PHASE 4
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UNIVERSAL TECHNICAL INSTITUTE

LIST OF LAB PROJECTS

PHASE 4 - FUEL AND IGNITION SYSTEMS

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INSTRUCTOR________________

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DETONATION AND PRE-IGNITION

For many years, one of the most misunderstood and misconceived phenomena taking place in the internal combustion engine is pre-ignition and detonation. In general terms, most people refer to these items as **"Spark-Knock" or "Engine Ping."**

In order to understand just what is happening when pre-ignition or detonation occurs, let us first separate the two items and examine each. Mainly, as you will soon see, they are two distinct phenomena taking place, separate of each other; but they also work hand-in-hand to deteriorate or completely destroy an internal combustion engine.

First, let us examine pre-ignition. We think of the word pre-ignition as referring to an explosion. This is axactly what happens when pre-ignition occurs. A simple definition of pre-ignition would be: **The unwanted and uncontrolled explosion of the fuel mixture in the combustion chamber before natural combustion and ignition takes place.**

Detonation takes place when the fuel mixtures ahead of the advancing flame front (that begins at the spark plug) reaches self-ignition temperature. The burning process of this self-igniting fuel mixture is vastly greater than that of normal combustion due to the high temperature involved. Detonation is most likely to occur at low speed, heavy load with wide open throttle, such as when accelerating.

Examine briefly the combustion and ignition process: The piston comes up towards the top of the cylinder on the compression stroke. A few degrees **before** T.D.C. (top dead center) the spark plug fires and ignites the fuel mixture. Consequently, in addition to the temperature rise given the unburned mixture by the advancing flame front, mixture temperature is further raised by the added mechanical compression of the piston raising further in the cylinder until it reaches actual top dead center.

In normal combustion, the flame front advances through the mixture before a self-ignition temperature is reached by the combined effect of heat transfer to the unburned mixture and from heat produced by further mechanical compression. Normal combustion is further characterized by a gradual increase in cylinder pressure.

When detonation occurs, however, there is an abrupt and intense increase in cylinder pressure; which sets up high energy shock waves that bounce off the cylinder walls and cause the metallic sounding "ping" or "knock". Vibration of the cylinder walls accounts for the sound of detonation.

Though detonation, when it occurs, is relatively the same, irrespective of fuel type (octane rating) and compression ratio in any given engine, very severe detonation would occur with a very low octane rated gasoline used in an engine with a high compression ratio. An example would be: 70 to 80 octane gasoline in an engine with a compression ratio of 10 to 1. Here it is doubtful that the trial and error method of reducing the throttle valve opening would prevent detonation. With such a mismatch of fuel and engine, the engine would likely detonate under very mild load conditions.

Aside from using the correct octane rated fuel, detonation can be further avoided by correct ignition timing. If, for example, ignition occurs too early, there is more time for the unburned mixture to absorb heat from the advancing flame front. Thus, it is more likely that the mixture will reach the self-ignition temperature before normal combustion takes place. For a given engine and octane fuel, it may be necessary to retard the ignition timing to obtain proper operation that is free of detonation.

At times of high engine load, mild detonation is not necessarily harmful, and may or may not be heard. There will be some loss of power output, however, it may not be noticed. Physical damage to the engine is not likely.

Severe detonation, on the other hand, is very harmful, even if only for a short period of time; and must be avoided. Spark plug electrodes can be destroyed by the abnormally high temperature involved; and pistons and rings can be destroyed by the high temperatures and extra high pressures that accompany detonation. If severe detonation is allowed to take place for a sustained period of time, it could completely destroy an engine.

Pre-ignition is described as: **The ignition of the fuel mixture before the actual firing of the spark plug.**

Detonation cannot only be very harmful to the engine, it can also lead to pre-ignition. It is believed that the abnormally high pressures and temperatures involved in detonation wash away a protective film of relatively stagnant mixture that is immediately adjacent to all surfaces in the combustion chamber. Normally, this film insulates combustion chamber surfaces from the full heat of normal combustion, which at times can be as high as 3,000 deg. F. or higher. Blunt edges, such as spark plug electrodes, valve heads or piston heads are particularly vulnerable. Also, any nicks or scratches on piston heads, or carbon deposits, are also vulnerable to this excessive heat, if exposed by the effect of detonation to the insulating mixture. These surfaces can become red hot and ignite the mixture before normal ignition takes place. Thus, the name **"Pre-Ignition."**

While detonation may or may not lead to pre-ignition, the greatly increased heat flow to the piston head can, nonetheless, create a serious problem. The piston may expand until it is forced tight against the cylinder wall, where excessive friction and still more heat is formed. This can lead to more serious pre-ignition and detonation. It can also destroy the engine.

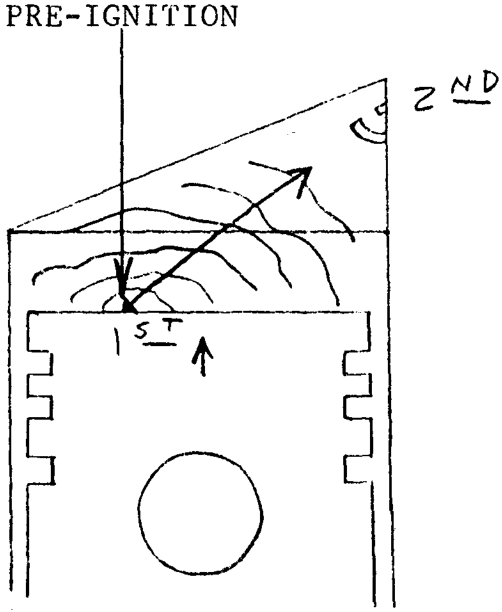
Piston destruction can also result from pre-ignition in a less direct manner. When the extra heat flow from detonation is sufficient to cause an exposed surface, such as a spark plug electrode, to become red hot and pre-ignite the mixture, a chain reaction develops. Pre-ignition means more time is available for the mixture to reach self-ignition temperature; and higher and higher surface temperatures result as pre-ignition repeats. In other words, pre-ignition is self-perpetuating. Once it starts in an engine, it is likely to continue until something is destroyed, if the engine is not stopped beforehand.

On a single-cylinder engine, sustained pre-ignition would, inevitably, cause the engine to stop, even if the piston did not seize the cylinder wall; and thereby forcibly stop the engine. The progressive deterioration of the combustion process would stop the engine, since insufficient power would be developed to overcome normal engine friction. On a multi-cylinder engine, however, those cylinders with normal combustion would drag the faulty cylinder(s) along until severe piston damage would result. To further explain, the damage caused by this condition, the audible noises that are heard from detonation, is the violent explosion slamming down on the head of the piston.

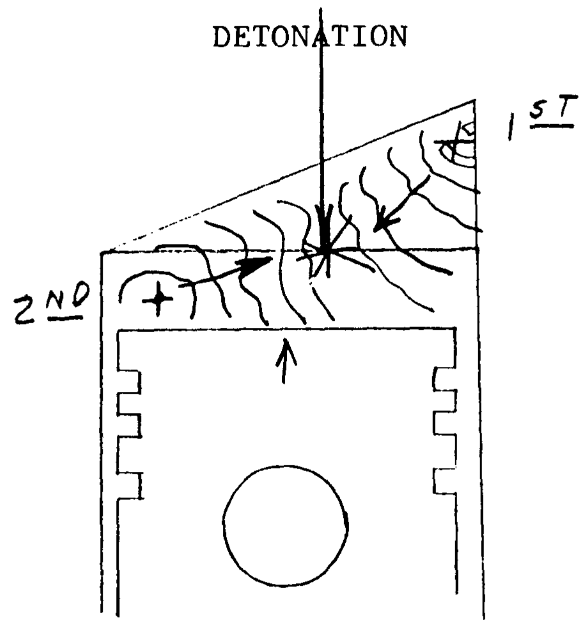
In conclusion, we might say that detonation can lead to pre-ignition and vice versa. A number of faults in the engine can cause one or the other. Such things as piston heads can cause this chain reaction to start. Improper ignition timing and gasoline octane rating would also cause either detonation or pre-ignition. By performing the proper maintenance on the engine using the manufacturers specifications when tuning the engine and using the proper fuel, pre-ignition and detonation can be held to a minimum.

Pre-ignition causes a loss in power and an increase in an early shock load to the piston, but no raise in temperature. Detonation causes a rapid increase in temperature and an early shock load in the piston.

PRE-IGNITION



DETONATION



The trick of getting maximum power is to make the intake pack the mixture into the engine and the exhaust to haul the products out. This is more easily said than done. The secret is in the **"tuning."**

There are two phenomena employed in tuning the system, and while they are quite different, both are at work in all intake and exhaust systems. First is the **"ram"** effect. All matter has weight, even air. When it is set in motion, it tends to remain in motion. In practical terms, this means that the fuel air mixture, rushing into the cylinder on the intake stroke, will continue to pour in for some time after the piston has completed the intake stroke. Also, exhaust products tend to keep rushing out the exhaust pipe, even though the piston's exhaust stroke is completed.

The magnitude of this effect depends on the length and diameter of the passages. The diameter determines how fast the gases will be moving and the length determines the length of the column of gases. This business of length is quite important, as a long column of gases will have a greater inertia effect, at any given velocity, than a short one.

The second event, and the one for which **"tuning"** was named, has to do with the motion of pressure waves inside the intake and exhaust systems. These pressure waves travel at the speed of sound (1,100 feet per second in standard air at 32 deg. F., with an increase of one foot per second with each 1 deg. F. rise in temperature).

What is required is to have the respective pipes at the length where the pressure waves arrive and depart, at the proper time, to push more mixture into the cylinder or pull more exhaust products from it.

The problem is complicated by the fact that the speed of the pressure waves varies with atmospheric pressure and with temperature. For purposes of calculation, we may consider that the wave speed inside the intake system will be 1,100 feet per second and in the exhaust system about 1,700 feet per second. The situation in the exhaust system is complicated by great changes in temperature and the motion of the piston. Experiments indicate that the wave speed may be as high as 2,200 feet per second at some times, and as low as 1,300 at others.

Here it might be well to discuss the nature and behavior of waves in pipes. The waves do not have an up and down motion, as seen in the sea or in the usual graphic representations of a wave form. Instead, they consist of what is called **"condensations" and "rarefactions"** in the transmitting of gas. If, for example, you have a pipe and you give the air at one end a "kick" with a piston, or by some other means; the air immediately in front of the piston will be compressed. Then this compressed portion of the air will begin to move down the pipe. The wave of compressed air (condensation) will move onward, keeping molecules of air together as it reaches them and releasing them after it passes. You can find this process described in great detail in any physics book.

Now when the wave reaches the far end of the pipe, it will surge out into the air and create, as it leaves the pipe, another wave. This second wave will be negative (a slight vacuum) and it will travel back down the pipe toward the starting point. If the starting point is closed, the negative wave will be **"reflected"** back up the pipe, still being negative. If, however, that end of the pipe is open, the negative wave will rush out into the surrounding air and collapse, which will send a positive wave back up the pipe.

This is the rule for the behavior of waves in pipes. If the wave reaches a closed end of a pipe, it is reflected with the same value as before, positive or negative. If the pipe end is open, then the wave value reverses - positive becomes negative and vice versa.

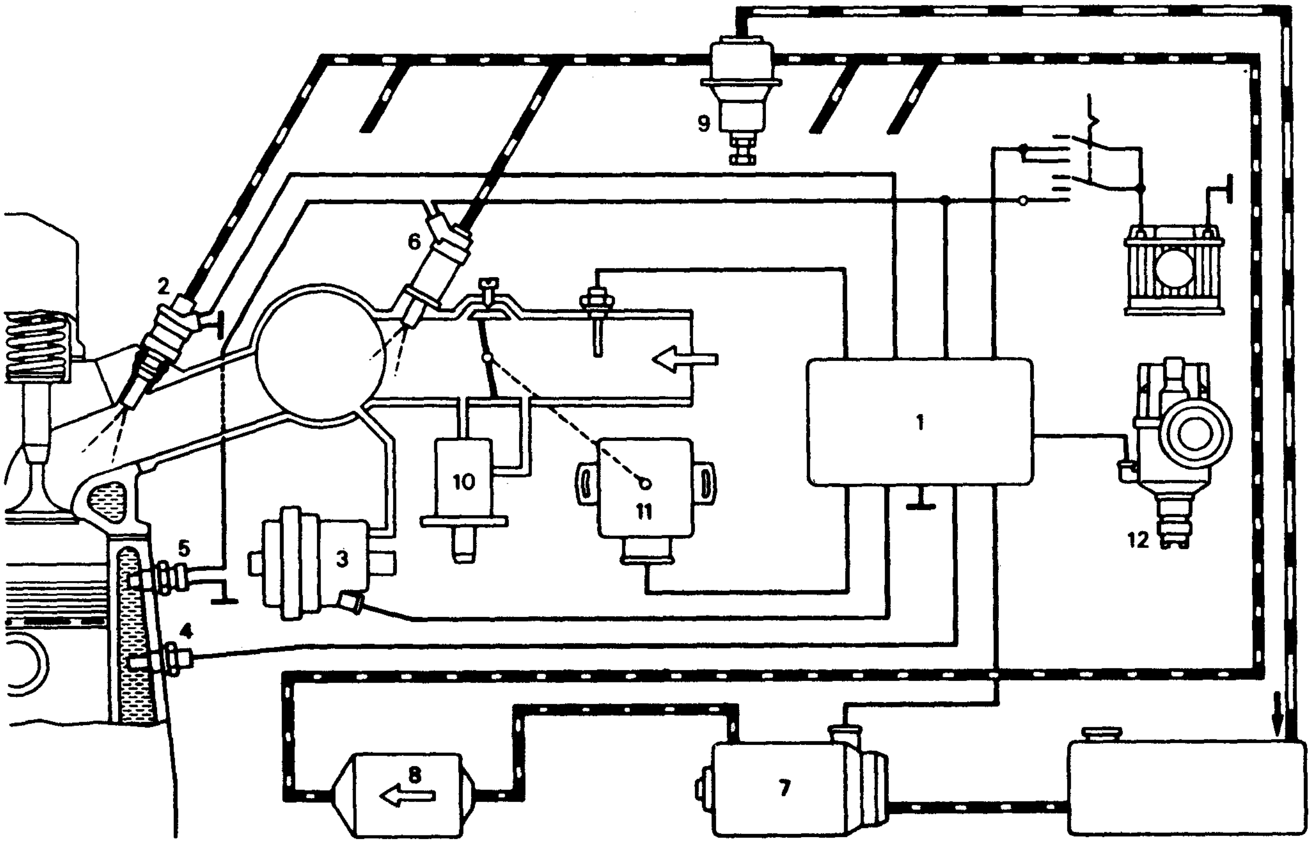
We will treat the intake and exhaust system as separate problems, although they should be designed to be mutually helpful. In the tuned intake system, the sudden downward motion of the piston on its intake stroke creates a **"rarefaction"**, or negative pressure wave. This wave immediately starts moving out of the intake port, manifold and carburetor. Upon reaching the atmosphere, the negative wave collapses and is reflected as a positive pressure wave. If the length of the pipe is correct and the engine speed is at the level where the system is designed to work, then the reflected pulse will arrive back in the cylinder just before the intake valve closes. The closing of the valve will trap the gases moved by the action of the wave in the cylinder.

In low-speed engines, the wave is employed to overcome the effects of the very short time available for charging the cylinder. In other words, it maintains the engine's ability to breathe at much higher speeds than would otherwise be possible.

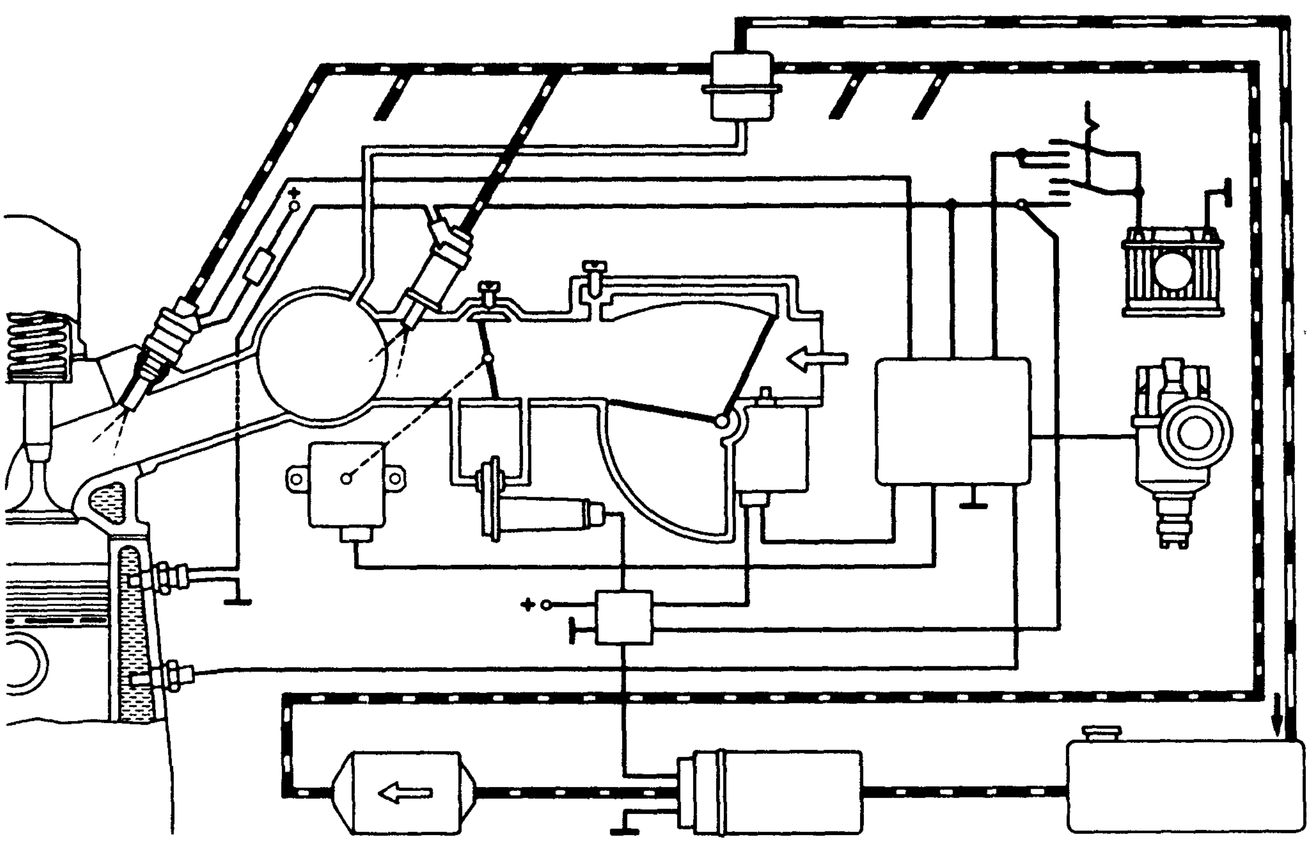
These are the methods and procedures used by car manufacturers in designing their exhaust systems.

CARBURETOR CIRCUIT OPERATION AND COMBUSTION EFFECTIVENESS

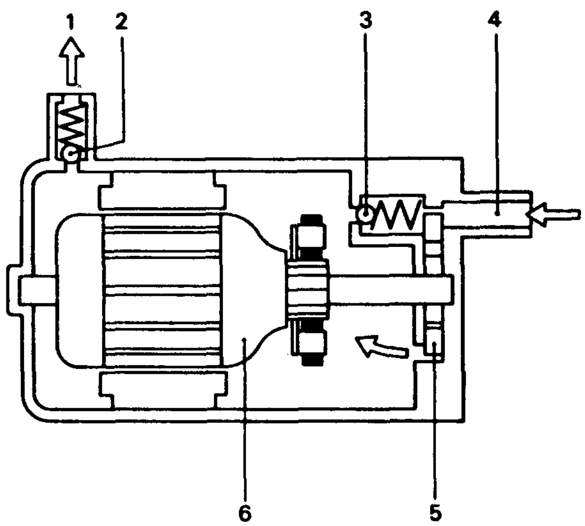
MPH	0 - 25		25 - 40	40 - 60	60 - MAX.
RPM	800 →	1200 →	1800 →	3500 →	MAX. →
COMBUSTION EFFICIENCY	76%	76% - 80%	80%	80% - 90%	65% - 70%
AIR FUEL RATIO	11.5 - 12.5:1		12.5 - 13.0:1	15.0 - 16.0:1	11.0 - 12.5:1
IDLE CIRCUIT	←	→			
IDLE/ LOW SPEED CIRCUIT	←		→		
MAIN METERING CIRCUIT			←		→
ACCELERATION CIRCUIT	←		→		
POWER CIRCUIT	←				(NORMAL →)



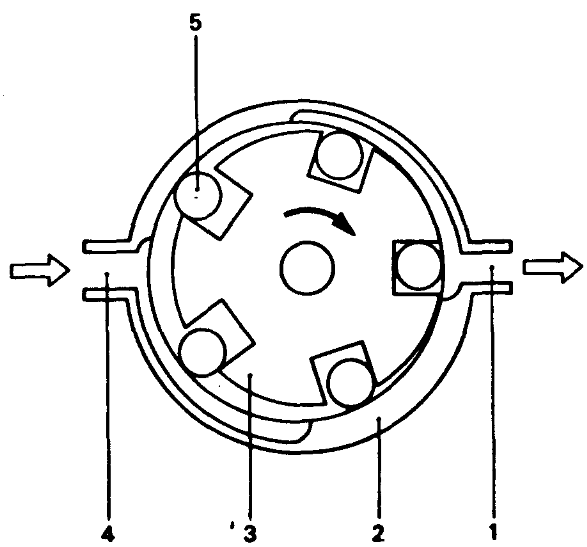
The Bosch EFI-D fuel injection system.
(Courtesy of Robert Bosch [Canada] Ltd.)



