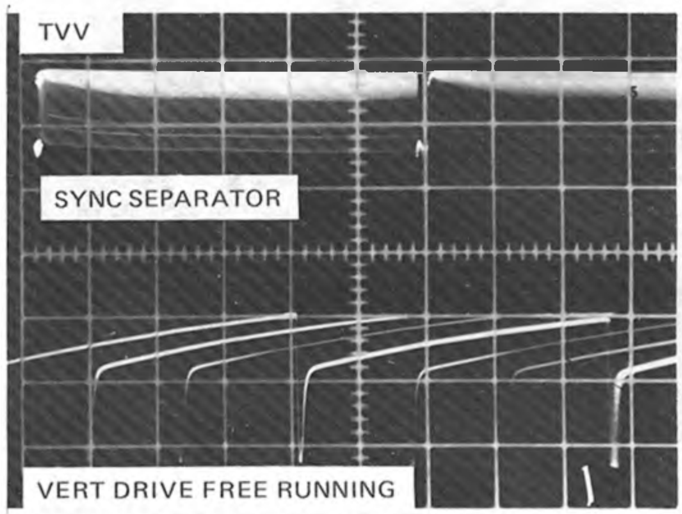
7. VERTICAL OUTPUT DUAL TRACE

If the sync is good at the separator, but we still have an unstable picture, the problem may be in the local oscillator or the output amplifier. A dual trace scope is best here, but we will also show a technique for the Minute Man.

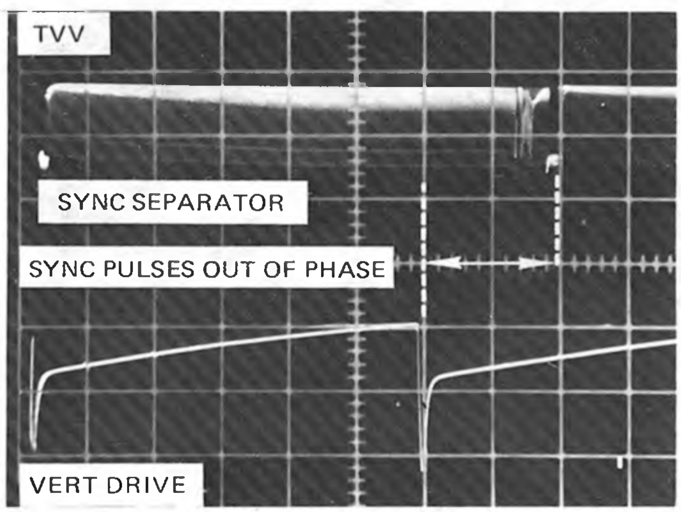
PS163: Time: TVV
Mode: Dual Chop
Sync: Ch A, negative

Test Point: Channel A: Sync Sep "J"
Channel B: Vert Drive "O"





Symptom: Vertical roll
Cause: Local oscillator free running
Check: Oscillator input, oscillator circuit



Symptom: Vertical jitter
Cause: Oscillator not synced
Check: Oscillator input, phase detector

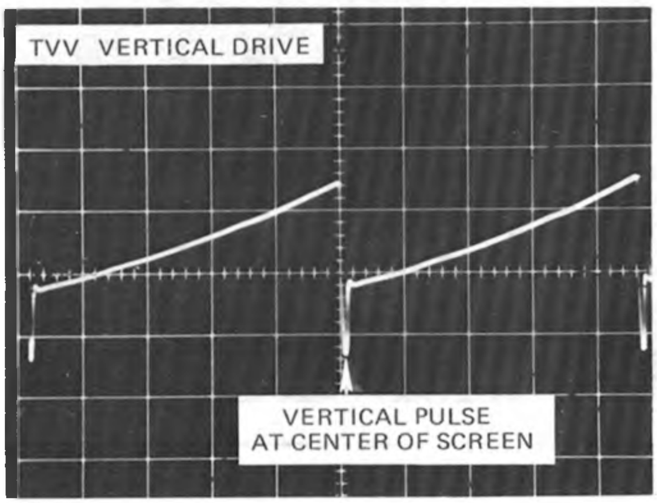
8. VERTICAL OUTPUT (Single Trace)

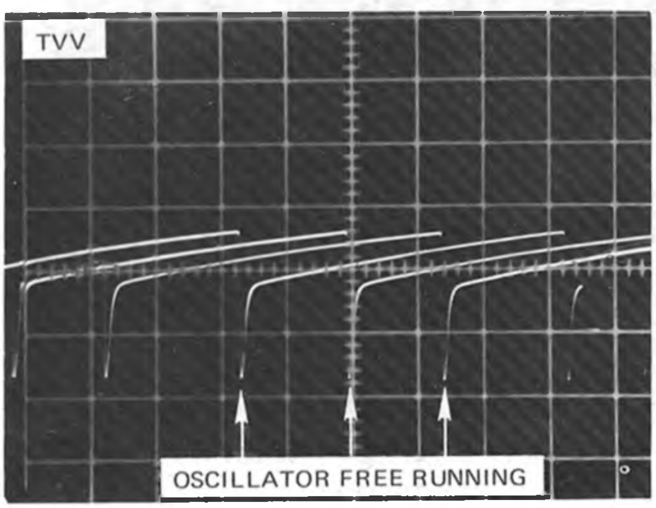
Since the two waveforms can't be compared on a single trace scope, connect probe to Sync Separator and note position of sync pulse at the center line. Then move to the vertical output drive. The trace should also be at center line.

PS29: Button: TVV
Sync: Ext., –
(Connect to Sync Sep.)

Test Point: "J" Sync Separator (note position of center pulse.)

