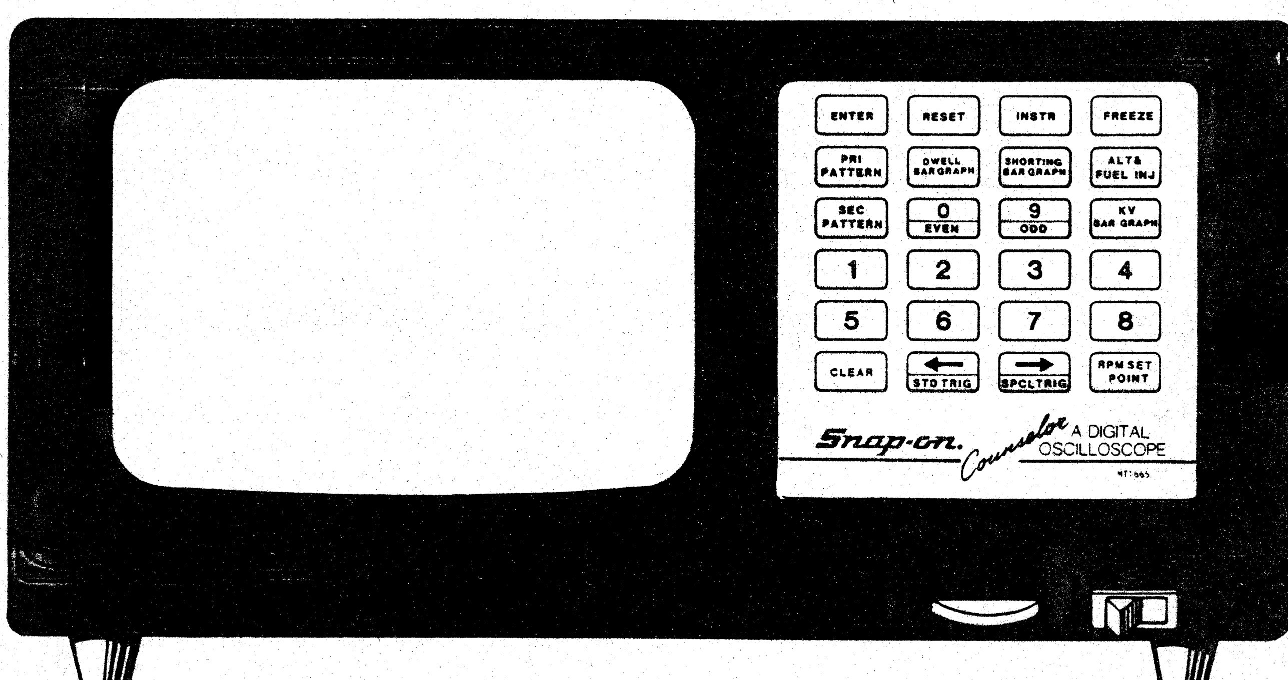
Appologies for the quality!

This is a scan, of a 25 year old photocopy, of an originally poor manual (that appears to have been done on a typewriter).

USER'S MANUAL
MT 1665

Counselor™

DIGITAL OSCILLOSCOPE



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Form ZMT1665/2
5M-UGG

Printed in U.S.A.
9-87

Table of Contents

Specifications

RPM Range .... 0 - 9990 RPM (10 RPM increments)
KV Range .... 0 - 50 KV maximum (1 KV increments)
Dwell Range .... 0 - 360° (1° increments)
.... 0 - 100%
DC Voltage Range .... -27.99 VDC - +27.99 VDC
.. [0.01 Volt (10 millivolt) resolution]
Operating Power Requirements
AC Operation: .... 120 VAC, .65 Amps, 70 Watts
DC Operation: ..... 12 VDC (negative ground), 4.5 Amps
Operating Temperature Range .... 35°F - 110°F
Storage Temperature Range .... -20°F - 130°F
Relative Humidity Range .... 0 - 85% (non-condensing)
Total Weight .... 94 lb.
Oscilloscope Weight .... 41 lb.
Roll Stand Weight .... 53 lb.
Roll Stand Dimensions
Height .... 42"
Width .... 21"
Depth .... 18"
Oscilloscope Dimensions
Height .... 8"
Width .... 17"
Depth .... 21"

Total Height (Stand w/Oscilloscope) ....51"

Introduction

The Counselor is a portable AC or DC powered digital oscilloscope, voltmeter, dwell meter and tachometer. The Counselor displays five waveform test screens: primary ignition circuit, secondary ignition circuit, alternator, fuel injection, and voltage. It also displays three bar graph screens: kilovolt (kV), cylinder shorting, and dwell. All screens provide numerical test data.

The Counselor's many special features make diagnosis and troubleshooting more versatile, efficient and accurate:

PATTERN SHIFT	Repositions a primary or secondary waveform for easier evaluation of different portions of a pattern.
PATTERN EXPAND	Enlarges a waveform for closer examination and more precise millisecond measurement.
FREEZE	Stops "live" screen action for evaluation and measurement.
RPM SET POINT	Stops "live" screen action automatically when engine speed reaches desired RPM.
MILLISECOND CURSOR CURTAIN	Measures in milliseconds the time value of any portion(s) of a waveform. Other cylinders can be called up and compared to cursor curtain position to check for variations.
CYLINDER SHORTING	Shorts individual cylinders for power balance testing using primary waveform, secondary waveform and cylinder shorting bar graph screens. Also shorts even and odd cylinders for carburetor balance testing.
MEMORY	Stores any frozen waveform and all the bar graphs. Allows operator to maintain screen data, do some other supportive testing, and return to screen for further examination. After power is turned off (AC or DC) the Counselor will retain screen data in MEMORY for at least three days.

The Counselor is designed to meet the needs of the professional automotive technician. It offers the combination of state-of-the-art technology, high quality components, and the finest in workmanship; all backed by the Snap-on GOOD AS GOLD Limited Warranty

READ THIS MANUAL THOROUGHLY BEFORE OPERATING THE MT1665 COUNSELOR

Cautions and Warnings

1. Read this instruction manual completely before using the MT1665 Digital Oscilloscope.

2 Always wear approved eye protection when testing vehicles, and make sure everyone within close proximity is protected.

3. Gases produced by a battery are highly explosive. Observe the following warnings, and those provided by the manufacturers of battery and vehicle.

   a. When connecting power leads to battery, connect positive lead (red) to positive terminal and then negative lead (black) to negative terminal. When disconnecting the power leads, remove the negative lead first.

   b. Keep cigarettes, sparks and open flame away from battery at all times.

   c. Testing should be done in a well ventilated area.

   d. Be sure test leads are properly connected before proceeding with a test.

   e. Avoid making accidental connection between battery terminals through tools, jumper leads, etc.

4. Always use extreme care when working around high voltage spark plugs and coil terminals.

5. Exhaust gas contains deadly poison. When testing with engine running, test in a well ventilated area or route the exhaust out-of-doors.

6. The 12 VDC power receptacle is only rated for a 12 VDC power source. Connection to 120/240 VAC 50/60 Hz power source can create a shock hazard and damage the equipment.

7. To avoid electrical shock, the AC power cord must be connected to a properly grounded power outlet.

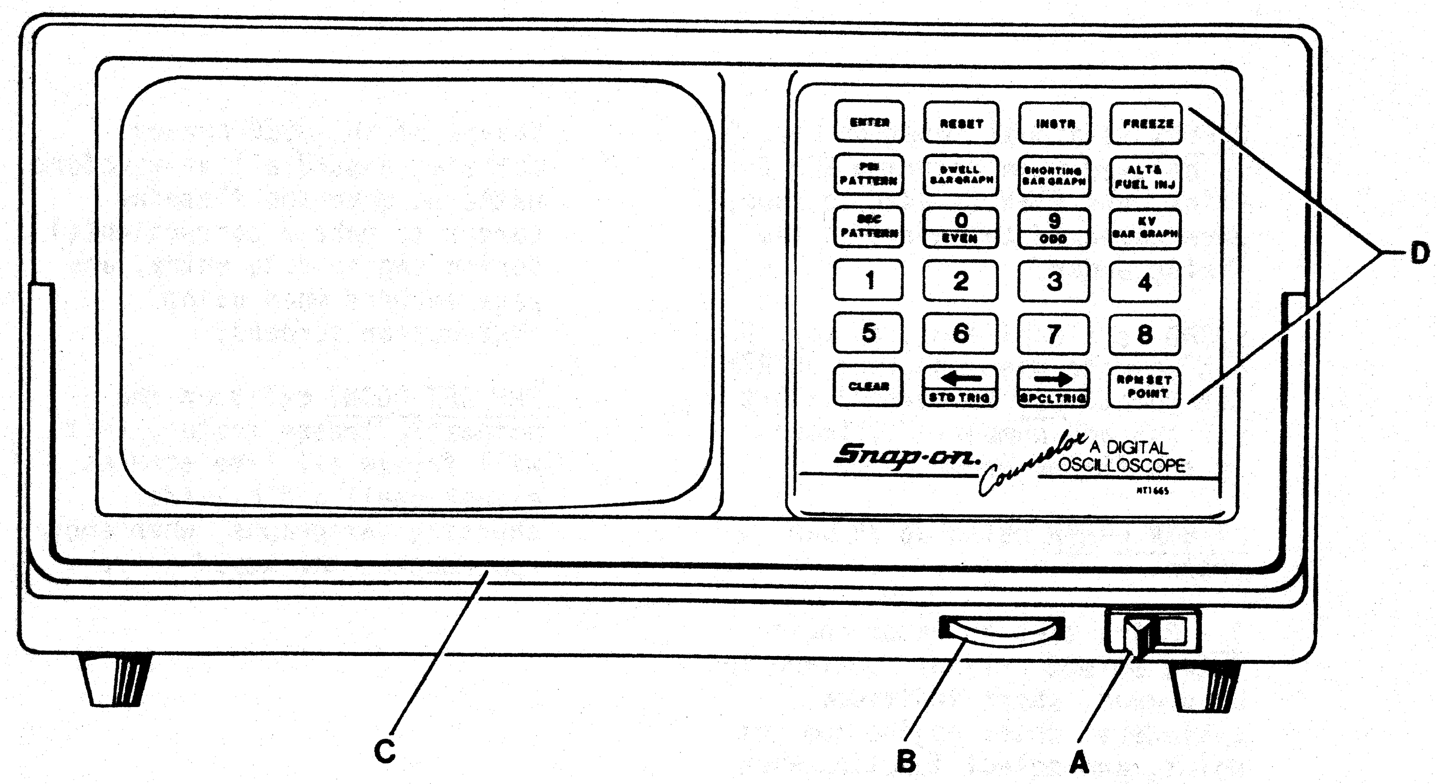
8. Keep self, clothing and test equipment clear of all moving or hot engine parts. Remove rings, wrist watch and other jewelry before working on vehicle.

9. Never puncture an ignition wire in order to connect test equipment.

10. Never disconnect test leads by pulling on them. Always squeeze the clip open.

11. Do not place test equipment on fender or other places where it may slip and fall.

12. Unless otherwise instructed, the parking brake should be set and the gear selector in neutral (standard transmission) or park (automatic transmission) and the drive wheels blocked before performing a test with the engine running. If vehicle has automatic parking brake release, disconnect the release mechanism.



Functional Description

Front Panel

A ON/OFF - 2-way power switch.

B INTENSITY CONTROL - Brightness adjustment thumbwheel.

C HANDLE

D CONTROL PANEL - 24 key panel used to enter engine data and RPM Set Point, call up and page through instructions, select test screens and use their applicable features.

ENTER is used when entering engine data, to switch edge control of mSEC CURSOR curtain, and to select EXPAND or TRIGGER (pattern shift) feature when in PRI or SEC patterns.

RESET clears whatever is on screen and returns it to Engine Data or Engine Data Entry screen. Pressing "RESET-2-RESET" clears any waveform and all bargraphs from MEMORY.

INSTR calls up the instruction screens. Engine data must be entered before instructions can be called up.

FREEZE will freeze any "live" screen and store data in memory. Pressing it again unfreezes screen.

PRI PATTERN calls up primary ignition waveform pattern.

DWELL BAR GRAPH calls up dwell bar graph.

SHORTING BAR GRAPH calls up cylinder shorting bar graph.

ALT & FUEL INJ calls up Alternator, Fuel Injection, and Voltage waveform pattern selection screen, which instructs you to press 1 for alternator, 2 for fuel injection, or 3 for voltage wave form pattern.

SEC PATTERN calls up secondary ignition waveform pattern.

O/EVEN is a dual function key. 0 is be used when entering RPM Set Point, and EVEN is used to short even numbered cylinders in the firing order.

9/ODD is a dual function key. 9 can be used when entering an RPM Set Point. ODD is used to short all the odd numbered cylinders in the firing order.

KV BAR GRAPH calls up kV bar graph.

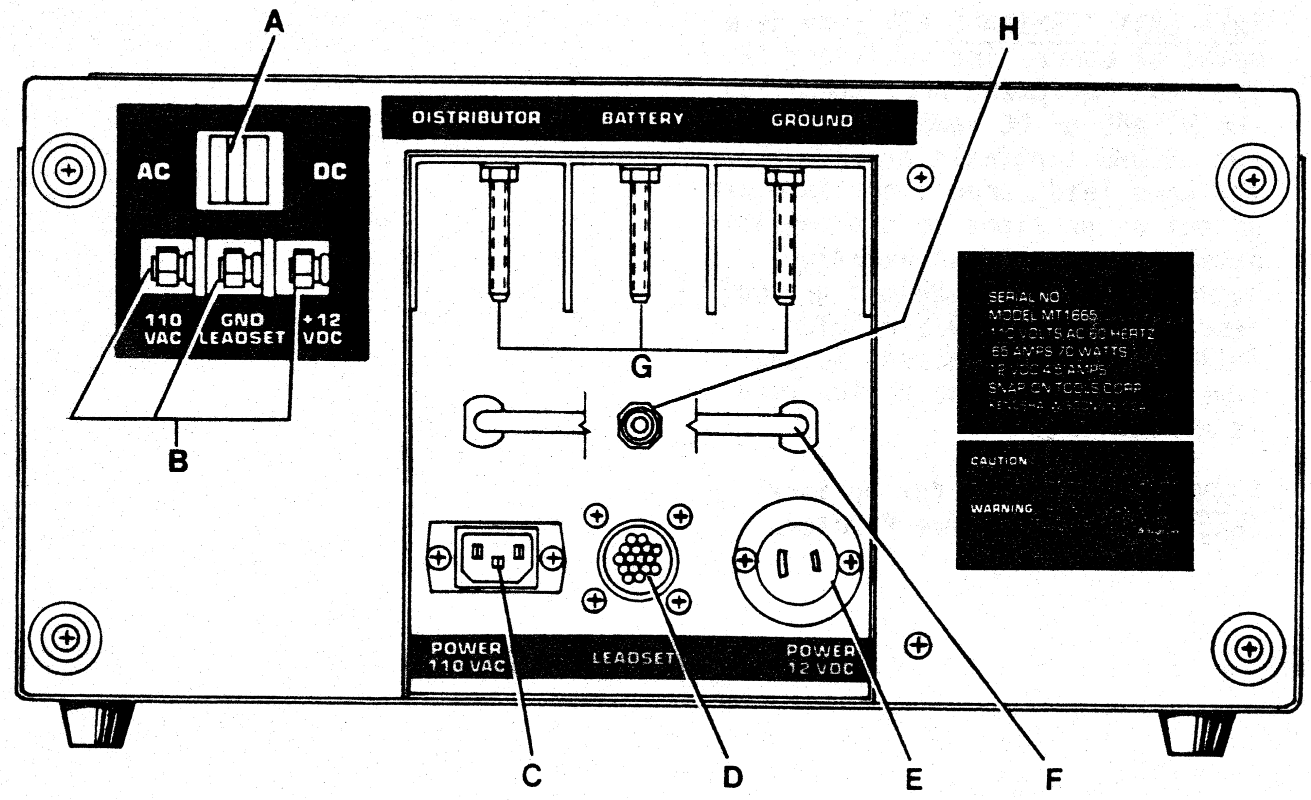
1 - 8 are used to enter engine data, select cylinder pattern to be viewed, short individual cylinders, enter engine rpm set point, and select function when ALT & Fuel INJ and VOLT screen appears. 2 is also used with the reset key to clear all bar graphs and wave forms from memory; refer to RESET above.