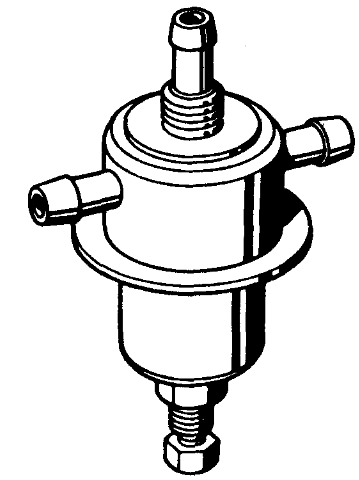
The Bosch EFI-L fuel injection system.
(Courtesy of Robert Bosch [Canada] Ltd.)



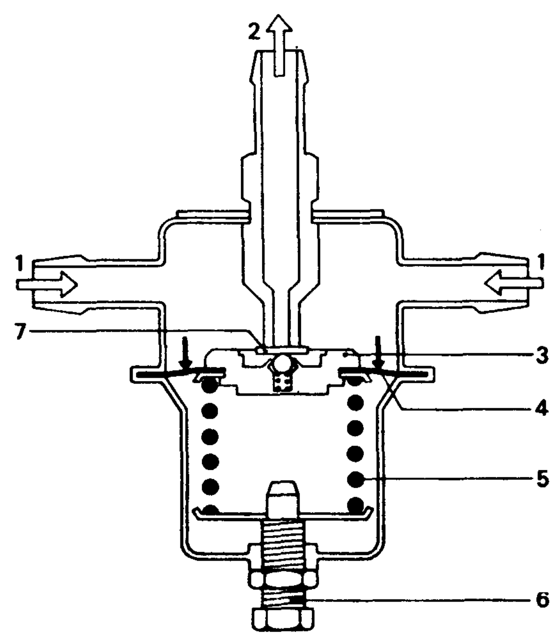
A roller cell fuel pump. (Courtesy of Robert Bosch [Canada] Ltd.)



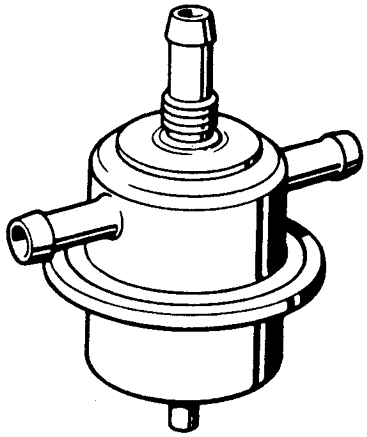
Schematic of a roller cell fuel pump: (1) pressure side, (2) pump housing, (3) pump rotor, (4) suction side, (5) roller, (6) electric motor armature. (Courtesy of Robert Bosch [Canada] Ltd.)



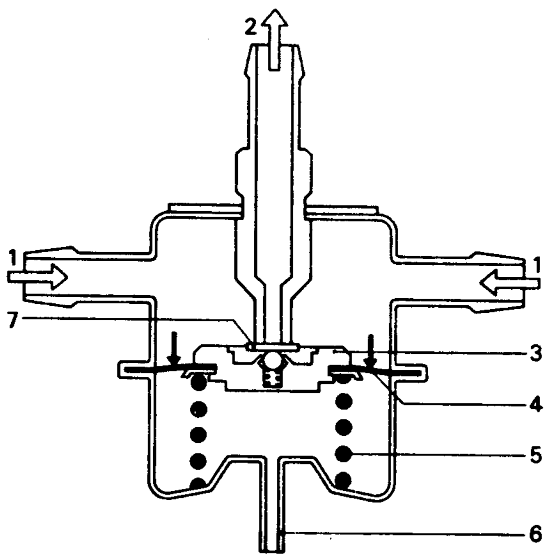
An EFI-D fuel pressure regulator. (Courtesy of Robert Bosch [Canada] Ltd.)



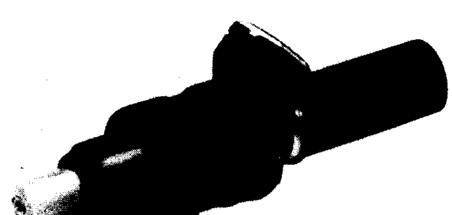
Cross-sectional drawing of the EFI-D fuel pressure regulator: (1) fuel connection, (2) return flow to fuel tank, (3) valve support, (4) diaphragm, (5) pressure spring, (6) adjustment screw, (7) valve. (Courtesy of Robert Bosch [Canada] Ltd.)



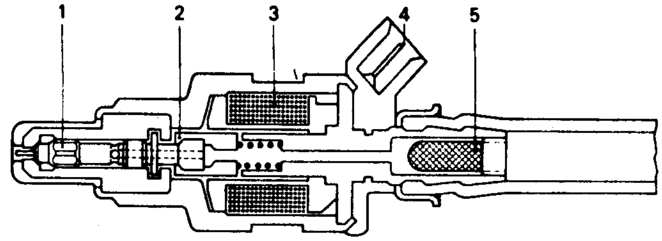
An EFI-L fuel pressure regulator. (Courtesy of Robert Bosch [Canada] Ltd.)



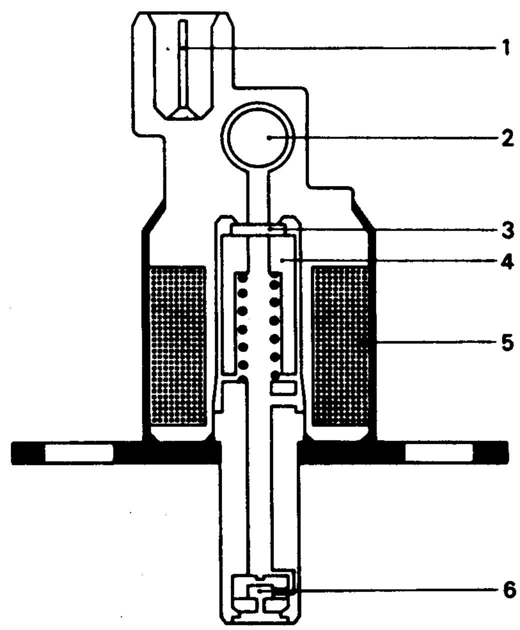
Cross-sectional drawing of the fuel pressure regulator: (1) fuel connection, (2) return line to fuel tank, (3) valve support, (4) diaphragm, (5) pressure spring, (6) connection to intake manifold, (7) valve. (Courtesy of Robert Bosch [Canada] Ltd.)



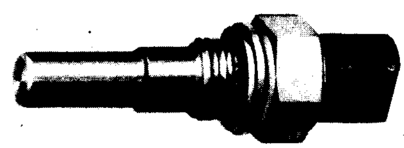
A fuel injection valve. (Courtesy of Robert Bosch [Canada] Ltd.)



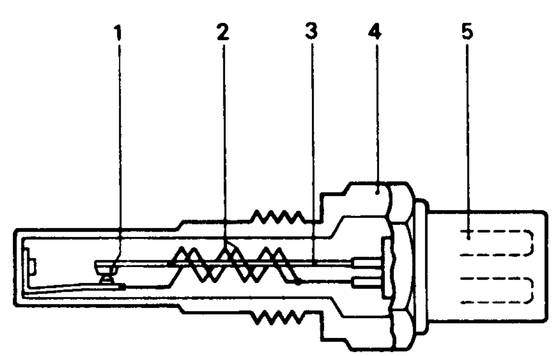
Cross-sectional drawing of the injection valve: (1) nozzle valve, (2) solenoid armature, (3) solenoid winding, (4) electrical connection, (5) filter. (Courtesy of Robert Bosch [Canada] Ltd.)



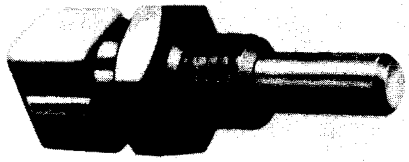
Cross-sectional drawing of a start valve: (1) electrical connection, (2) fuel inlet, (3) seal, (4) solenoid armature, (5) solenoid winding, (6) swirl nozzle. (Courtesy of Robert Bosch [Canada] Ltd.)



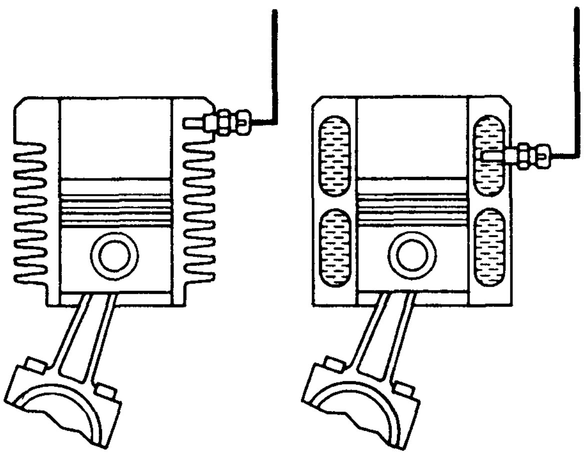
A thermo-time switch. (Courtesy of Robert Bosch [Canada] Ltd.)



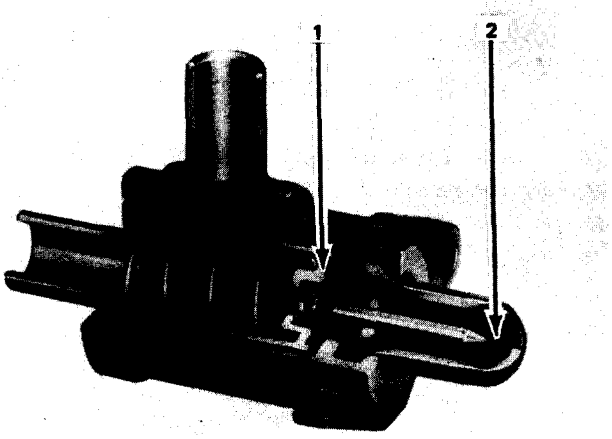
Cross-sectional drawing of the thermo-time switch: (1) contact, (2) heating windings, (3) bimetallic strip, (4) housing, (5) electrical connection. (Courtesy of Robert Bosch [Canada] Ltd.)



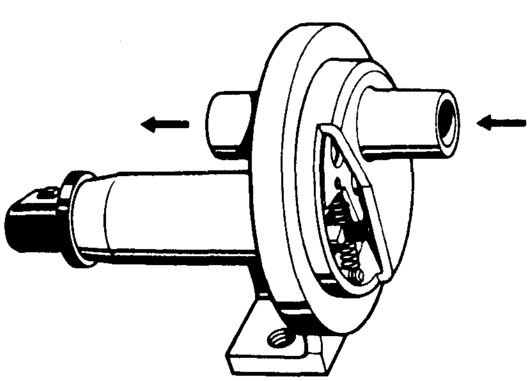
A temperature sensor. (Courtesy of Robert Bosch [Canada] Ltd.)



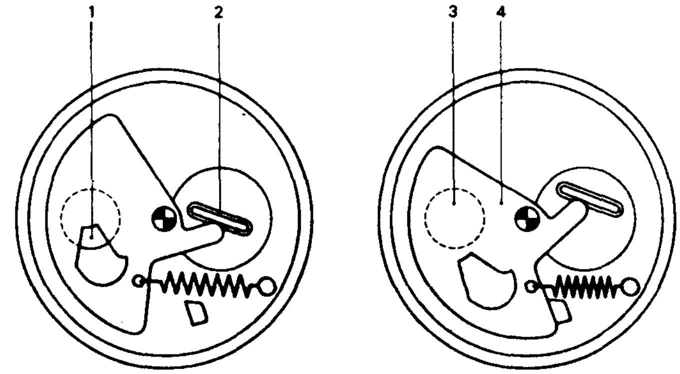
A temperature sensor installed in an (A) air-cooled and (B) water-cooled engine. (Courtesy of Robert Bosch [Canada] Ltd.)



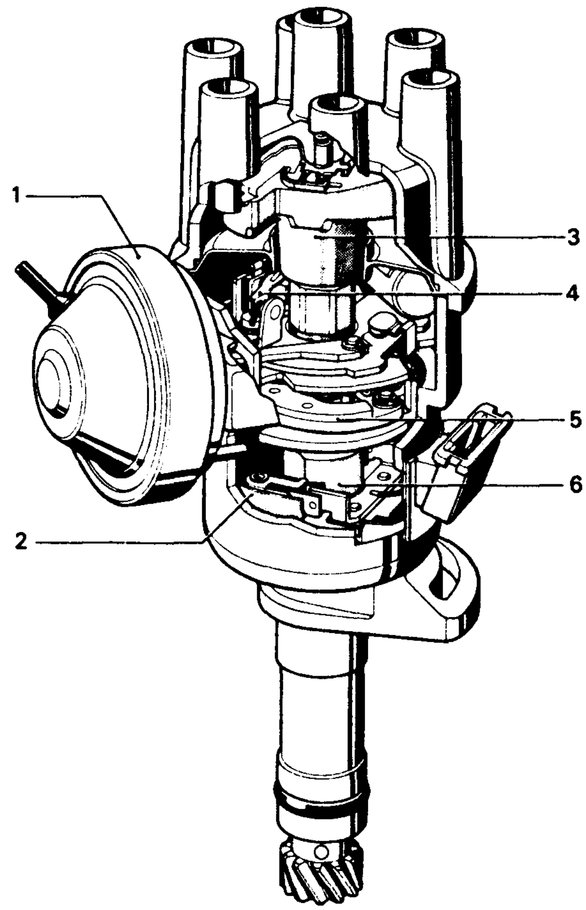
An auxiliary air device with an expansion element (1) and piston (2). (Courtesy of Robert Bosch [Canada] Ltd.)



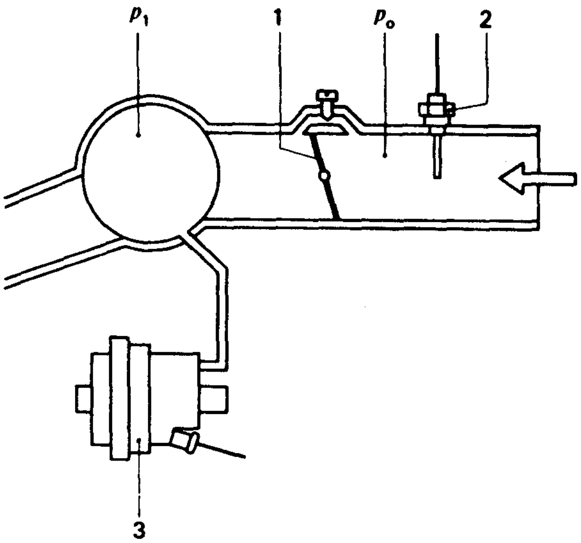
An auxiliary air device with external heating. (Courtesy of Robert Bosch [Canada] Ltd.)



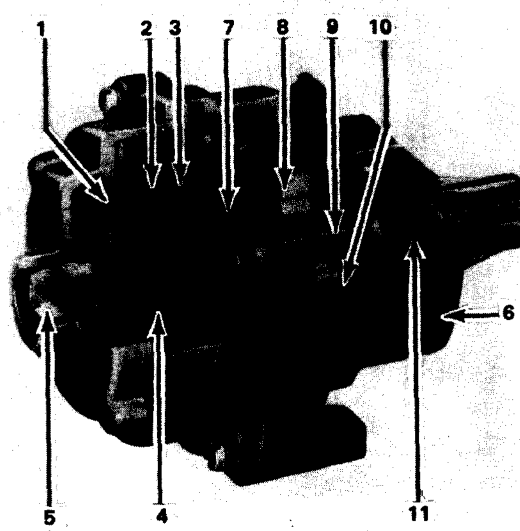
Operation of the auxiliary air device: (1) opening for auxiliary air, (2) bimetallic strip with heating winding, (3) bypass channel partly open in View A, closed in View B, (4) blocking plate. (Courtesy of Robert Bosch [Canada] Ltd.)



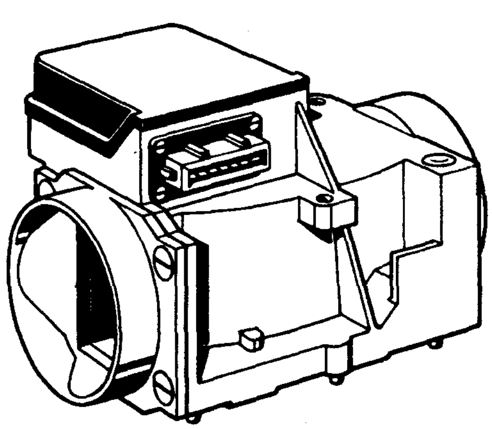
EFI-D ignition distributor with trigger contacts: (1) vacuum unit, (2) trigger contacts, (3) distributor rotor, (4) distributor contact points, (5) centrifugal advance mechanism, (6) cam (opens trigger points). (Courtesy of Robert Bosch [Canada] Ltd.)



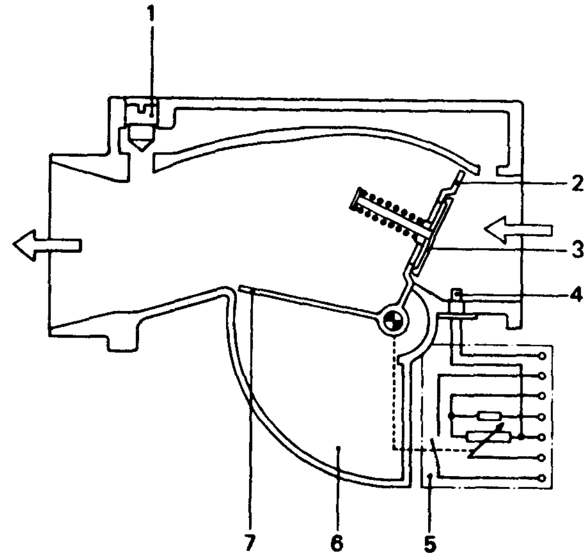
Pressure conditions in the EFI-D intake manifold: (P_0) atmospheric pressure, (P_1) pressure in the common intake manifold, (1) throttle valve, (2) temperature sensor, (3) pressure sensor. (Courtesy of Robert Bosch [Canada] Ltd.)



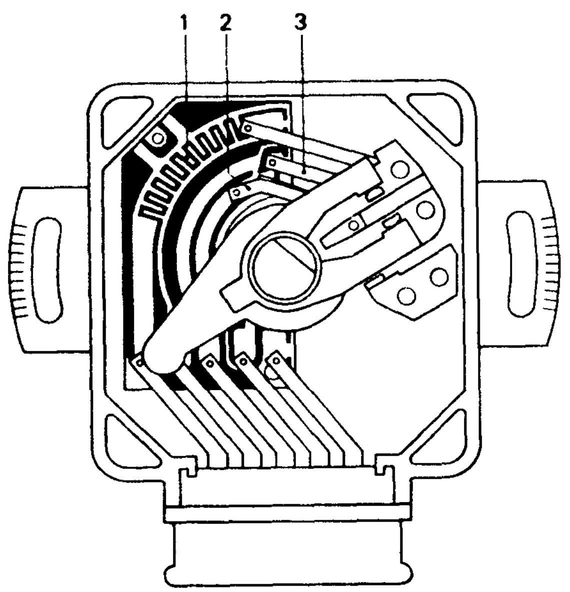
EFI-D pressure sensor with additional diaphragm for full-load enrichment: (1) full-load enrichment diaphragm, (2) diaphragm cell, (3) diaphragm cell, (4) part-load stop, (5) full-load stop, (6) housing, (7) flat spring, (8) coil, (9) armature, (10) core, (11) valve. (Courtesy of Robert Bosch [Canada] Ltd.)