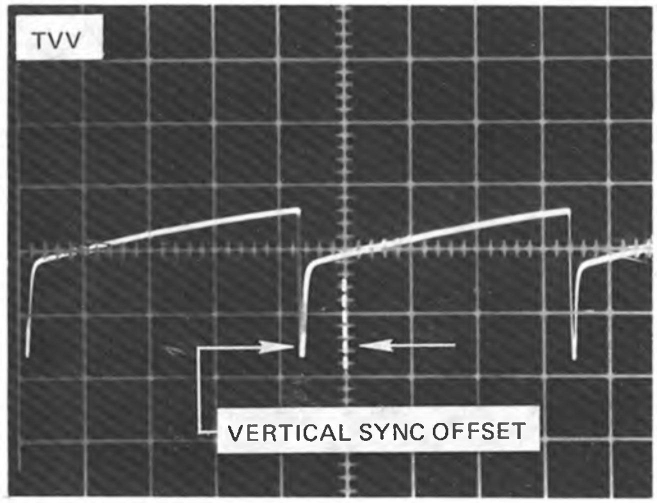
Then "O" Vert Drive Output





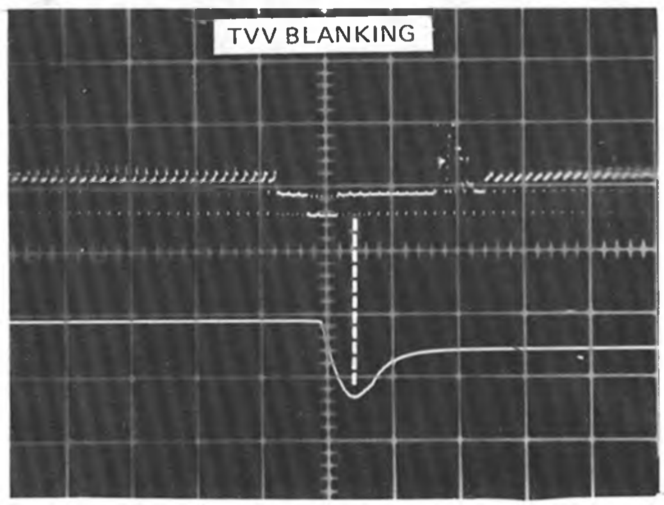
Same

Test Point: TPB: Vert Drive "O"



Same

9. BLANKING



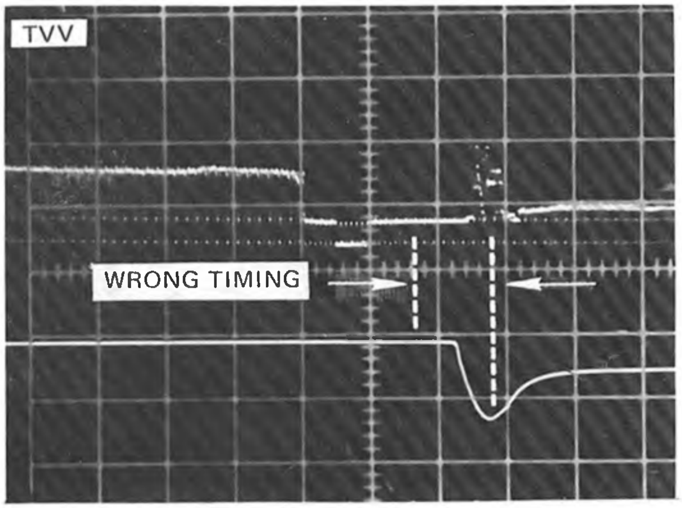
The same techniques can also be used for troubleshooting a vertical problem, by using the scopes TVV positions and the proper test points.

The timing of the retrace and blanking information determines if retrace lines will be present on our picture. The screen should "blank" after the sync pulse.

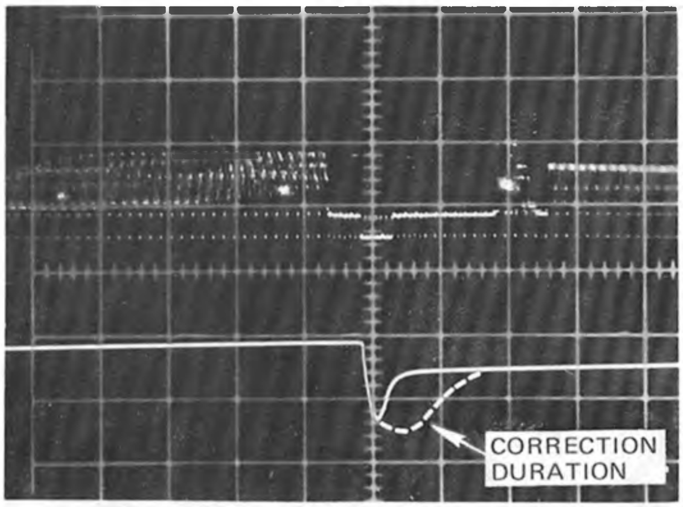
PS163: Timebase: TVV
Sync: Ch A, negative
Mode: Dual Chop

PS29: Not recommended

Test Point: "P" blanking



Symptom:	Retrace lines with black bar at top of picture
Cause:	Retrace blanking mistimed
Check:	Vertical oscillator, Vertical hold



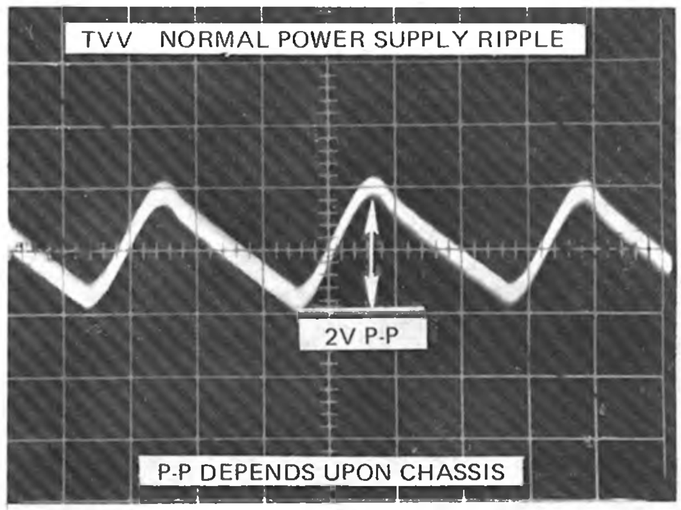
Symptom:	Retrace lines
Cause:	Retrace blanking pulse too short
Check:	Blanking timing circuit