CLEAR clears KV BAR GRAPH MIN and MAX KV readings, and SHORTING BAR GRAPH bars and RPM DROP readings.

←/STD TRIG is a multiple function key. It is used to shift the firing section of a live primary or secondary ignition waveform pattern to the left side of the screen, control the travel of the mSEC cursor curtain, close-up an expanded live waveform pattern, move the flashing cursor to make a correction(s) during engine data entry, and page back when using instruction screens.

→/SPCL TRIG is a multiple function key. It is used to shift the firing section of a live primary or secondary ignition waveform pattern from the left side of the screen towards the center, control the travel of the mSEC cursor curtain, expand a live waveform pattern, move the flashing cursor to make a correction(s) during engine data entry, and page forward when using instruction screens.

RPM SET POINT calls up the automatic freeze feature that will freeze all live screens, except dwell and cylinder shorting bar graphs, when engine rpm reaches the keyed-in rpm.



Back Panel

A AC/DC power source switch is set to AC for 120 VAC and to DC for 12 VDC.

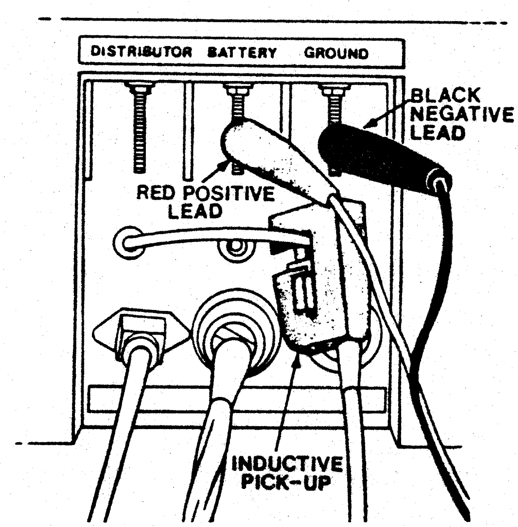
B CIRCUIT BREAKERS (3) provide full load protection for the 120 VAC circuit (rated 3 AMPS), ground circuit (rated 15 AMPS) and the 12 VDC circuit (rated 15 AMPS).

C POWER 120 VAC receptacle accepts 120 VAC line cord for 120 VAC operation.

D LEADSET receptacle accepts the leadset harness assembly.

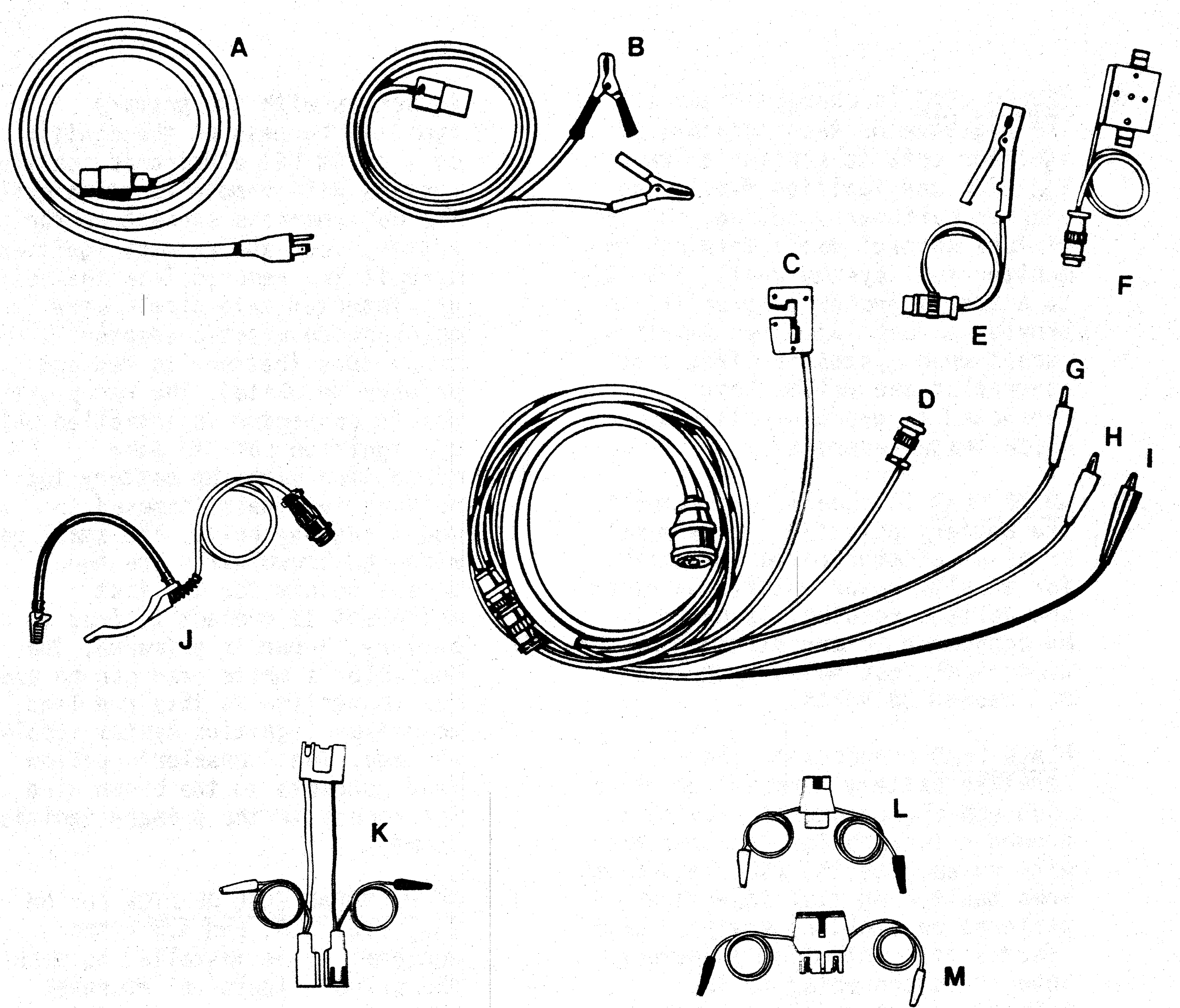
E POWER 12 VDC receptacle accepts 12 VDC power lead for 12 VDC operation.

F INDUCTIVE PICK-UP LOOP accepts the following auxiliary test equipment that is equipped with an inductive pick-up lead: secondary tach, timing-advance meter, and timing light. Lead connections shown below.



G AUXILIARY TERMINALS (3) provide a means of connecting auxiliary 12 VDC test equipment when operating the MT1665 on DC power. BATTERY and GROUND terminals provide for the same lead connections as would direct connections to the positive battery terminal and negative battery terminal (vehicle ground) respectively. The DISTRIBUTOR terminal provides access to the same signal that the yellow lead is monitoring.

H PRINTER RECEPTACLE for optional Snap-on MT1670 Scribe Printer.



Leads & Adaptors

A AC POWER LEAD connects to the POWER 120 VAC receptacle and to a standard 120 VAC grounded power outlet.

B DC POWER LEAD plugs into to the POWER 12 VDC receptacle. The red clip is connected to the positive battery terminal and the black clip to the negative battery terminal or other good vehicle ground.

C INDUCTIVE PICK-UP clamps over #1 spark plug wire. It provides the MT1665 with engine RPM data and a reference point for identifying cylinders in the firing order.

D CAPACITIVE/HEI SECONDARY LEAD connects to either the Capacitive or HEI pick-up.

E CAPACITIVE PICK-UP clamps over the coil wire on remote ignition coil type systems and senses the coil's secondary high voltage surges.

F HEI PICK-UP is a capacitive pick-up with an adjustable clamp that connects to the top of integral coil type (HEI) distributors and senses the secondary high voltage surges supplied to the spark plugs.

G YELLOW LEAD is connected to: (1) the negative or tach terminal of ignition coil to monitor primary ignition and ignition dwell, and enables cylinder shorting; (2) the mixture control dwell terminal to monitor fuel system dwell; and (3) to a fuel injector adaptor (K) to provide a fuel injection waveform, except when system is "feed-side" controlled and yellow lead is connected to ground (yellow & black leads reversed).

H WHITE LEAD is usually connected to the battery positive (+) terminal or at alternator output terminal for an alternator voltage waveform and voltage reading. It can also be connected to any other electrical test point that does not exceed 28 volts.

I BLACK LEAD connects to the negative battery terminal or other good vehicle ground to provide a ground reference for the Counselor with respect to the vehicle,except when monitoring fuel injection patterns on vehicles equipped with "feed-side" controlled injectors. Then it is connected to the injector adaptor (black & yellow leads reversed).

J TOYOTA AND CHEVROLET NOVA IIA (INTEGRATED IGNITION ASSEMBLY) COIL ADAPTOR enables you to access the secondary ignition signals. To attach the adaptor, (1) hold the pick-up portion against the coil side of the distributor cap with the end of the pick-up that the lead is attached to towards the number 1 and 3 spark plug terminals, (2) wrap the rubber tubing around the cap, and (3) attach the hook on the end of the tubing to the slot on the other end of the pick-up. The adaptor's lead connects to the Capacitive/HEI Secondary Lead (D).

K GM EXTERNAL COIL ADAPTOR connects in series with the primary ignition harness at the ignition coil on GM HEI electronic ignition systems with remote ignition coil. The coil harness connectors for battery feed and primary ignition circuit are removed from the coil and inserted into single wire color coded plastic adaptor connectors (battery to red and primary to white). The red plastic double connector is installed onto the ignition coil to make connection with the battery and primary terminals (indexed to mount one way only). The small red wire and brown wires are the access points for the test equipment to connect to (red is battery, brown is primary). The Counselor's white lead can be used for connection to this red lead, to measure ignition system supply voltage. The Counselor's yellow lead connects to the brown wire for access to the primary ignition signal.

L GM MICROPAK COIL ADAPTOR for GM 2.0, 2.5, 2.8, and 4.3 litre engines. It is installed between the primary ignition "Micropak" harness connector and ignition coil terminals to provide easy access to the primary signal. The small red wire and brown wires are the access points for the test equipment to connect to (red is battery, brown is primary). The Counselor's white lead can be used for connection to this red lead, to measure ignition system supply voltage. The Counselor's yellow lead connects to the brown wire for access to the primary ignition signal.

M FORD TFI (THICK FILM IGNITION) COIL ADAPTOR is used for Ford E-Coils. It is installed between the primary ignition harness connector and ignition coil terminals to provide easy access to the primary signal. The small red wire and brown wires are the access points for the test equipment to connect to (red is battery, brown is primary). The Counselor's white lead can be used for connection to this red lead, to measure ignition system supply voltage. The Counselor's yellow lead connects to the brown wire for access to the primary ignition signal.

N   GM TBI FUEL INJECTOR ADAPTOR connects between injector terminals and injector harness connector. Yellow lead is connected to this adaptor.

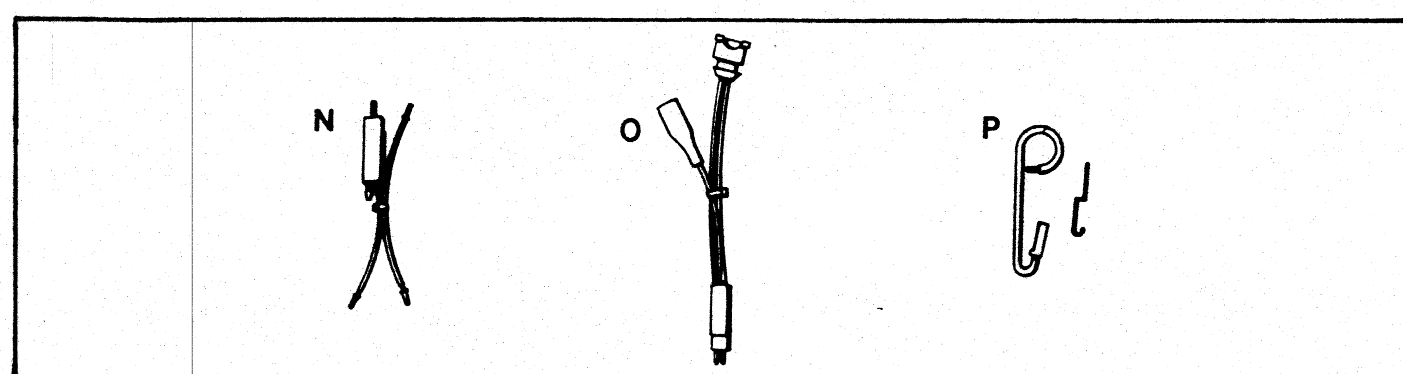
O   BOSCH FUEL INJECTOR ADAPTOR connects between injector terminals and injector harness connector. Yellow lead is connected to this adaptor.

P   COIL ADAPTOR SET contains a flexible GM integral coil adaptor that is connected at the tach terminal, and a Ford coil adaptor clip that connects to the negative ignition coil terminal.

Q   24" JUMPER LEAD (not shown) is included with the Counselor for performing systematic grounding techniques during troubleshooting.

R   SPARK PLUG PLIERS (not shown) are also included for performing systematic grounding techniques during troubleshooting.

S   LEADSET CLAMPS (not shown) clamp around leadset wires to reduce lead tangling.



Start-Up & Engine Data Entry Procedure

Apply power to the Counselor through either the AC or DC power lead, and set the AC/DC switch on the back panel to the proper position.

Set ON/OFF switch to ON and adjust the INTENSITY CONTROL as required. Either the ENGINE DATA SCREEN (Fig. 2-1) or the first of three ENGINE DATA ENTRY SCREENS (Fig. 2-2) will be displayed.

> ENGINE DATA SCREEN will appear if the Counselor has engine data retained in its MEMORY feature.
>
> **ENGINE DATA ENTRY SCREEN will** appear if the Counselor has no engine data in MEMORY.

The ENGINE DATA SCREEN asks you "IS THIS INFORMATION CORRECT?" and instructs you to "PRESS 1 FOR YES 2 FOR NO."

> Pressing 1 calls up the FUNCTION SELECTION SCREEN (Fig. 2-3). FUNCTION SELECTION SCREEN description and instructions are on pg. 2-3.
>
> Pressing 2 calls up the ENGINE DATA ENTRY SCREENS (Figs. 2-2, 2-4 and 2-5).

ENGINE DATA ENTRY SCREENS, of which there are three (3), ask you to enter the following data for the engine being tested:

> The first screen (Fig. 2-2) asks you to "PLEASE ENTER THE NUMBER OF CYLINDERS." Enter the number of cylinders by pressing a number from 1 thru 8, and press ENTER.
>
> > ERROR will appear on the screen when ENTER is pressed if any number other than 1 thru 8 was pressed. If ERROR appears, press the correct number and press ENTER again.