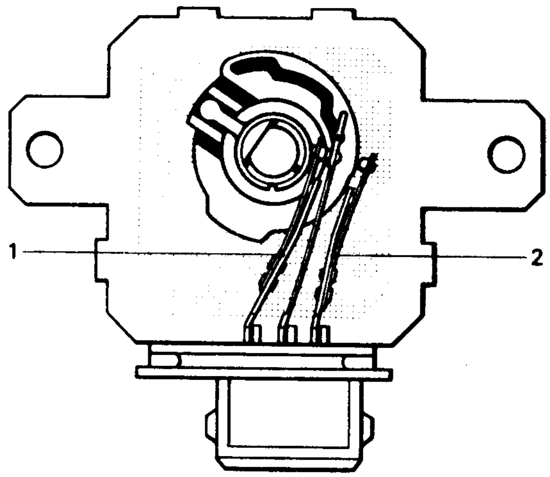
An EFI-L air-flow sensor. (Courtesy of Robert Bosch [Canada] Ltd.)



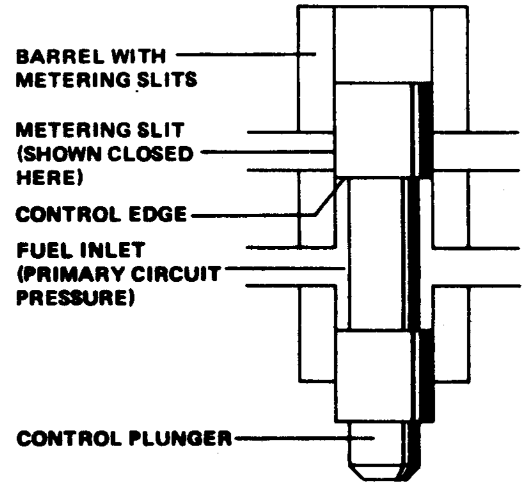
Cross-sectional drawing of the EFI-L air-flow sensor: (1) idle mixture adjustment screw, (2) air-flow sensor flap, (3) nonreturn valve, (4) air temperature sensor, (5) electrical connections, (6) dampening chamber, (7) compensation flap. (Courtesy of Robert Bosch [Canada] Ltd.)



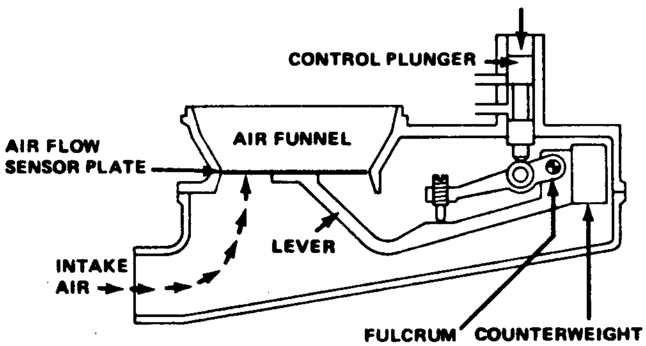
An EFI-D throttle switch: (1) contact path for acceleration enrichment, (2) full-load contact, (3) idle contact. (Courtesy of Robert Bosch [Canada] Ltd.)



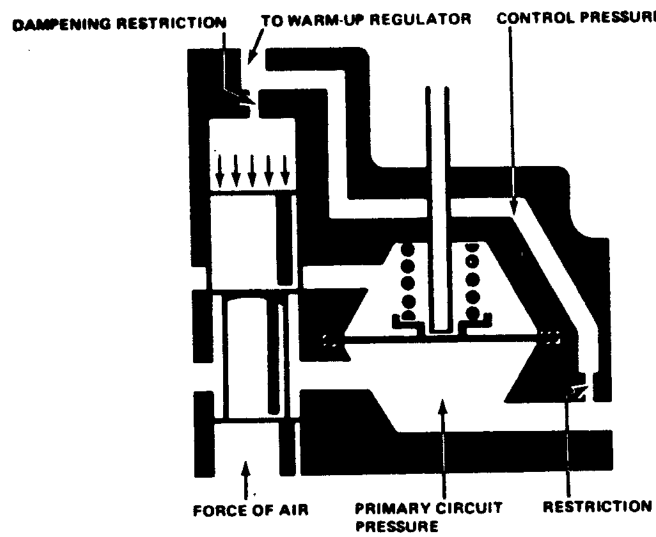
An EFI-L throttle valve switch: (1) idle contact, (2) full-load contact. (Courtesy of Robert Bosch [Canada] Ltd.)



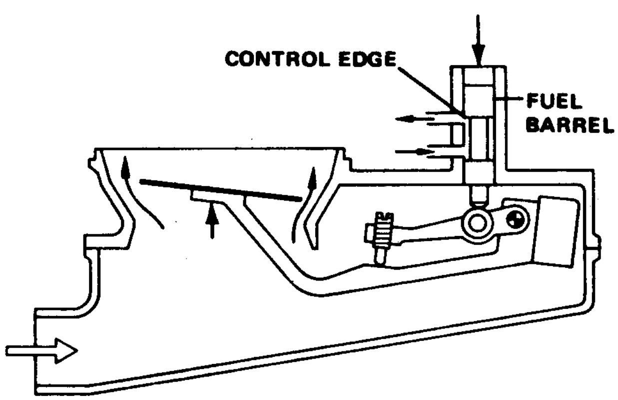
Barrel with metering slits and control plunger. (Courtesy of Robert Bosch [Canada] Ltd.)



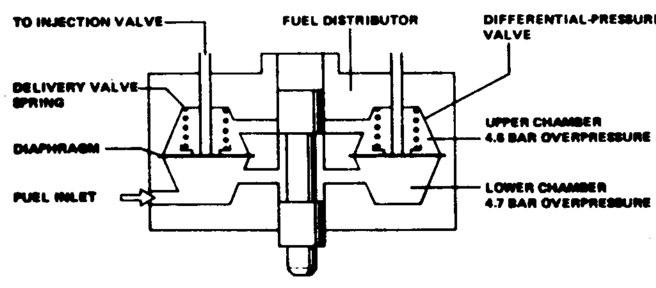
Schematic diagram of the air-flow sensor. (Courtesy of Robert Bosch [Canada] Ltd.)



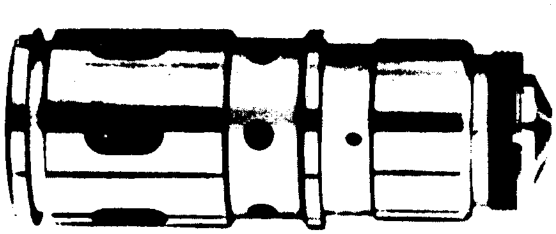
Pressure balance on the control plunger. (Courtesy of Robert Bosch [Canada] Ltd.)



Fuel control in the mixture control unit. (Courtesy of Robert Bosch [Canada] Ltd.)

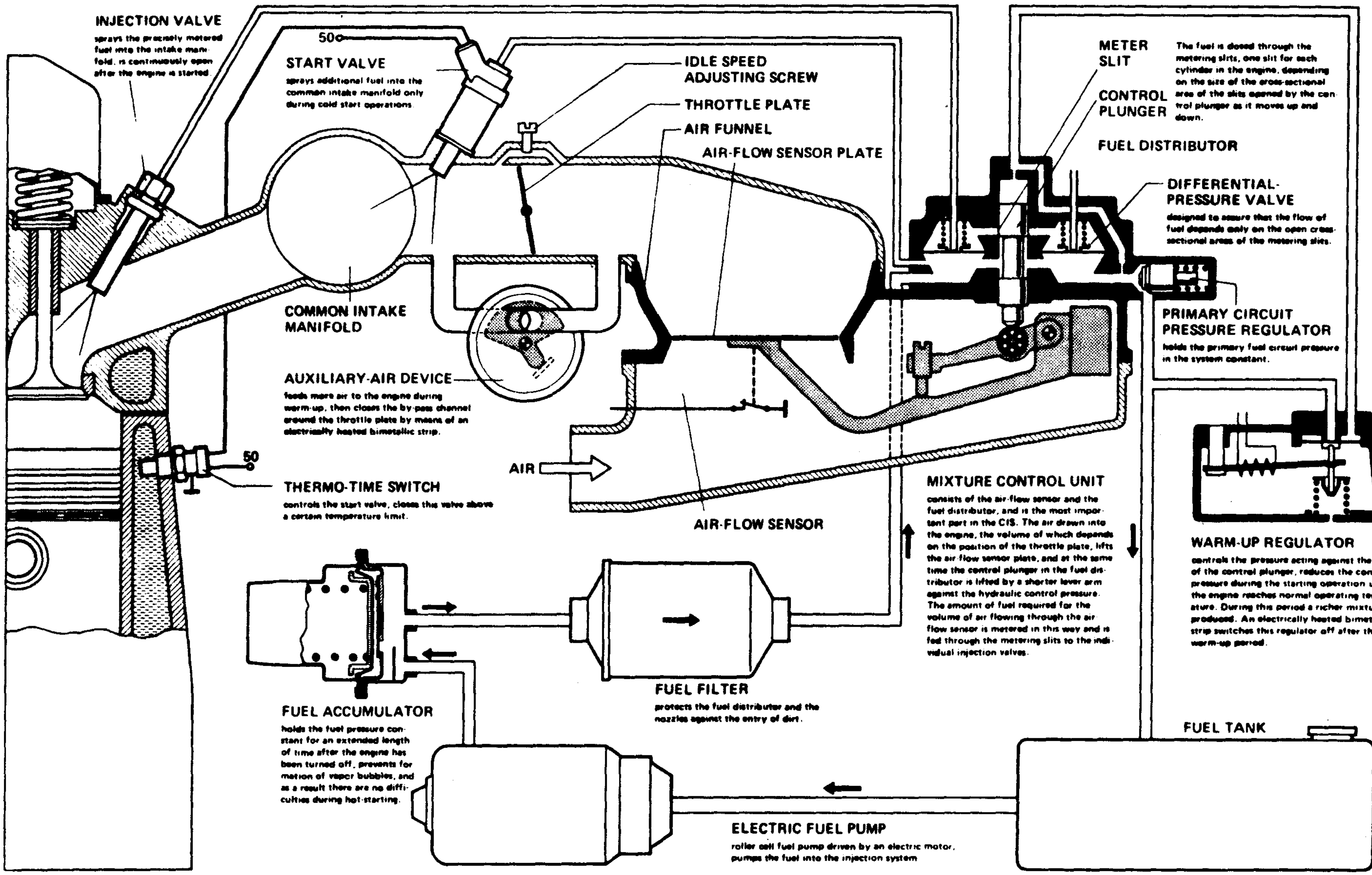


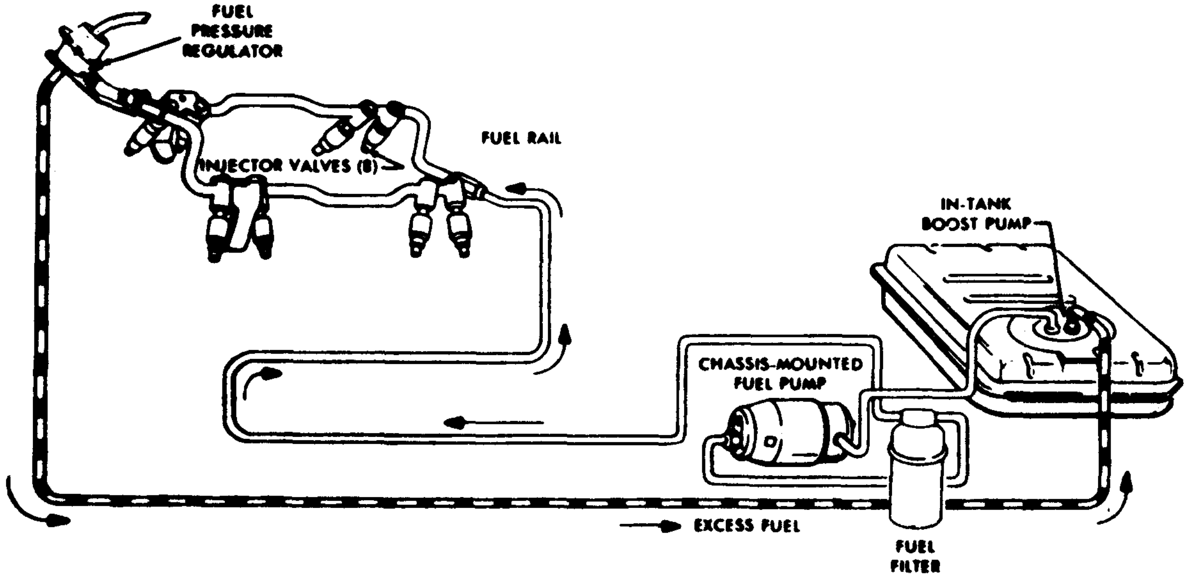
A fuel distributor with differential pressure valves. (Courtesy of Robert Bosch [Canada] Ltd.)



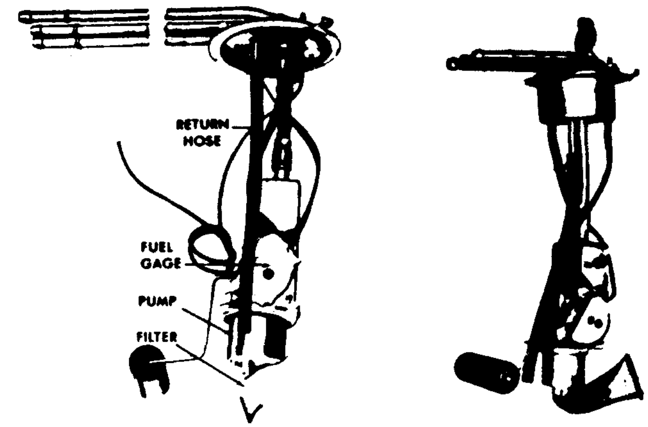
The fuel barrel. (Courtesy of Robert Bosch [Canada] Ltd.)

A continuous injection system. (Courtesy of Robert Bosch [Canada] Ltd.)

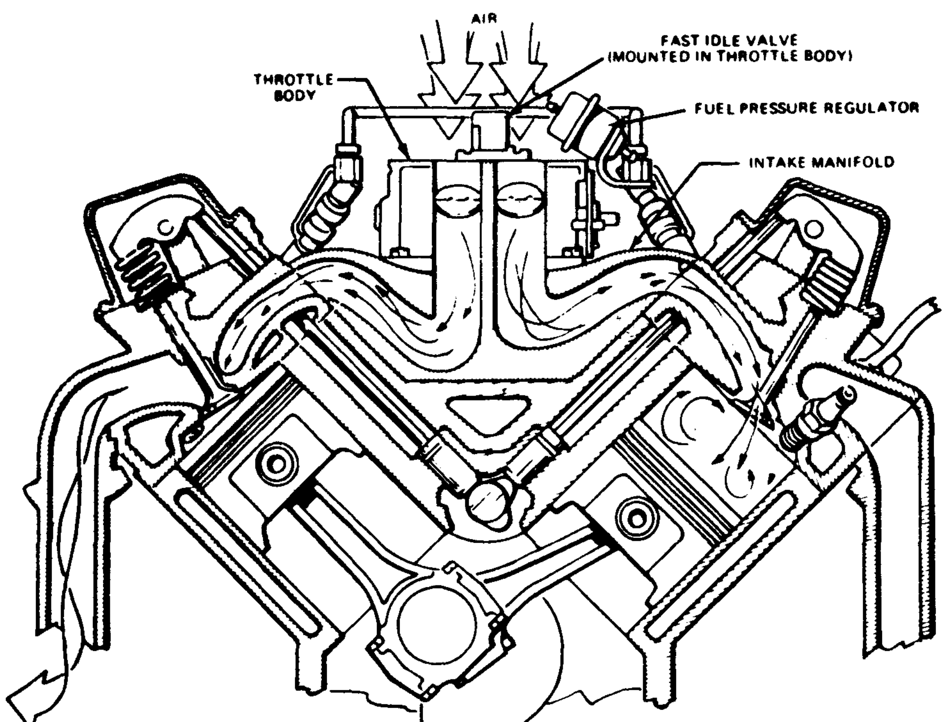




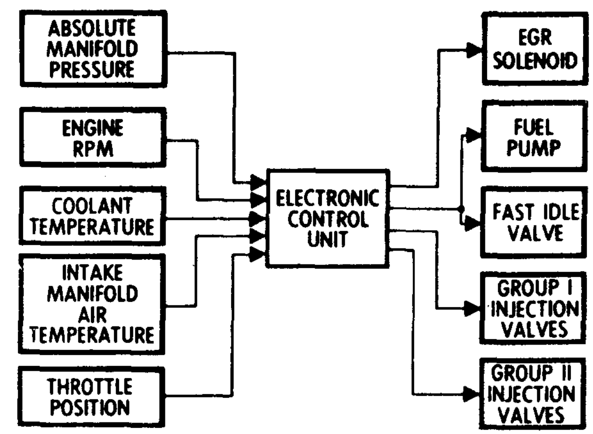
The EFI fuel delivery system. (Courtesy of General Motors of Canada Limited)



In-tank fuel pumps. (Courtesy of General Motors of Canada Limited)

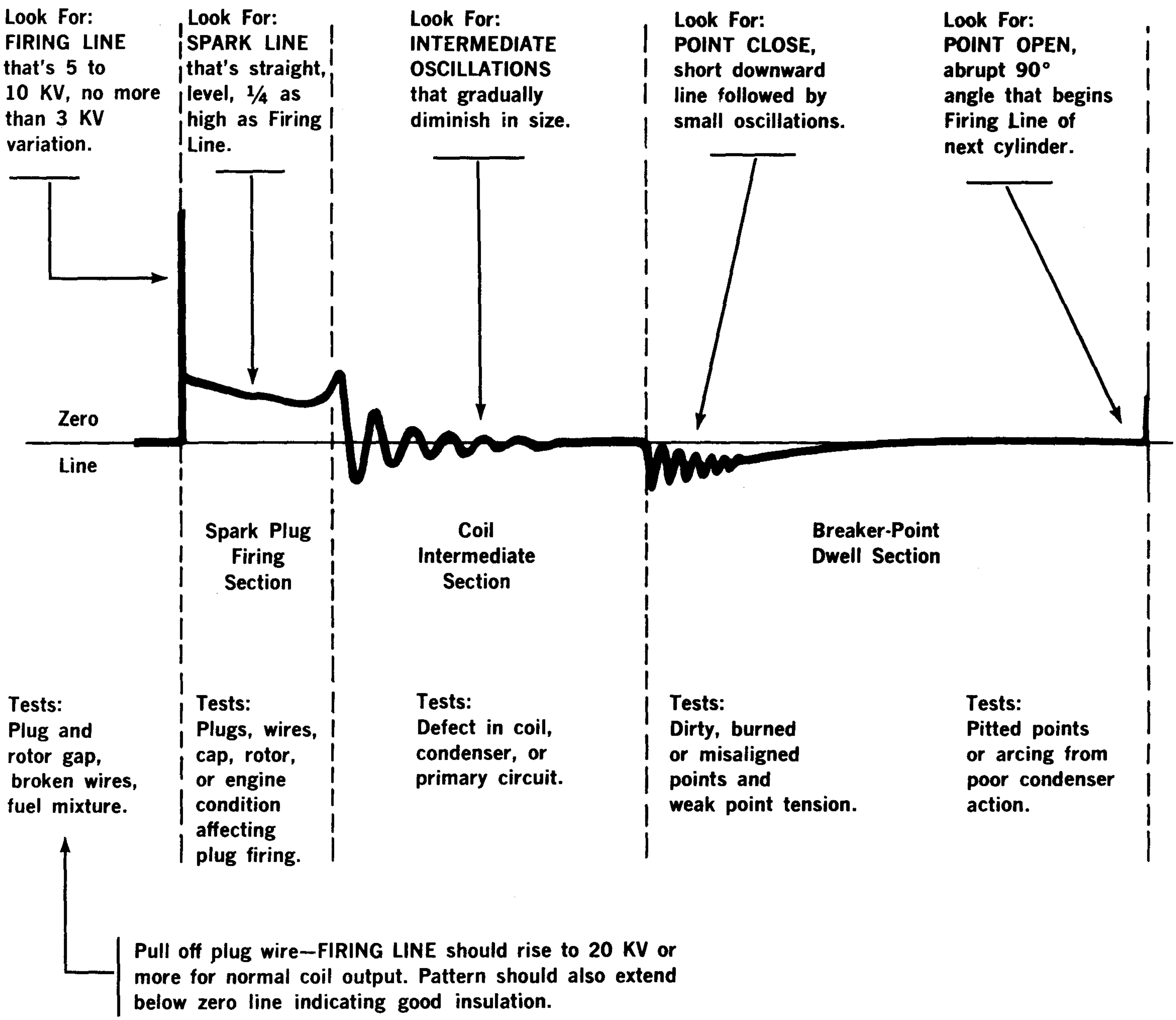


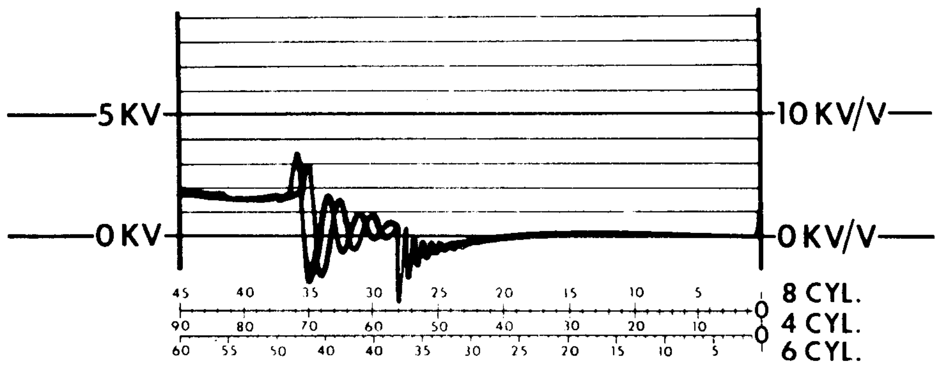
An air induction system. (Courtesy of General Motors of Canada Limited)



