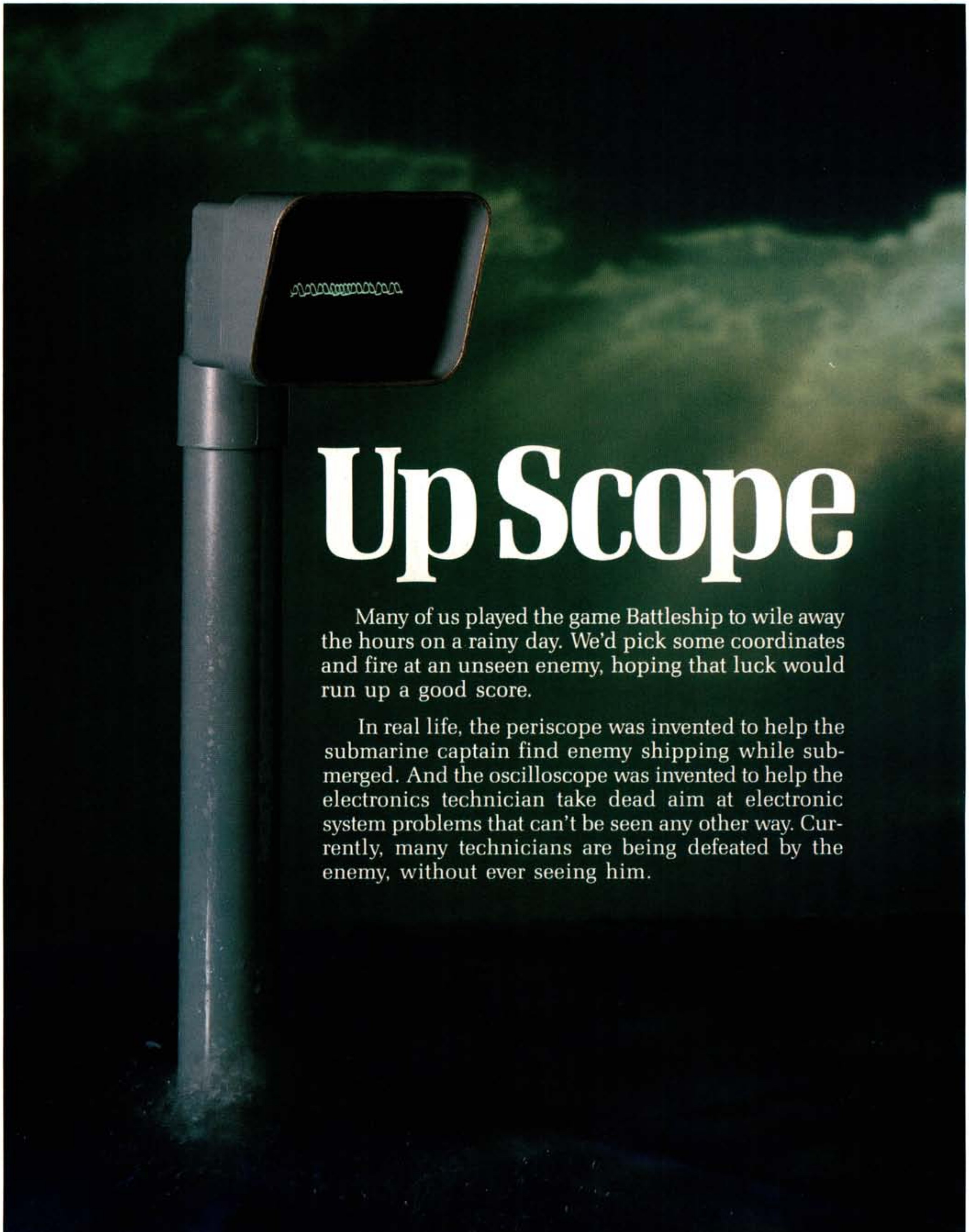


Up Scope

Many of us played the game Battleship to wile away the hours on a rainy day. We'd pick some coordinates and fire at an unseen enemy, hoping that luck would run up a good score.

In real life, the periscope was invented to help the submarine captain find enemy shipping while submerged. And the oscilloscope was invented to help the electronics technician take dead aim at electronic system problems that can't be seen any other way. Currently, many technicians are being defeated by the enemy, without ever seeing him.

On this first cruise, we'll stay submerged and use our scope to see where our electrical enemies are hiding. Then we'll take aim and sink 'em once and for all.

Keeping It Simple

The best way for us to get familiar with a scope and its operation is to K.I.S. (keep it simple) at first. We'll start our cruise with a general purpose dual trace scope, but we'll keep it in single trace mode until this shakedown cruise is complete. We'll also cover S.O.P (Standard Operating Procedures) for proper scope use, and leave you with a final check list that will let you set up the scope for most operations.

Finally, we'll perform some basic voltage and ground tests for battery voltage and accessory grounds, just so you can get the feel of things. In later articles, we'll do more complicated testing, but you gotta float before you can swim.

Why A Scope?