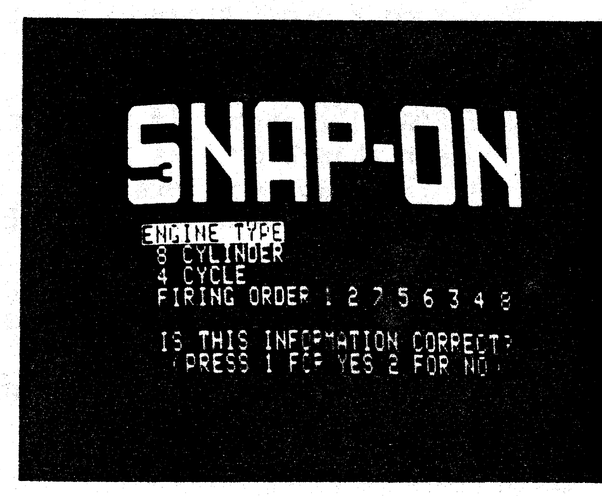


Fig. 2-1

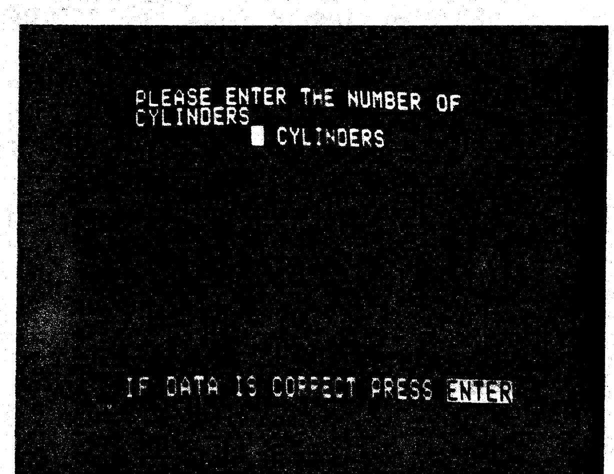


Fig. 2-2

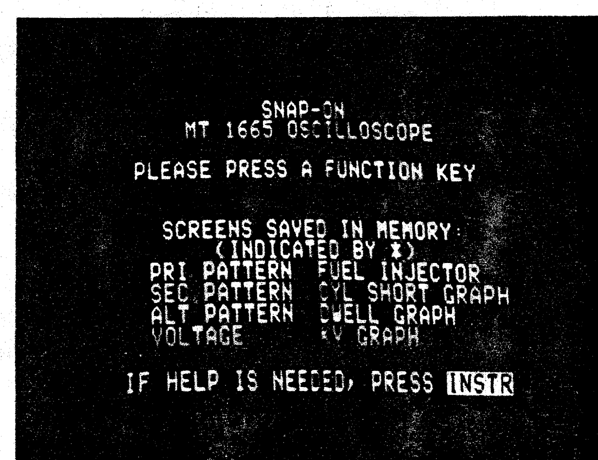


Fig. 2-3

The second screen (Fig. 2-4) asks you to "PLEASE ENTER WHETHER THIS IS A 2 OR 4 CYCLE ENGINE." Press 2 or 4 and ENTER.

ERROR will appear if any number other than 2 or 4 is pressed. If ERROR appears, press the correct number and press ENTER again.

The third screen (Fig. 2-5) asks you to "PLEASE ENTER THE FIRING ORDER." Enter the engine's firing order and press ENTER. The ENGINE DATA SCREEN will appear.

ERROR will appear when ENTER is pressed if a cylinder number appears more than once, or if a higher number than the "NUMBER OF CYLINDERS" entered was pressed, such as pressing the number 7 after having entered 6 as the number of cylinders. If ERROR appears the complete firing order may be reentered, or the arrow keys can be used to position the highlighted flashing cursor to the incorrect number(s) for correction. Press ENTER when the firing order is corrected.

If the "0" (zero) key is pressed while entering the firing order entry, the Counselor will return to either the ENGINE DATA ENTRY (Fig. 1) or the PLEASE ENTER THE NUMBER OF CYLINDERS (Fig. 2-2) screen. If this occurs, press ENTER key (once or twice as required) to return to firing order entry screen.

NOTE: The Counselor only detects the errors listed above, not errors in the sequence of a firing order entry. Make sure the sequence of the firing order is correct.

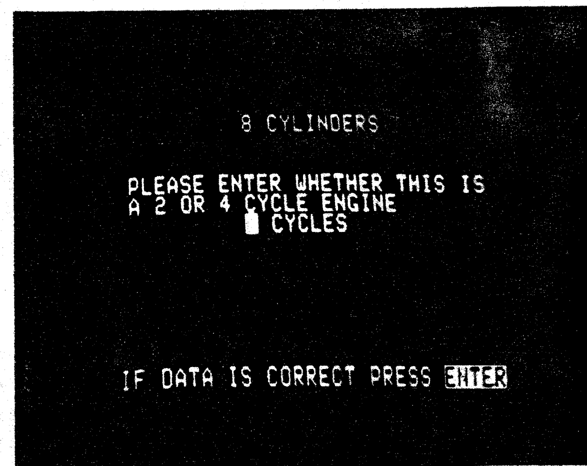


Fig. 2-4

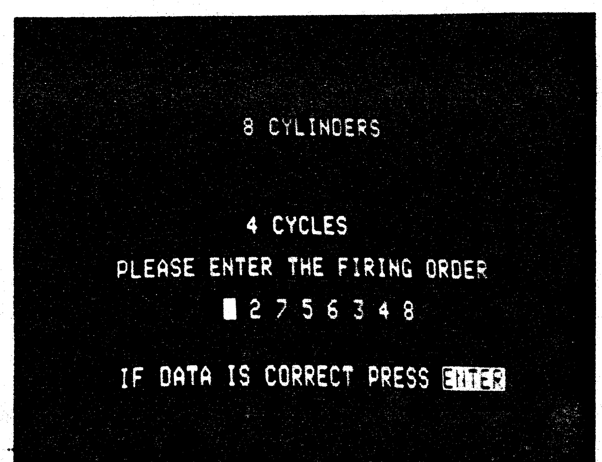


Fig. 2-5

The ENGINE DATA SCREEN asks you "IS THIS INFORMATION CORRECT?" and instructs you to "PRESS 1 FOR YES 2 FOR NO."

Pressing 1 places the engine data you just entered in MEMORY (previous data is lost) and calls up the FUNCTION SELECTION SCREEN (Fig. 2-3).

Pressing 2 calls up the first of the ENGINE DATA ENTRY SCREENS (number of cylinders) again (Fig. 2-2). Correct all engine data errors on the entry screens. When the information on the ENGINE DATA SCREEN is correct, press 1 for the FUNCTION SELECTION SCREEN.

FUNCTION SELECTION SCREEN (Fig. 2-3) asks you to "PLEASE PRESS A FUNCTION KEY." Select the desired function screen.

The FUNCTION SELECTION SCREEN lists the Counselor's waveform pattern and bar graph function screens and indicates with a flashing asterisk (*) if any, or which, of the functions have data stored in memory.

If there is data stored in the function screen selected, a memory screen will be displayed.

Refer to the appropriate Test Screens section for information on the proper lead connections, test procedures, and interpretation of test data pertaining to the screens below.

Page

Standard Lead Connections

Fig. 3-1 (below) and Fig. 3-2 (next page) are representative of the lead connections used for all test procedures, except the following:

Fuel System Dwell/Duty Cycle Alternator Fuel Injection Voltage	REFER TO TEST SECTIONS FOR LEAD CONNECTIONS

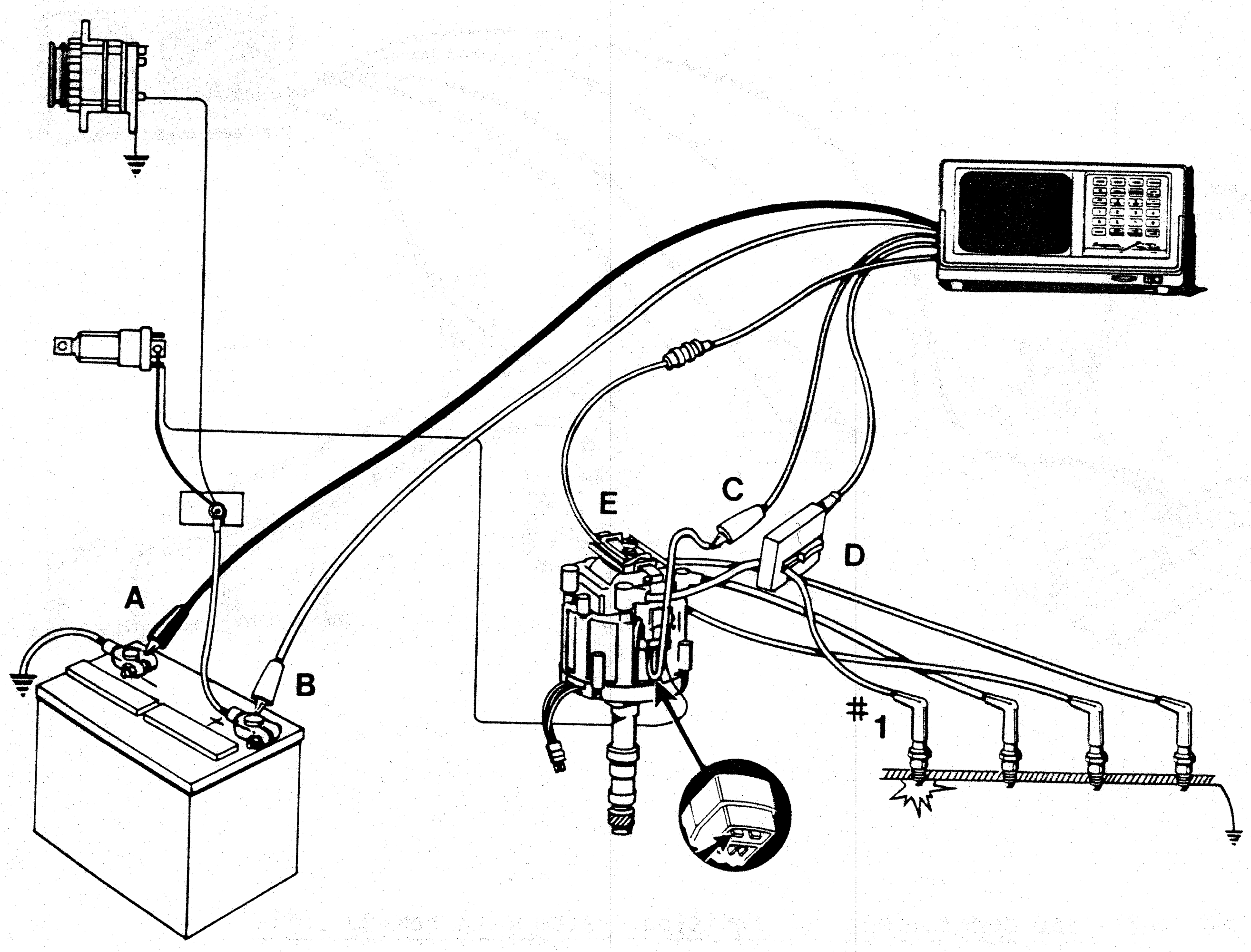


Fig. 3-1--lead connections for GM-HEI integral coil-type ignition system:

A black clip .... negative (-) battery terminal
B white clip .... positive (+) battery terminal
C yellow clip .... negative or tach terminal of ignition coil
D inductive pick-up ..... #1 spark plug wire
E secondary pick-up ..... coil wire on remote coil system, or on top of integral coil on HEI type system

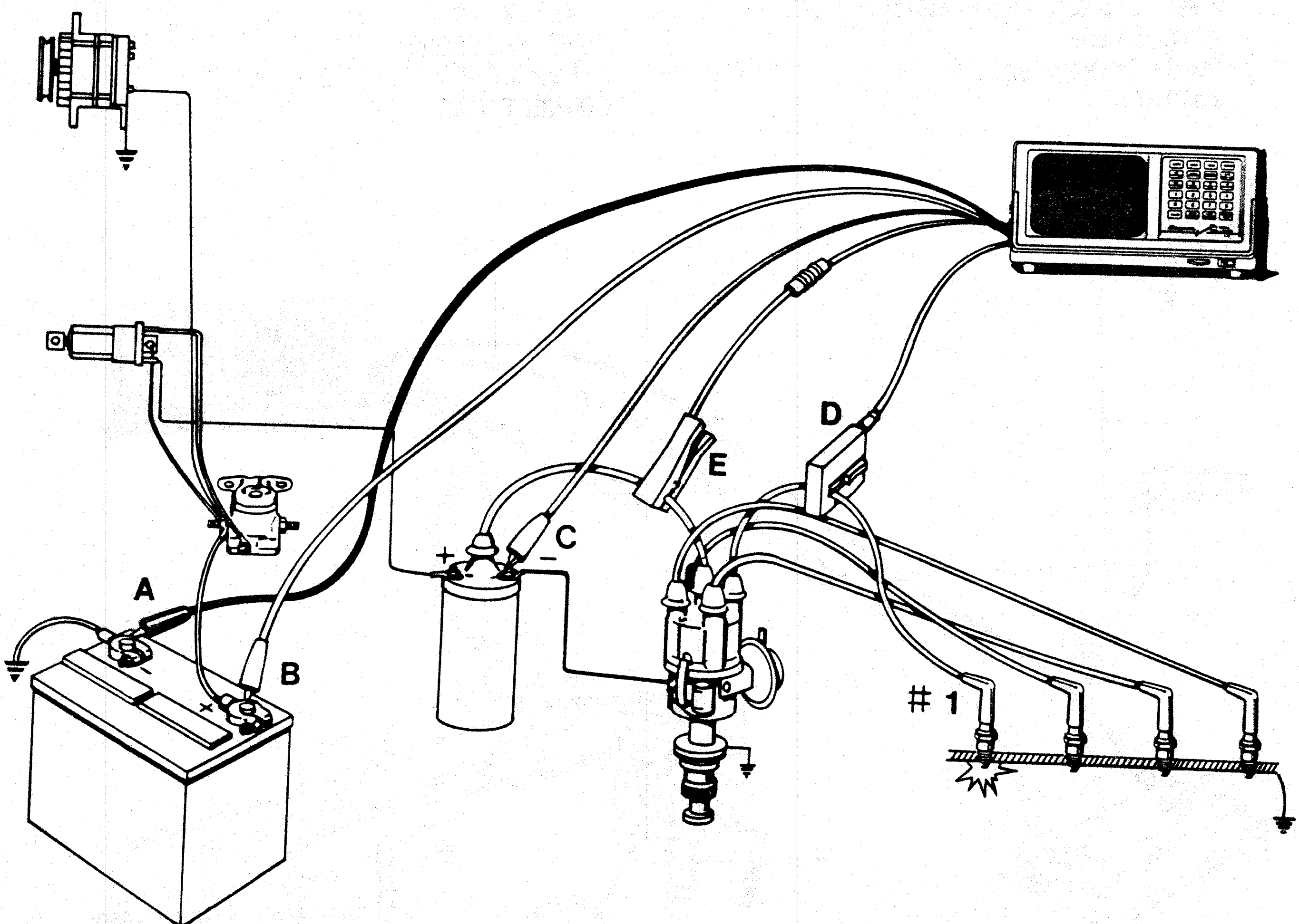


Fig. 3-2--lead connections for ignition system with remote coil:

A	black clip	negative (-) battery terminal
B	white clip	positive (+) battery terminal
C	yellow clip	negative or tach terminal of ignition coil
D	inductive pick-up	#1 spark plug wire
E	secondary pick-up	coil wire on remote coil system, or on top of integral coil on HEI type system

Equipment Tips

1. The MT1665 scope requires ventilation to prevent it from overheating. Allow a mimimum of three inches of side and top panel vent clearance.