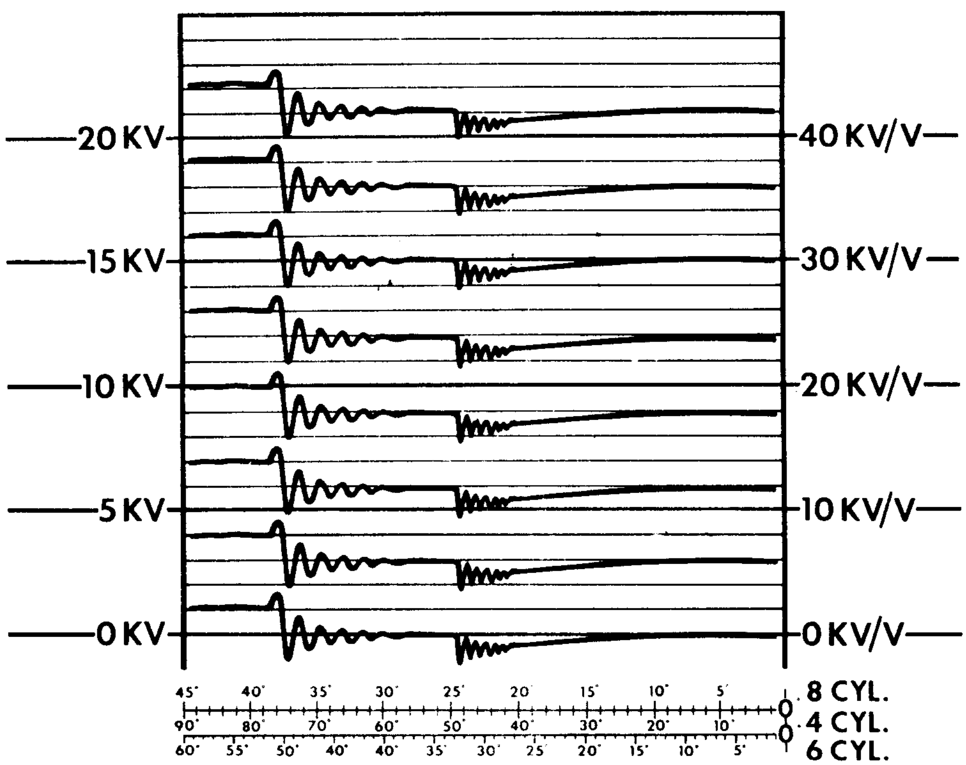
Functional block diagram showing the operation of the EFI system. (Courtesy of General Motors of Canada Limited)

Sun Scope Pattern

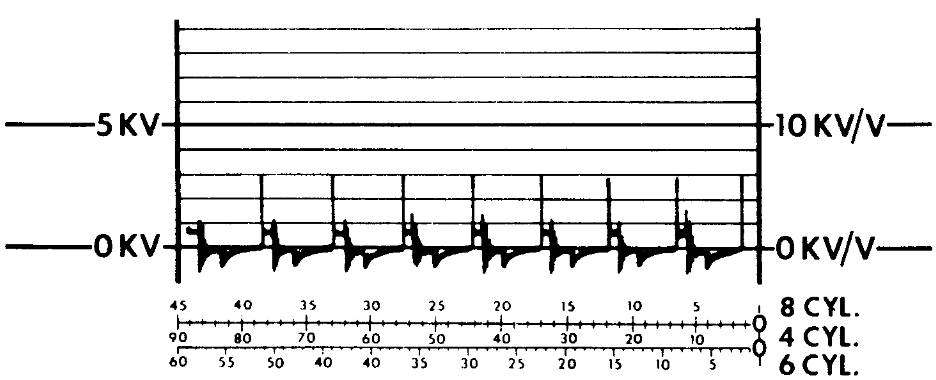




SUPERIMPOSED



RASTER



DISPLAY

AREA TESTING

AREA TESTING PROCEDURES

The factual information obtained from a systematized series of tests, when compared with specifications and known standards, provides an accurate picture of an engine's conditions. This series of tests to determine the true condition of the engine by testing the engine systems is called area testing. When the true condition of the engine is determined the mechanic has little trouble knowing what service or what further detailed testing to perform.

TESTER PREPARATION

1. Plug tester POWER CORD into proper AC outlet (see nameplate on tester).

2. Turn on AC POWER SWITCH (left end panel). Sign, Meters and Scale Indicators will light and a trace will appear on the scope screen.

POSITION SCOPE CONTROLS

1. Push PATTERN POSITION CONV (CONVENTIONAL) button.

2. Adjust BRIGHTNESS control as desired.

3. Adjust VERTICAL control so that scope trace line rests on scope zero line.

4. Adjust HORIZONTAL control to align the left end of the scope trace with the left edge (0-25 KV line) of the scope screen.

5. Adjust the LENGTH control to align the right end of the scope trace with the right edge (0-50 KV line) of the scope screen.

   NOTE: To adjust LENGTH control, the NO. OF CYLINDERS knob must be set to 8 or engine must be running.

6. Set FUNCTION SELECTOR knob to SECONDARY.

7. Set PATTERN HEIGHT knob to HIGH.

8. Set PATTERN SELECTOR knob to DISPLAY.

   NOTE: The RASTER control is not adjusted at this time. Adjust RASTER when necessary during testing.

POSITION TESTER CONTROLS

1. Push CYLINDER SELECT MODE SHORT button.

2. Set ENGINE KILL button to Green. (Green is the Run position. Red means ignition is disabled and engine will not run).

3. Push CYLINDER SELECTOR Red CANCEL button.

4. Push the 4 CYCLE button for automotive engines except the Rotary engine.

5. Set the AMPERE-DWELL-RPM knob to AUTO-TACH/500A position.

6. Set the IGNITION SELECTOR knob to #1 position except as follows:

   a. Delco HEI and Prestolite BID system, set to #2 position.

   b. Capacitive Discharge (CD) systems, set to #4 position.

7. Set NO. OF CYLINDERS knob to match the number of cylinders in engine being tested.

8. Set VOLT-OHM knob to 20V position.

9. Turn VACUUM DAMPER knob fully counter-clockwise.

LEAD CONNECTIONS TO VEHICLE

Instructions for negative ground systems are given. Only two connections need to be changed for positive ground systems. The Red PRIMARY PICKUP MUST be connected to coil positive and THE AMPS PICKUP arrow must point toward the battery.

1. Clamp Chrome PATTERN PICKUP around the secondary coil wire. (On G.M. V-8 and V-6 HEI Systems, use Adapter #1747-102.) See Figure 7.

   a. Connect Red PRIMARY PICKUP to the negative terminal of the ignition coil (on electronic and transistor ignition, to the specified terminal).

   b. Connect Black (Ground) PRIMARY PICKUP to a good engine ground.

2. Clamp Red TRIGGER PICKUP around number 1 spark plug wire close to the distributor cap.

3. Connect VOLT-OHM leads to battery posts, Red to positive and Black to negative.

4. Clamp Green AMMETER PICKUP around negative battery cable (all negative cables if there are more than one) with arrow pointing away from the battery.

   a. Connect Green SPECIAL PATTERNS PICKUP to the positive (+) battery post.

   NOTE: If accessible, the alternator output (+) terminal can be used.

5. Connect VACUUM HOSE to a source of engine vacuum.

TESTING PROCEDURE

A systematic method of troubleshooting is needed. Such a method provides quick area testing of each automotive system to determine how it is contributing to engine performance. This area testing is divided into seven tests. In the process, any customer complaint will be validated, while at the same time making sure there is not more than one system causing the customer complaint.

For best results use the Sun TUT-1015 Engine Performance Test Report (0692-0924-1). Enter specifications, perform specified tests, and enter test results for evaluation when finished. Then, refer to the section, Area Performance Analysis Guide, for a guide to interpreting the results of area testing.

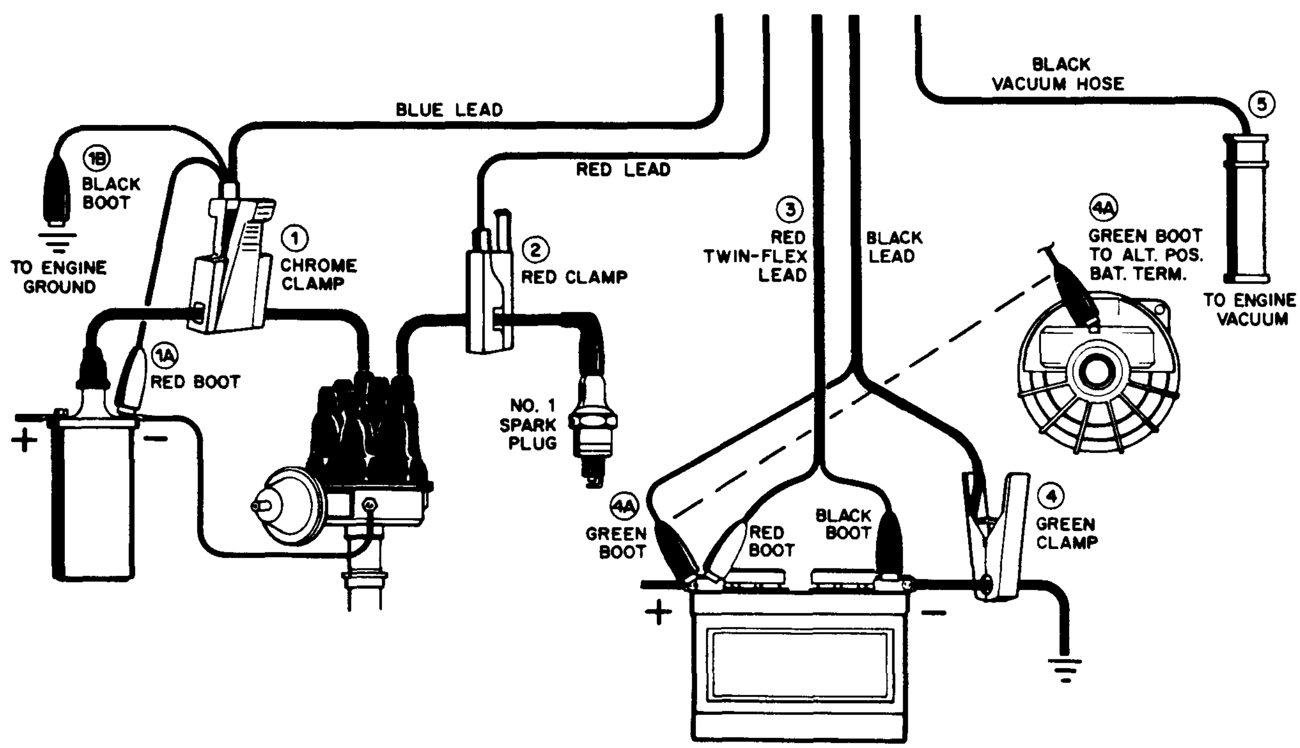


FIGURE 7—Test lead connections to engine.

Area Testing

Test 1 - Cranking Tests

1. Disable the ignition system by disconnecting secondary coil wire from distributor cap. (To disable V-6 and V-8 HEI ignition systems, push ENGINE KILL button so it shows Red.) Turn off all lights and accessories.

2. Crank engine while reading the indications on the tester instruments.

   a. Note Cranking Coil Output in kilovolts on 50 KV scale of scope.

   NOTE: This test void when using ENGINE KILL button.

   b. Read Cranking Starter Current on Blue 500 amps scale of ammeter.

   c. Read Cranking Battery Voltage on Red 20 volt scale of voltmeter.

   d. Read Cranking Engine Vacuum on vacuum gauge.

Test 2 - Charging Tests

1. Turn AMPERE-DWELL-RPM knob to AUTO-TACH/100A scale.

2. Set FUNCTION SELECTOR knob to SPECIAL PATTERNS.

3. Set PATTERN HEIGHT knob to VARIABLE, and set VARIABLE ADJUST to full clockwise.

4. Set PATTERN SELECTOR knob to RASTER.

5. Prepare engine to run. Enable ignition system or release ENGINE KILL button to Green.

6. Start engine, accelerate to 2000 rpm.

   a. Note alternator output on Blue 100 amps scale of ammeter.

   b. Note condition of diodes/stator as indicated by scope patterns.

   (Use RASTER control if necessary to space scope patterns for best viewing.)

7. Return engine to idle speed.

Test 3 - Idle Tests

1. Turn AMPERES-DWELL-RPM knob to AUTO-TACH/DWELL.

2. Set FUNCTION SELECTOR knob to SECONDARY.

3. Set PATTERN HEIGHT knob to HIGH.

4. Set PATTERN SELECTOR knob to DISPLAY.

5. Warm up engine until choke is open and engine is at normal idle speed.

   a. Read idle rpm on Red 0-1500 rpm scale of tachometer.

   b. Read Dwell on Red dwell meter scale.

   c. Check Initial Timing with timing light.

   d. Read Engine Manifold Vacuum on vacuum gauge.

   e. Test PCV valve per manufacturer's recommended procedure.

Test 4 - 1200 rpm Low Cruise

1. Run engine at approximately 1200 rpm and perform scope tests.

   a. Coil Polarity.

   b. Spark Plug Firing Voltage (KV).

   c. Maximum Coil Output (available voltage).

   d. Secondary Insulation.

   e. Secondary Resistance.

   f. Coil and Condenser Condition.

   g. Breaker Point Condition.

   NOTE: Static point resistance test can also be made to check Breaker Point Condition.

   h. Cylinder Timing Accuracy.

Test 5 - Cylinder Power Balance

1. Set PATTERN SELECTOR knob to DISPLAY.

2. Run engine at desired test speed - record base rpm.

3. Press CYLINDER SELECTOR buttons one at a time until all cylinders have been shorted and released one at a time.

4. Note and record rpm produced with each cylinder shorted.

Area Testing

Test 6 - Snap Acceleration

1. Snap accelerate throttle to approximately 2500 rpm and then release while observing spark plug firing lines on scope.
2. Note cylinders having firing lines too high or too low.

Test 7 - 2500 rpm High Cruise

1. Set engine speed to approximately 2500 rpm.
2. Check timing advance with timing light following manufacturer's recommended procedure.
3. Read Dwell in degrees on dwell meter.
4. Read Charging Volts on 20V scale of voltmeter.
5. Read engine manifold vacuum on vacuum gauge.
6. Stop engine.

Analyze tests results, compare with specifications and perform pinpoint tests or make service recommendations as required. See Engine Performance Analysis Guide.

ENGINE PERFORMANCE ANALYSIS GUIDE

AREA PERFORMANCE TEST ANALYSIS

Analyzing the results on the Engine Performance Test Report requires comparing the test results with manufacturer's specifications to determine which tests to mark NO-GO. Analyzing all of the tests marked NO-GO is the basis for determining what engine areas have problems, what specific Pinpoint Tests to perform, and what service recommendations to make.

The Sun Specification cards, underhood stickers and manufacturer's manuals and bulletins are used to obtain the specifications needed. Where no factory specifications are furnished, the technician must base his decision (GO or NO-GO) on what is normal for good engines of the make and model being tested based on past experience.

The following Analysis Guide lists the GO and NO-GO considerations and shows the most common Test Indications and the Action Required for each NO-GO Test Result.

ANALYSIS GUIDE

1. CRANKING MODE

COIL OUTPUT

GO - Height of scope pattern reaches or exceeds specified minimum.

NO-GO - Scope pattern height is below minimum.

Test Indications:

a. Battery voltage low.
   See Cranking Battery Voltage test result on Test Report.
b. Dwell too low.
   See result of dwell test in Idle Mode.
c. Bypass circuit bad.
   Test bypass circuit with voltmeter.
d. Low primary ignition current.
   Check with ammeter. Check for resistance in primary circuit and points. Check for possibility of wrong coil.
e. Coil or condenser bad.
   Test with Sun coil and condenser testers.
f. Bad coil wire to distributor cap.
   Test with ohmmeter.

NOTE: On electronic ignition, follow specified test procedure.

STARTER CURRENT

GO - Starter Current draw is not more than specified maximum.

NO-GO - Starter current draw is too high.

Test Indications:

a. Battery discharged, defective, or too small for application.
   Make complete battery test.
   Check battery rating with specifications.
b. Battery cables, starter solenoid or starter motor bad.
   Make complete starting system test.
c. Tight or hot engine.
   Cool off and retest.

BATTERY VOLTAGE

GO - Cranking battery voltage is at or above specified minimum.

NO-GO - Voltage is below specified minimum.

Test Indications:

a. Same test indications as Starter Current.

ENGINE VACUUM

GO - Vacuum reading steady at normal level.

NO-GO - Vacuum reading uneven or much lower than normal.

Test Indications:

a. Vacuum leaks.
   (1) Examine all vacuum hoses including emission controls and accessories.
   (2) Tighten engine manifold bolts, carburetor mounting bolts, etc.

b. Engine mechanical condition.
   Test with cylinder leakage tester and compression tester.

2. CHARGING MODE

CHARGING SYSTEM

GO - Ammeter reading shows alternator is charging at least half of rated output, and Diode/Stator test is GO.

NO-GO- Ammeter shows low output or no charge or Diode/Stator test is NO-GO.

NOTE: **In most cases, when the alternator output is checked after making cranking tests, the ammeter reading seen at the instant the engine is started and "revved up" will be well over half of rated output. However, the condition of the battery, the length of time the engine was cranked and the speed the engine reached all can affect this reading.**

Test Indications:

a. Fan belt loose or worn out.
   Check and correct as necessary.

b. Accessory load very high.
   Check current draw with key on. Add this reading to output obtained. Compare to specifications.

c. Alternator defective.
   Check alternator output with amps pickup at alternator and all accessories on.

d. Voltage regulator defective.
   Use Starting and Charging System tester, bypass regulator and check alternator output.

DIODE STATOR

GO - Scope shows even ripple.

NO-GO - Scope shows uneven ripple.

Test Indications:

a. Output diodes or stator bad.
   Remove and disassemble alternator and test components.

3. IDLE MODE

REVOLUTIONS PER MINUTE (RPM)

GO - Meets manufacturer's specified idle speed at specified test condition.

NO-GO - Idle speed not set to specifications.

Test Indications:

a. Carburetor idle speed and/or mixture screws not properly adjusted.
   Correct as necessary.

b. Choke sticking or not fully open.
   Correct as necessary.

c. Idle solenoid not adjusted correctly, if so equipped.
   Correct as necessary.

d. Test not made under specified conditions. See specifications and under hood sticker.
   Test as specified.

e. Mechanical Engine Condition.
   Check all test results for indications of problems like fouled plugs, weak cylinders, etc.

f. Bad emission control devices, especially EGR valve.
   Test and service per factory recommendations.