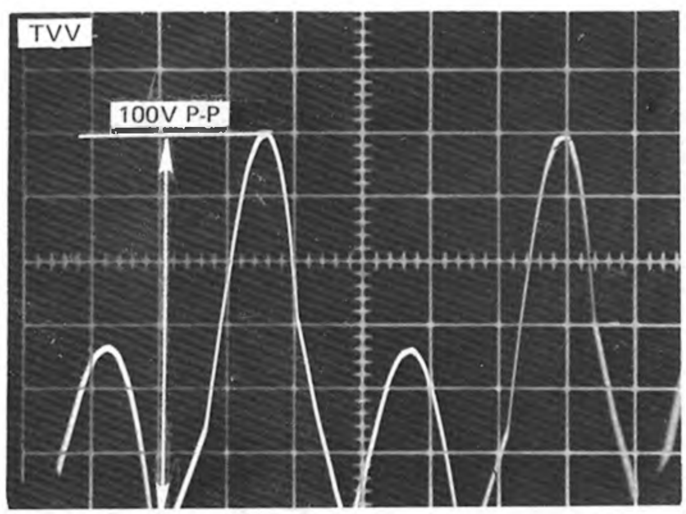
10. FULL WAVE POWER SUPPLY

One last waveform to be familiar with is the Power Supply. A DC coupled scope can be used to measure the DC level by first placing the input switch to ground and noting the position of the trace. Then select DC coupling and measuring the amount of vertical displacement. To measure the AC content (ripple) put the switch in AC coupling and only the AC peak to peak portion of the signal will be displayed.

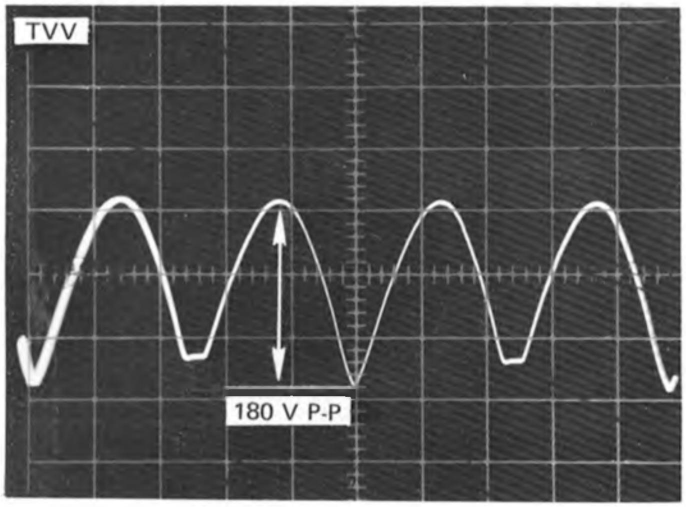
To find out if the ripple is coming from the Power Supply or if a bad decoupling capacitor is feeding vertical information from another circuit, put the sync switch in "Line" position and note the signal locks in. If it does, the ripple is from the Power Supply. If it moves slowly, it is coming from the vertical section.

Test Point:	"Q" B+
PS163:	Timebase: 5 mS Sync: Line, + or —, Auto
PS29:	Button: Varispeed Timebase: 1mS Sync: Line, + or —





Symptom:	Single "Hum Bar" on picture
Cause:	Failure of part of Rectifier Circuit
Check:	Rectifiers



Symptom: 2 "hum bars"
Cause: Failure of filter
Check: Filter capacitors

NOTE

STEREO WAVEFORM ANALYSIS

As in TV servicing, the use of a block diagram greatly simplifies servicing of a stereo system. Once again, we will find that the block diagram is basically the same for each brand or type of stereo system. The specific stereo system you may be asked to service may not have all of the sections shown here. In some the tuner section is not included, or is part of another unit. Other systems may have both the tuner and amplifier in one case — which makes the unit a "receiver." Still other systems may include special functions, such as rhythm sections, which are not shown here.

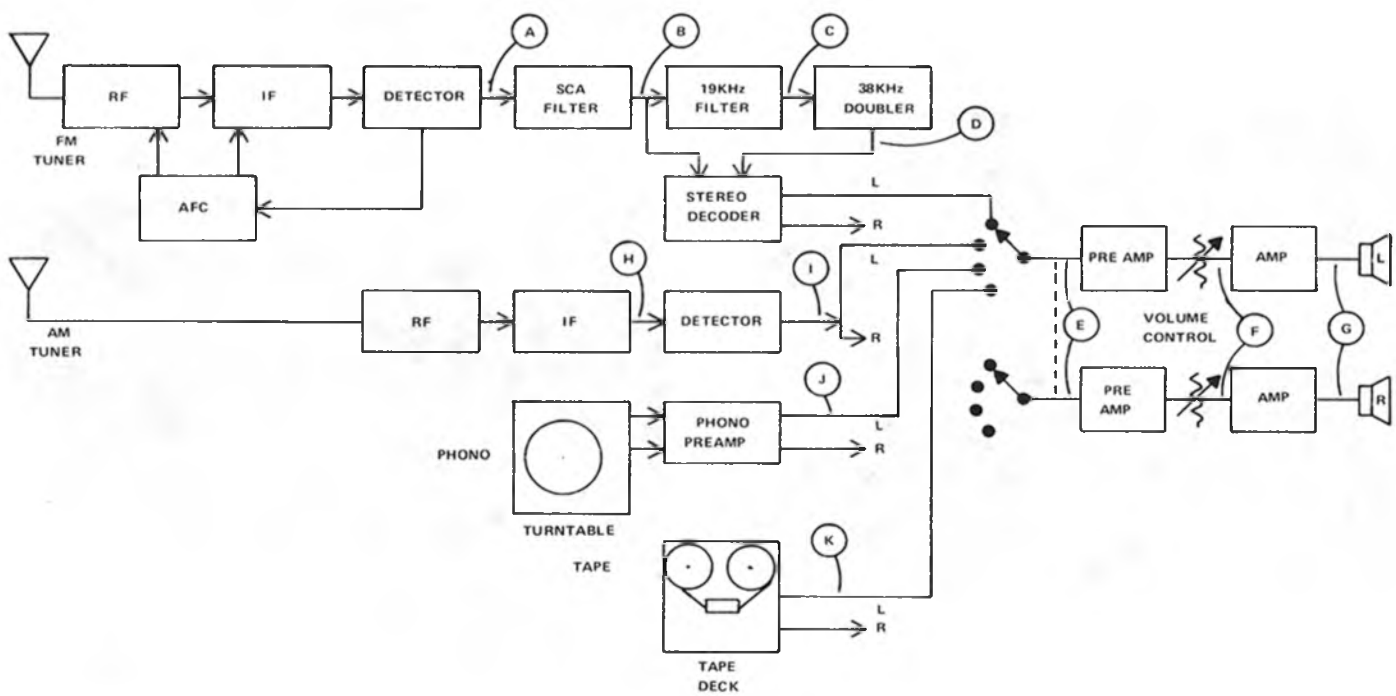
By treating each stereo as a system made of individual blocks, the defective section may be localized using the same basic techniques — whether the sections are in one cabinet or several.