2. To operate the scope on DC power, a 12 VDC negative ground system is required. Reliable operation requires a minimum of 10.5 VDC available. Be sure ON/OFF switch is in "OFF" position before connecting DC power leads.

3. If AC or DC power is interrupted, press the "RESET" key to restart the scope after power is restored. If it does not restart, turn power switch to OFF and then back to ON.

4. Never move the scope by pulling on the test leads or power leads.

5. Never set anything on the scope that could spill and enter the top vent.

6. Do not drive over test lead set or power leads with vehicle, floor jacks, etc.

7. Handle the inductive pick-up with care. When not in use it should be stored in the open position to help protect it in case it is dropped.

8. Occasionally inspect the contacts on the inductive and capacitive pick-ups for dirt build-up or other foreign matter. Clean with CRC Lectra-Motive 05018 Cleaner or equivalent. Spray contacts with tube tip 1" away. Dry with air nozzle from a distance of 6" or more.

9. Immediately clean any spills from scope's exterior to protect its finish - especially spills such as: gasoline, brake fluid, battery acid, cleaning solvents, penetrating oil, etc.

Testing Tips

1. Refer to manufacturer's test procedures and specifications before testing a vehicle.

2. When test readings are first displayed on screen, allow a few seconds for readings to stabilize.

3. Engine should be at normal operating temperature for accurate test results.

4. If the test vehicle's 12 volt battery and/or terminals are difficult to access with the power leads (side terminals or battery located beneath floor, behind seat, etc.), the scope can be powered by connecting the positive (+) lead to the alternator output terminal and the negative (-) to a good vehicle ground.

5. When connecting the inductive pick-up over a spark plug wire, make sure that the jaws are firmly seated; the push button should be in the "lock" position.

6. A bad spark plug wire can cause inaccurate RPM readings. If a bad wire is supected, replace the wire or take the reading from a different plug wire.

7. When testing, periodically check external lead connections to make sure they are secure.

8. High voltage (kV) arcing at any of the scope's leads or pick-ups may cause a momentary malfunction of the unit. If this occurs, press RESET to return to proper operation. If it does not, turn power switch to OFF and then back to ON.

9. Some solid core and special application aftermarket ignition wires can cause irratic scope operation. For testing, replace the coil wire and #1 spark plug wire with standard TVS (television radio suppresion) wires.

Vehicle Inspection

A preliminary vehicle inspection should precede any testing, as an accurate engine performance diagnosis is dependent upon the operation of related components or systems. Perform the following quick inspection (look, listen, feel & smell) and repair or replace items as required.

CHECK FLUID LEVELS
- Engine Oil
- Transmission Oil
- Coolant Level
- Battery Electrolyte

CHECK FILTERS
- Air Filter
- Fuel Filter
- Breather Filter (crankcase)
- Charcoal Canister Filter
- Air Pump Filter

CHECK HOSES (connections, cracks, leaks, etc.)
- Vacuum Hoses
- Fuel Lines/Hoses
- Heater Hoses
- Radiator Hoses

CHECK BELTS (cracks, tension, glazing, etc.)
- Fan Belt
- Alternator Belt
- A/C Belt
- Power Steering Belt

CHECK ELECTRICAL WIRING (connections, insulation, shorts, corrosion, etc.)
- Cranking System Circuit
- Charging System Circuit
- Ignition System Circuit
- Fuel System Circuit

CHECK BATTERY
- State of Charge
- Terminals (tightness and corrosion)
- Battery Case (leaks)
- Hold-Down Bracket (loose or overtightened)

CHECK EXHAUST SYSTEM (leaks or blockages)
- Exhaust Pipes
- Catalytic Converter
- Muffler
- Resonator
- Tailpipe

Primary & Secondary Pattern Waveform Screens

Primary and secondary pattern screens (Figs. 5-1, 5-2, & 5-7) give you graphic "pictures" of what's going on within an ignition system. The pictures are used to (1) determine if the ignition system is functioning properly or (2) locate ignition system malfunctions. Each specific phase of ignition system operation is represented on primary and secondary ignition voltage waveforms (Fig. 5-1 & Fig. 5-2). The condition of a vehicle's ignition system can be determined by observing the waveforms and relating the sections of the waveform to the phases of ignition system operation they represent. Malfunctions are identified by waveform movement uncharacteristic to the ignition system being tested.

The primary pattern screen displays a waveform of the primary ignition circuit, and the secondary pattern screen displays a waveform of the secondary ignition circuit. The waveforms represent voltage values in relation to time values. The vertical line or height of a pattern represents voltage; the higher the pattern the greater the voltage. Horizontal movement represents time. The time value of any portion of a frozen waveform pattern can be measured with the mSEC cursor.

Both the primary and secondary patterns display engine RPM and engine firing order. They also highlight the cylinder being tested in the firing order. When either waveform pattern is frozen, the primary or secondary pattern for each of the other cylinders is also frozen. These can be called up for individual examination by pressing their cylinder number key. Screen information differs in that the primary pattern screen displays an average dwell reading for all engine cylinders in the upper right hand corner, whereas the secondary pattern screen displays a peak kilovolt (kV) reading taken at the firing line of the cylinder being tested.

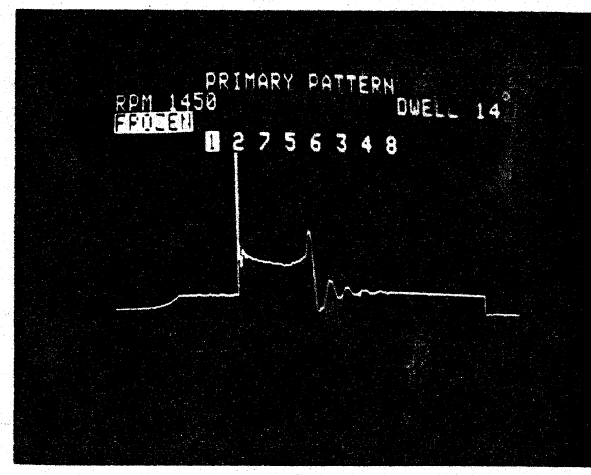


Fig. 5-1

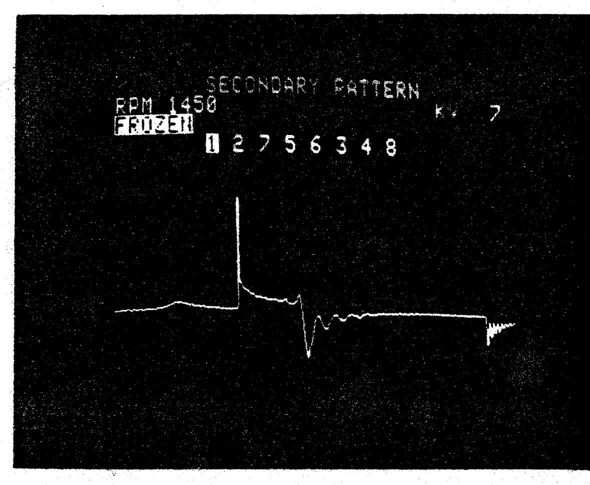


Fig. 5-2

Primary & Secondary Waveforms

The waveform patterns illustrated below graphically display all of the phases of ignition system operation. They are a composite of the two waveforms you can view by using the PATTERN SHIFT feature.

The illustrations start with a firing line on the left (4), continue through the phases of ignition system operation, and end with another firing line on the right (4). However, the actual ignition cycle for a cylinder should be considered from one primary turn-on (1) to the next primary turn-on. Therefore the description and explanation of the waveforms will begin just before primary turn-on.

Fig. 5-3
primary waveform

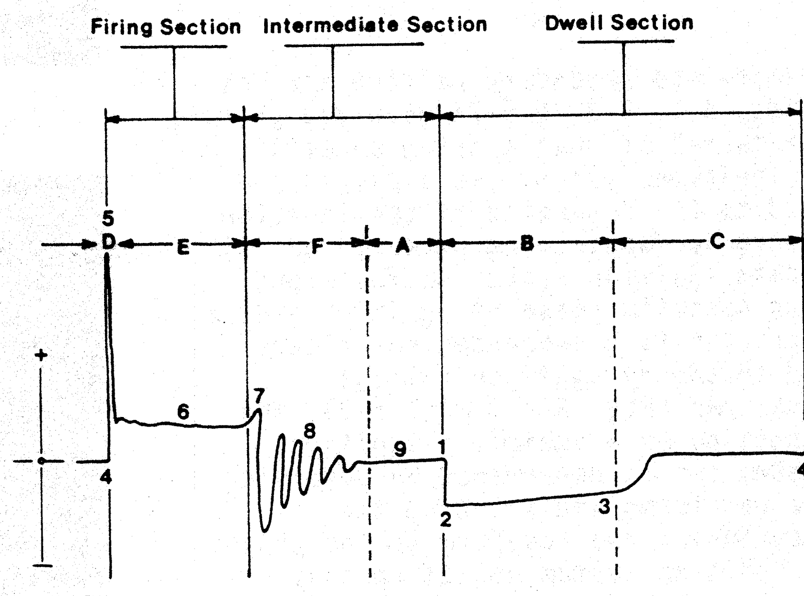
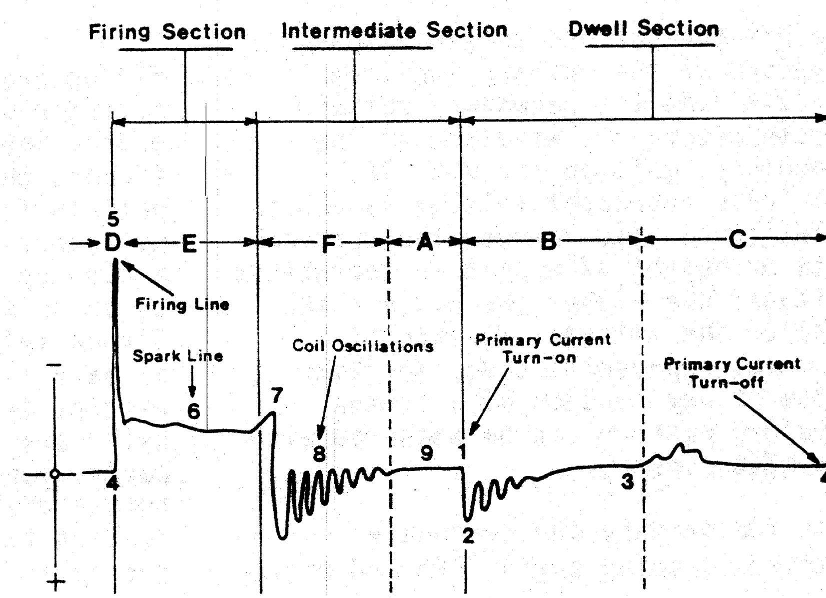


Fig. 5-4
secondary waveform



Intermediate Section - A

At 9 there is no primary current flow. No current will flow until the ignition control module receives a turn-on signal.

The module responds to a signal it receives from a triggering device. The most common triggering device is the magnetic pulse generator type (Fig. 5-5). It is located inside the distributor and consists of a trigger wheel (reluctor, armature, timer core, etc.) attached to the distributor shaft, permanent magnet with a pole piece(s), and a pick-up coil (stator).

The trigger wheel is made of steel designed to accept magnetism, but not retain it. As it rotates its teeth will approach, align, pass, and be separated from the pole piece. One rotation of the distributor shaft fires all engine cylinders.

At A the trigger wheel tooth and pole piece are separated. Primary current flow cannot begin until the tooth approaches alignment.

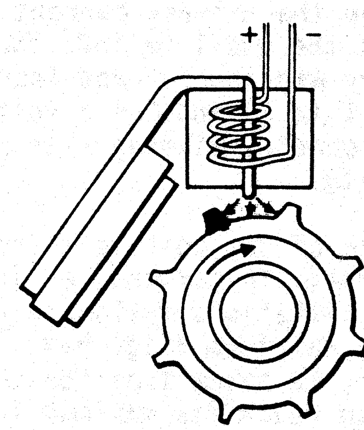


Fig. 5-5 - trigger wheel tooth approaching alignment

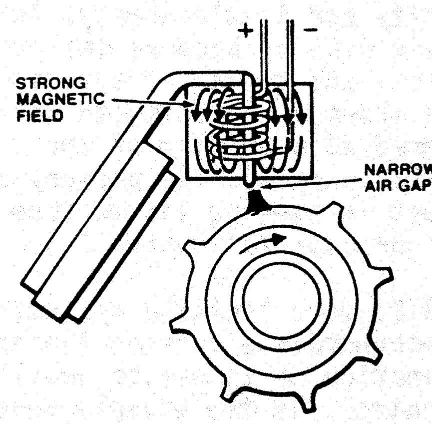


Fig. 5-6 - trigger wheel tooth aligned

Dwell Section

From 1 to 4 the ignition module provides primary current flow to the coil. The current establishes a magnetic field through both the primary and secondary windings. At 4 the module turns off the current.

The turn-on signal the control module receives from the magnetic pulse generator is a slight electrical current. It is induced in the pick-up coil as a tooth on the wheel approaches a pole piece

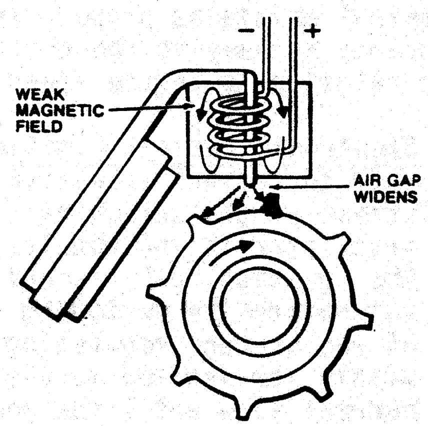


Fig. 5-7 - trigger wheel tooth past alignment of the permanent magnet (Fig. 5-5). This signals the ignition module to turn on the primary current, and begins the dwell period. The primary winding current increase (from 1 to 2) induces a voltage in the secondary winding with positive polarity.

The nature of the coil is to resist sudden change in current, as indicated by the oscillations following 2 on the secondary waveform (Fig. 5-4). Therefore, it takes time for the current to reach its maximum level. During the initial surge of current, a magnetic field in the ignition coil starts to grow in strength. As a result of this growth, a voltage is induced in the secondary with opposite polarity and little energy. As the primary winding becomes charged with current, the growth of the magnetic field slows down. This can be seen by the gradual weakening of the oscillations (B). The primary coil current is seeking its maximum current level or coil saturation (C).

NOTE: Some ignition systems may incorporate a current limiting function or automatic dwell control. In the example waveform, current limiting is indicated by the "hump" to the right of 3. The hump could appear earlier or later in the dwell line depending upon the engine speed. Automatic dwell control maintains proper timing advance by varying the dwell period in relation to engine speed.

Electronic Current Limiting is used to prevent excessive current stress at the switching transistor in the module. When the ignition coil reaches full saturation the switching action of the current regulating circuit within the igniton module limits current flow until the power transistor turns off the primary current (4).