DWELL

GO - Dwell is within specifications.

NO-GO - Dwell is too high or too low.

Test Indications:

a. Ignition points improperly adjusted.
   Reset to spec.

b. Distributor defective.
   Make complete distributor test in Sun Distributor Tester.

NOTE: **On electronic ignition, see manufacturer's recommendations.**

INITIAL TIMING

GO - Timing set to specifications.

NO-GO - Timing is too early or too late.

Test Indications:

a. Timing not adjusted properly.
   Reset to specifications.

b. Distributor advance mechanism bad.
   Remove and test distributor on Sun Distributor Tester.

c. Engine not running at proper speed.
   Vacuum retard not disconnected during test, if so specified.

NOTE: **Timing must be adjusted according to specified procedure at specified rpm after dwell is set correctly.**

ENGINE VACUUM

GO - Steady at or above specified minimum

NO-GO - Unsteady or below specified minimum.

Test Indications:

a. Same test indications as for cranking engine vacuum.

POSITIVE CRANKCASE VENTILATION (PCV)

GO - Engine rpm and/or vacuum changes as specified when PCV is plugged.

NO-GO - RPM and/or vacuum does not change when PCV is plugged.

Test Indications:

a. PCV valve is plugged or defective. Clean or replace and retest.
b. PCV hose or vacuum source is plugged or hose is cracked. Repair as needed.
c. Wrong PCV valve. Replace with correct one.

4. 1200 RPM LOW CRUISE MODE

COIL POLARITY

GO - Pattern right side up.

NO-GO - Pattern inverted (firing lines extend downward).

Test Indications:

a. Ignition coil wires reversed. (Should match battery ground polarity.) Check and correct as necessary. Make sure coil is correct one.
b. Battery installed backwards or charged backwards. Check with voltmeter. Correct as required.

SPARK PLUGS

GO - Firing voltages fairly even and normal for engine being tested.

NO-GO - Firing voltages vary more than 3 KV. All firing lines excessively high or excessively low.

Test Indications:

a. Spark plug or rotor gaps not correct. Bad resistor spark plugs. Rotor, distributor or wires defective. Use grounding probe to pinpoint cause of high readings, visual inspection for narrow plug or rotor gaps.
b. Fuel mixture incorrect. Check choke and carburetor adjustment. Check for vacuum leaks.
c. Timing or advance incorrect. See Initial Timing test result in Idle Mode, Timing Advance test results in High Cruise Mode.

MAXIMUM COIL OUTPUT

GO - Reaches or exceeds specified minimum.

NO-GO - Output is less than minimum specified.

Test Indications:

a. Dwell too low. See Dwel Test Results in Idle Mode and High Cruise Mode.
b. Excessive resistance in ignition switch, primary circuit or points. Check with voltmeter, ohmmeter.
c. Low voltage due to charging system problem. See Charging Volts Test Result in High Cruise mode.
d. Insulation bad in secondary circuit. If coil output is under 25 KV and lower extent of waveform is intermittent or missing, test for insulation breakdown in wires, cap, or rotor.
e. Coil or Condenser defective. Test and replace as needed.

SECONDARY INSULATION

GO - Lower extent of coil waveform (downspike) is steady and equal to about one half of upward extent.

NOTE: **This does not apply to high output systems such as HEI that produce over 30 KV since the spark will jump inside the distributor cap on good systems.**

NO-GO - Coil output is less that 25 KV and the downspike is intermittent or missing.

Test Indications:

a. Wires, cap, rotor, or coil bad. Make secondary insulation test of all cylinders to isolate problem.

SECONDARY RESISTANCE

GO - Length and slope of spark lines is normal for engine being tested.

NO-GO - One or more spark lines slants excessively and is too short.

Test Indications:

a. Excessive resistance in plugs, wires, rotor, or distributor cap, or coil tower. Isolate problem using grounding probe.

COIL-CONDENSER

GO - Normal number and size of oscillations in intermediate section.

NO-GO - Oscillations diminished or missing in intermediate section.

Test Indications:
a. Coil or condenser defective.
Test and replace as necessary.
b. Points, condenser, or ground pigtail loose in distributor.
Make complete distributor test.

NOTE: Some ignition systems such as Chrysler Electronic Ignition will not show oscillations.

BREAKER POINTS

GO - Point close and point open signal normal.

NO-GO - Point close or point open signal irregular or show arcing.

Test Indications:
a. Dirty, burned, or misaligned points.
Replace points, test condenser.
b. Weak point spring tension.
Replace points, adjust spring tension.
c. Dwell too high or primary current too high.
Check dwell, measure primary current, correct as necessary.
d. Wrong coil or ballast resistor.
Check and correct as needed.
e. Charging voltage incorrect.
See Test Result in High Cruise Mode.

CYLINDER TIMING

GO - Point open signals even within specifications.

NO-GO - Point open signals vary more than specified (usually $\pm 2°$).

Test Indications:
a. Distributor cam defective.
Remove and test distributor in Sun Distributor Tester.
b. Breaker plate or bushings worn or defective. Wrong point spring tension.
Remove and test distributor in Distributor Tester.
c. Problem in engine such as bad distributor bushing in block or loose timing chain.
Check and repair as needed.

5. CYLINDER POWER BALANCE MODE

GO - RPM with each cylinder shorted dropped approximately the same amount.

NOTE: Amount of drop and allowable variation depends upon type of engine, number of cylinders, and speed at which test was made.

NO-GO - RPM does not change or changes very little on one or more cylinders.

Test Indications:
a. Ignition problems.
Check results of scope tests in Low Cruise Mode.
b. Engine problems.
Check compression and cylinder leakage.
c. Fuel mixture or distribution problems.
Check for vacuum leaks.
Check carburetor adjustment and balance.

6. SNAP ACCELERATION MODE

PLUGS UNDER LOAD

GO - Firing lines increase moderately and evenly and firing voltages does not exceed maximum specified.

NO-GO - Firing lines do not increase evenly or firing voltages exceed maximum specified.

Test Indications:
a. Spark plugs worn out, gapped wrong, or are fouling out.
Clean and regap or replace as required.
b. Lean fuel mixtures.
Check carburetor accelerator pump, and high speed circuit.

7. 2500 RPM HIGH CRUISE MODE

TIMING ADVANCE

GO - Timing is advanced specified amount.

NO-GO - Timing advance too little or too much.

Test Indications:
a. Vacuum advance chamber is leaking or inoperative.
(1) Check vacuum chamber with external vacuum source.
(2) If vehicle is equipped with transmission controlled spark, recheck advance as specified for this type of system.
(3) Check vacuum supply to distributor advance unit.
b. Mechanical advance sticking or inoperative.
Disconnect vacuum advance and repeat advance test. This checks mechanical advance only.
Remove and repair distributor.
c. Wrong distributor for engine.
See specifications.

DWELL

GO - Dwell reading does not change more than specified from dwell at idle.

NO-GO - Dwell reading changed more than allowable for system being tested.

NOTE: Some electronic ignition systems incorporate a dwell change in the design. See specifications and recommendations for system being tested.

Test Indications:

a. Distributor in poor mechanical condition.
   Remove and test in distributor tester. Repair as needed.

CHARGING VOLTS

GO - Voltmeter reading within specifications.

NO-GO - Voltage higher or lower than specfied.

Test Indications:

a. Make complete charging system test with Starting and Charging system tester.

ENGINE VACUUM

GO - Reading steady and higher than at idle.

NO-GO - Vacuum unsteady or lower than at idle.

Test Indications:

a. Engine problems.
   Check cylinder power balance test results.
b. Exhaust system restricted.
c. Timing not advancing properly.
   Check results of timing advance test.

ANALOG SCOPE PINPOINT TESTING

ANALOG SCOPE IGNITION TESTING

The basic function of the Analog Scope is to provide an instantaneous display of voltage waveforms which are necessary for analyzing ignition system and other electrical system operations. To fully utilize the test facilities provided by the Analog Scope, the operator should practice its applications whenever possible.

INITIAL SETUP

During the initial setup of the tester, the Analog Scope may require some minor adjustments before the scope is used for ignition system testing.

To perform these preliminary adjustments, turn the 1015 Tester ON. After a few moments, a horizontal line will appear on the scope screen. The position of this line is controlled by means of knobs located on the panel. Use the VERTICAL, HORIZONTAL and LENGTH controls to position the scope trace directly on the scope Zero line with the beginning of the trace at the left end of the scale and the end of the trace at the right end of the scale.

The BRIGHTNESS control is adjusted to suit the desire of the operator. The RASTER control may be adjusted at a later time to control the vertical spacing between waveforms when ignition patterns are displayed in a raster manner.

If the VERTICAL, HORIZONTAL or BRIGHTNESS controls are adjusted to the extreme end of their range, the scope trace may be completely off of the face of the scope tube and not be visible to the operator. If the scope trace is not visible after the tester has been on for a few seconds, simply rotate the BRIGHTNESS, VERTICAL and HORIZONTAL controls until it appears somewhere on the screen.

STANDARD IGNITON TESTING

A standard ignition system is defined as a system that uses contact points and a condenser to switch primary circuit current on and off in an ignition system. An electronic ignition system is defined as any original manufacturer's equipment that makes use of an electronic circuit to switch the primary circuit current on and off instead of conventional contact points and a condenser.

NOTE: In this section, standard ignition system testing will be covered. Electronic ignition testing will be covered in the next section.

The following test information will outline some of the Scope's most frequently used applications to standard ignition systems and suggest how the scope operating controls should be positioned for each basic test.

TEST LEAD CONNECTIONS

For proper functioning, the PATTERN and TRIGGER PICKUP leads should be connected to the engine in the same manner as for performing a complete series of area tests. The Red TRIGGER PICKUP should be clamped around the number one spark plug lead, as close as possible to the distributor cap. The PATTERN PICKUP is clamped around the coil to distributor secondary lead. Connect the Red clip to the distributor terminal of the ignition coil and the Black clip to a good engine ground. Refer to Figure 7, Page 8.

INTERPRETING SCOPE PATTERNS

The Sun Analog Scope provides a convenient means of observing ignition system operation while the engine is running. It displays a graphic waveform trace pattern that is easy to interpret because each part of the waveform represents a specific phase of ignition system operation.

The waveform has three sections, representing three phases of operation. The three sections are the firing section, the intermediate section, and the dwell section. The three sections of the secondary circuit will now be discussed.

The Firing Section

During this section of the secondary circuit waveform firing of the spark plug takes place. This section of the pattern is composed of two lines:

1. The Firing Line - a vertical line indicating the voltage required to overcome the plug and rotor gaps.

2. The Spark Line - a horizontal line indicating the voltage required to maintain the spark.

Figure 8, Portion A to B is the firing line. The *firing line* indicates the voltage required to initially fire or arc the spark plug. The firing line is affected by the spark plug, plug wire, distributor rotor gap, coil wire, fuel mixture and compression. For example, if the spark plug electrode gap or the rotor gap is too wide, greater voltage is required to fire the plug. A very lean fuel mixture will also be harder to fire.

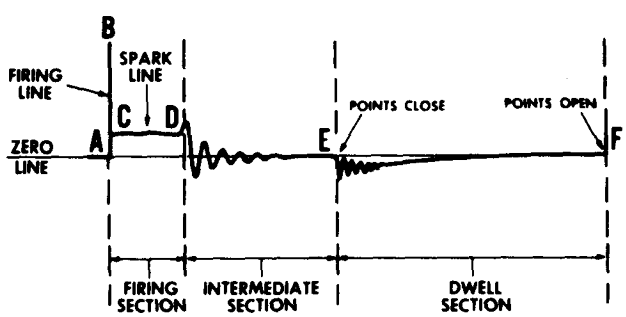


FIGURE 8—The three sections of a single cylinder waveform during secondary circuit testing.

Figure 8, Portion C to D is the *spark line.* The spark line is the voltage required to continue the arcing after the spark plug's initial firing. The firing line and the spark line together make up the firing section of the pattern. This firing section is affected by the condition of the spark plug, plug wires, and the coil wire.

The Intermediate Section

This section is seen as a series of gradually diminishing oscillations which disappear or nearly disappear by the time the dwell section begins. Figure 8, Portion D to E is the intermediate section (sometimes called the *coil and condenser* section). The intermediate section is the period of time after the spark plug ceases arcing, and the remaining coil energy dissipates itself as oscillating current. The current oscillates back and forth between coil and condenser until dissipated.

The Dwell Section

The dwell section extends from breaker point closing to breaker point opening. Closing the points causes a short downward line followed by a series of small rapidly diminishing oscillations. These oscillations represent the buildup of the magnetic field around the coil that occurs when the breaker points are closed.

Figure 8, E is when the ignition points close to start a new dwell period. This area of the pattern is affected by the ignition points and coil. Figure 8, F is when the *points open* to end the dwell period. This area is affected by the ignition points, condenser, and the distributor. For example, if the distributor shaft is wobbling, the dwell time will be erratic.

Figure 8, Portion E to F is the *dwell period.* This section is affected by the point setting. The dwell period is figured in degrees.

Primary Circuit Interpretation

Since any voltage variation in the primary ignition circuit will be reflected in secondary circuit testing, it is not always necessary to use primary circuit testing to determine the general condition of the ignition system. Testing of the primary circuit is usually done to pinpoint troubles found during secondary testing.

The trace patterns of the primary circuit are very similar to that of the secondary (Figure 9). It also divides into the three sections, firing section, intermediate section, and dwell section. Although the primary and secondary patterns are similar, the voltage values represented in the primary patterns are much lower than those represented in the secondary patterns.

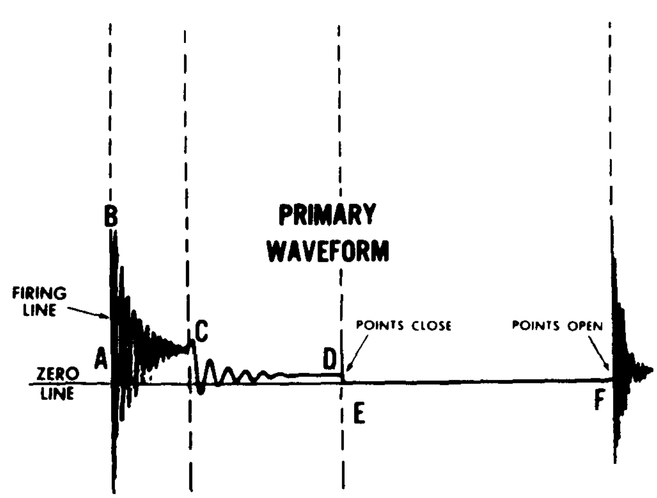


FIGURE 9—The three sections of a single cylinder waveform during primary circuit testing.

Primary Firing Section

This section displays the series of rapid oscillations that take place in the ignition primary circuit during the period of time in which the spark plug fires. Figure 9, point A represents the instant at which the breaker points separate.

The vertical rise from "A" to "B" and the diminishing oscillations which follow, represent the initial and repeated charging and discharging of the condenser and the induced voltage surges in the primary circuit while the spark plug is firing. As the spark bridges the gap and energy is being drained from the coil, the amplitude of these oscillations will diminish until the spark is extinguished as indicated at point "C".

Primary Intermediate Section

As in the secondary pattern, the Intermediate Section is seen as a series of gradually diminishing oscillations which disappear or nearly disappear by the time the Dwell Section begins. Beginning at point "C", what energy still remains in the coil will dissipate itself as an oscillating current which gradually dies out as it approaches point "D".

Primary Dwell Section

The Intermediate Section ends and the Dwell Section begins simultaneously when the distributor contacts close, and can be observed as a faint downward line from point "D" to point "E". The Dwell Section is represented by the horizontal line which extends from point "E" to the point "F", and it is during this period that the points remain closed.

PROGRAMMING SCOPE CONTROLS

The scope controls are located on the scope panel. Refer to Figure 3, Page 2. The scope is capable of displaying primary and secondary circuit ignition patterns in the following ways:

1. Display Pattern
2. Display Pattern in Shift
3. Display Pattern in Shift and Compare
4. Display Pattern in Compare
5. Raster Pattern
6. Raster Pattern in Shift
7. Superimposed Pattern
8. Single Cylinder Pattern
9. Special Patterns such as alternator waveform analysis

Display Pattern

With the PATTERN POSITION CONV button depressed, the PATTERN SELECTOR knob set at DISPLAY, the PATTERN HEIGHT knob at HIGH, and the FUNCTION SELECTOR knob at SECONDARY, the scope will present a parade of all cylinders as shown in Figure 10. With the TRIGGER PICKUP clamped around the number one spark plug wire, the waveform viewed on the scope screen will begin on the left with the pattern for number one cylinder. However, it should be noted that the *firing line* of number one cylinder is displayed at the extreme right at the end of the trace. The trace moves from left to right displaying the ignition cycles of each cylinder consecutively in the engines *firing order* until all cylinders are displayed on the screen.

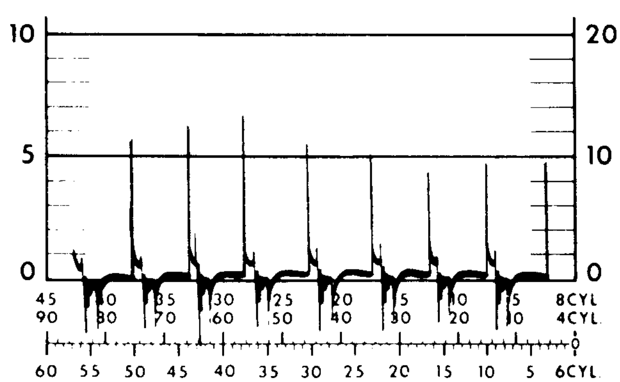


FIGURE 10—A display pattern of a normal engine.

The display type of pattern allows firing voltages to be measured. When measuring secondary voltages during maximum coil output or spark plug firing voltages, for example, the display type of pattern provides best results. For accurate voltage measurements, the base of the pattern's *firing line* must be adjusted to the zero line on the scope screen graticule.

Analog Scope Pinpoint Testing

If the operator wishes to move the number one cylinder's firing line from the extreme right to the left of the screen, all he need do is push the PATTERN POSITION SHIFT button. Now the display pattern has the firing line of the number one cylinder at the extreme left as shown in Figure 11.

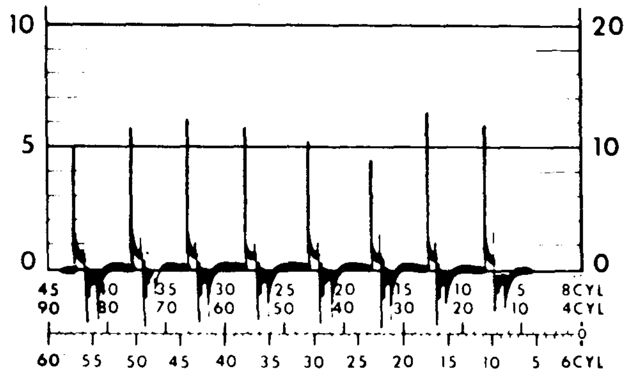


FIGURE 11—A display pattern of a normal engine with shift button depressed.

If the operator wishes to move one of the cylinder traces from the parade display and extend it across the screen, he may push the CYLINDER SELECT MODE COMP button and the button number of the CYLINDER SELECTOR control which corresponds to the number of the cylinder that the operator wishes to view. This cylinder's display will then be traced at the top of screen as in Figure 12. Two or more cylinders can be superimposed at the top of the screen for close comparison by pressing more than one CYLINDER SELECTOR button.

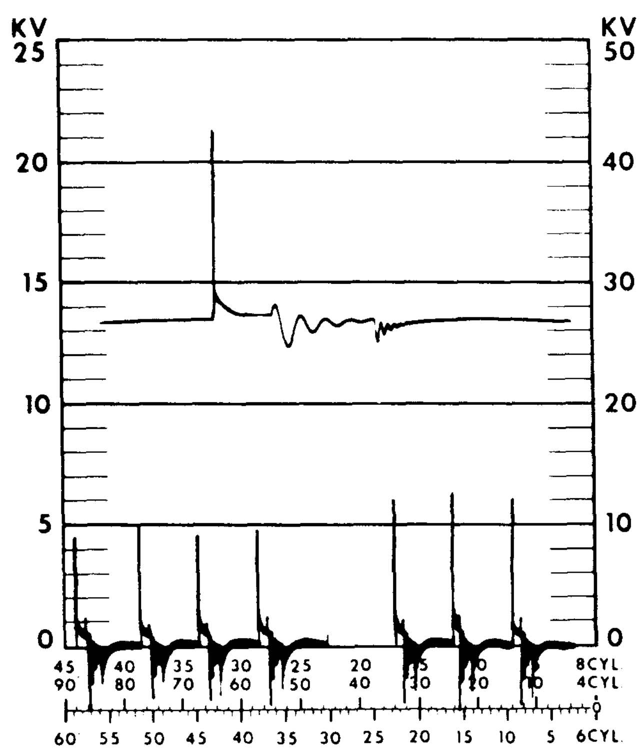


FIGURE 12—A display pattern with the shift button, the compare button, and the number five cylinder button of the cylinder selection control depressed.