The waveforms shown here show what a waveform should look like in a properly operating system, as well in some defective ones. This allows us to quickly compare the waveforms shown with those we may find in actual troubleshooting situations.

Using the Sencore SG165 Stereo Analyzer as our signal source provides us with the proper reference signals in whatever section we are testing. This completely eliminates the need of an off-the-air signal for troubleshooting or aligning any stereo system.

As a general rule, the scope will be easier to trigger if we connect a test lead from one of the speaker outputs to the external trigger input of the scope. This will allow us to reference the scope to the audio output when looking for a signal in any other section of the stereo section.

For more information on troubleshooting or aligning of a stereo system, refer to the SG165 instruction manual, SG165 and TC28 Sencore News, or troubleshooting information included for that system you may be working on.



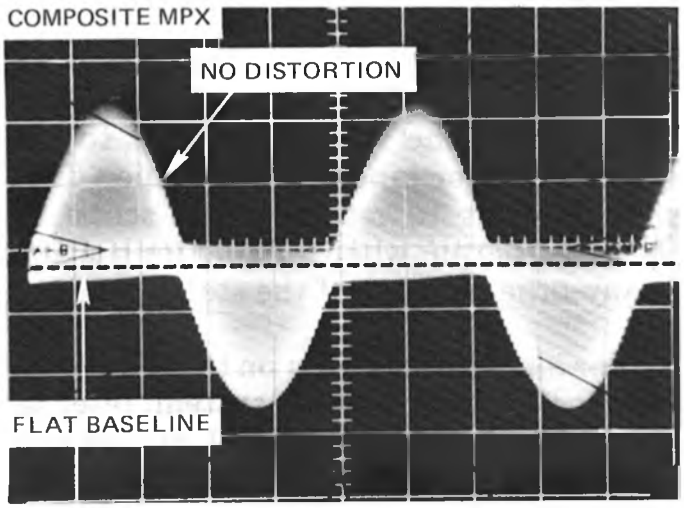
1. FM DETECTOR

FM MPX input at antenna terminals

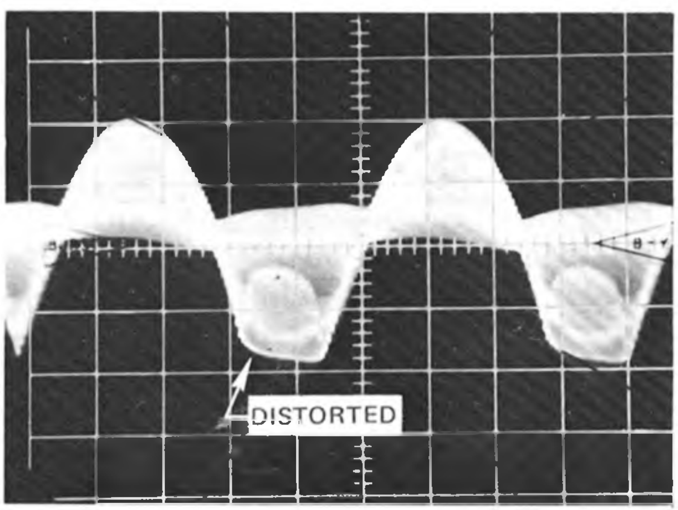
PS163: Timebase: 1mS
Sync: Auto, Ext., + or —

PS29: Button: Varispeed
Sync: Ext., + or —
(Ext. Sync to left channel speaker output)

Test Point: "A" FM Detector output

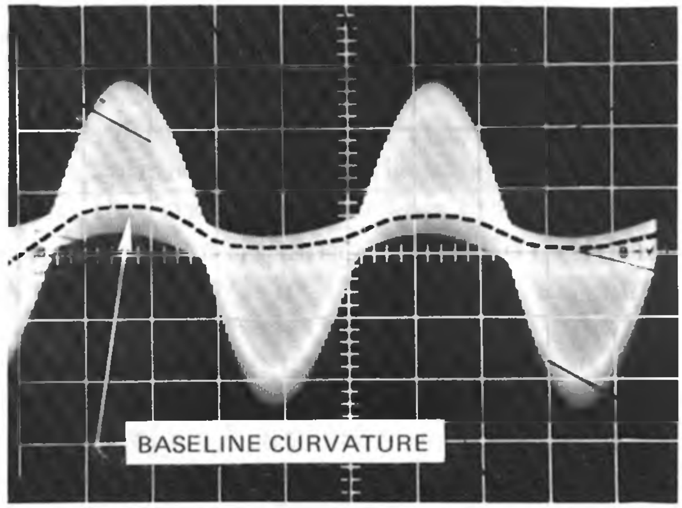


MODULATION L—ON R—OFF



MODULATION L—ON R—OFF

Symptom: Distorted output
Cause: Narrow IF Bandwidth
Check: IF alignment



MODULATION L—ON R—OFF

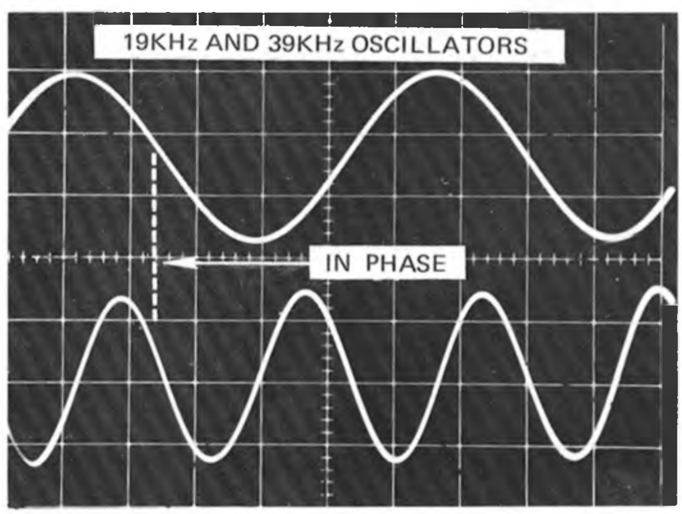
Symptom: Poor separation
Cause: IF phase shift
Check: IF alignment