Oscilloscopes let us see problems in circuits—problems that can't be detected by other means. One good example is electronic noise, an elusive and deadly enemy, especially when it invades the engine computer through input sensor wires. Electronic noise on the input sensor wire makes the computer's heart skip a beat here and there (called computer resets). This causes erratic operation of the computer and often leads to replacement of the ECU in a misguided effort to fix the problem by replacing hardware.

This is the dreaded "intermittent" problem that has driven us all insane on more occasions than we'd like to remember—or admit.

AC/DC

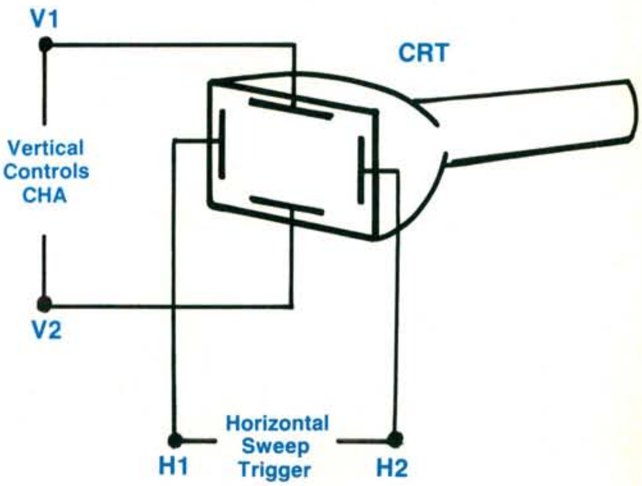
Before we start, remember that most patterns will have both a DC and an AC component. It helps in signal analysis to look at both components at the same time, and we'll try to help you recognize both.

Follow our basic scope set-up procedures for single trace operation as a starting point for scope operation. Our scope is a relatively inexpensive analog model without all the expensive option packages. Our thanks to Elenco Mfg. for providing us with MO 1251 scopes used in the preparation of this article.

So grab your life preservers and settle down for an interesting cruise. Your survival in the computer combat zone may be at stake.

Basic Intelligence

Our first step is to decode some of the scientific mumbo-jumbo that usually comes with your scope operator's manual. For starters, it's enough to say that a lab scope displays its signals on a CRT (Cathode Ray Tube), just like the one in your shop's diagnostic machine, and a little like your ship's radar screen. The scope's CRT has a big vacuum tube. A CRT has to warm up before it starts displaying an image.



When a CRT filament reaches operating temperature, it begins to fire its own beam of electronic torpedoes through the vacuum tube against a phosphorescent screen. As the phosphorous material is struck by the electrons, it lights up to show a direct hit. The movement of the scope's electronic beam is determined by signals from the component being tested, and is modified by the scope before firing the electron torpedoes.

Vertical/Horizontal Hold

The electron beam (negatively charged) passes between horizontal and vertical deflection plates. These plates make the beam do a bank shot off their faces to control the side to side (horizontal) and up and down (vertical) movement of the beam.

Let's also keep it simple, and say that we can set limits on the movement of the scope pattern, both up and down, and side to side.

Keep the following in mind at all times:

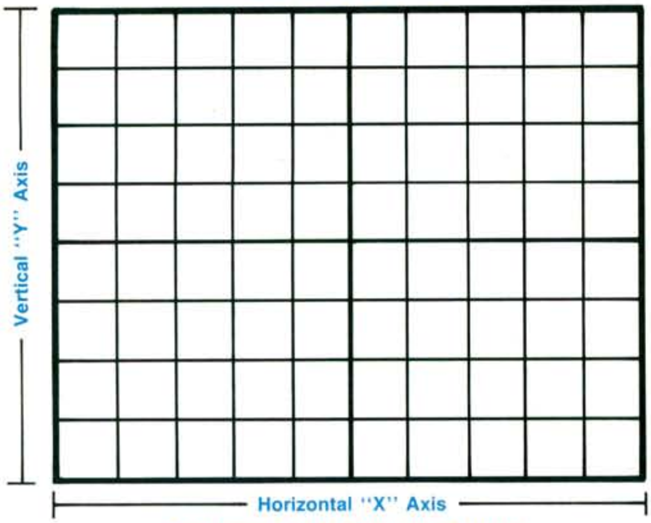
- **Up and down (vertical) movement of the pattern represents voltage.**
- **Side to side, or horizontal movement represents the amount of time it takes for a voltage signal to repeat itself, called frequency.**

The screen of the scope is broken into a grid called a graticule scale that's painted or etched on the screen surface. This graticule scale has 8 vertical major divisions called Y coordinates. Those of you with a little math background may refer to them as the Y axis. Each of these divisions or lines is one centimeter apart.

There are also 10 horizontal major divisions called X coordinates, also one centimeter apart. Refer to each horizontal line as the X axis.

Another way to say it, is that each block on the face of the scope is one centimeter square.

Graticule Scale



Each Block Is One Centimeter Square

We can adjust the scope so that each graticule division has a different value. It's like setting the scale on your DVOM. You wouldn't try to check auto DC voltage using a 400 volt DC scale. Same thing applies here. You can select the correct vertical and horizontal settings for each block on the graticule. Selecting the correct range for the test you're performing gives you a useful image on the screen.