The cylinder may also be displayed at the top of the screen without being in the SHIFT condition by pressing all the buttons previously depressed but with the PATTERN POSITION control CONV button depressed. This display is shown in Figure 13.

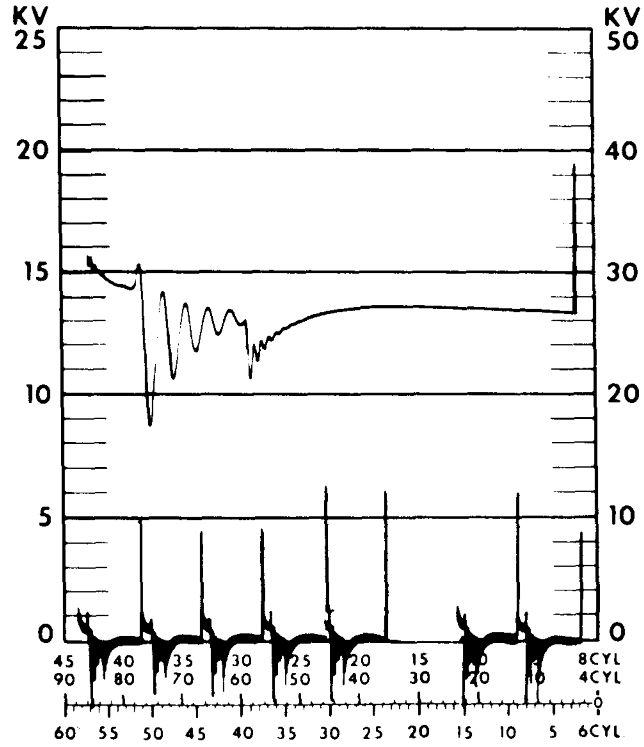


FIGURE 13—A display pattern with the conventional button, the compare button, and the number six cylinder button of the cylinder selection control depressed.

Raster Pattern

The raster pattern makes use of the vertical size of the scope screen by stacking the cylinder patterns one above the other. All individual patterns are vertically distributed on the screen.

This permits individual cylinder identification while viewing all cylinders at the same time. The raster pattern is especially helpful for cylinder identification of variations in the pattern waveforms observed in the superimposed pattern.

With the TRIGGER PICKUP clamped around number one spark plug wire, the number one cylinder will be displayed at the bottom of the screen. The remaining pattern waveforms will appear in the firing order sequence starting at the bottom and moving to the top of the scope screen.

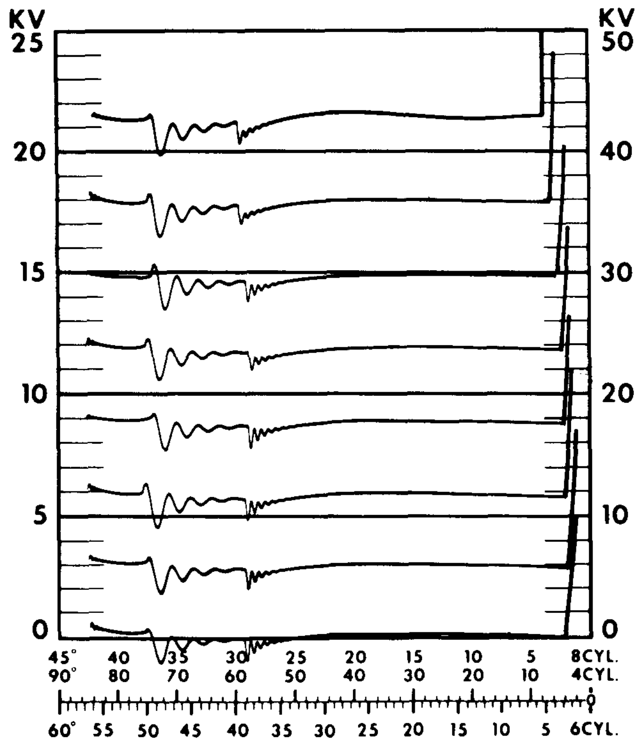


FIGURE 14—A raster pattern of a normal operating engine.

By setting the PATTERN SELECTOR knob at RASTER, the PATTERN HEIGHT knob at HIGH, the FUNCTION SELECTOR knob at SECONDARY, and the CONV button depressed, the scope will display a raster pattern (Figure 14). The DISPLAY position of the PATTERN SELECTOR must be used for viewing the firing lines for measuring voltage potentials. The raster pattern in the SHIFT position does show the firing lines but this display is normally used for ease of viewing the cylinder patterns in raster. To get a raster pattern in the SHIFT position program the scope as above but press the SHIFT button (Figure 15).

Superimposed Pattern

A superimposed pattern is the display obtained by placing all cylinder patterns one in front, or on top, of the other. Superimposed cylinder patterns provide a convenient method of testing an ignition system for overall uniformity. By having all cylinder display patterns one on top of the other, any variation of any individual cylinder pattern can be easily detected.

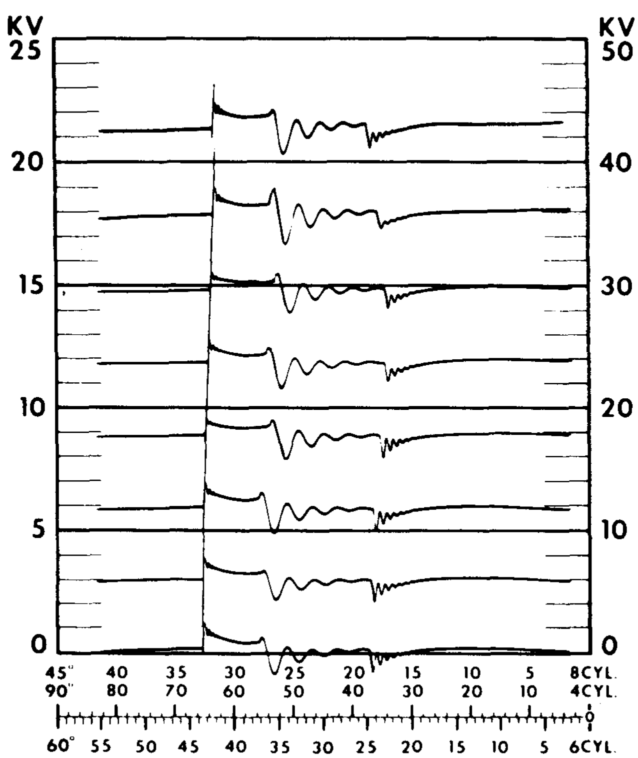


FIGURE 15—A raster pattern in the shift position [shift button depressed].

To obtain a secondary circuit superimposed pattern, set PATTERN SELECTOR to SUPERIMPOSE, PATTERN HEIGHT to HIGH, FUNCTION SELECTOR to SECONDARY, and push the CONV button on PATTERN POSITION controls (Figure 16). With the analog scope programmed for superimposed as above, a single cylinder display can be obtained by pushing the COMP button and one of the cylinder buttons on the CYLINDER SELECTOR. This gives a display of a single cylinder. The operator can view any single cylinder display by depressing the corresponding cylinder button on the CYLINDER SELECTOR. This cylinder will be displayed below the zero line on the dwell scale (Figure 17).

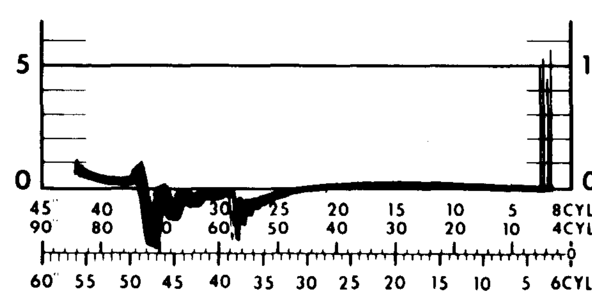


FIGURE 16—A superimposed pattern displaying all cylinder patterns on top of each other.

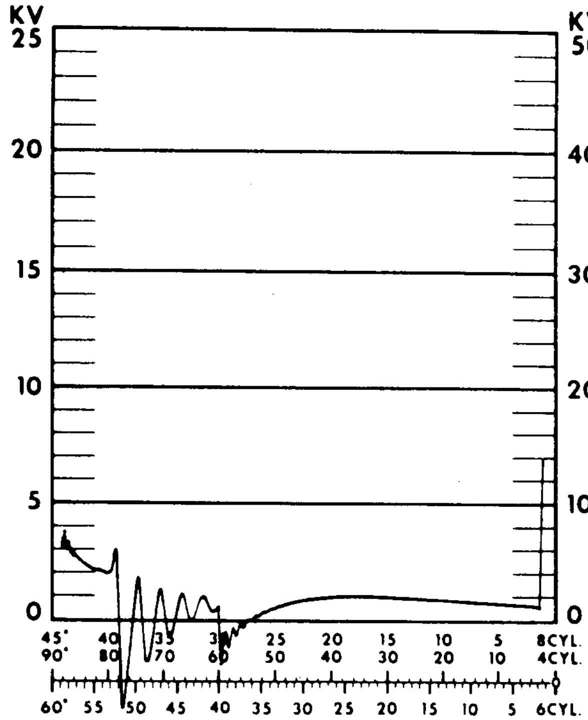


FIGURE 17—A single cylinder display obtained from superimposed pattern in compare.

COIL OUTPUT CRANKING

1. Disconnect the coil Secondary Lead from the center terminal of the distributor cap.
2. Set FUNCTION SELECTOR to SECONDARY.
3. Set PATTERN HEIGHT selector to HIGH.
4. Set PATTERN SELECTOR to DISPLAY.
5. Crank engine with Ignition Key ON.
6. Note and record maximum rise of waveform on 50 KV scale.
7. Stop cranking and reconnect coil lead.

COIL POLARITY

1. Start engine and operate at 1000 to 1500 rpm.
2. Set FUNCTION SELECTOR to SECONDARY.
3. Set PATTERN HEIGHT selector to LOW.
4. Set PATTERN SELECTOR to DISPLAY.
5. Set PATTERN POSITION for either CONV or SHIFT.
6. Note and record position of waveform firing line. If pattern is upside down, the coil polarity is reversed.

IGNITION SECONDARY (Min. and Max.)

1. Operate engine at 1000 to 1500 rpm.
2. Set FUNCTION SELECTOR to SECONDARY.
3. Set PATTERN HEIGHT selector to LOW.
4. Set PATTERN SELECTOR to DISPLAY.
5. Set PATTERN POSITION for either CONV or SHIFT.
6. Note and record the height of each firing line on the 25KV scale.

MAXIMUM COIL OUTPUT

1. Operate engine at 1000 to 1500 rpm.
2. Set FUNCTION SELECTOR to SECONDARY.
3. Set PATTERN HEIGHT selector to HIGH.
4. Set PATTERN SELECTOR to DISPLAY.
5. Set PATTERN POSITION for either CONV or SHIFT.
6. Note and record position of waveform firing lines.

SPARK PLUG FIRING VOLTAGES

1. Operate engine at 1000 to 1500 rpm.
2. Set FUNCTION SELECTOR to SECONDARY.
3. Set PATTERN HEIGHT selector to LOW.
4. Set PATTERN SELECTOR to DISPLAY.
5. Set PATTERN POSITION for either CONV or SHIFT.
6. Note and record the height of each firing line on the 25 KV scale.

MAXIMUM COIL OUTPUT

1. Operate engine at 1000 to 1500 rpm.
2. Set FUNCTION SELECTOR to SECONDARY.
3. Set PATTERN HEIGHT selector to HIGH.
4. Set PATTERN SELECTOR to DISPLAY.

5. Set PATTERN POSITION for either CONV. or SHIFT.

6. Use insulated pliers to disconnect one spark plug wire and hold wire away from engine ground.

7. Note and record maximum rise of waveform on 50 KV scale (Figure 18).

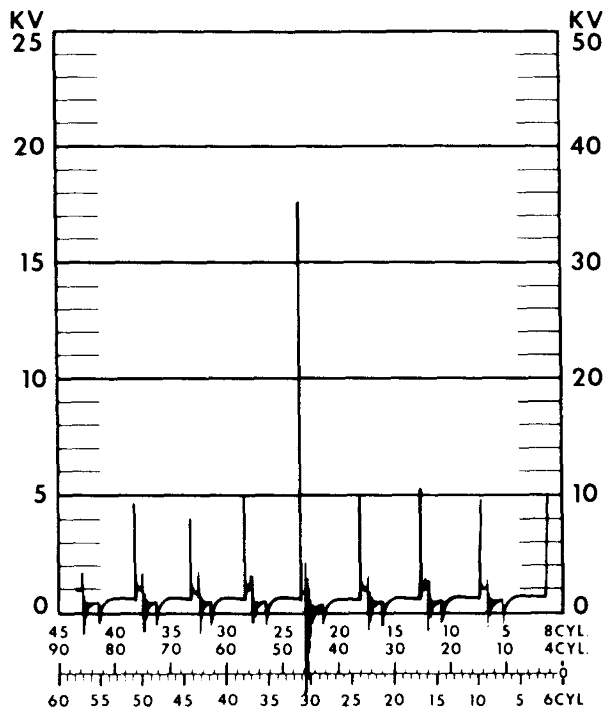


FIGURE 18—Maximum available coil output voltage.

8. Reconnect spark plug wire to spark plug.

SECONDARY CIRCUIT INSULATION

1. Operate engine at 1000 to 1500 rpm.

2. Set FUNCTION SELECTOR to SECONDARY.

3. Set PATTERN HEIGHT selector to HIGH.

4. Set PATTERN SELECTOR to DISPLAY.

5. Set PATTERN POSITION for either CONV or SHIFT.

6. Use insulated pliers to disconnect one spark plug wire and hold wire away from engine ground.

7. Note and record maximum downspike of waveform on 50 KV scale.

8. Reconnect spark plug wire to spark plug.

NOTE: This test does not apply to high output systems such as HEI that produce over 30 KV since the spark will jump inside the distributor cap on good systems.

SECONDARY CIRCUIT RESISTANCE

1. Operate engine at 1000 to 1500 rpm.

2. Set FUNCTION SELECTOR to SECONDARY.

3. Set PATTERN HEIGHT selector to LOW.

4. Set PATTERN SELECTOR to RASTER.

5. Set PATTERN POSITION for either CONV or SHIFT.

6. Note and record the appearance of each waveform spark line.

COIL AND CONDENSER ACTION

1. Operate engine at 1000 to 1500 rpm.

2. Set FUNCTION SELECTOR to either SECONDARY or PRIMARY.

3. Set PATTERN HEIGHT selector to HIGH.

4. Set PATTERN SELECTOR to RASTER or SUPERIMPOSE.

5. Set PATTERN POSITION for either CONV or SHIFT.

6. Note and record appearance of Intermediate Section waveform.

BREAKER POINT CONDITION

1. Operate engine at 1000 to 1500 rpm.

2. Set FUNCTION SELECTOR to either PRIMARY or SECONDARY.

3. Set PATTERN HEIGHT selector to LOW.

4. Set PATTERN SELECTOR to RASTER or SUPERIMPOSE.

5. Set PATTERN POSITION for SHIFT.

6. Note and record Point Open and Point Close portion of Dwell Section.

Analog Scope Pinpoint Testing

CYLINDER TIMING ACCURACY

1. Operate engine at 1000 to 1500 rpm.
2. Set FUNCTION SELECTOR to either PRIMARY or SECONDARY.
3. Set PATTERN HEIGHT selector to LOW.
4. Set PATTERN SELECTOR to SUPERIMPOSE.
5. Set PATTERN POSITION for SHIFT.
6. Note and record the misalignment in degrees of the waveform point open signals.

SNAP ACCELERATION

1. Operate engine at idle.
2. Set FUNCTION SELECTOR to SECONDARY.
3. Set PATTERN HEIGHT selector to HIGH.
4. Set PATTERN SELECTOR to DISPLAY.
5. Set PATTERN POSITION for SHIFT.
6. Snap accelerate engine to approximately 2000 rpm; then release throttle.
7. Note and record maximum and minimum rise of firing lines on the 50 KV scale.

CYLINDER COMPARISON

Occasionally it becomes desirable to enlarge a particular waveform for detailed comparison with the others being viewed on the screen. This is easily accomplished when viewing either Secondary or Primary Patterns in the following manner.

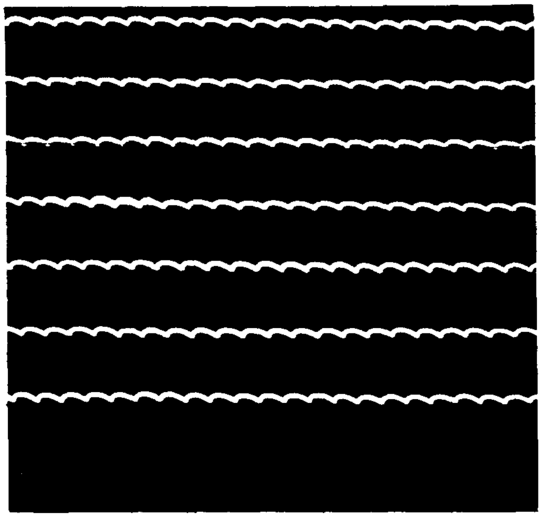
1. Operate the engine at the desired test speed.
2. Set the FUNCTION SELECTOR to either SECONDARY or PRIMARY as desired.
3. Set the PATTERN HEIGHT selector to HIGH.
4. Set the PATTERN SELECTOR to DISPLAY.
5. Set the PATTERN POSITION for either CONV or SHIFT as desired.
6. Push the COMP button of the CYLINDER SELECTOR MODE control.
7. Select the cylinder to be compared with the others and depress the corresponding button of the CYLINDER SELECTOR.
8. Compare the characteristics of the enlarged waveform at the top of the screen with the other waveforms being displayed.
9. Press the same CYLINDER SELECTOR button, or the CANCEL button to return the enlarged waveform to its former position in the display.
10. Repeat steps 7, 8 & 9 to enlarge any of the other cylinder waveforms for comparison.
11. Push two or more CYLINDER SELECTOR buttons and compare the cylinder waveforms. They will be superimposed at the top of the screen.

ALTERNATOR DIODE TEST

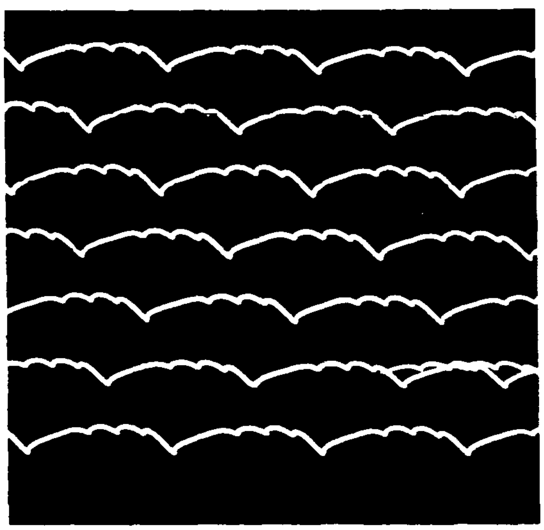
1. Turn PATTERN SELECTOR knob to the RASTER position and set PATTERN HEIGHT knob to VARIABLE.
2. Turn VARIABLE knob fully clockwise.
3. Turn FUNCTION SELECTOR knob to SPECIAL PATTERNS position.
4. Connect test leads.

   a. Clamp the Chrome PATTERN PICKUP around the coil high tension wire, and connect PRIMARY PICKUP, Red to distributor side of coil and Black to ground.

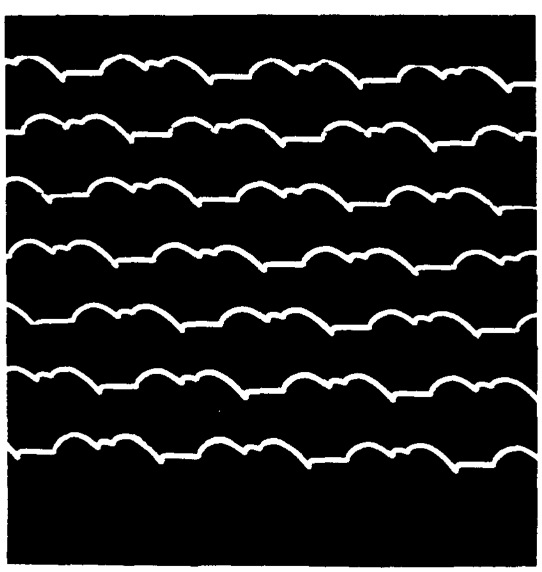
   b. Clamp the Green SPECIAL PATTERNS PICKUP around the alternator output (+) lead or to the positive battery cable.
5. Start the engine and operate at approximately 1000 rpm.
6. Turn headlights on and to high beam to apply an electrical load to the alternator.