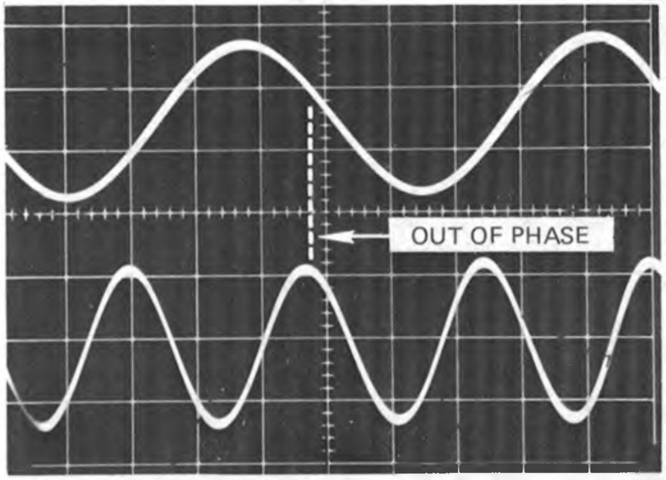
2. MPX DECODER

PS163: Mode: Dual Alt.
Sync: Int., + or —
(Sync on 38KHz signal)

PS29: Button: Varispeed
Sync: Int., + or —

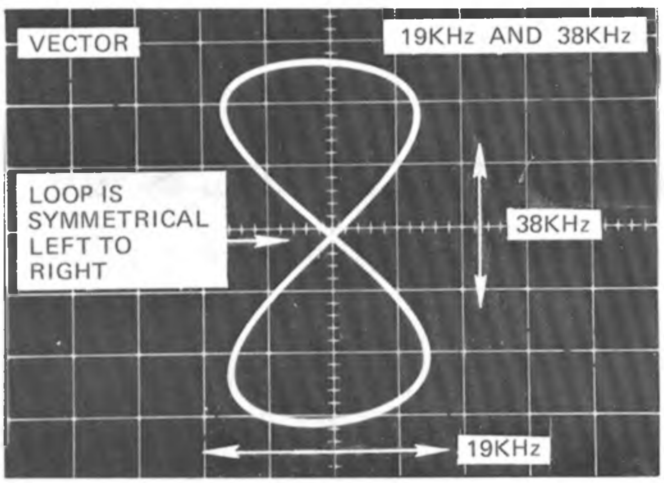
Test Points: "C" 19KHz Filter
"D" 39KHz Doubler

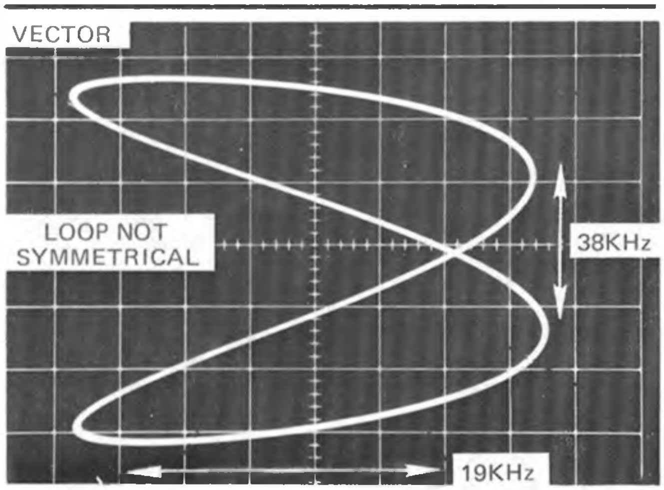




Symptom: Poor separation
Cause: Improper 19KHz and 38KHz phase
Check: MPX section alignment

PS163: Mode: Vector
PS29: Button: Vector



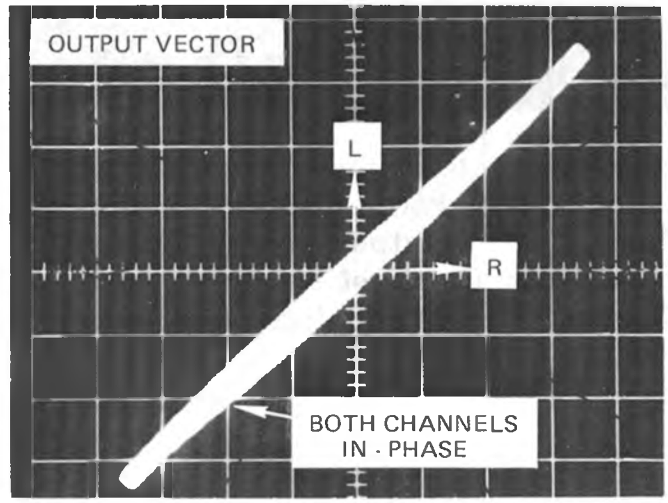


Symptom: Poor separation
Cause: Improper 19KHz and 38KHz phase
Check: MPX section alignment

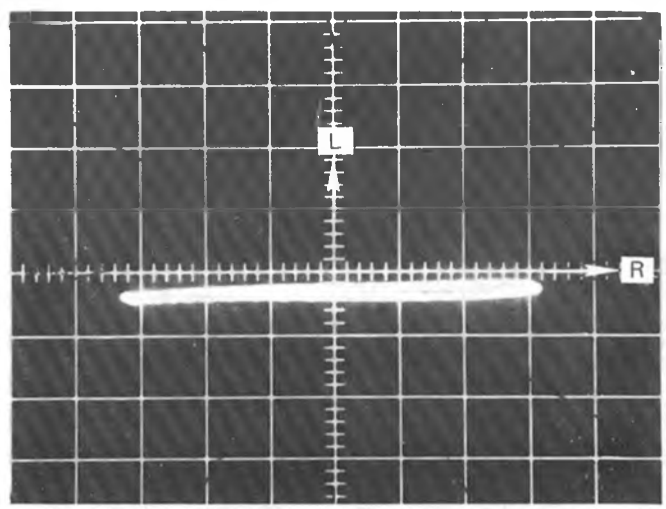
3. OUTPUT VECTOR

PS163: Mode: Vector
PS29: Button: Vector

Test Point: "G" Speaker output
Vertical axis - left channel
Horizontal axis - right channel