Automatic Dwell Control minimizes power dissipation in the electronic circuitry while maintaining maximum performance throughout the speed range. The voltage signal that the ignition module receives from the pick-up coil is represented in Fig. 5-8 (page 5-5). As the trigger wheel approaches alignment with the pole piece (Fig. 5-5), the output voltage increases in positve polarity. As it passes through alignment, the output voltage abruptly reverses and crosses through zero voltage to negative polarity. This "0" (zero) voltage cross-over point is a precisely located switching point for accurate spark firing (firing line).

The relatively slow positive-going portion of the waveform is used by the ignition module to establish the point at which coil current is turned on in preparation for the next spark firing. It senses the output voltage increase at a particular time after a turn-off signal and adjusts the next turn-on point so there is just enough time for the coil current to reach saturation (5.5 Amps on GM HEI). Consequently, turn-on occurs just prior to ignition at low speed and advances toward the previous ignition pulse at high speed.

As the tooth on the trigger wheel approaches alignment with the pole piece it provides a low resistance path for magnetic lines of force which causes the magnetic field to expand. At the instant that the tooth begins to move out of alignment (D) the magnetic field suddenly weakens and induces a signal voltage into the pickup coil that is of opposite polarity. The ignition control module senses this change and its switching transistor turns off the primary current (4) and ends the dwell period.

Firing Section

At primary turn-off (4) the magnetic field that had built up in and around the primary and secondary coil windings during the dwell period rapidly collapses. The relative motion of magnetic lines of force cutting across the coil windings induces a voltage in both the primary and secondary windings. This produces a primary voltage "kick" (self induced), and the high secondary voltage (mutually induced) for spark plug firing. The high secondary voltage produced is called "available" voltage.

NOTE: If the coil uses the standard secondary to primary winding turns ratio of 100 to 1, an induced voltage in the primary of 350 volts can result in a mutual inductance secondary voltage of 35,000 volts (35kV) in the secondary circuit under a "no load" or open-circuit condition.

After the primary voltage kick, the primary pattern parallels the secondary pattern in the firing and intermediate sections. It does so at a step-down ratio of about 100:1.

When the high secondary voltage surge is first delivered to the spark plug center electrode the air/fuel mixture in the gap between the electrodes cannot conduct a arc. The spark plug acts as a capacitor, with the center electrode storing a negative charge and the grounded side electrode storing a positive charge. The gap acts as an insulator.

NOTE: This is opposite of normal electrical system negative ground polarity and results from the polarity of the coil secondary windings. Since electrons flow more readily from a hot surface than from a cold surface (thermionic

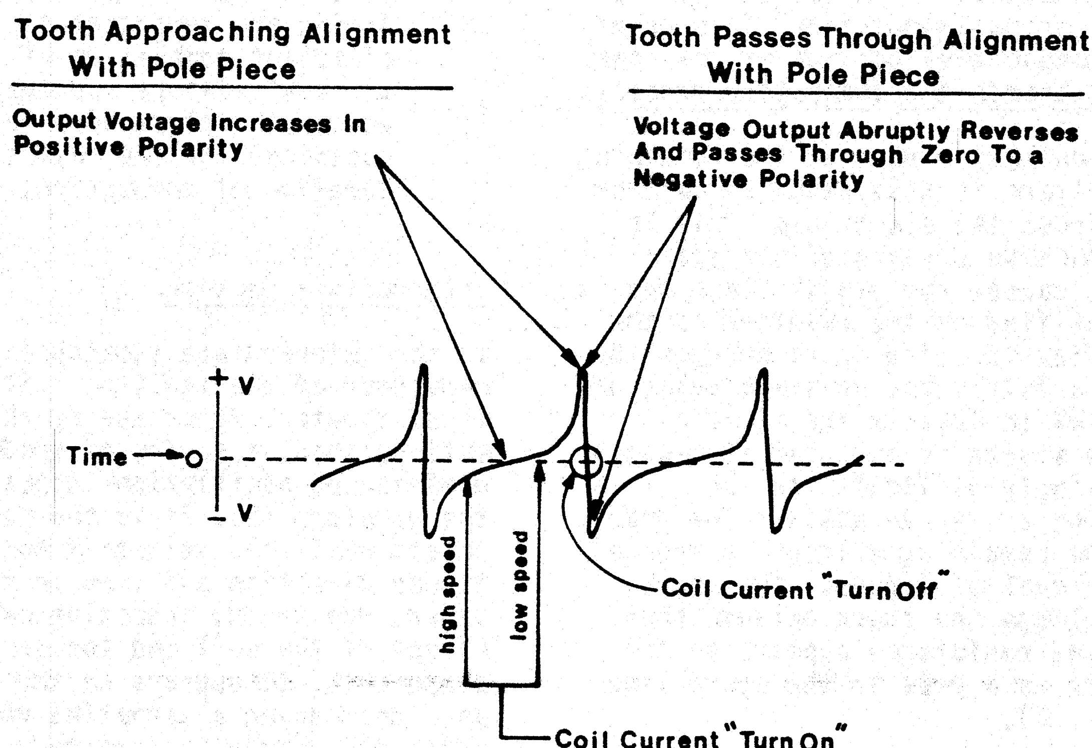


Fig. 5-8 - illustration of a voltage signal produced by a magnetic pulse generator emission), ionization occurs more readily from the center electrode, the hottest part of the spark plug.

As secondary voltage increases, the charges in the spark plug strengthen until the different charges at the electrodes are great enough to ionize the space between the electrodes. The air/fuel mixture in the gap is changed from a nonconductor to a conductor. This could consume between 4kV to 18kV of the available voltage. The amount it should consume varies from model to model and ignition system to ignition system; check manufacturer's specification.

The amount of secondary coil voltage that is used to ionize the gap is indicated by the peak of the firing line (5). This, the amount of voltage needed to overcome rotor and spark plug gap resistance is called "required," "firing," or "ionization" voltage.

At the instant of ionization (5) the voltage drops immediately. This drop is the capacitive portion of the spark arc. It starts the combustion process.

After ionization most of the remaining coil voltage is dissipated as current flow across the electrodes. This is the inductive portion of the spark arc. It causes the visual flash and it is identified on the waveform as the spark line (6). The spark bridges the gap at a fairly low constant value of about 1kV to 4kV. As the air/fuel mixture starts to burn out it becomes increasingly difficult for the remaining energy to sustain the spark. When the remaining voltage is reduced to the level of (equals) the spark line voltage the spark extinguishes. Increased resistance appears on the waveform as a rise in the spark line towards (7).

NOTE: With engines that use rich fuel mixtures the inductive portion of spark plug firing contributes little or nothing to efficient combustion of the air/fuel mixture; it just erodes the electrodes and causes electrical interference. With a richer fuel mixture there are more gas molecules in the combustion chamber which are very densely packed. So when the capacitive portion of spark plug firing ignites some, they in turn ignite others, and this continues until combustion is completed.

Engines with emission controls are designed to operate on a leaner fuel mixture. The density of the gas molecules is sparser and it is more difficult for the molecules to ignite one another. Because of this, it is possible for combustion to stop with much of the fuel mixture still unburned. Therefore the capacitive and inductive portions (E) of spark plug firing are important to efficient combustion of the air/fuel mixture and the spark across the electrodes should be sustained for the entire duration of combustion.

Intermediate Section

In the intermediate section (F), the remainder of the ignition coil energy is dissipated. After the spark has extinguished, a series of gradually diminishing oscillations appears in the waveform (8). It is the result of unused available voltage flowing first in one direction and then in the other, due to the inductive-capacitive effect of the coil and the secondary components. It appears on the waveform as a decreasing alternating voltage until the energy is consumed. No current flow is indicated when the oscillations stop (9).

Another tooth of the rotating trigger wheel is now separated from, and approaching, the pole piece (A). The ignition cycle is repeated for the next cylinder in the firing order.

Interpreting Breaker Point Ignition System Patterns

Breaker point ignition system patterns are similar to those for electronic ignition systems. The major difference occurs at the spark line on the primary patterns. The condenser in the breaker point system causes oscillations; electronic systems have no condenser. Some variations will also be evident in the primary and secondary dwell sections when comparing a breaker point system to electronic systems that incorporate a current limiting function or automatic dwell control.

1. At 1 the distributor points close to begin the dwell period.

2. At 2 current is flowing through the primary circuit establishing a magnetic field in the coil. This appears on the secondary pattern as a series of diminishing oscillations following 2. It is the result of an induced voltage caused by increasing current flow in the primary.

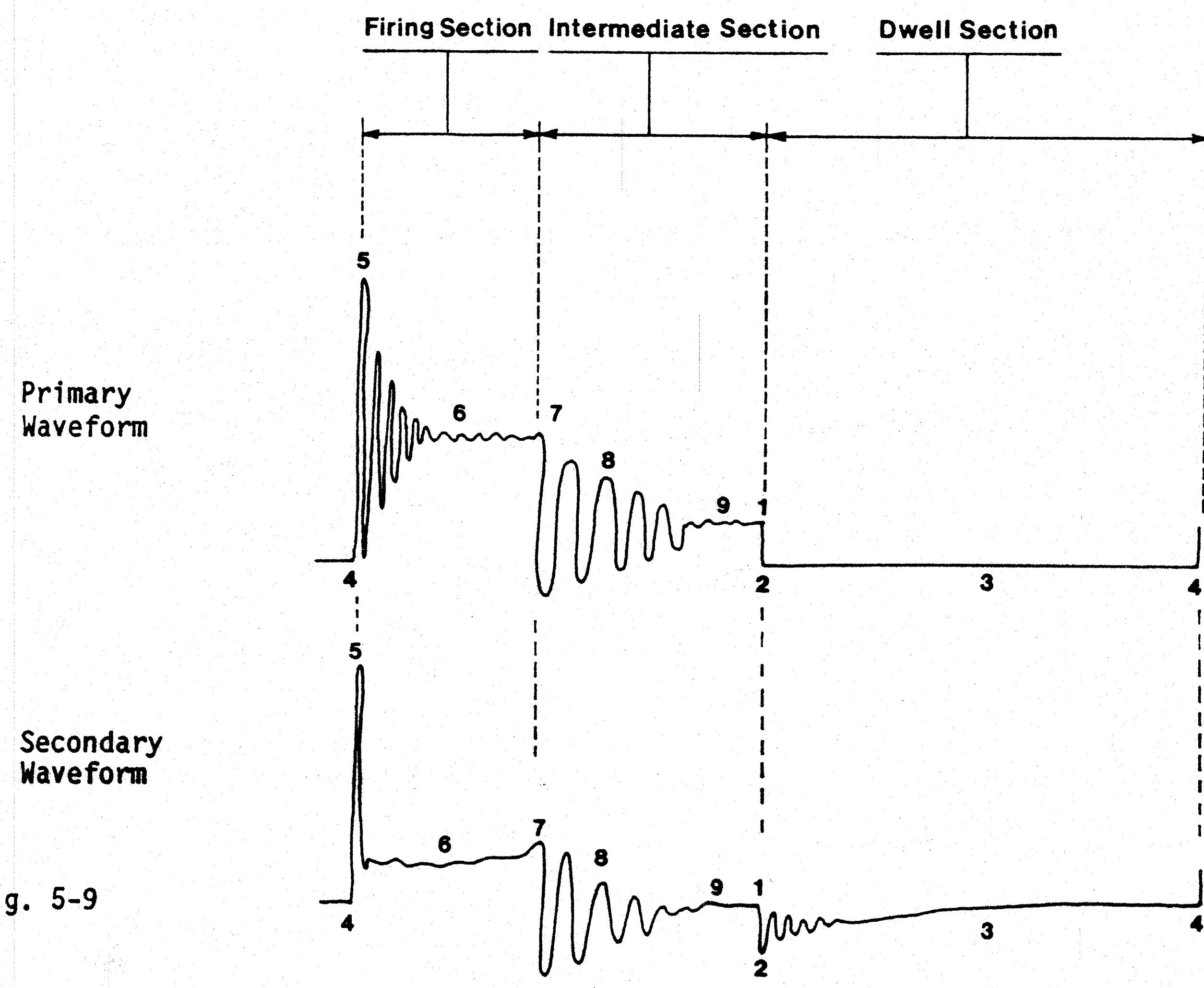


Fig. 5-9

3. Line 3 represents the time or number of degrees that the points remain closed. It is called the dwell period or cam angle.

4. At 4 the distributor points open and the coil primary windings' magnetic field collapses inducing a high voltage in the secondary windings.

5. At 5 the secondary voltage overcomes the resistances in the secondary circuit up to the spark plug gap. The spark plug gap is ionized and current arcs across the electrodes to produce the spark that initiates combustion.

6. Line 6 shows the discharge across the spark gap.

7. At 7 the coil energy is no longer able to sustain the spark across the electrodes.

8. At 8 the dissipation of the energy remaining in the coil and condenser is indicated by the diminishing oscillations.

9. At 9 coil and condenser energy is dissipated - no current is flowing in the primary circuit.

The ignition cycle for one cylinder has been completed. The cycle is repeated for the next cylinder in the firing order.

Primary & Secondary Waveform Testing

Testing Tips

1. For accurate test results make sure that the battery's state-of-charge is at least 65% (minimum of 1.225 specific gravity or 12.3 open circuit voltage), and that ignition timing is correct.

2. Test engine should be at normal operating temperature.

3. An air conditioner or electric cooling fan cycling on and off can effect test results. Turn air conditioner off. Either use a jumper wire to make the fan run continuously or disconnect the fan electrically. If you disconnect the fan make sure that the engine does not overheat.

TEST

1. Refer to any available manufacturer's procedures and specifications.

2. With Start-Up & Engine Data Entry Procedure completed (Pg. 2-1) and the test leads connected as shown in Fig. 3-1 or Fig. 3-2, start the engine.

3. Press SEC PATTERN key and check each cylinder's secondary ignition circuit waveform and kV reading for abnormal characteristics. Test at idle, cruise, and snap acceleration and observe the waveforms for the proper response to the conditions.

   Twelve typical waveforms are provided for waveform comparison (Fig. 5-10); for others, refer to manufacturer's shop manual or other reliable service manual.

   NOTE: When testing breaker point ignition systems, check both the primary and secondary waveforms. Refer to Fig. 5-9 on page 5-7.

   The following feature modes can be very helpful in waveform diagnosis:

   a. Pattern Shift - Reposition a waveform for a different view.

   b. Pattern Expand - Expand a waveform for closer examination.

   c. Freeze & RPM Set Point - Freeze a normal or expanded wave form manually with Freeze, or automatically at a predetermined RPM with RPM Set Point.

   d. mSEC Cursor - Measure the time period of any portion(s) of the waveform in milli-seconds. Leave the cursor curtain up after measuring one cylinder waveform, and then call-up other cylinders to check for variations in beginning point, length, and end.

   e. Memory - Leave a frozen waveform to do supportive testing with the dwell, kV, or cylinder shorting bar graphs, and then recall the waveform for further examination if desired. NOTE: Frozen waveform will be lost if it is unfrozen (FREEZE is pressed), or if any other waveform key is pressed.

   f. Cylinder Shorting - Kill cylinders and observe RPM to see if they are providing their share of power.

4. If the waveforms and kV readings do not appear normal for the ignition system being tested proceed to Troubleshooting the Ignition System Using the Secondary Waveform.