Normal Alternator



Open Diode



Shorted Diode

FIGURE 19—Normal and abnormal alternator output waveforms.

7. Observe waveform and compare to Figure 19.

   If waveform is other than normal, alternator must be removed from vehicle for service.

ELECTRONIC IGNITION SCOPE TESTING

Most electronic ignition systems are tested in a manner similar to the procedure followed when testing standard systems. The following gives test connections for electronic ignition systems. Refer to other Sun Publications for detailed testing and diagnostic information on these systems.

The American Motors and Jeep electronic system is called the Breakerless Inductive Discharge (BID) ignition system. The scope test connections to the BID system are the same as for a standard ignition system as follows:

1. Clamp the Chrome PATTERN PICKUP around the secondary coil wire.
2. Clamp the Red TRIGGER PICKUP around the No. 1 spark plug wire near the distributor cap.
3. Connect the Red Dwell Lead to the Coil Negative terminal.
4. Connect the Black Dwell Lead to a good engine ground.

Chrysler has two electronic ignition systems, the Chrysler Electronic Ignition system and the Chrysler Lean Burn system. The scope test connections to both systems are the same as for standard systems. Standard connections are listed for American Motors above.

NOTE: The distinguishing feature of the Chrysler Electronic Ignition waveform on the scope is that an Intermediate Section does not appear.

Ford's electronic ignition system is called Ford Solid State Ignition. The scope connections to Solid State Ignition are the same as for standard systems as listed for American Motors above, except that the Red Dwell lead is connected to a terminal marked TACH TEST (Coil negative) on the Coil Connector.

The General Motors Delco Remy electronic ignition system is called High Energy Ignition (HEI). The scope test connections for the HEI system are as follows:

Analog Scope Pinpoint Testing

1. For L6 and 4 cylinder engines, clamp the Chrome PATTERN PICKUP around the secondary coil wire (Figure 20).

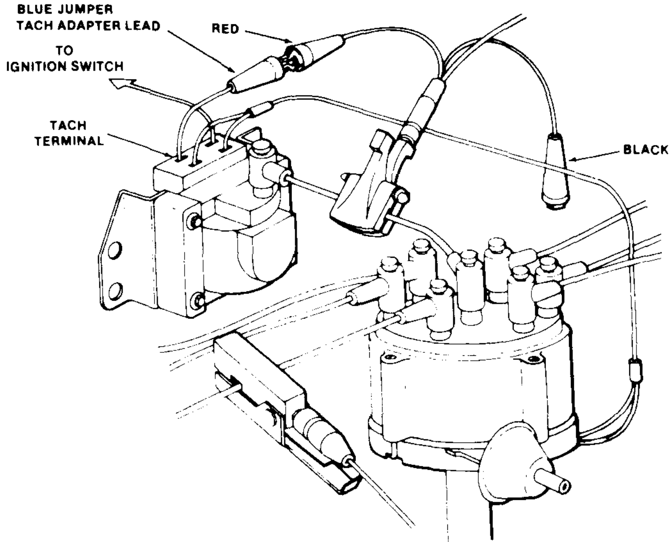


FIGURE 20—Tester connections on Delco HEI L6 and 4 cylinder ignitions.

For V8 and V6 cylinder engines, snap the HEI adapter into place on top of the coil cover (Figure 21).

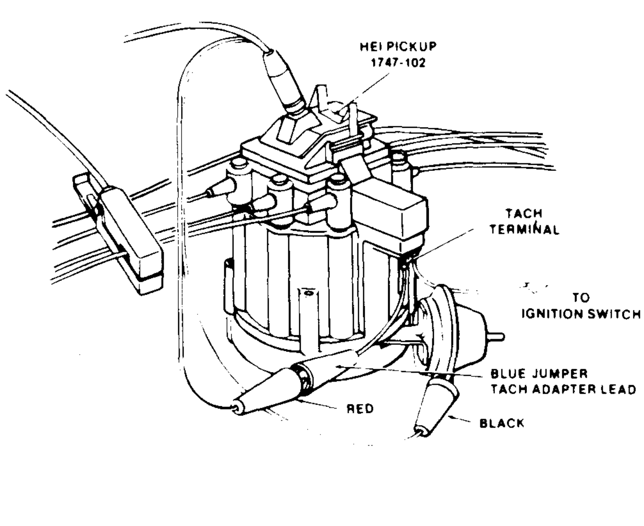


FIGURE 21—Tester connections on Delco HEI V8 and V6 cylinder ignitions.

2. Clamp the Red TRIGGER PICKUP around the No. 1 spark plug wire near the distributor.

3. With the aid of a Sun adapter lead (#6002-048), connect the Red lead of the PATTERN PICKUP to the system's "TACH" terminal.

4. Connect the Black lead of the PATTERN PICKUP to any convenient vehicle ground.

HEI TESTING INFORMATION

1. Start engine, allow to stabilize within the normal operating temperature range.

2. Dwell check.

   Run engine at idle speed and observe dwell reading on scope.

   Slowly accelerate engine to 2000 rpm. Dwell should extend in relationship to engine speed and should be considerably greater than at idle speed.

   No dwell increase - indicates a distributor module malfunction.

3. Initial Timing and Timing Advance. Check as on standard systems. Observe procedure for specific vehicle being tested - see manufacturer's specifications.

All scope checks and test indications are similar to those made on standard ignition systems except available voltage and insulation breakdown tests and dwell variation.

Normal available voltage will be well above 30 KV - possibly 35 to 38 KV. If there is no insulation breakdown in the wires, the spark can jump to another spark plug terminal in the cap and the arcing in the cap can be heard. The down spike, normally 1/2 of the available voltage spike, will be about 1/4 the length of the upward spike. If there is an insulation leak from a spark plug wire to ground there will be no down spike and no arcing will be heard in the cap.

METER AND GAUGE TESTING

RPM X 100 TACHOMETER

Revolutions per minute (rpm) can be measured from 0 to 12000 rpm. With the AMPERES-DWELL-RPM knob in the AUTO-TACH/DWELL position, the Red 0-1500 and the Blue 0-6000 scales are activated. Engine speed determines which scale applies and which indicator lamp is lit. When engine rpm is in the 0-1500 range, the 1500 RPM indicator lamp will light. When engine rpm is in the 0-6000 range, the 6000 RPM indicator lamp will light. With the AMPERES-DWELL-RPM knob in the 12000 RPM/DWELL position, only the Blue 0-12000 scale and the 0-12000 RPM indicator lamp are activated.

TEST CONNECTIONS

1. Clamp the Red TRIGGER PICKUP onto the wire lead of the timing spark plug (normally No. 1 in the firing order).
2. Set NO. OF CYLINDER control to match the number of cylinders of engine being tested.
3. Push CYCLE button 2 or 4 to match the type of engine being tested.

Tachometer readings can be obtained from the primary as well, by connecting the Red Boot of the Blue lead to the distributor side of the coil, and the Black Boot to ground.

CYLINDER POWER BALANCE TEST

The power balance test provides a means of shorting out cylinders individually or in combinations to determine how well the engine runs with the remaining cylinders. This test compares the change in engine rpm with one cylinder at a time or with similar groups of cylinders shorted. The test results indicate whether or not any cylinder or combination of cylinders is developing its share of drive power. The less power produced by a given cylinder, the less rpm will be lost when that cylinder is shorted out.

Shorting In Pairs

Shorting in pairs is primarily used on 4-cylinder engines.

1. Start engine and operate at approximately 1000 rpm. (If attempting to troubleshoot a specific performance problem, operate engine at speed that problem is most noticeable.)
2. Push CANCEL button of the CYLINDER SELECTOR controls.
3. Push 1 and 3 buttons of CYLINDER SELECTOR controls. Then push the CYLINDER SELECT MODE SHORT button.

   NOTE: The operator has 20 seconds to record a data reading. The SHORT button should be cancelled after approximately 20 seconds.

4. Note and record rpm with cylinders shorted.
5. Perform Steps 2, 3, and 4 with buttons 2 and 4 depressed.
6. Push the CANCEL button. Allow engine base speed to stabilize, and then record engine base speed.

   NOTE: The individual rpm readings must be subtracted from the base rpm to find the change in rpm. The weak cylinders are those with the least amount of change in rpm when they are shorted out.

7. Record and evaluate the test data.

Shorting In Combinations

This test is applicable on engines with any number of cylinders.

CAUTION: On cars with catalytic converters, consult manufacturer's instructions telling how many cylinders can be safely shorted out at one time.

The method of doing the power balance test is given under the heading, Shorting In Pairs. Other tests can be devised for shorting other combinations of cylinders, but the test procedure must conform to the test steps under Shorting In Pairs.

When testing with odd or even cylinders shorted, for example, follow the procedure under Shorting In Pairs, except short the odd numbered cylinders first and get an rpm reading. Then, short the even numbered cylinders and get an rpm reading.

Compare the engine rpm results to see if the two groups of cylinders are balanced.

The combinations of cylinders that can be shorted are many and varied. The operator can create many test combinations to fit his testing needs, provided he follows the method of operating the tester as demonstrated under Shorting In Pairs.

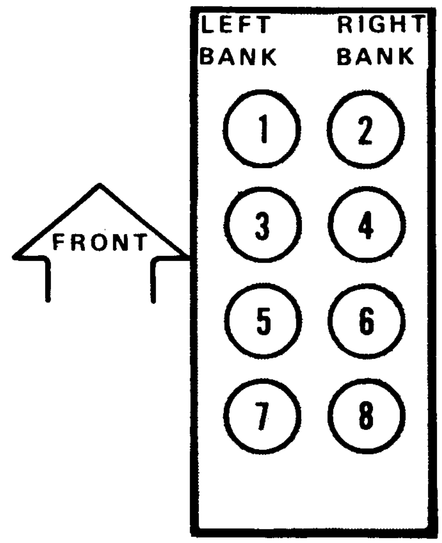


FIGURE 22—One method used in numbering cylinders.

CARBURETOR POWER BALANCE TEST

This test procedure works well on most standard production V-8 engines. However, there may be some high performance engines or special intake manifolds that follow a different fuel distribution pattern.

1. Identify each engine cylinder by number on an engine chart. Cylinder numbers are identified on Sun Specification Cards and in manufacturers engine service manuals.

   NOTE: The cylinders may be numbered like many American Motors, Chrysler and General Motors engines (Figure 22). One, three, five and seven are in the left bank, and two, four, six and eight are in the right bank, and fire in the sequence of 1, 8, 4, 3, 6, 5, 7, 2. By writing the firing order in the space provided below the Power Balance buttons, it can be readily seen that depressing the odd numbered buttons will short out the four cylinders (1, 4, 6 and 7) being fed from the left barrel of the carburetor (Figure 23). On the other hand, if the even numbered buttons are depressed, the cylinders fed by the right barrel (2, 3, 5 and 8) will be shorted out.

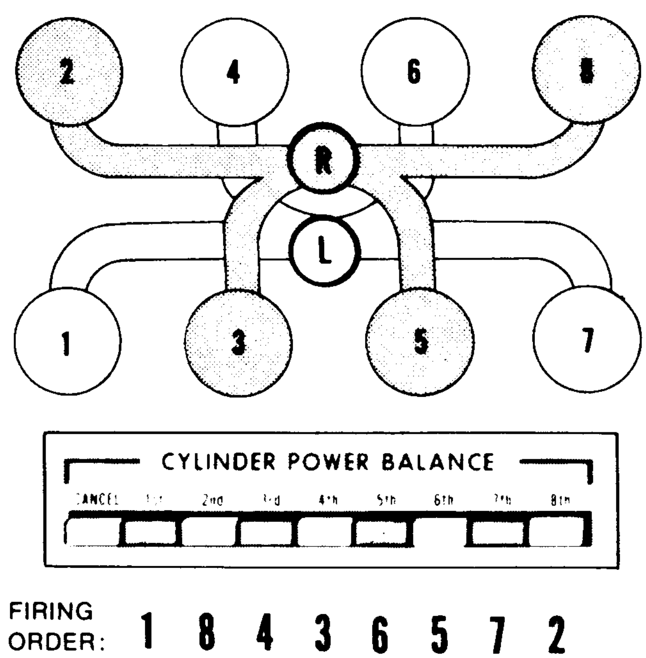


FIGURE 23—The cylinders fed by the left and right carburetor barrels related to the cylinder power balance buttons and the firing order of one engine.

2. Run the engine at idle speed.

3. Short out the "even" half of the cylinders and note the engine rpm. The Power Balance function of the tester is used for this test. The Power Balance Test has been explained previously.

   CAUTION: On vehicles equipped with catalytic converters, do not run for more than 20 seconds at a time with four cylinders shorted.

4. Short out the "odd" half of the cylinders and note the engine rpm.

5. Compare these engine speeds and adjust carburetor as required.

IDLE SPEED

Follow manufacturer's procedure for setting engine idle speed. The type of engine, transmission and accessories installed will frequently determine the correct idle speed.

1. With tester connected, start engine and run until it is at normal operating temperature (choke open).

2. Place transmission and accessories in the operating condition indicated by manufacturer's specifications for Idle Speed Test (for example: Automatic Transmission in Drive, Air Conditioning ON).

3. Observe Engine rpm and compare with manufacturer's specification for Idle Speed.

POSITIVE CRANKCASE VENTILATION TEST

A test of the PCV system can be conducted by closing off the system at a point prior to its connection at the intake manifold and noting the change in engine rpm.

1. Place at idle rpm and normal operating temperature (choke fully open).

2. Close off or plug the PCV hose to the intake manifold.

3. Observe the tachometer for change in engine speed.

   a. Engine speed decreases by 50 rpm or more (unless otherwise specified by manufacturer) - indicates PCV operation normal.

   b. Engine speed does not change - indicates PCV valve, hoses, or air intake clogged.

DWELL-AMPS METER

The DWELL-AMPS meter is used to measure dwell, current and distributor resistance. With the AMPERES-DWELL-RPM knob in the AUTO-TACH/DWELL or the 12000 RPM/DWELL position, the Red Dwell scale is activated. The Dwell Meter measures and registers the average dwell for all cylinders in terms of degrees of distributor cam rotation.

DWELL TEST CONNECTIONS

1. Connect and prepare the Tachometer as outlined in RPM x 100 Tachometer Section.

2. Connect Red primary pickup lead to the coil primary terminal on the distributor.

3. Connect the Black primary pickup lead to engine ground.

Dwell Test

1. Operate engine at idle speed.

2. Observe the indication on the Red Dwell Meter scale. Compare with manufacturer's specifications.

Dwell Variation

Dwell variation is determined by noting any dwell change as the engine is operated at different speeds. Excessive variation indicates a change in point opening that can result from shaft or bushing wear, or from the distributor plate shifting because of wear or looseness.

1. Measure distributor dwell at idle speed.

2. Increase speed to 1500 rpm.

3. Note dwell reading at 1500 rpm; then slowly reduce speed to idle while watching Red Dwell scale. Dwell reading should not change more than 3 degrees on most vehicles.

Compare with manufacturer's specifications.

Distributor Resistance

Distributor resistance tests are made to determine the primary circuit resistance from the negative terminal of the coil through the distributor to engine ground.

1. Place the AMPERES-DWELL-RPM knob in the DIST RES position.

2. Crank engine until distributor contact points are closed.

3. With the ignition switch on, observe the Red Dwell scale.

   The resistance is normal if the pointer stays within the Black DIST RES portion of the scale.

AMPS TEST PROCEDURE

1. Clamp the Ammeter probe around one wire of the circuit to be tested with the arrow on the probe pointing in the direction of expected current flow.

2. Read circuit amperage on appropriate Blue AMPS scale. If the ampere meter pointer goes above the top of the AUTO-TACH/100A scale, change the AMPERES-DWELL-RPM knob to the AUTO-TACH/500A position.

Alternator Output Test

1. Clamp the AMPS PICKUP around the alternator output wire with arrow pointing away from alternator.

2. Set the AMPERES-DWELL-RPM knob to AUTO-TACH/100A.

3. Start engine and run at approximately 1500 rpm.

4. Turn on headlights and all accessories.

5. Observe the Blue AMPS scale for alternator output indication.

   Testing in this manner will usually cause the alternator to charge within specification. However, it is possible that if the accessory load is not great enough, the output seen may not be maximum. If there is any question concerning the condition of the alternator, test with a Volts-Ampere Tester that has an adjustable load.

VOLT-OHM METER

The VOLT-OHM meter is used to measure voltage and resistance. The Voltmeter indicates the difference in electrical pressure in volts between any two points in a circuit. The ohmmeter indicates the resistance in ohms between any two points in a circuit.

CRANKING VOLTAGE TEST

1. Connect the VOLT-OHM leads to the battery posts, Red to positive and Black to negative.

2. Turn VOLT-OHM knob to the 20V position for 6 and 12 volt systems and 40V position for 24 volt systems.

3. Disable ignition system by disconnecting the secondary coil wire from the distributor cap. (On V-6 and V-8 HEI systems, disconnect battery wire from ignition system.)

4. Crank engine.

5. Observe cranking voltage, cranking speed and evenness of cranking. Indication should be even and within manufacturer's specifications.

CHARGING VOLTAGE TEST

1. Turn VOLT-OHM knob to the 20V or 40V position depending on the vehicle's voltage.

2. Connect VOLT-OHM leads to the battery posts, Red to positive and Black to negative.

3. With the Tachometer connected as previously outlined, operate engine at a speed of 1500 to 2000 rpm.

4. Note Voltmeter reading after the meter pointer stops climbing. Indications should be within manufacturer's specification.

IGNITION PRIMARY AND BYPASS CIRCUIT TEST

1. Turn VOLT-OHM knob to 4V position.

2. Connect the VOLT-OHM leads, Red to the positive battery post and Black to the positive side of the ignition coil.

3. Ground the primary terminal of the distributor using a jumper wire.

4. With all lights and accessories turned off, crank engine and observe Voltmeter indication. Cranking voltage should be below 0.5 volt or that specified by the manufacturer.

OHMMETER CALIBRATION

The OHMS CAL knob is used to zero the ohm scale on the VOLT-OHM meter when the VOLT-OHM knob is set to the OHM position. When the VOLT-OHM knob is set to either the OHM x 100 or OHM x 1000 positions, the tester automatically sets the pointer to zero.

1. Set VOLT-OHM knob to OHM position.

2. With two ohm leads clamped together, turn OHMS CAL knob to the left or right as necessary until the meter pointer is set at zero.

COIL PRIMARY RESISTANCE TEST

1. Set VOLT-OHM knob to 4V position.
2. Connect VOLT-OHM leads, Red to one coil primary terminal and Black to the other coil primary terminal.
3. Observe meter indication and compare with specifications.

COIL SECONDARY RESISTANCE TEST

1. Set VOLT-OHM knob to OHM x 1000 position.
2. Install a Pickup Extension in the tower of coil.
3. Connect VOLT-OHM leads, Red to coil negative or positive primary terminal and Black to the Pickup Extension.
4. Observe Blue Ohmmeter scale and compare with coil specifications.

COIL PRIMARY GROUND TEST

1. Connect VOLT-OHM leads, Red to coil negative or positive primary terminal and Black to the coil case.
2. Turn VOLT-OHM knob to OHM x 1000 position.
3. Blue Ohmmeter scale should show no pointer movement. Otherwise, a grounded primary winding is indicated.

SECONDARY IGNITION CIRCUIT RESISTANCE TEST

1. Place VOLT-OHM knob in the OHM x 1000 position.
2. Connect VOLT-OHM leads, Red to a Test Contactor and Black to an 18 inch jumper wire.
3. Remove distributor cap from the distributor and the spark plug wires from the spark plugs.
4. Connect 18 inch jumper wire (clip) to one of the distributor cap terminals.
5. Connect the Test Contactor to the spark plug end of the wire connected to this distributor cap terminal. Observe Blue Ohmmeter scale indication.
6. Repeat Steps 4 and 5 for each spark plug wire and the coil wire. Indications should be as specified by manufacturer.

