Inside Scopes

The automotive oscilloscope is the thinking man's diagnostic tool. There isn't too much that can escape the eye of the master scope operator. Analog scope analysis is one of the real art forms in the automotive trade.

That's why *Import Service* adopted the ripple pattern and screen as its logo.

That's also why we're going to start spending some time with scopes, both analog and digital, as an aid to pinpointing problems on our newer, more complicated automobiles.

After careful thought, we have once again opted to do an initial article dealing with the fundamentals. Yes, we know you scope pros know all this, and more. But there are trainees out there who don't.

So we're going to walk through the basics of a conventional ignition system as groundwork for some more ambitious projects later.

We have every intention of developing a series dedicated to analyzing patterns on some specific import vehicles for future issues. At that time we'll also cover some more advanced troubleshooting techniques. Currently, most of the schematic charts depicting specific patterns have not yet been expanded to include import vehicles.

What You See Is What You Get

The real beauty of the scope is that it measures voltage in the ignition system and displays that voltage in terms of time. If you remember that all vertical lines represent voltage, and horizontal lines represent the time needed for these voltages to occur, you're off and rolling.

What Voltages?

If we want to measure ignition voltage it only makes sense to connect our oscilloscope to the terminals where those voltages occur. Common hook-ups are as follows:

1) Primary—This is connected to the primary side of the coil, the side the condenser hooks to. Also known as the negative side of the coil. (The positive side of the coil receives current and is called the positive side.)

2) Secondary—This voltage is measured at the coil wire with a capacitive clip-on pickup.

3) Number One Pickup—This inductive pickup tells the scope the starting point of the engine's firing order using a signal from the number one spark plug wire.

4) Ground wire—This connects to the engine ground.

Primary? Secondary?

Ignition coils have been used since your grandfather's day to supply the spark needed to fire a spark plug and ignite the compressed fuel/air mixture to power the car. That lonely spark is asked to jump the plug gap in a very hostile environment. It needs to be strong going in, have good staying power, and arrive at the right time. Voltage and timing are essential here.

Our interpretation of that scope pattern will only be as good as our understanding of how that spark is generated and delivered. Without that basic understanding, the scope pattern is just a pretty phosphorescent squiggle on a screen.

The primary circuit is used to generate a magnetic field inside the coil primary winding. Conventional ignitions use a set of contact points as a switching mechanism. (And a condenser we'll discuss in a moment.)

The points stay closed until the coil primary windings are properly energized, or saturated. Then the points open, eliminating ground to the primary circuit.

There's a lot of frantic activity inside the coil at this instant as that charge in the winding searches for ground.

The escape route is provided as the field in the primary winding collapses into the secondary winding. The secondary has more turns of a finer strand wire than the primary. A higher voltage, known as secondary voltage is induced as a result. This is that big, fat, blue spark needed to travel through the rotor to the distributor cap and then down each insulated wire to the spark plugs. This spark fearlessly leaps the gap to the grounding tab of the plug. The spark ignites the fuel mixture and the process is repeated—again and again for each succeeding cylinder.

The Condenser

My 1924 edition of *Dykes Automobile and Gasoline Engine Encyclopedia* describes the purpose of the condenser as follows:

- To absorb the self induced current of the primary, thereby allowing the magnetic field to collapse with the greatest possible speed, and also eliminating the spark at the contact points.
- To discharge in an oscillating (alternating) manner back and forth into the primary circuit, thus completely neutralizing or demagnetizing the iron core and thereby preparing it for repeated action.

You might want to think of the condenser as an electrical shock absorber.

So Who Uses Points?

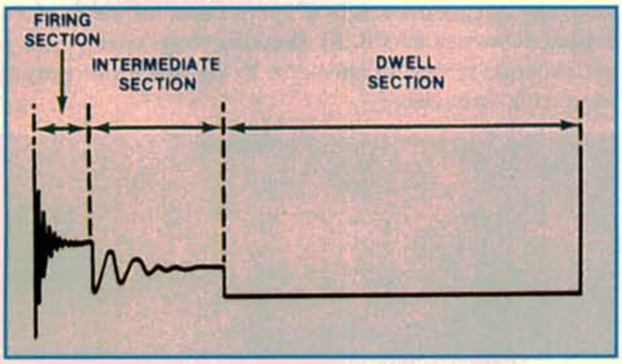
Ignition point/condenser triggering is obsolete. So why bother? We use transistorized, solid state controls now.