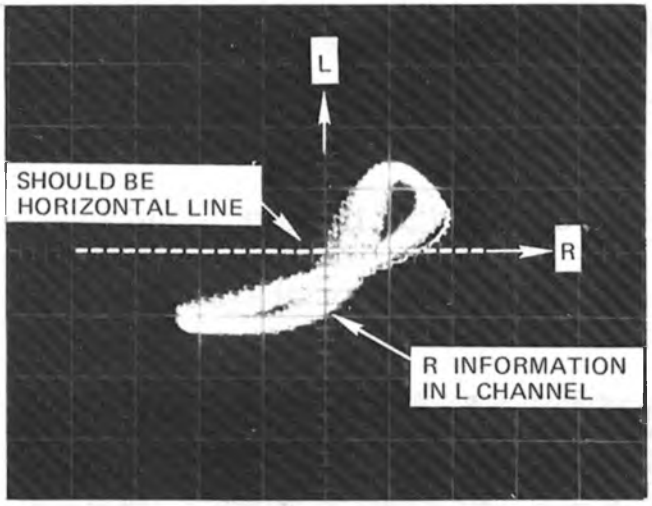


MODULATION L - ON R - OFF



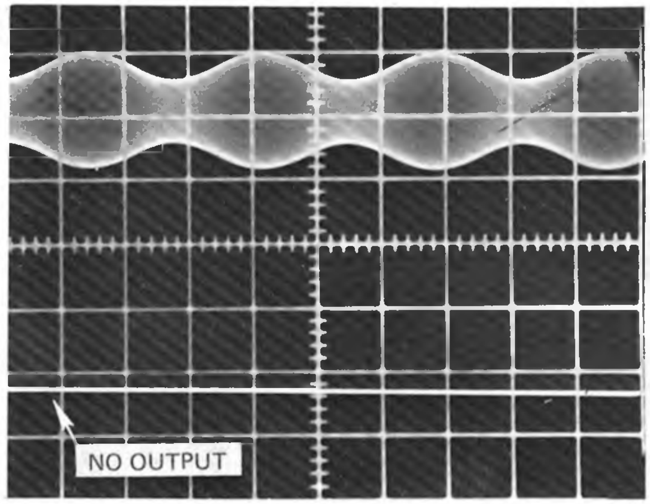
MODULATION L—ON R—ON

Symptom: One channel dead
Cause: Defective amplifier stage or alignment
Check: Signal at each stage, stereo alignment



MODULATION L–OFF R–ON

Symptom: Poor separation
Cause: Output from decoder not correct
Check: IF and decoder alignment

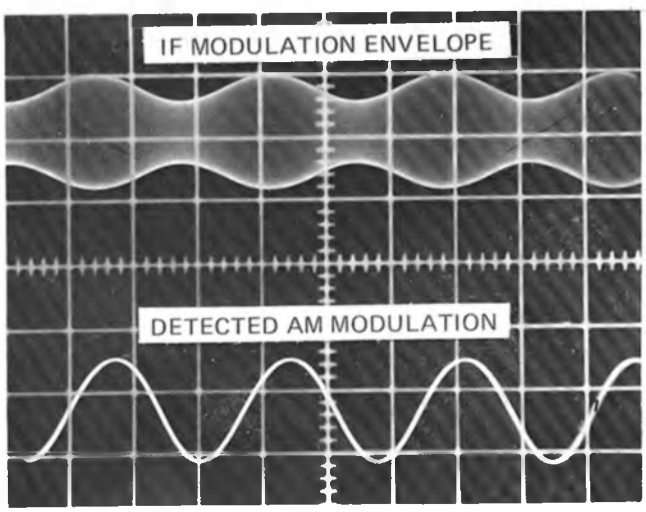


Symptom: No output
Cause: Defective detector
Check: Detector

4. AM DETECTOR

PS163: Timebase: 1mS
Mode: Dual Alt.
Sync: Ext., + or –
PS29: Button: Varispeed
Sync: Ext., + or –

Test Point: "H" - AM IF (use demodulator probe)
"I" - AM Detector output

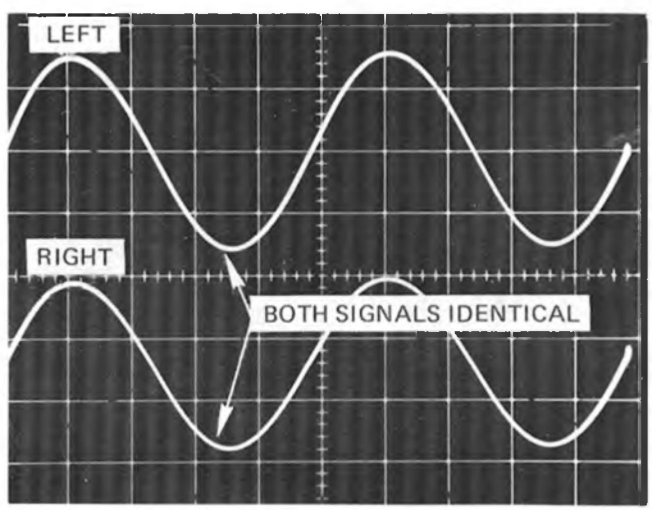


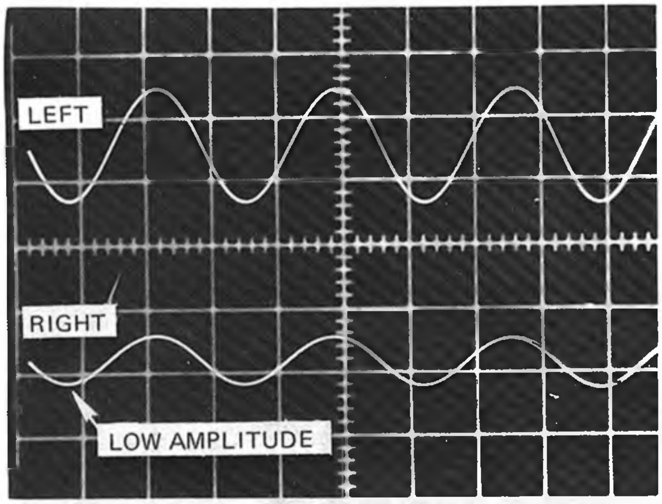
5. AUDIO AMPLIFIERS

(Sine Wave Analysis)