Basic Set-Up Procedures

The MO 1251 is a scope with dual trace capabilities, although as we said, we'll be using it for single trace operations for the time being. It has a 20 mhz bandwidth which is usually plenty for automotive applications. (20 mhz is the maximum frequency this scope can "see" to display.)

While not all scopes have identical markings on their controls, the MO 1251 is similar to many other scopes of this general type. If you have a similar scope from a different manufacturer, the control markings may be slightly different, but should be similar enough for you to follow along.

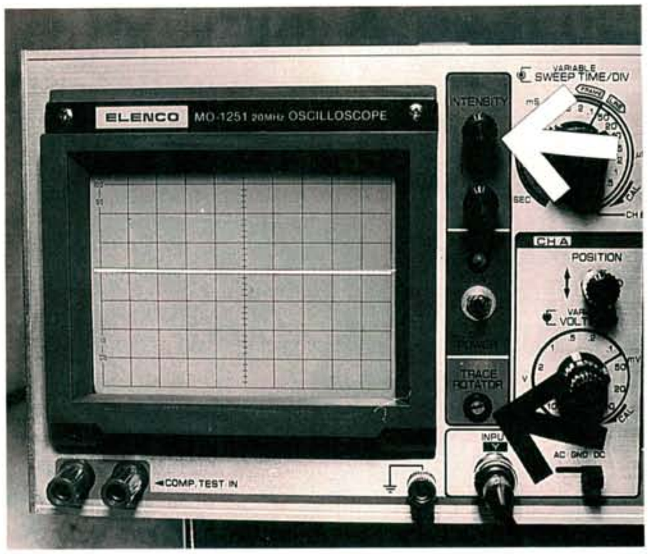
Single-Trace Operation

We'll cover scope operation and control adjustments for single trace operation and break them down into five major subsystems of scope operation:

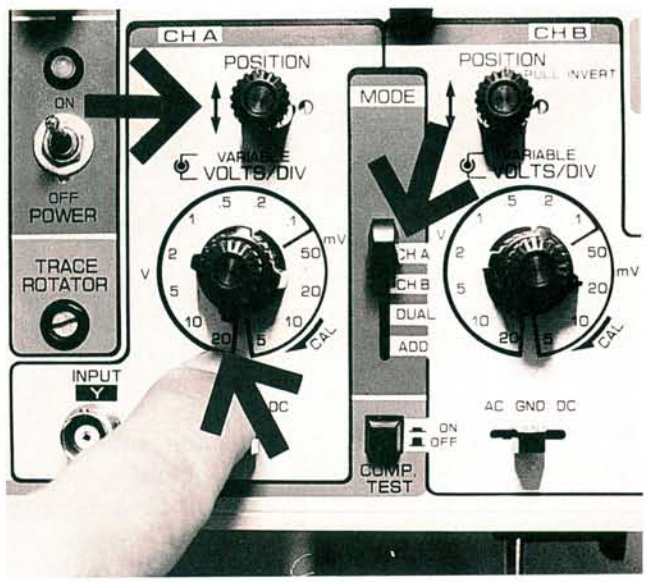
1) Beam preparation
2) Vertical system adjustments
3) Horizontal system adjustments
4) Trigger system theory and operation
5) Probe connections

—By Vince Fischelli

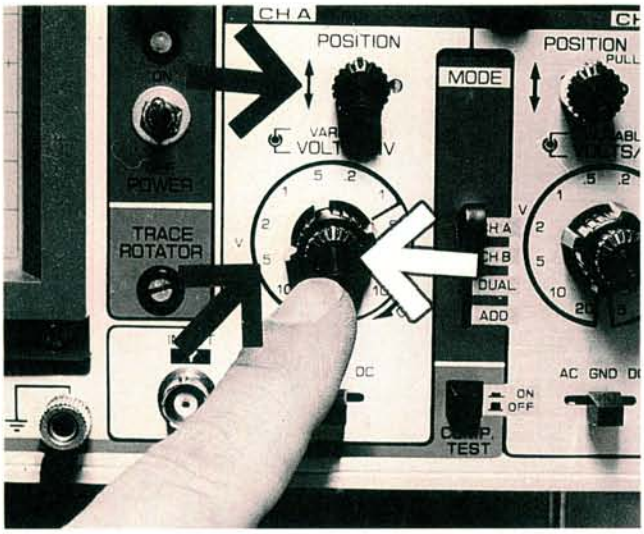
Scope available from:
Elenco Electronics
Circle No. 200



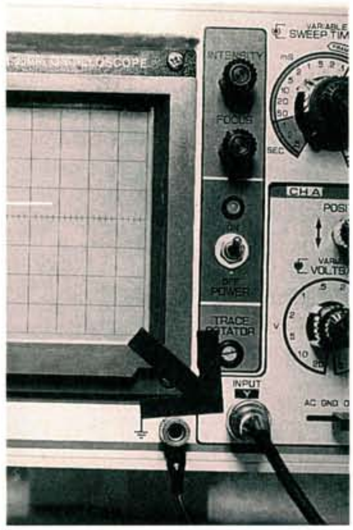
TURN ON THE SCOPE: (1) Turn on the scope with the ON/OFF switch. A trace (the beam) will appear in about 10 seconds and stabilize in 15 seconds or less. (2) Adjust the INTENSITY CONTROL until the trace is bright enough to be seen in existing light. Not too bright, or you'll shorten the life of the CRT's phosphor coating. (3) Adjust the FOCUS for a clear sharp trace. (4) Adjust the TRACE ROTATOR with a small screwdriver until the trace is parallel with the horizontal lines on the graticule.