You're right. But a look at conventional patterns will allow us to establish a set of generic rules for scope interpretation. Remember that we can't have good secondary voltage without enough primary voltage for coil saturation.

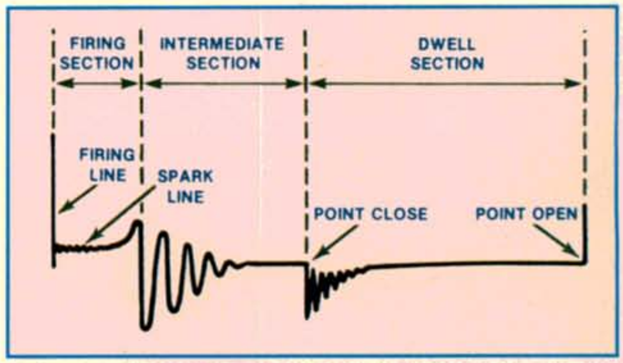
Our first two illustrations divide and label the primary and secondary patterns into three sections each.

- Firing—The point at which secondary voltage fires the plug.
- Intermediate—The section where the coil and condenser work together to gradually dissipate any remaining coil voltage.
- Dwell—The "primary on" section where the points close, allowing the primary to recharge.

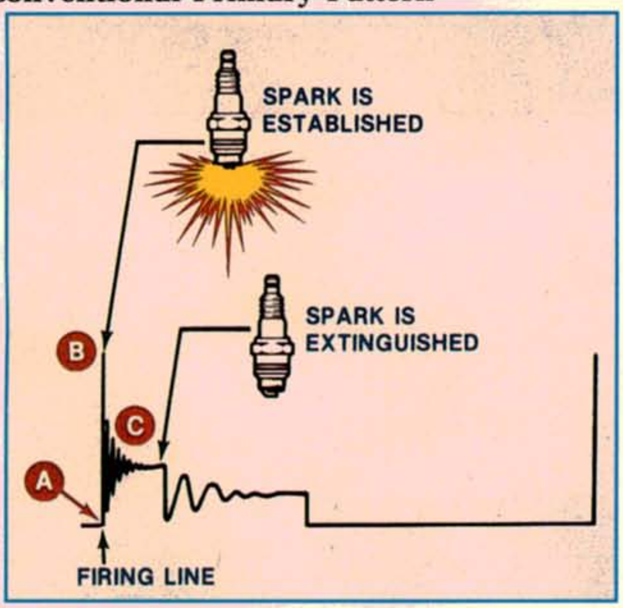
—by Ralph Birnbaum



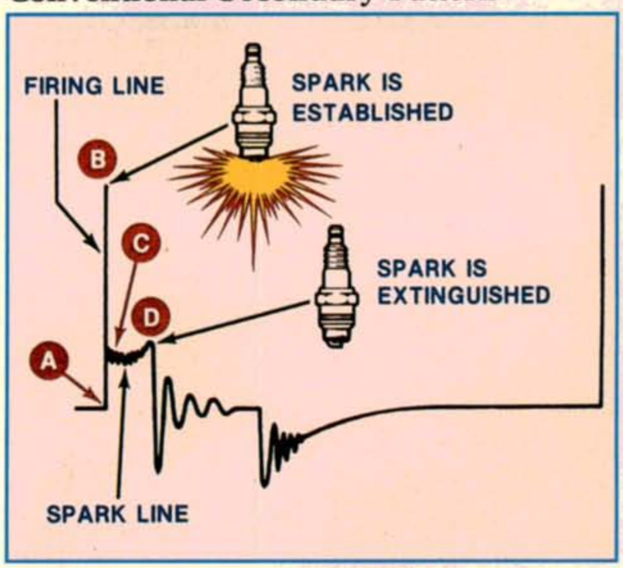
Conventional Primary Pattern



Conventional Secondary Pattern



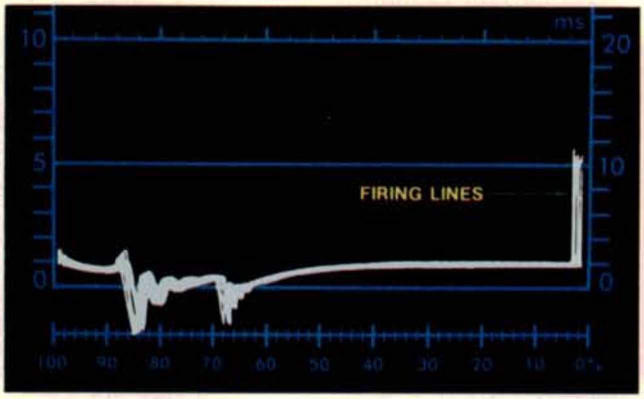
Primary Firing Section
A) Ignition points open
B) With A, this line forms the initial charging of the condenser. Look for four or more diminished oscillations until the spark goes out at point C.