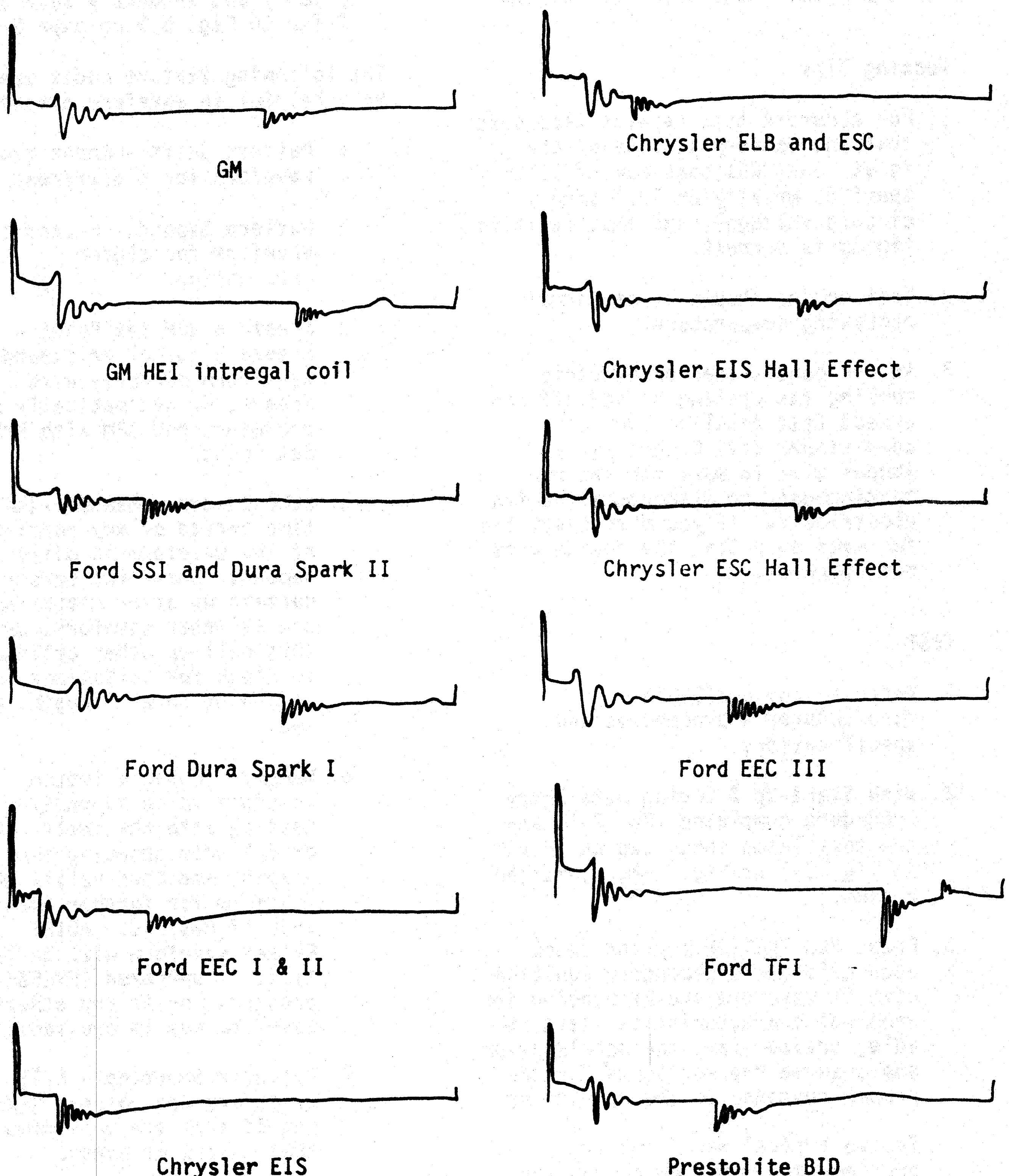


Fig. 5-10 - Typical waveforms for twelve common electronic ignition systems. The sample waveforms are to be used as a guide and should not be considered as exact representations.

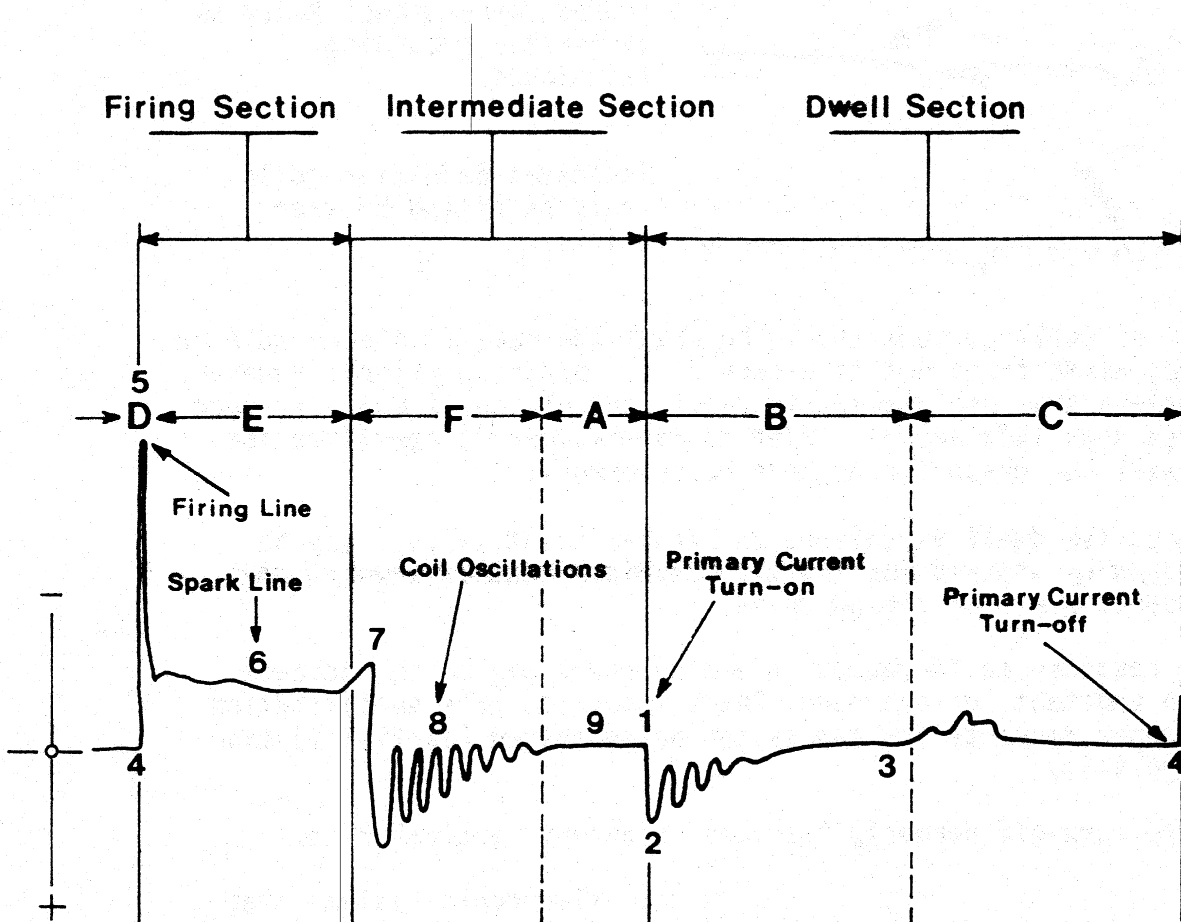
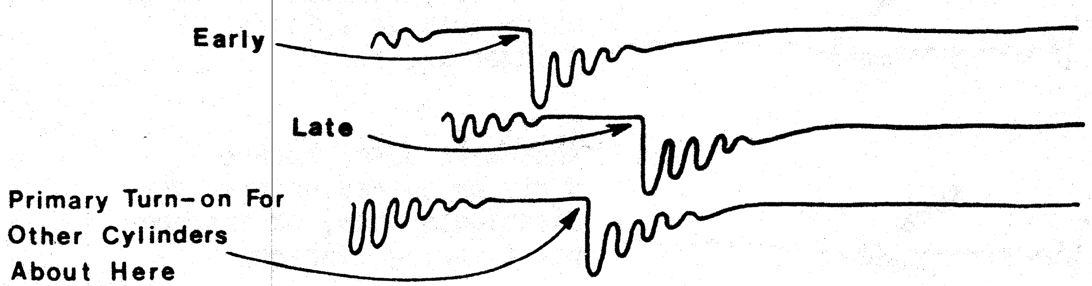


Fig. 5-11 - example of secondary ignition waveform (GM HEI)

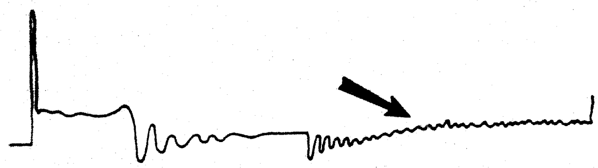
Dwell Section

Primary current turn-on at 1 should be at about the same point for all cylinders.

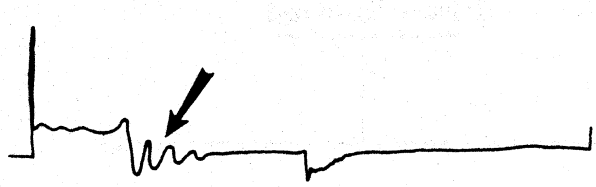
If not check: trigger wheel and distributor shaft. Problem could be in control module.



Oscillations to the right of 2 should be steadily diminishing.



indicates poor coil to ground connections. Refer to systematic grounding techniques.



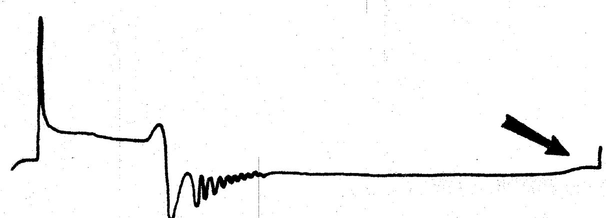
indicates defective coil; could be pitted breaker points.

Length of dwell periods should be about the same at steady idle or cruise, differences not to exceed 3° (5° older Chrysler). However, on systems that use electronic dwell control, dwell may vary more or less than this amount. Refer to manufacturer's specification. Use dwell bar graph for degrees measurements.

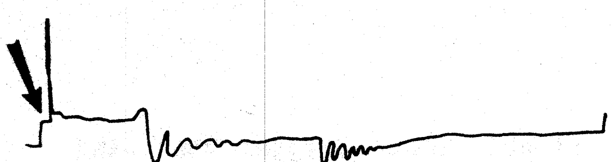
Excessive dwell variations on breaker point systems may be caused by distributor shaft or bushings, cam lobe wear, worn breaker plate or timing chain.

Dwell response to increases in engine speed may be to increase, remain constant, or decrease. Check manufacturer's specification for proper response for the system being tested (partial listing on page 8-3).

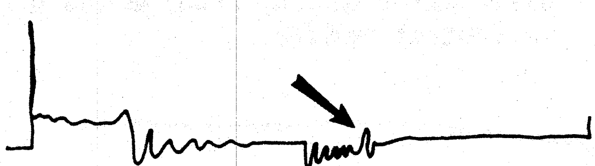
Primary turn-off normally produces an abrupt vertical rise.



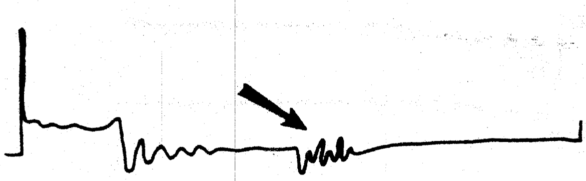
on electronic systems that use current limiting, it is possible for the hump in the waveform pattern to meet the firing line when testing at higher engine speeds. This is not a malfunction.



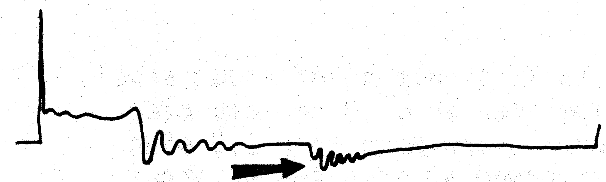
on a breaker point system this indicates burnt, dirty, or misaligned points, or a defective condenser.



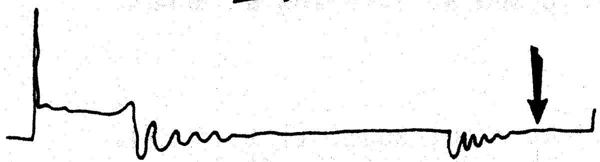
indicates loose connection in primary ignition circuit, which acts as a false trigger signal.



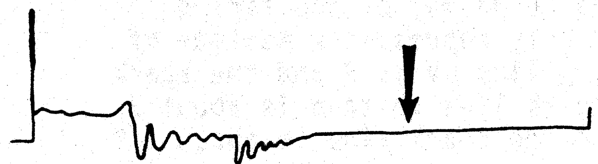
indicates point bounce, dirty or burned points, dry distributor cam, or improper point spring tension.



indicates resistive points.



indicates dwell too short.



indicates dwell too long.

Firing Section

NOTE: The kV bar graph provides the best way to compare firing line voltages.

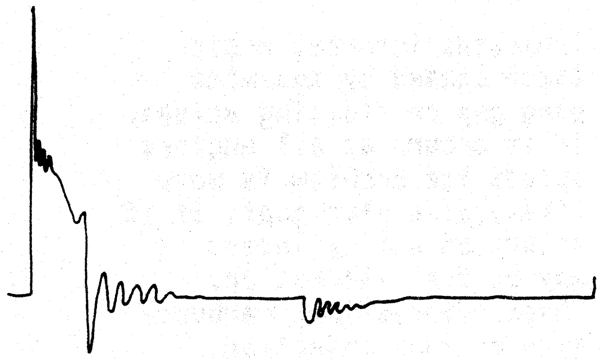
Firing line (5) voltages should normally be between 4 to 18 kV at a steady engine speed. On electronic systems the difference between the highest and lowest reading should be less than 50% of the highest voltage reading. On breaker point systems the kV reading should not vary by over 3-4 kV.

The firing line kV reading should not exceed 40% of available coil voltage. On electronic ignition systems assume that the firing line kV is good if the duration of the spark line is within manufacturer's specification. On breaker point systems test coil output by removing any spark plug wire, other than #1; use spark plug boot pliers. Hold wire away from ground and check kV reading. A minimum of 20 kV is considered adequate for most systems.

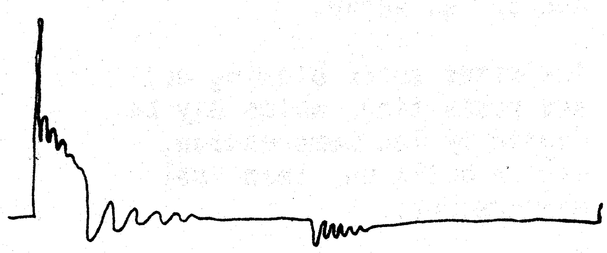
If coil output is low check for leakage to ground in secondary insulated circuit, excessive secondary resistance, or reversed coil polarity.