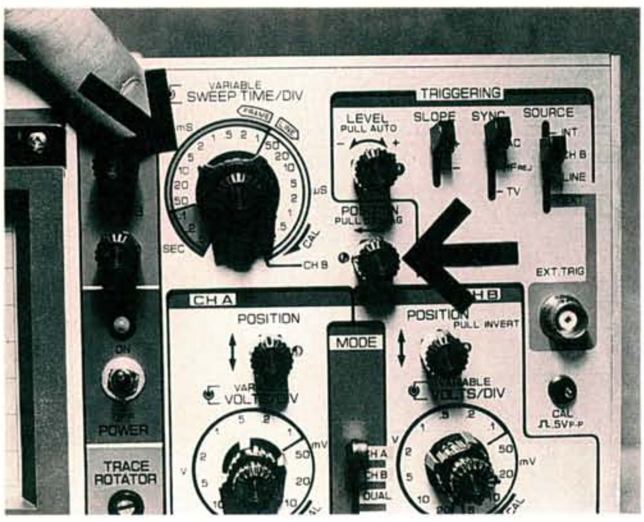
STILL NO TRACE?: If no trace appears, check the following: (1) Be sure the scope is set to CHA. This is the setting for Channel A, or single-trace mode. (2) Set the vertical gain adjustment to 20 VOLTS/DIV. (3) Set the vertical POSITION adjustment for CHA to its mid-range setting. (4) Pull the LEVEL knob to its "out" position (the "automatic" position). Have a trace now? Good. Your "peri" scope is out of the water and ready for a look around.



CALIBRATE THE VERTICAL SYSTEM: Set the CHA vertical controls as follows: (1) Set the vertical VOLTS/DIV to 5 volts. Now each centimeter division in the vertical graticule scale is 5 volts. (2) Set the inside VARIABLE knob to the fully clockwise position. (This top knob is a manual override for the preset calibrations of the VOLTS/DIV knob. For our purposes, the VARIABLE knob in the center should always be left in the fully clockwise position). (3) Set the vertical (POSITION) knob until the trace is sitting right on top of the center horizontal line on the screen.



HOOK UP A PROBE TO THE VERTICAL SYSTEM: Now we're ready to hook up a probe to the vertical (voltage) system. (1) Connect a probe to the "Y" female connector. This is the vertical input for Channel A (CHA). (2) There's a tiny switch on the side of the probe. Set it at X1. We'll discuss X10 on another cruise. (3) Set the AC-GND-DC Switch to the DC setting. (In the DC setting, both DC and AC signals can be displayed. In the AC position, you'll only get AC signals.)



SET UP THE HORIZONTAL SYSTEM: Now we're ready to set up the horizontal (time) system. (1) Set the SWEEP TIME/DIV to 5ms (milliseconds). This means that the trace will move from left to right, and that it will take 5ms for it to travel across each one centimeter block on the graticule. This is a good starting place. We may change this setting later depending on how rapidly the vertical (voltage) signal is repeated. The speed at which the signal is repeated is called frequency. (2) Turn the horizontal position knob until each trace starts even with the first vertical line at the far left.

SWEEP-TRIGGER SYSTEM: If you've gotten this far with the scope, congratulations. You are promoted to scope mate 2nd class. After completing our normal scope set-up in preparation for complete signal analysis, we'll be ready to go. But first we need to learn about the sweep-trigger system. This system tells the scope when to sweep the trace and at what time and rate to sweep to give us a good display. The SWEEP-TRIGGER adjustment synchronizes the speed of the scope to the speed of the signal being tested. This is where a lot of technicians get seasick, but hang on, it's really quite easy.

The Sweep-Trigger System

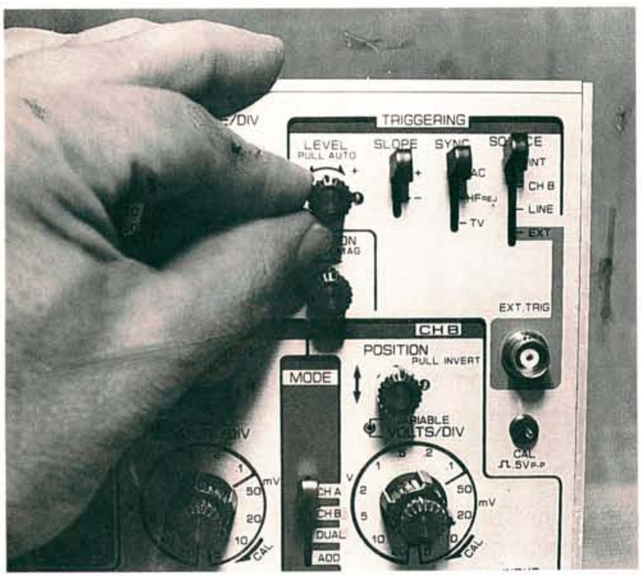
The secret to successful lab scope troubleshooting is to understand how the sweep-trigger system works.