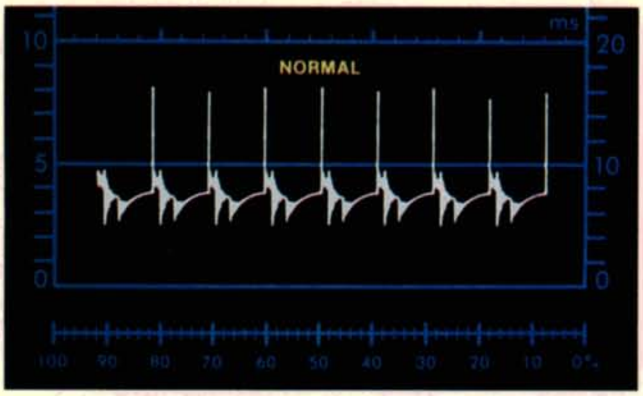
Secondary Firing Section
A) Points open here inducing high voltage.
B) With point A this line represents the voltage needed to initially jump the rotor and plug gaps.
C) The spark continues to bridge the gap
D) The spark goes out.

Normal and Abnormal Patterns

Here are some sample patterns to view and compare. Raster, display, and superimposed patterns allow you to highlight and reposition different parts of the patterns for closer inspection.



To save valuable space we combined raster and superimposed. Superimposed stacks the images for comparison. Raster patterns allow for faster comparison of the voltages' elapsed time.

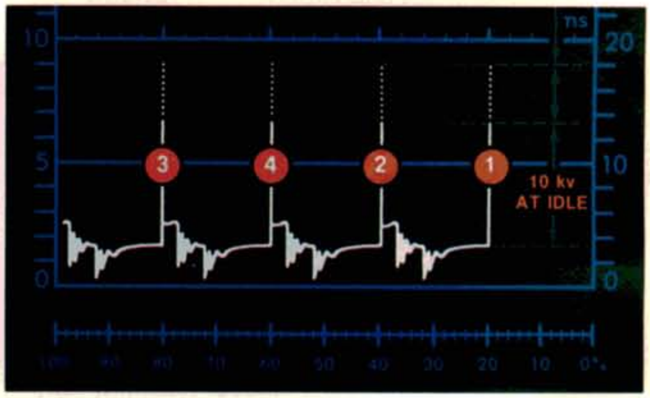


This pattern shows normal polarity. The spikes point up as they should. But what if someone reversed the leads to the coil or worse, the battery?

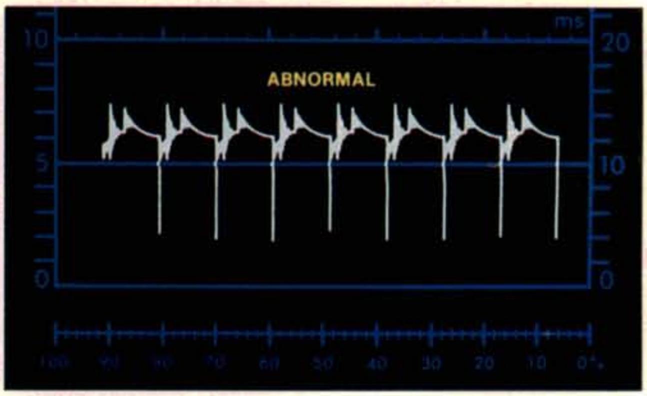
Snap the throttle open and shut to check the plugs under load. Use the screen's reference lines and make sure that firing voltages rise evenly.