Firing voltage requirements are effected as follows:

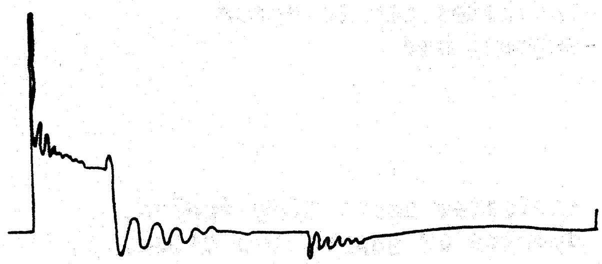
	Voltage Requirement	
	HIGH KV	LOW KV
Eroded spark plug electrodes	X	
Secondary circuit resistance	X	
Open circuit secondary wire	X	
Grounded secondary circuit		X
Primary circuit fault (resistance)		X
High primary current	X	
Spark plug gap	wide	narrow
Temperature of electrodes	cooler	hotter
Ignition timing	retarded	advanced
Fuel mixture	lean or very rich	rich
Compression	high	low
Combustion chamber temperature	cooler	hotter



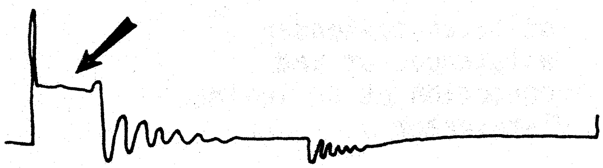
indicates high secondary resistance.



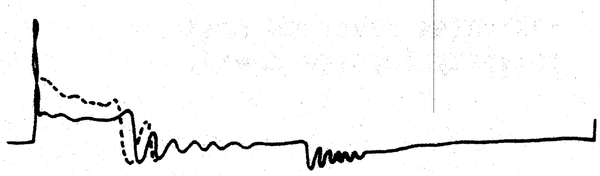
indicates high spark plug circuit resistance - downward sloping spark line and high firing line.



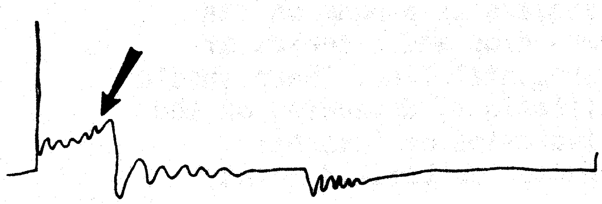
indicates high secondary resistance - spark line height too high.



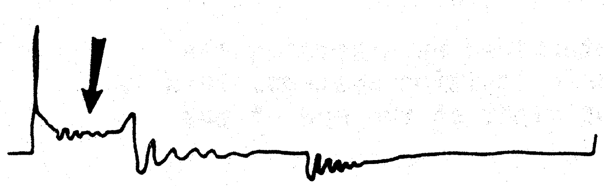
indicates excessive secondary resistance - high spark line. May be spark plug gap, lean fuel mixture, or vacuum leak. If on all cylinders, may be high resistance plugs or wires.



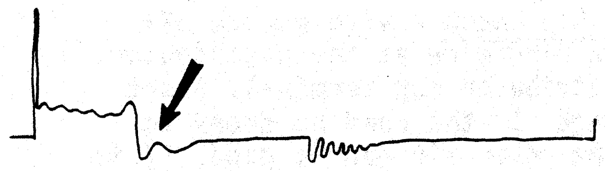
indicates intermittent problem - secondary resistance or sticking valve causing a lean fuel mixture.



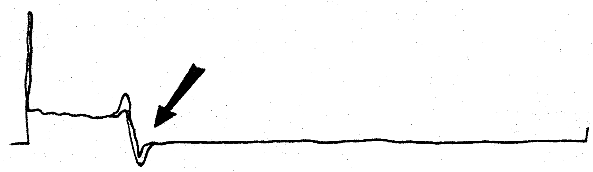
indicates spark plug resistance - upward sloping spark line.



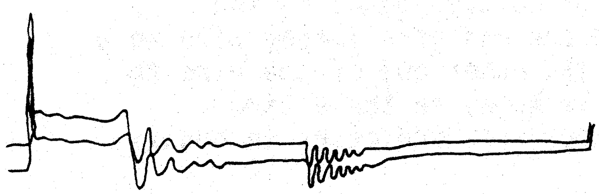
indicates rich fuel mixture. Sparkline is also lower and longer than normal.



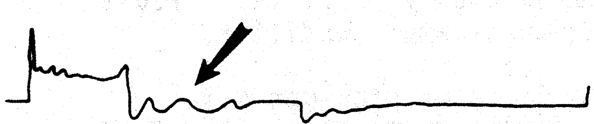
indicates partially shorted coil or leaky condenser.



indicates an open at coil tower connection. NOTE: no primary turn-on.



indicates intermittent open in coil secondary winding.



indicates leaky insulation in secondary winding.

Systematic Grounding Techniques

If a problem is common to one or several cylinders check the following components for the problem cylinder(s): spark plug, spark plug wire, and distributor cap segment.

If a problem is common to all cylinders check coil, coil wire, primary circuit, and distributor cap center button.

If a circuit's wiring or connections are suspect, bypass any portion of it with a jumper lead to determine whether or not it effects the waveform.

CAUTIONS:

If a vehicle is equipped with an electronic ignition system do not disconnect (open circuit) a spark plug wire while the engine running. To run the engine with a plug wire disconnected, a jumper wire must be used to direct the secondary voltage to ground.

On vehicles equipped with a catalytic converter, do not run the engine in excess of 10 seconds with a cylinder disabled.

Spark Plug Check - With the engine off, disconnect the spark plug wire at the plug. Secure one end of a jumper wire to a good ground and the other to the plug wire. Start the engine and observe the firing voltage. If the kV reading drops 3 to 5 kV the high kV reading was caused by the spark plug. If it did not drop, check the spark plug wire.

Spark Plug Wire and/or Distributor Cap Check - With engine off disconnect problem cylinder's spark plug wire at the distributor. Connect grounded jumper wire at distributor cap terminal. Start engine and observe the firing voltage. If the reading drops to less than 10 kV the wire is bad; the rotor air gap is good. If it does not drop the problem is in the distributor cap.

Secondary Insulated Circuit Leak Testing

A jumper wire can be used to test for voltage leaks in the secondary insulated circuit. Secure one end of a jumper wire to a good ground. Start the engine. Use the other end of the wire to probe a suspected area or point of leakage, or the entire secondary system. An arc to the jumper wire indicates secondary leakage.

NOTE: Spraying a mist of water on the secondary insulated circuit may aid in locating a "misfires-when-damp" condition.

High voltage (kV) arcing to any leads or pick-ups may cause a momentary malfunction. If the scope does not return to proper operation, press RESET. If this fails to correct the situation, using the ON/OFF switch, turn the Counselor off and on.

KV Bar Graph

The kV bar graph screen (Fig. 6-1) offers valuable diagnostic information on the condition of secondary ignition circuit components. It simultaneously displays each cylinder's changing spark plug firing voltage requirements, and also the lowest and highest voltages that were required to fire each spark plug.

The screen displays a dynamic representation of each cylinder's firing line voltage requirement using "live" bars. Firing line voltage requirements for each cylinder firing can be observed, and be measured on the 20 kV scale to the left of the bars. The highest and lowest firing line voltage requirements (MIN and MAX) for each cylinder are shown on the left side of the screen. The bars and numeric readings are identified by cylinder number and are displayed in the sequence of the engine's firing order. Engine RPM is displayed in the upper left hand corner.

KV Testing

KV test information, combined with primary and secondary waveform test information, can be used to confirm the proper operation of the secondary circuit or to identify problem areas. Problem areas that can be identified include: spark plugs, spark plug wires/connections, coil wire/ connections, ignition coil, and distributor cap-to-rotor air gap. If the ignition system checks out good and a problem(s) is indicated on the bar graph and/or waveforms, the problem(s) is in another area, such as: timing, fuel mixture, engine compression, temperature, etc.

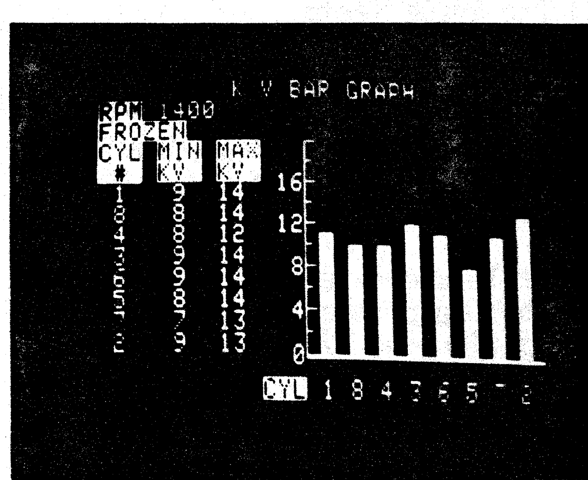


Fig. 6-1

Firing line kV testing is performed under the following engine operating conditions: no load, snap acceleration, and under load. The information obtained from the three tests is combined and analyzed to determine if a problem(s) exists. If a problem(s) exists, the information is used to identify the problem area and the most probable cause(s).

Testing Tips

1. For accurate test results make sure that the battery's state-of-charge is at least 65% (minimum of 1.225 specific gravity or 12.3 open circuit voltage), and that ignition timing is correct.

2. Test engine should be at normal operating temperature.

3. An A/C or electric cooling fan cycling on and off can effect test results. Turn A/C off. Either use a jumper wire to make the fan run continuously or disconnect the fan electrically. If you disconnect the fan make sure that the engine does not overheat.

4. After the Start-Up & Engine Data Entry Procedure is completed and the leads are connected, testing can be performed from the driver's seat, watching the kV readings through the window.

KV Bar Graph Tests

This test procedure is performed to determine if the voltage requirements for spark plug firing are within specifications.

1. Follow manufacturer's procedures and specifications when performing KV bar graph tests.

2. Complete Start-Up & Engine Data Entry Procedure (Pg. 2-1) and connect test leads as shown on pages 3-1 or 3-2.

No Load kV

3. Start engine and adjust RPM to manufacturer's specification. If specification is not available set RPM to about 1200.

4. Check the height of each bar for uniformity and note the minimum and maximum readings. NOTE: MIN and MAX reading can be cleared at any time using the CLEAR key.

   KV bars should indicate between 4 to 18 kV (4-15 kV for breaker points). The difference between the highest and lowest bar heights should be less than 50% of the highest bar height (not exceed 3-4 kV on breaker points).

   NOTE: Firing line kV varies model to model and system to system. Typically, older engines with richer fuel mixtures will be in the 4 - 12 kV range, engines with somewhat leaner mixtures 5 - 15 kV, and newer engines with lean fuel mixtures 7 - 18 kV. Also, when testing on a dynamometer a slight increase in kV is normal.

Snap Acceleration KV

Before testing snap acceleration kV, note any "suspect" no load test MIN and MAX readings.

5. While watching the bars, quickly "snap" accelerate to wide open throttle and release. This should create a momentary lean fuel mixture which will increase the firing voltage requirements, and then a rich condition as the throttle returns which will cause the voltage requirements to decrease.

   Bars should increase moderately and evenly in height.

   New MIN readings should drop to rotor gap spec (within 1 kV).

   New MAX readings should increase, but not exceed spec.

KV Under Load (automatic transmission only)

KV testing under load may reveal some borderline or marginal problems that would not appear during no load or snap kV testing.

WARNINGS: Do not perform the following "KV Under Load" test on vehicles with manual transmission. Test vehicles with manual transmission using a chassis dynamometer, or road test them with the Counselor.

Do not perform an under load kV test on a vehicle if the motor mounts are not secure or are not in good condition.

6. Set RPM SET POINT to about 1500 RPM.

7. Press CLEAR.

8. With drive wheels blocked and emergency brake set, apply the foot brake and place gear selector in drive. Quickly accelerate engine to slightly above set point (freeze screen) and return to idle. Place gear selector in park. Turn off engine if desired; the Counselor will retain the information.

   MAX readings should be similar to snap acceleration readings, and be within specifications.

See kV Bar Graph Analysis on next page.

4. After snap kV test how did the MIN(s) and MAX(s) react? The following list will help you identify some of the more common problems and their probable causes:

   a. A MIN reading that does not go low - indicates excessive secondary resistance, such as an open spark plug wire.

   b. All MIN readings consistently high - indicates high secondary resistance external to the combustion chamber, such as coil wire.

   c. A cylinder's MIN reading drops to rotor air gap kV and its MAX has little or no change - indicates secondary leakage to ground, such as a spark plug wire arcing to ground or a too narrow spark plug.

   d. MAX goes too high - indicates a problem internal to the combustion chamber, such as a partially fouled spark plug.

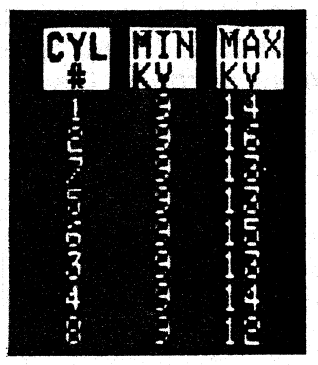
   e. A cylinder has a low no load MIN and low snap kV MIN - indicates very low secondary resistance (internal or external) such as narrow spark plug gap.

   f. A cylinder has a high no load MAX and high snap kV MAX - indicates high secondary resistance (internal or external), such as wide spark plug gap or open spark plug wire.

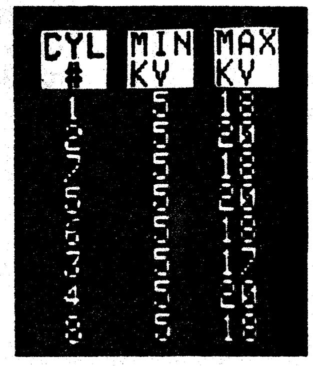
   g. A cylinder has a low no load MAX and a low snap kV MAX - indicates low secondary resistance (internal or external), such as grounded secondary circuit, spark plug gap too narrow, or low compression.

   h. Every other cylinder in the firing order shows a high or a low kV reading - indicates unbalanced carburetion.

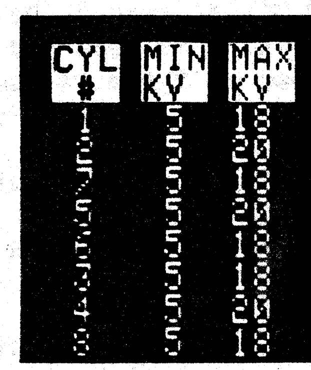
Example of MIN & MAX Readings for a Vehicle with No-Problems



No Load kV



Snap kV



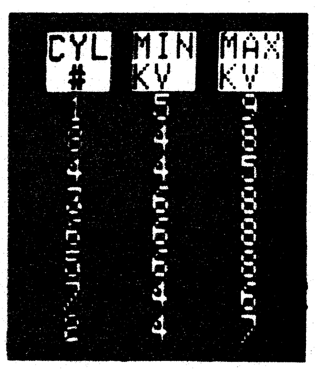
Under Load kV

1982 GM - Computer Equipped Vehicle with Fuel Injection and High Energy Ignition System

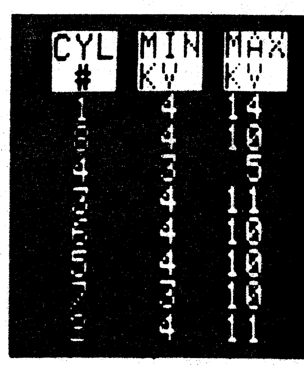
No problems indicated

MIN-MAX no load kV, snap kV and under load kV readings for this vehicle are even and within specifications.