Let's start with an example. Try thinking of two cars traveling side by side down a highway. Both are traveling at the same speed. As long as they maintain the same speed, it's easy to see the occupants of the other car.

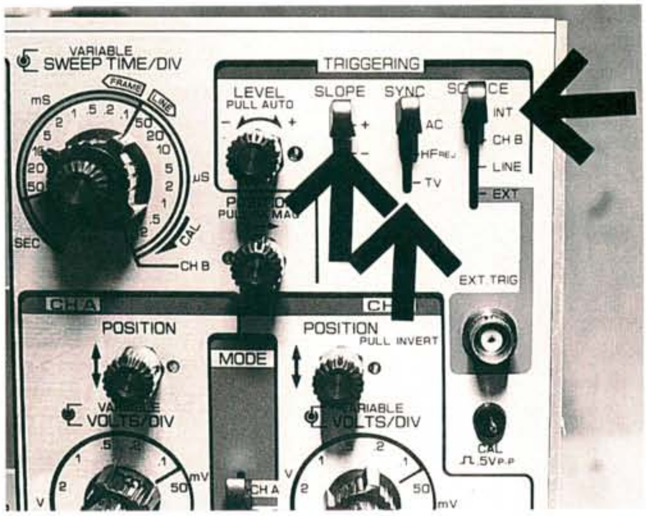
If the other car were your only reference, you might not have any sense of motion at all (unless you stepped out for a moment!).

Let's designate car number 2 as the scope, and designate car number 1 as the signal being tested. Since the movement of both the scope (car 2), and the signal (car 1) are the same, they are "locked on, or synchronized" to one another. If one of the cars slams on the brakes, or suddenly accelerates, the distance between the two gets so wide that the drivers of the two cars lose sight of one another.

But if we can keep the speed of the two cars synchronized, the two cars (or signals if you prefer) can keep each other in sight, and signal analysis is easy. Remember, it's much easier to hit the enemy if he's standing still.

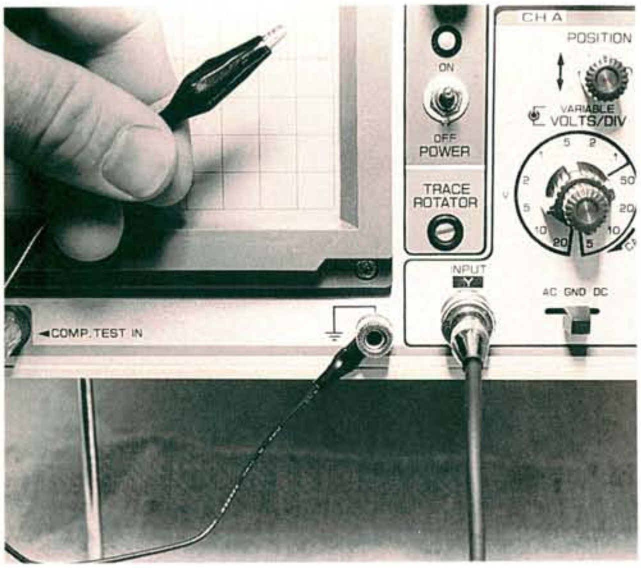


LOCK-ON WITH THE LEVEL CONTROL KNOB PULLED OUT: (1) Connect the scope probe to a point in the circuit to be tested. If the measurement contains a constantly changing signal, the scope pattern will jump around so much that you won't be able to read it. (2) Turn the LEVEL control through its mid-range setting until the display is stopped with a resounding "thud." The display signal freezes on the screen as the scope locks-on, or synchronizes to the signal of the frequency in the circuit being tested. Now car 1 and car 2 are traveling at the same speed.

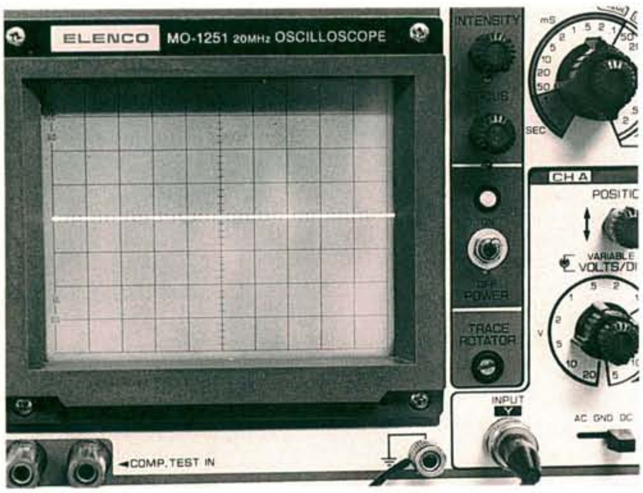


SETTING UP THE TRIGGER SYSTEM: Remember K.I.S. (Keep It Simple) (1) Set the Source switch to INT (Internal) and leave it there. This lets the scope lock-on to CHA (Channel A's) signal. (2) Set the SYNC Switch to AC and leave it there. This allows for normal triggering. (3) Set the SLOPE adjustment to (+). The Slope adjustment, either (+) or (−) determines where the scope will start its trigger. But don't worry about that right now, because for our purposes, most of the time it won't make any difference.