We've also included some patterns showing normal and abnormal ignition system conditions, test procedures, and possible trouble spots.

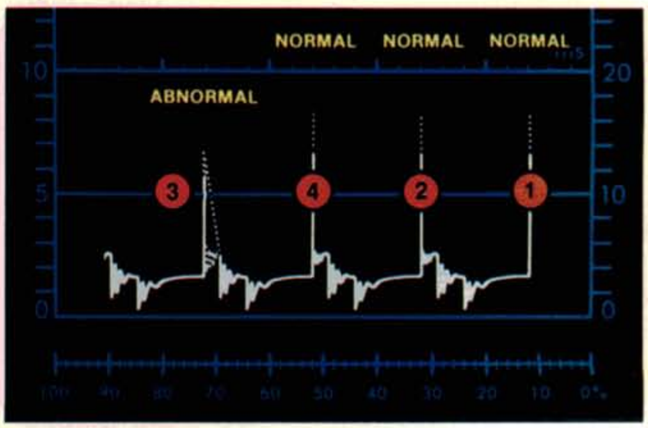
You may not be dealing with points, but you will have problems with coils, caps, rotors, plugs, and wires. As a result, we've only used secondary patterns.



When comparing the height of spark lines, for instance, the display pattern is useful. By showing these spark lines as vertical spikes, we can check for firing line uniformity by comparing voltages.



Reversed polarity increases the voltage requirements needed to fire the plugs and may cause a misfire. You'll find it quickly with the scope.



This pattern is also abnormal. Possible causes? A shorted plug wire, fouled plug, broken plug insulator, or very low compression.

This Mortal Coil

We offer these additional tests with a strongly worded **CAUTION.** Disconnecting high tension cables when performing these tests can damage some electrical systems. Before performing these tests always refer to the shop manual for the car you're working on to see if it prohibits these tests.

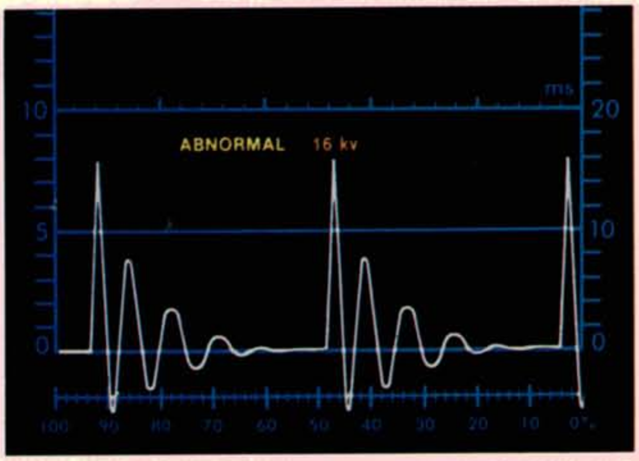
Also, make sure you get a good pair of insulated pliers before starting. Don't open-circuit a wire for longer than 15 seconds or raw fuel may foul the catalytic converter.

Our sincere thanks to the Sun Electric Company for their help in preparing this article.

To check for normal coil output, run the engine and disconnect a plug wire using insulated pliers. The coil should produce a minimum 20KV as shown.

If the voltage is low, as shown, test the coil. Also look for high resistance in the primary circuit or signs of leaking secondary insulation.

Cranking coil output is one good test for those hard to start engines. Set the pattern to the display mode and set the pattern on the zero line so you can use the vertical scales on the screen. Remove the high tension wire from the coil and crank the engine. Note the readings and reconnect the coil high tension wire.



Cranking coil output too low? Check the following: low battery voltage, high current starter draw (either will usually be accompanied by slow cranking), low primary voltage, a bad coil wire, a bad coil, or a bad ignition switch. Aside from coil failure, this problem is usually caused by insufficient voltage, high resistance, or some combination.