ALTERNATOR ROTOR CIRCUIT RESISTANCE

1. Place VOLT-OHM knob in the OHM x 100 position.
2. Disconnect alternator field wire from alternator field terminal.
3. Using an appropriate adapter, connect VOLT-OHM leads one to alternator field terminal and the other to alternator or engine ground.
4. Observe Blue Ohmmeter scale for field circuit resistance. Indication should be within specifications.

VACUUM GAUGE

The vacuum gauge is used to measure pressures below atmospheric pressure. The scale ranges from 0 to 30 inches. In addition, a scale in millimeters (0-700 mm) is provided for comparison with international car specifications. The tester is provided with VACUUM DAMPER knob to stabilize the gauge pointer for more accurate measurements.

CRANKING VACUUM TEST

1. Connect vacuum gauge hose to a source of intake manifold vacuum. Use Tee adapter hoses as required.
2. Disable ignition by disconnecting secondary coil wire from distributor cap. (On V-6 and V-8 HEI Systems disconnect battery wire from ignition system.)
3. Crank the engine and note the action of the Vacuum Gauge. If the vacuum is very low (less than 1"), it may be necessary to back out the idle speed control or disconnect the electrical throttle stop solenoid in order to increase the cranking vacuum to a higher, more readable level.
4. At the conclusion of the test, restore ignition system operation, and make sure all engine vacuum lines are reconnected properly and securely.

Normal engine condition will result in a steady vacuum that is even and has a rhythmic pulsation.

PCV VALVE TEST

This simple test quickly determines whether or not the PCV system is working properly.

1. Connect the VACUUM gauge lead and disable the ignition system as for the Cranking Vacuum test.

2. While cranking the engine, pinch the PCV hose or close the end of the PCV valve to prevent air from leaking into the intake manifold.

3. Watch the VACUUM gauge.

   An increase in vacuum with the PCV blocked, indicates the PCV system is open and capable of functioning.

4. Enable engine.

IDLE VACUUM TEST

Idle vacuum readings aid in determining the existence of any problems relating to compression leaks in the cylinders or intake manifold, leaking or sticky valves, improper timing or fuel mixture which may affect engine operation.

1. Connect VACUUM gauge as for cranking vacuum test.

2. Start engine and operate at specified idle rpm.

A steady vacuum reading between 15" and 22" indicates the engine is in good condition and operating normally.

EXHAUST RESTRICTION TEST

Any unusual restriction in the exhaust system will result in inefficient engine performance at higher than idle speeds. To determine whether restrictions exist, proceed as follows:

1. Connect the VACUUM gauge to the intake manifold in the usual manner.

2. Start engine, operate at idle rpm and note the vacuum reading.

3. Increase engine speed to approximately 2500 rpm and again note the vacuum reading.

An increase in vacuum over the vacuum obtained at idle indicates that the exhaust system is free of restrictions.

FUEL PUMP VACUUM TEST

The fuel pump vacuum test is an auxiliary test and is necessary only when the pump output does not meet the pressure or volume specifications. The fuel pump vacuum test is made to determine whether the defect is in the pump or in the fuel line.

1. Disconnect fuel pump flexible line from tank fuel delivery line.

2. Install proper Tee adapter fitting in flex line and attach VACUUM gauge hose.

3. Start engine and operate at idle speed.

4. Run engine for a period of time sufficient to permit VACUUM gauge to reach its maximum reading.

5. Stop engine and observe VACUUM gauge for ten or fifteen seconds.

If maximum vacuum is ten inches or more, and does not fall off when the engine is stopped, the flex line, pump valves, and filter bowl gaskets do not leak.

If maximum reading is less than 10 inches, or vacuum falls off rapidly, remove flex line and couple vacuum gauge directly to the inlet opening of the fuel pump and retest pump.

TIMING ADVANCE UNIT

This unit provides a means of measuring initial ignition timing and the timing advance provided by the mechanical and vacuum advance mechanisms.

INITIAL TIMING

1. Connect trigger pickup to the timing cylinder, usually No. 1.

2. Place the CYCLE selector to the proper position, 4 CYCLE or 2 CYCLE.

3. Set AMPERES-DWELL-RPM knob to AUTO-TACH/DWELL.

4. Start and warm the engine.

5. Set the engine rpm to the speed specified for initial timing.

6. Remove or disconnect vacuum hoses if specified. Plug vacuum source to prevent rpm change.

7. Set Timing Light Switch to ON, and aim timing light at engine timing marks.

8. Adjust rotating control on the back of timing light assembly until the timing mark on the rotating pulley aligns with the zero mark on the engine timing scale.

   Initial Timing should be within 1 degree of specification.

9. Replace vacuum line(s) if removed.

TIMING ADVANCE

1. Adjust engine rpm to the next desired test point.

2. Readjust the rotating control on the back of the light until the timing mark is again aligned with the zero mark on the timing scale.

3. Record timing advance indicated.

   NOTE: Reading will not include vacuum advance on vehicles equipped with a Transmission Controlled Spark (TCS) system. On most TCS systems, full vacuum advance at the distributor is not attained unless the transmission is in high gear.

4. Repeat Steps 1, 2 and 3 at each desired check point.

   Timing advance should be within specifications.

   NOTE: If desired, the operation of only the mechanical advance can be tested in the same manner as outlined above except that the vacuum line is not reconnected at the end of the Initial Timing test.

SUN 1115/TUT-1015
ENGINE PERFORMANCE TEST REPORT

Customer Name ______________________ Phone ______________ Date ____________

Address ______________________ City/State ______________ License ____________

Make/Year/Model ______________________ Mileage __________ Mileage Since Tune-Up ____________

Engine ______________ Transmission—Auto ☐ Std ☐ Air Conditioning—Yes ☐ No ☐

Carburetor ____________ Ignition Type ____________ Air Pump—Yes ☐ No ☐ Converter—Yes ☐ No ☐

Reason For Tests ______________________ Tested By ______________

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#1 CRANKING	COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	STARTER CURRENT	AMMETER	AMPS (MAX)				
	BATTERY VOLTAGE	VOLTMETER	VOLTS (MIN)				
	ENGINE VACUUM	VACUUM GAUGE	STEADY				
#2 CHARGING	CHARGING SYSTEM	AMMETER	SHOWS CHARGE				
	DIODE STATOR	SCOPE (ALT)	EVEN RIPPLE				
#3 IDLE	RPM	TACHOMETER	RPM				
	DWELL	DWELL METER	DEGREES				
	INITIAL TIMING	TIMING LIGHT	DEGREES				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				
	PCV	TACH, VACUUM GAUGE	RPM · VAC				
#4 1200 RPM LOW CRUISE	COIL POLARITY	SCOPE (DISPLAY)	VISUAL				
	SPARK PLUGS	SCOPE (DISPLAY)	KV				
	MAX COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	SECONDARY INSUL.	SCOPE (DISPLAY)	VISUAL				
	SECONDARY RESISTANCE	SCOPE (RASTER SHIFT)	VISUAL				
	COIL, CONDENSER	SCOPE (RASTER SHIFT)	VISUAL				
	BREAKER POINTS	SCOPE (RASTER SHIFT)	VISUAL				
	CYLINDER TIMING	SCOPE (SUPER-CONV)	VISUAL				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				

#5 CYLINDER POWER BALANCE	ENGINE			TACHOMETER			BASE RPM					
	SHORTED RPM	1	2	3	4	5	6	7	8			

#6 SNAP ACCELERATION	SPARK PLUGS UNDER LOAD	SCOPE (DISPLAY)	KV (MAX)				
	ACCELERATOR PUMP ACTION	CO METER	% (MAX)				
#7 2500 RPM HIGH CRUISE	TIMING ADVANCE	TIMING LIGHT	DEGREES				
	DWELL	DWELL METER	DEGREES				
	CHARGING VOLTS	VOLTMETER	VOLTS				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				

SUN 1115/TUT-1015
ENGINE PERFORMANCE TEST REPORT

Customer Name ______________________ Phone ______________ Date __________

Address ______________________ City/State ______________ License __________

Make/Year/Model ______________________ Mileage __________ Mileage Since Tune-Up __________

Engine ______________ Transmission—Auto ☐ Std ☐ Air Conditioning—Yes ☐ No ☐

Carburetor ______________ Ignition Type ______________ Air Pump—Yes ☐ No ☐ Converter—Yes ☐ No ☐

Reason For Tests ______________________ Tested By ______________

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#1 CRANKING	COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	STARTER CURRENT	AMMETER	AMPS (MAX)				
	BATTERY VOLTAGE	VOLTMETER	VOLTS (MIN)				
	ENGINE VACUUM	VACUUM GAUGE	STEADY				
#2 CHARGING	CHARGING SYSTEM	AMMETER	SHOWS CHARGE				
	DIODE STATOR	SCOPE (ALT)	EVEN RIPPLE				
#3 IDLE	RPM	TACHOMETER	RPM				
	DWELL	DWELL METER	DEGREES				
	INITIAL TIMING	TIMING LIGHT	DEGREES				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				
	PCV	TACH, VACUUM GAUGE	RPM - VAC				
#4 1200 RPM LOW CRUISE	COIL POLARITY	SCOPE (DISPLAY)	VISUAL				
	SPARK PLUGS	SCOPE (DISPLAY)	KV				
	MAX COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	SECONDARY INSUL.	SCOPE (DISPLAY)	VISUAL				
	SECONDARY RESISTANCE	SCOPE (RASTER SHIFT)	VISUAL				
	COIL, CONDENSER	SCOPE (RASTER SHIFT)	VISUAL				
	BREAKER POINTS	SCOPE (RASTER SHIFT)	VISUAL				
	CYLINDER TIMING	SCOPE (SUPER-CONV)	VISUAL				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				

#5 CYLINDER POWER BALANCE											
ENGINE	TACHOMETER					BASE RPM					
SHORTED RPM	1	2	3	4	5	6	7	8			

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#6 SNAP ACCELERATION	SPARK PLUGS UNDER LOAD	SCOPE (DISPLAY)	KV (MAX)				
	ACCELERATOR PUMP ACTION	CO METER	% (MAX)				
#7 2500 RPM HIGH CRUISE	TIMING ADVANCE	TIMING LIGHT	DEGREES				
	DWELL	DWELL METER	DEGREES				
	CHARGING VOLTS	VOLTMETER	VOLTS				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				

SUN 1115/TUT-1015
ENGINE PERFORMANCE TEST REPORT

Customer Name ______________________ Phone ______________ Date ____________

Address ______________________ City/State ______________ License ____________

Make/Year/Model ______________________ Mileage ______________ Mileage Since Tune-Up ____________

Engine ______________ Transmission—Auto ☐ Std ☐ Air Conditioning—Yes ☐ No ☐

Carburetor ______________ Ignition Type ______________ Air Pump—Yes ☐ No ☐ Converter—Yes ☐ No ☐

Reason For Tests ______________________ Tested By ______________________

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#1 CRANKING	COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	STARTER CURRENT	AMMETER	AMPS (MAX)				
	BATTERY VOLTAGE	VOLTMETER	VOLTS (MIN)				
	ENGINE VACUUM	VACUUM GAUGE	STEADY				
#2 CHARGING	CHARGING SYSTEM	AMMETER	SHOWS CHARGE				
	DIODE STATOR	SCOPE (ALT)	EVEN RIPPLE				
#3 IDLE	RPM	TACHOMETER	RPM				
	DWELL	DWELL METER	DEGREES				
	INITIAL TIMING	TIMING LIGHT	DEGREES				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				
	PCV	TACH, VACUUM GAUGE	RPM - VAC				
#4 1200 RPM LOW CRUISE	COIL POLARITY	SCOPE (DISPLAY)	VISUAL				
	SPARK PLUGS	SCOPE (DISPLAY)	KV				
	MAX COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	SECONDARY INSUL.	SCOPE (DISPLAY)	VISUAL				
	SECONDARY RESISTANCE	SCOPE (RASTER SHIFT)	VISUAL				
	COIL, CONDENSER	SCOPE (RASTER SHIFT)	VISUAL				
	BREAKER POINTS	SCOPE (RASTER SHIFT)	VISUAL				
	CYLINDER TIMING	SCOPE (SUPER-CONV)	VISUAL				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				

TEST MODE											
#5 CYLINDER POWER BALANCE	ENGINE	TACHOMETER				BASE RPM					
	SHORTED RPM	1	2	3	4	5	6	7	8		

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#6 SNAP ACCELERATION	SPARK PLUGS UNDER LOAD	SCOPE (DISPLAY)	KV (MAX)				
	ACCELERATOR PUMP ACTION	CO METER	% (MAX)				
#7 2500 RPM HIGH CRUISE	TIMING ADVANCE	TIMING LIGHT	DEGREES				
	DWELL	DWELL METER	DEGREES				
	CHARGING VOLTS	VOLTMETER	VOLTS				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				

SUN 1115/TUT-1015
ENGINE PERFORMANCE TEST REPORT

Customer Name ______________________ Phone ______________ Date __________

Address ______________________ City/State ______________ License __________

Make/Year/Model ______________________ Mileage __________ Mileage Since Tune-Up __________

Engine ______________ Transmission—Auto ☐ Std ☐ Air Conditioning—Yes ☐ No ☐

Carburetor __________ Ignition Type __________ Air Pump—Yes ☐ No ☐ Converter—Yes ☐ No ☐

Reason For Tests ______________________ Tested By ______________________

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#1 CRANKING	COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	STARTER CURRENT	AMMETER	AMPS (MAX)				
	BATTERY VOLTAGE	VOLTMETER	VOLTS (MIN)				
	ENGINE VACUUM	VACUUM GAUGE	STEADY				
#2 CHARGING	CHARGING SYSTEM	AMMETER	SHOWS CHARGE				
	DIODE STATOR	SCOPE (ALT)	EVEN RIPPLE				
#3 IDLE	RPM	TACHOMETER	RPM				
	DWELL	DWELL METER	DEGREES				
	INITIAL TIMING	TIMING LIGHT	DEGREES				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				
	PCV	TACH. VACUUM GAUGE	RPM - VAC				
#4 1200 RPM LOW CRUISE	COIL POLARITY	SCOPE (DISPLAY)	VISUAL				
	SPARK PLUGS	SCOPE (DISPLAY)	KV				
	MAX COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	SECONDARY INSUL.	SCOPE (DISPLAY)	VISUAL				
	SECONDARY RESISTANCE	SCOPE (RASTER SHIFT)	VISUAL				
	COIL, CONDENSER	SCOPE (RASTER SHIFT)	VISUAL				
	BREAKER POINTS	SCOPE (RASTER SHIFT)	VISUAL				
	CYLINDER TIMING	SCOPE (SUPER-CONV)	VISUAL				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				

TEST MODE											TEST RESULT	GO	NO GO
#5 CYLINDER POWER BALANCE	ENGINE		TACHOMETER				BASE RPM						
	SHORTED RPM	1	2	3	4	5	6	7	8				

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#6 SNAP ACCELERATION	SPARK PLUGS UNDER LOAD	SCOPE (DISPLAY)	KV (MAX)				
	ACCELERATOR PUMP ACTION	CO METER	% (MAX)				
#7 2500 RPM HIGH CRUISE	TIMING ADVANCE	TIMING LIGHT	DEGREES				
	DWELL	DWELL METER	DEGREES				
	CHARGING VOLTS	VOLTMETER	VOLTS				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				

SUN 1115 / TUT-1015
ENGINE PERFORMANCE TEST REPORT

Customer Name ________________ Phone ________________ Date ________________

Address ________________ City/State ________________ License ________________

Make/Year/Model ________________ Mileage ________________ Mileage Since Tune-Up ________________

Engine ________________ Transmission—Auto ☐ Std ☐ Air Conditioning—Yes ☐ No ☐

Carburetor ________________ Ignition Type ________________ Air Pump—Yes ☐ No ☐ Converter—Yes ☐ No ☐

Reason For Tests ________________ Tested By ________________

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#1 CRANKING	COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	STARTER CURRENT	AMMETER	AMPS (MAX)				
	BATTERY VOLTAGE	VOLTMETER	VOLTS (MIN)				
	ENGINE VACUUM	VACUUM GAUGE	STEADY				
#2 CHARGING	CHARGING SYSTEM	AMMETER	SHOWS CHARGE				
	DIODE STATOR	SCOPE (ALT)	EVEN RIPPLE				
#3 IDLE	RPM	TACHOMETER	RPM				
	DWELL	DWELL METER	DEGREES				
	INITIAL TIMING	TIMING LIGHT	DEGREES				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				
	PCV	TACH. VACUUM GAUGE	RPM - VAC				
#4 1200 RPM LOW CRUISE	COIL POLARITY	SCOPE (DISPLAY)	VISUAL				
	SPARK PLUGS	SCOPE (DISPLAY)	KV				
	MAX COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	SECONDARY INSUL.	SCOPE (DISPLAY)	VISUAL				
	SECONDARY RESISTANCE	SCOPE (RASTER SHIFT)	VISUAL				
	COIL, CONDENSER	SCOPE (RASTER SHIFT)	VISUAL				
	BREAKER POINTS	SCOPE (RASTER SHIFT)	VISUAL				
	CYLINDER TIMING	SCOPE (SUPER-CONV)	VISUAL				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				

#5 CYLINDER POWER BALANCE											
ENGINE	TACHOMETER				BASE RPM						
SHORTED RPM	1	2	3	4	5	6	7	8			

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#6 SNAP ACCELERATION	SPARK PLUGS UNDER LOAD	SCOPE (DISPLAY)	KV (MAX)				
	ACCELERATOR PUMP ACTION	CO METER	% (MAX)				
#7 2500 RPM HIGH CRUISE	TIMING ADVANCE	TIMING LIGHT	DEGREES				
	DWELL	DWELL METER	DEGREES				
	CHARGING VOLTS	VOLTMETER	VOLTS				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				

SUN 1115 / TUT-1015
ENGINE PERFORMANCE TEST REPORT

Customer Name ______________________ Phone ______________ Date __________

Address ______________________ City/State ______________ License __________

Make/Year/Model ______________________ Mileage __________ Mileage Since Tune-Up __________

Engine ______________ Transmission—Auto ☐ Std ☐ Air Conditioning—Yes ☐ No ☐

Carburetor __________ Ignition Type __________ Air Pump—Yes ☐ No ☐ Converter—Yes ☐ No ☐

Reason For Tests ______________________ Tested By ______________

TEST MODE	TESTS	READ	ENTER SPECIFICATIONS		TEST RESULT	GO	NO GO
#1 CRANKING	COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	STARTER CURRENT	AMMETER	AMPS (MAX)				
	BATTERY VOLTAGE	VOLTMETER	VOLTS (MIN)				
	ENGINE VACUUM	VACUUM GAUGE	STEADY				
#2 CHARGING	CHARGING SYSTEM	AMMETER	SHOWS CHARGE				
	DIODE STATOR	SCOPE (ALT)	EVEN RIPPLE				
#3 IDLE	RPM	TACHOMETER	RPM				
	DWELL	DWELL METER	DEGREES				
	INITIAL TIMING	TIMING LIGHT	DEGREES				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				
	PCV	TACH, VACUUM GAUGE	RPM - VAC				
#4 1200 RPM LOW CRUISE	COIL POLARITY	SCOPE (DISPLAY)	VISUAL				
	SPARK PLUGS	SCOPE (DISPLAY)	KV				
	MAX COIL OUTPUT	SCOPE (DISPLAY)	KV (MIN)				
	SECONDARY INSUL.	SCOPE (DISPLAY)	VISUAL				
	SECONDARY RESISTANCE	SCOPE (RASTER SHIFT)	VISUAL				
	COIL, CONDENSER	SCOPE (RASTER SHIFT)	VISUAL				
	BREAKER POINTS	SCOPE (RASTER SHIFT)	VISUAL				
	CYLINDER TIMING	SCOPE (SUPER-CONV)	VISUAL				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
#5 CYLINDER POWER BALANCE	ENGINE	TACHOMETER	BASE RPM				
	SHORTED RPM	1 / 2 / 3 / 4 / 5	6 / 7	8			
#6 SNAP ACCELERATION	SPARK PLUGS UNDER LOAD	SCOPE (DISPLAY)	KV (MAX)				
	ACCELERATOR PUMP ACTION	CO METER	% (MAX)				
#7 2500 RPM HIGH CRUISE	TIMING ADVANCE	TIMING LIGHT	DEGREES				
	DWELL	DWELL METER	DEGREES				
	CHARGING VOLTS	VOLTMETER	VOLTS				
	CARBON MONOXIDE	CO METER	%				
	HYDROCARBONS	HC METER	PPM				
	ENGINE VACUUM	VACUUM GAUGE	INCHES				