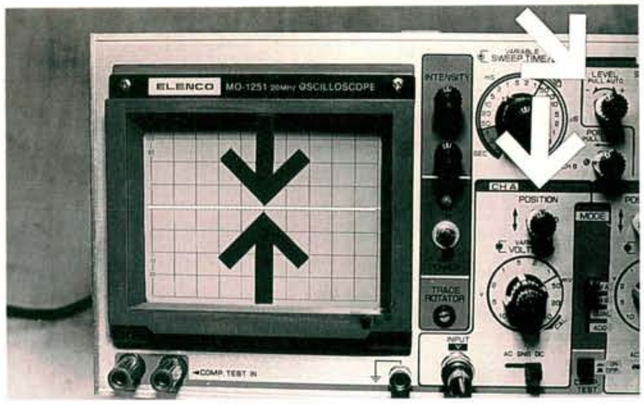
LOCKING-ON WITH THE LEVEL CONTROL KNOB PUSHED IN: When the LEVEL control knob is pushed *in*, the trace does not appear until the scope locks-on to the signal. This feature is designed to protect the phosphor coating in the CRT by blanking out the trace until scope and signal are in sync. If you forget that the Level Control knob is pushed in, and the scope is out of sync with the signal being tested, you'll have a blank screen and think the scope is bad. Always measure DC voltages with the LEVEL CONTROL pulled *out*.



GROUND THE SCOPE TO THE VEHICLE: Connecting the scope to a good ground on the vehicle is extremely important—just as important as it would be if you were using your DVOM. All scopes have a main ground connection. On the MO-1251 it's located at the bottom center of the front panel. Connect this ground post to the negative terminal of the vehicle battery with a heavy jumper lead. This will be your best ground connection.

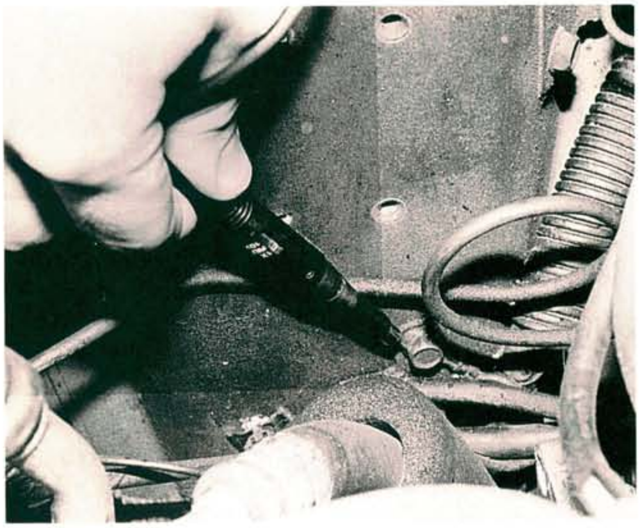


MEASURING DC (BATTERY) VOLTAGE: (First follow S.O.P. for ground calibration.) The following is S.O.P. for checking DC voltages with a scope. Remember that we adjusted the voltage range so that each block on the graticule represents 5 volts. Each time the trace moves upward one block, we've measured 5 volts. (1) With the engine off and the ignition switched off, and the scope grounded to the negative side of the battery, touch the probe to the positive side of the battery. (2) Read the scope. Our trace has moved up two and one half squares on the graticule. It's indicating about 12.5-12.6 volts, or normal battery voltage. No enemy here, hold your fire.

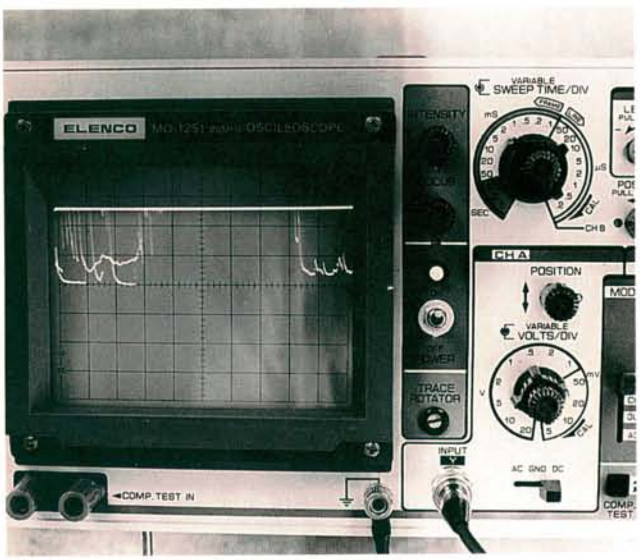


S.O.P. FOR GROUND CALIBRATION: We want to ''zero'' the scope trace to indicate a ground of 0.0 volts on the center (horizontal) graticule line. (1) Pull the LEVEL control knob out. (2) Move the AC-GND-DC switch to the GND position. This grounds the input to Channel A (CHA). (3) Use the vertical POSITION knob to move the trace line up or down until it sits right on top of the center horizontal graticule line. This is ground or zero volts. (4) Move the AC-GND-DC switch back to the DC position to unground the CHA input.