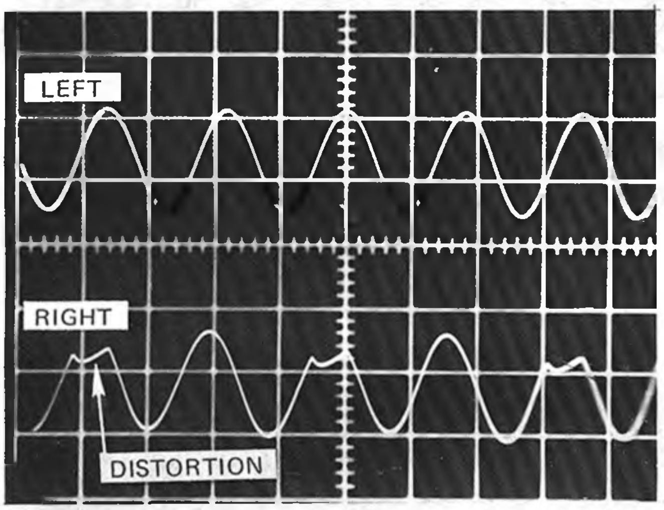
PS163: Timebase: 1mS
Mode: Dual Alt.
Sync: Ch A, + or –
PS29: Button: Varispeed
Sync: Int., + or –

Test Point: "G" Speaker output

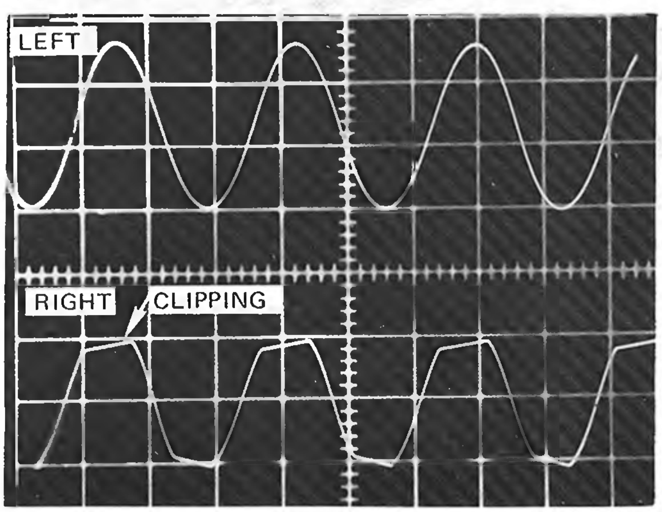




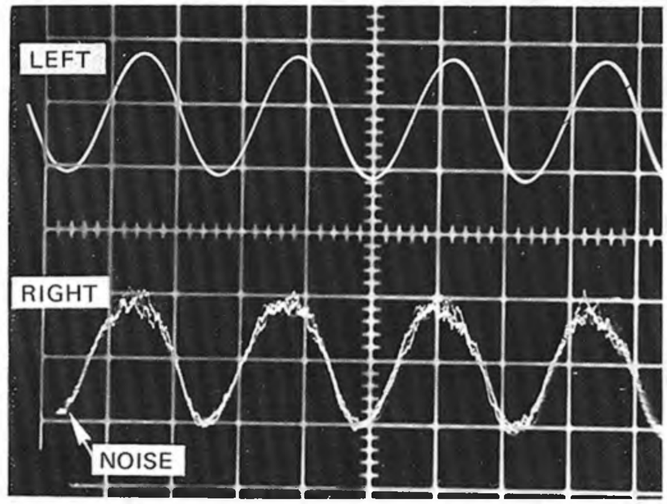
Symptom: Low output from one channel
Cause: Defective amp stage
Check: Each stage for proper gain



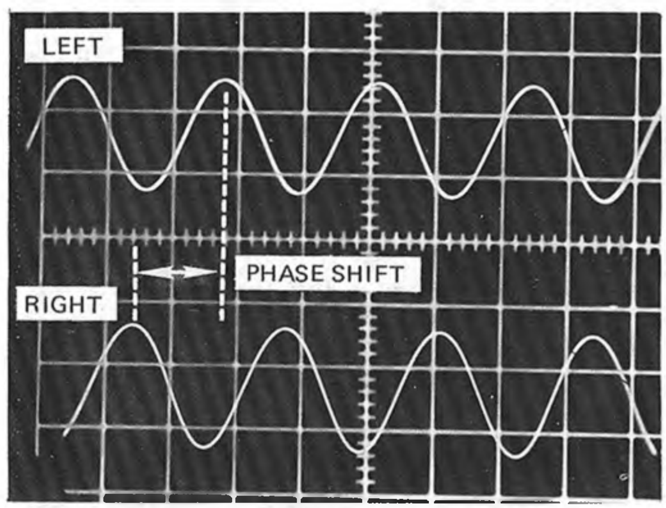
Symptom: One channel distorted
Cause: Ripple on one stage
Check: Decoupling capacitors
Power Supply



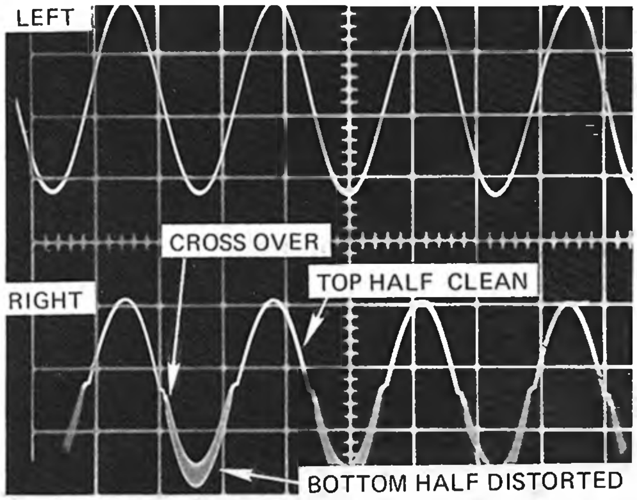
Symptom: Distorted output (1 or both channels)
Cause: Output clipped
Check: Power Supply for proper voltage, output amplifier, and each stage for cause of clipping