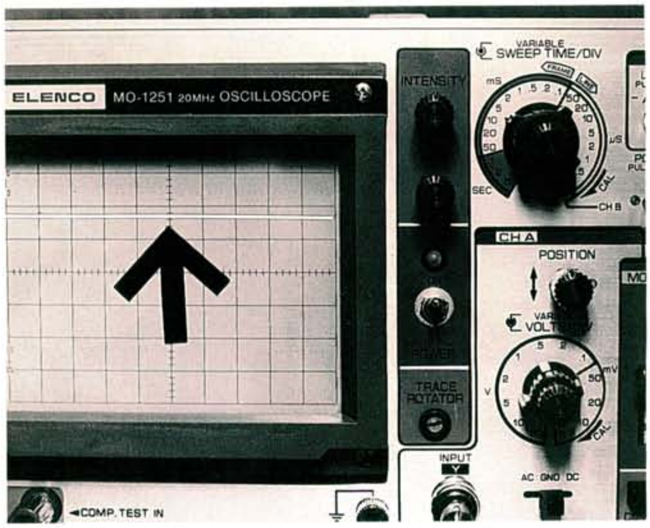
We are ready to measure DC voltage or signals. Stand by, men. We're about to engage the enemy. We'll lock and load, and stand ready to fire when the enemy is sighted.



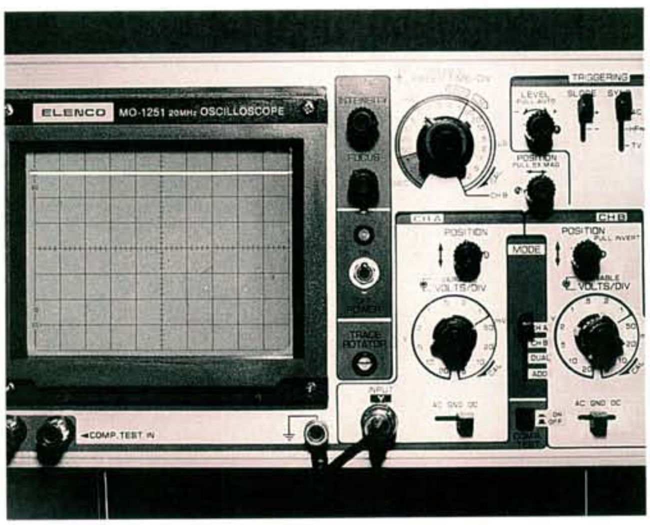
MEASURING GROUND CONNECTIONS: (First follow S.O.P. for ground calibration.) The following S.O.P. is for checking ground connections. You will be on the lookout for any DC voltage (or voltage drop) and any electrical noise present in the ground circuit. Engine off, key on, turn the heater blower and wipers on to their highest speeds. At the same time, turn on the radio, headlights, hit the stop lights, and open the driver door to turn on the courtesy light. This will send maximum accessory ground current through the accessory ground connection.



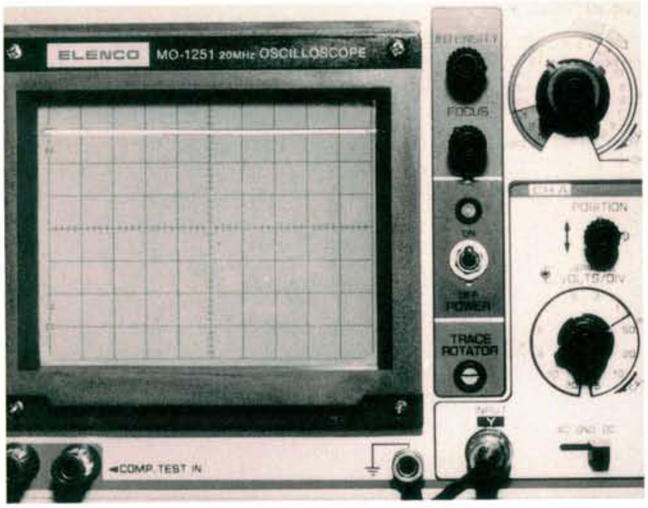
MEASURE GROUND FOR NOISE: (1) Wiggle the accessory ground connection. (2) Read the scope. Look for noise in the form of spikes jumping up from the ground voltage trace. Fire Two! We have lots of noise—noise that your DVOM would not see. This noise is caused by a loose connection that would occur from vibration of the vehicle while driving. Noise in the ground, or in any circuit for that matter, upsets the sensitive operating characteristics of electronic computers. You need a scope to see this noise.