Symptom: Noise, one or both channels
Cause: Distorting stage
Check: For broken connections, noisy transistor, noisy control



Symptom: "Doesn't sound right"
Cause: Phase shift
Check: Coupling capacitors, possible shorted transistor, phase reversal switch, proper cable connections

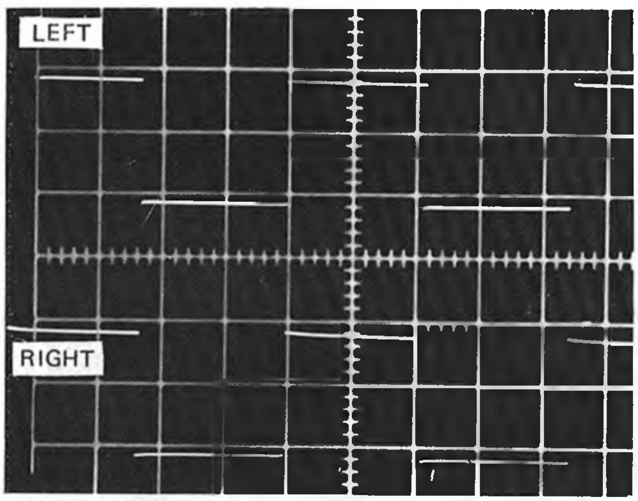


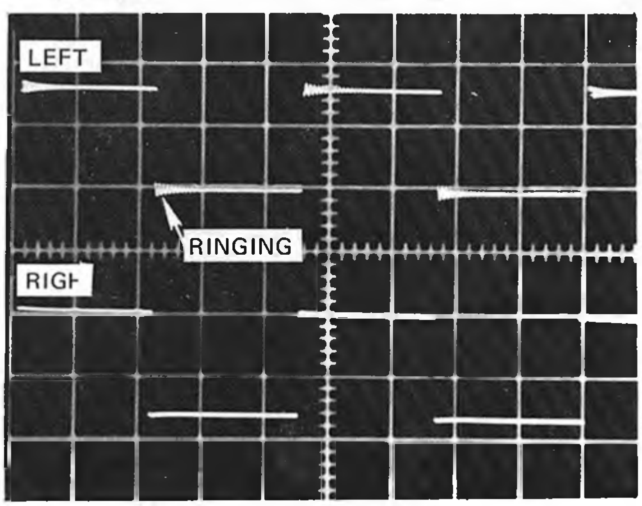
Symptom: Distorted output
Cause: Cross over distortion
Check: Output bias, gain of output transistors

6. AUDIO AMPLIFIERS

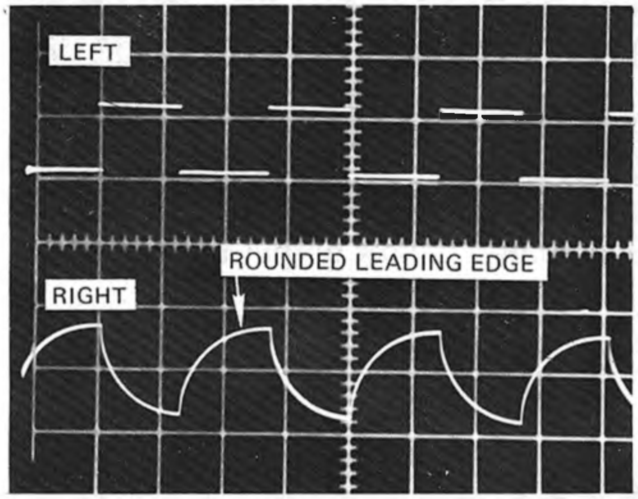
(Square Wave Analysis)

Test Points: "G" speaker output

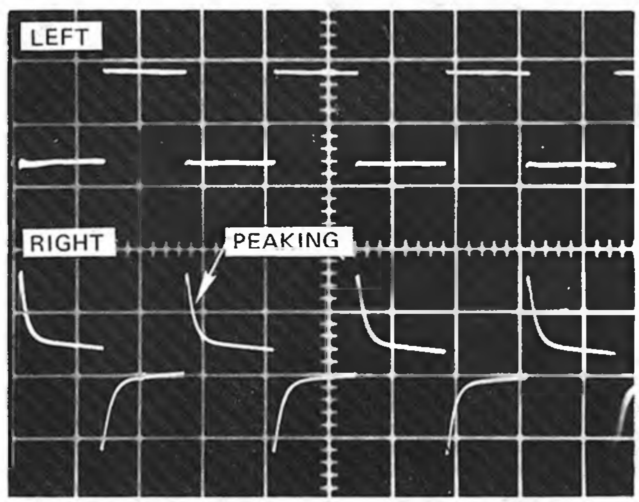




Symptom: Sounds "harsh"
Cause: Ringing
Check: Coupling circuits, transistor bias, phono needle wear, tape head alignment



Symptom: One or both channels "tinny"
Cause: Hi frequency peaking
Check: Tone and filter controls, loudness control, coupling capacitors, normal through phono preamp



Symptom: No bass
Cause: Bass roll off
Check: Tone and filter controls, loudness control, coupling capacitors

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SENCORE SCOPE SCHOOL INVITATION

This detailed Sencore Scope School workshop manual has been included with your Sencore oscilloscope as a special service to you as a Sencore customer, and is also your invitation to attend a Sencore Scope School.

The Sencore Scope School is a three hour, "Nut and Bolt" session, taught by a Sencore Field Engineer, on the operation and application of Sencore oscilloscopes. This workshop manual is the format for the School.

Contact your local Sencore Full Line Distributor about the date and time for the Sencore Scope School in your area, or contact your closest Sencore Regional Sales and Service Center.

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Manual Corrections:

Please note these corrections on the following pages:

Page 16. $\frac{1}{10\,(10^{-3})}$ is incorrect (10^{-3}) should be 10^{+3}

Page 60. Title for bottom right hand photo: 19KH and 39KHz oscillations.
39KHz is incorrect. Should be 38KHz