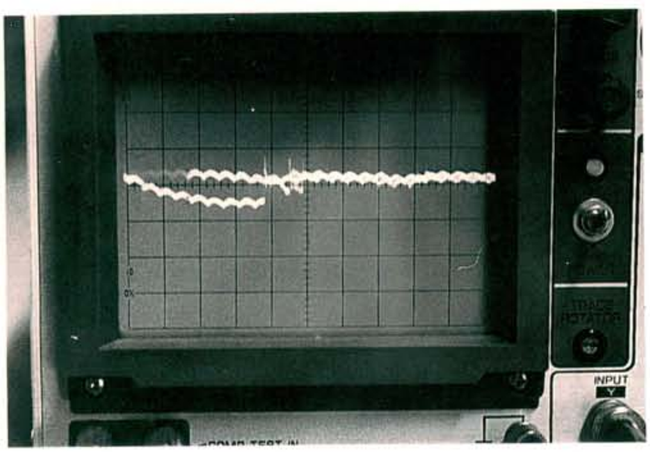
MEASURING GROUND VOLTAGE DROP: (1) Touch the probe to accessory ground metal chassis. (2) Read the scope. Any DC voltage drop in the ground side of the accessory circuit will cause the trace to rise. But don't forget that we're still on the 5 volt scale. A voltage drop in tenths of a volt may be hard to see on this setting. Move the (Vertical) VOLTS/DIV to the 0.1 volt scale and retest. Now each block of the graticule will represent 0.1 volt. If the ground circuit is good, the trace should not rise more than one block, 0.1 volt. If it does move more than one block, we've found an enemy. Fire One!



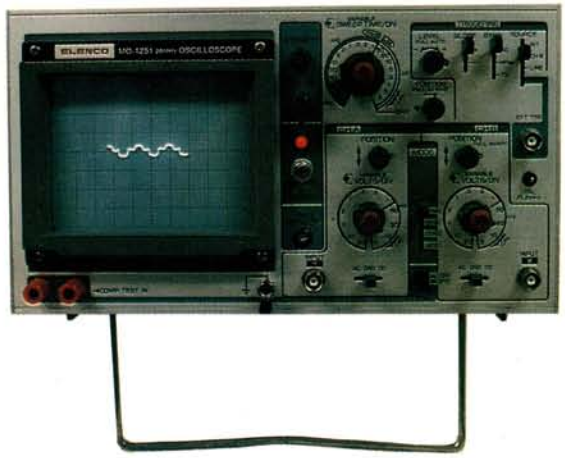
MEASURE AN AC SIGNAL COMPONENT WITHOUT DC: (First follow S.O.P. for ground calibration.) The following is S.O.P. for checking AC voltages with a scope and ignoring the DC component. An example is the ripple content of the alternator charging voltage. We'll start by testing DC output, then switch to AC. (1) Set the Vertical VOLTS/DIV back to 5 volts. Start the engine. (2) Touch the scope probe to the (+) terminal of the alternator. (3) Read the scope. The trace will move up almost three blocks on the graticule scale if the charging voltage is 14.0 volts.



SWITCH TO AC: (1) Move the AC-GND-DC switch to the AC position. Notice how the trace moves down to the zero volt reference line because the DC part of the charging voltage is now being blocked out with the scope in the AC position. The pattern you see now is the ripple amplitude content of the charging voltage. **Note:** Do not allow the scope probe cable to come into electro-magnetic pick-up range of ignition wires or the readings will be unusable. If you do get this garbage, try moving the probe to the positive battery terminal. (This is the same electrical point, but it should get you far enough away from the ignition wires.)



INCREASE VERTICAL SENSITIVITY: A bad positive or negative diode, or a shorted section of the rotor winding would cause a dramatic increase in the alternator ripple pattern amplitude. To get a closer look at the content of the signal, move the (Vertical) VOLTS/DIV to 2v, and then to 1v. Each time the ripple pattern will get larger in amplitude (taller) as the scope sensitivity is increased. If the amplitude of the ripple pattern is greater than the manufacturer's specification for that alternator, Fire Three! The alternator is generating excessive noise that can drive electronic components crazy.



S.O.P For Initial Scope Set-Up

BEAM PREPARATION
(1) Turn on scope
(2) Adjust intensity
(3) Adjust focus
(4) Adjust Trace Rotator

NO TRACE YET? FIND THE TRACE
(1) Select CHA with Mode Switch
(2) Set (Vertical) VOLTS/DIV to 20v
(3) Set (Vertical) POSITION (CHA) to mid-range position
(4) Pull the Level Knob "out"

CALIBRATE THE VERTICAL SYSTEM
(1) Set the (Vertical) VOLTS/DIV to 5v
(2) Set the inside Variable Knob fully clockwise
(3) Set the (Vertical) POSITION so trace is superimposed over the center horizontal graticule line

CONNECT SCOPE PROBE TO CHA INPUT
(1) Select X1 on the scope probe
(2) Set the AC-GND-DC switch to DC

CALIBRATE THE HORIZONTAL SYSTEM
(1) Set the SWEEP-TIME/DIV to 5ms (milliseconds)
(2) Set the (Horizontal) POSITION so the trace begins at the first vertical graticule line

SET UP THE TRIGGER SYSTEM
(1) Set the SOURCE switch to INT
(2) Set the sync switch to AC
(3) Set Slope to either (+) or (−)
(4) Pull the LEVEL KNOB "out"

GROUND THE SCOPE TO THE VEHICLE (BATTERY)

FOLLOW S.O.P. FOR GROUND CALIBRATION