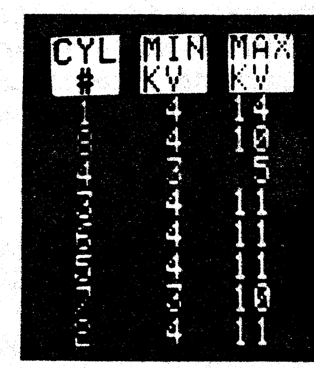
Examples of MIN & MAX Readings for Vehicles with Common Problems



No Load kV



Snap kV

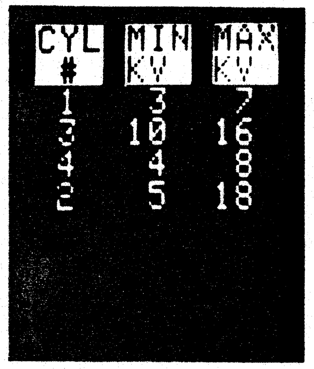


Under Load kV

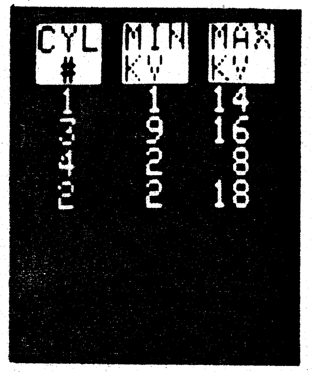
1979 Chrysler - Electronic Lean Burn (ELB)

Fouled spark plug on #4 cylinder

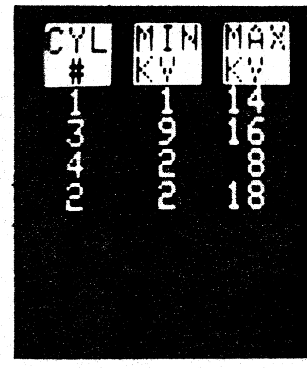
No load kV	MIN normal	-	MAX low
Snap kV	MIN normal	-	MAX stayed low
Under load kV	MIN normal	-	MAX stayed low



No Load kV



Snap kV



Under Load kV

1976 Ford - Carburetor Equipped Vehicle with Electronic Ignition System

Partially fouled plug on #1 cylinder

No load kV	MIN normal	-	MAX normal
Snap kV	MIN normal	-	MAX high
Under load kV	MIN normal	-	MAX high

Spark plug gap too wide on #2 cylinder

No load kV	MIN normal	-	MAX high
Snap kV	MIN normal	-	MAX high
Under load kV	MIN normal	-	MAX high

Open spark plug wire on #3 cylinder

No load kV	MIN high	-	MAX high
Snap kV	MIN high	-	MAX high
Under load kV	MIN high	-	MAX high

Narrow plug gap on #4 cylinder

No load kV	MIN normal	-	MAX normal
Snap kV	MIN normal	-	MAX no change
Under load kV	MIN normal	-	MAX no change

Cylinder Shorting Bar Graph

Note: The CLEAR key will set all cylinder shorting data back to zero when pressed, except when the screen reads "FROZEN" or "MEMORY."

Two basic engine performance tests are performed in the cylinder shorting bar graph function--the Cylinder Power Balance Test and the Carburetor Balance Test.

The cylinder power balance screen (Fig. 7-1) will always appear when the SHORTING BAR GRAPH key is pressed, unless the carburetor balance screen is in MEMORY (Fig. 7-2). If so, press FREEZE for a live screen and then press any of the engine's cylinder numbers.

Pressing the EVEN or ODD key will call up the carburetor balance screen when the cylinder power balance screen is up, unless the cylinder power balance screen is in MEMORY or frozen. If so, press the FREEZE key to return to a live bar graph and then press the EVEN or ODD key.

The screens are similar in that they both display engine rpm, and during shorting freeze and hold the rpm displayed when shorted; both have a timer that counts and displays the number of seconds during shorting; both record the number of seconds shorted and the drop in RPM in digital and bar graph form (maximum of 200 RPM drop indicated by bar graphs).

Note: It is possible for a shorted cylinder to show an RPM increase. This situation is covered in Cylinder Balance Test results. An increase in RPM is represented on the screen by a "+" in front of the digital readout and by a hollow bar graph (Fig. 7-3).

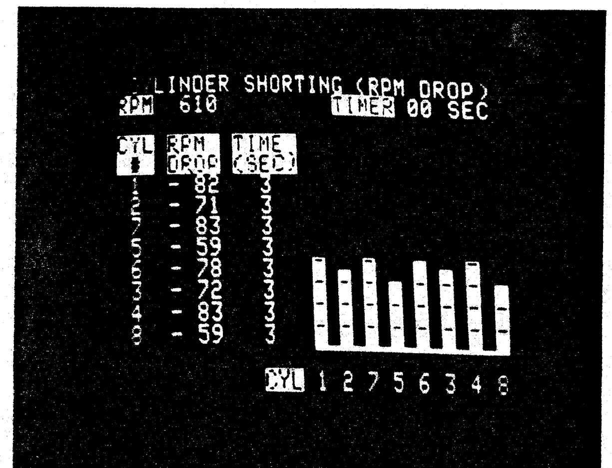


Fig. 7-1

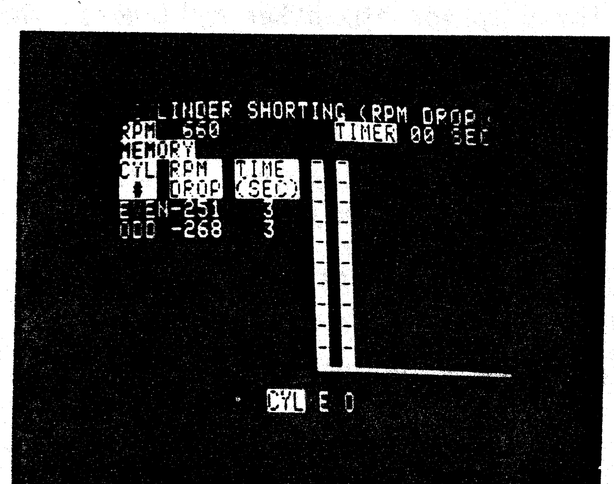


Fig. 7-2

The screens differ in that the cylinder power balance screen lists the test engine's cylinder numbers, in their firing order sequence, to the left of the digital test data columns and below the bar graphs; whereas the carburetor balance screen only identifies the data column and bargraphs as "E" (EVEN) and "O" (ODD).

> Note: EVEN and ODD correspond to the firing order sequence. For example, on an engine with a firing order of 1-8-4-3-6-5-7-2, ODD shorts cylinders 1-4-6-7 and EVEN shorts 8-3-5-2.

Cylinder Power Balance Testing

Each engine cylinder is shorted during a cylinder power balance test to determine which cylinders are, or are not, providing their share of power. If the RPM drop reading for a cylinder(s) is considerably less than the drop for the other cylinders, the RPM increases, or the variation is not within specifications, that cylinder is not producing its share of power. The problem may be in the ignition or fuel system, could be mechanical, or may be a combination of these. Futher testing will be required to isolate the problem(s).

CYLINDER SHORTING CAUTIONS & TIPS

CAUTION: Always refer to vehicle manufacturer's instructions for any cylinder shorting WARNINGS, CAUTIONS, or recommended procedures, such as the following example:

> When shorting cylinders on vehicles equipped with a catalytic converter, perform each cylinder shorting test as quickly as possible. Short each cylinder the same amount of time--not to exceed 10 seconds. Then allow at least 10 seconds between tests for clearing unburned fuel from the exhaust system.

Tips: Cylinder shorting test results are generally more reliable if

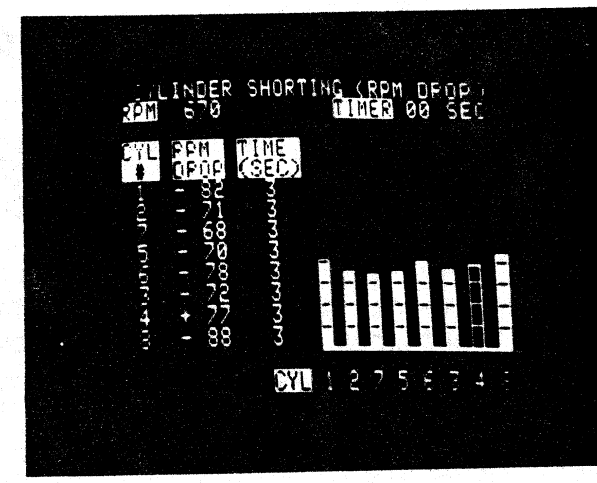


Fig. 7-3

taken with engine running at fast idle, such as 1000 to 1500 RPM.

On some vehicles equipped with a computerized control system, the computer regulates the engine idle speed. For accurate cylinder shorting test results on these vehicles the compensating device may have to be disconnected and/or special test procedures should be followed, such as the following examples:

> On GM vehicles (carbureted models) equipped with computerized engine control systems, where the air/fuel ratio is controlled by an oxygen sensor, cylinder shorting must be done in the "open loop" mode. On a warm engine this can be done by disconnecting the coolant temperature sensor. NOTE: After testing is completed, clear trouble codes that may have been set.

> On vehicles equipped with fuel injection and a computerized engine control

system, cylinder shorting should be held to a maximum of approximately 5 seconds per cylinder.

On Chrysler Electronic Lean Burn (ELB) systems, ground the carburetor switch or disconnect the hose at the vacuum transducer to prevent the timing mechanism from counting up during a cylinder power balance test.

Before shorting cylinders on engines equipped with an exhaust gas recirculation valve (EGR), disconnect and plug the hose to the EGR valve. Note: Engines equipped with floor jet EGR systems, such as 1972-73 Chryslers, cannot be reliably tested for cylinder power balance.

TEST

Refer to list of cylinder shorting preliminary procedures on page 7-5.

1. With the Start-Up & Engine Data Entry Procedure (Pg. 2-1) completed, connect the test leads as shown on pages 3-1 or 3-2, and start the engine.

2. With the cylinder power balance screen up, short all the engines's cylinders by pressing the corresponding numbered keys (example: keys 1 thru 6 for a six cylinder engine).

   Note: For your most accurate test results, observe the RPM reading at the moment you short the first cylinder. Short the other cylinders at or close to that RPM.

3. Compare the RPM drop readings.

   If RPM drop is about the same for all cylinders and within specified limits, each cylinder is considered to be developing its share of power. No problems are indicated.

   If the RPM drop for one or more cylinders is considerably less than for the other cylinders a mechanical, fuel system or ignition system problem is indicated. Further testing will be required. A compression and cylinder leakage test should be done on any cylinder not producing its share of power.

   If the engine speed increases when a cylinder is shorted, the RPM increase could be caused by an abnormal intake valve condition that allows combustion gases to enter and pollute the air/fuel mixture in the intake system. This condition reduces the efficiency of other cylinders. Consequently, when the problem cylinder is shorted, no polluting combustion gases are produced and the overall efficiency of the engine is increased. This condition can be tested for with a cylinder leakage test.

4. After testing is completed, reconnect or readjust any components altered for testing.

Carburetor Balance Testing

The carburetor balance test indicates if both carburetor primary bores are supplying the air/fuel mixture equally. This test can be performed on V-type engines equipped with a multi-barrel carburetor (except 2-stage 2-bore models) and 2-plane (divided) intake manifold.

Carburetor Balance Test on next page.

TEST

Observe Cylinder Shorting Test Cautions.

1. With the Start-Up & Engine Data Entry Procedure completed and the test leads connected as shown on page 3-1 or 3-2, start the engine.

2. With the carburetor balance screen up, short the even and then the odd cylinders.

3. Compare the RPM drop readings.

   If the readings are about equal, the carburetor is considered balanced.

   If the readings are not about equal, the carburetor is out of balance and the mixture screws must be adjusted.

4. After testing is completed, reconnect or readjust any components altered for testing.

Note: On engines without exhaust emission controls, the smoothest idle occurs when the highest engine speed is obtained while adjusting the mixture screws. On vehicles equipped with exhaust emission controls, the manufacturer's recommendations (located on decal in engine compartment) must be followed in order to comply with emission control laws.

PRELIMINARY PROCEDURES FOR CYLINDER SHORTING ENGINES EQUIPPED WITH COMPUTER CONTROL SYSTEMS (thru 1986)

It is recommended that you always refer to and follow the manufacturer's procedures for disabling computerized idle speed controls.

GENERAL MOTORS

C-3 Carbureted Systems
- —Disconnect idle speed control motor, or seal off vacuum hose going to idle load compensator.
- —Disconnect oxygen sensor.
- —Proceed with test.

C-3 Throttle Body Injected Systems
- —Disconnect oxygen sensor.
- —Disconnect the idle air control motor.
- —Start engine. Stabilize RPM by installing suitable plug tool(s) into throttle body air passage(s).
- —Proceed with test.

Multi-Port Fuel Injection System
- —Put engine in initial timing mode per underhood decal.
- —Disconnect oxygen sensor.
- —Disconnect and plug vacuum hose to fuel pressure regulator.
- —Turn ignition "on", ground ALDL test terminal at connector under dash.
- —Disconnect idle air control valve.
- —Proceed with test.

1985 Corvette
- —Disconnect timing wire near the power brake.
- —Disconnect and plug vacuum hose going to the fuel pressure regulator.
- —Disconnect idle air control valve and oxygen sensor.
- —Proceed with test.

FORD MOTOR COMPANY

EEC-III, EEC-IV and MCU Without Port Fuel Injection
- —Disconnect oxygen sensor and throttle kicker.
- —Disconnect yellow wire at distributor.
- —Disconnect and plug MAP sensor vacuum hose (may also be B-MAP sensor).
- —Connect hand-held vacuum pump to MAP sensor and apply 12 to 16 inches of vacuum.
- —Proceed with test.

1985 Ford Port Fuel Injection
- —Disconnect oxygen sensor and idle speed control valve.
- —Disconnect yellow wire at the distributor.
- —Disconnect and plug MAP sensor vacuum hose. Connect a vacuum pump and apply 12 to 16 inches of vacuum.
- —Disconnect and plug the fuel pressure regulator vacuum hose.
- —Proceed with test.

1986 Port Fuel Injection
- —Disconnect MAP sensor wires.
- —Disconnect and plug fuel pressure regulator vacuum hose.
- —Proceed with test.

AMERICAN MOTORS

1983-86 Alliance and Encore
- —Most American Motors vehicles are equipped with a new ignition control module with an integral ignition coil. Because the coil primary terminals are not exposed on the ignition module, primary lead connections for power balance are not possible. An alternative, however, is the coil primary negative pin which is accessible through an opening in the ignition module housing. Attach a jumper wire to the coil primary negative pin and attach the other end to the tester primary lead.
- —Disconnect Idle Speed Actuator.
- —Disconnect and plug vacuum hose to vacuum sensor mounted on Ignition Control Module.
- —Disconnect O_2 Sensor.
- —Proceed with test.

1985 Renault Ducellier
- —Remove coil from unit.
- —Slip a piece of electrical wire into contacts where the negative coil posts slide in.
- —Reinstall coil.
- —Proceed with test.

CHRYSLER CORPORATION

Lean Burn Systems
- —Ground carburetor switch. Refer to reliable shop manual for switch location.
- —Disconnect oxygen sensor, if applicable.
- —Disconnect and plug the spark control computer vacuum hose. Connect hand-held vacuum pump and apply 12 to 16 inches of vacuum.
- —Proceed with test.

1985-86 Turbocharged 4-Cylinder
- —Disconnect oxygen sensor.
- —Disconnect the coolant temperature sensor. The coolant fan will run continuously with sensor disconnected.
- —Disconnect and plug spark control computer vacuum hose.
- —Disconnect 6-pin fire wall connector.
- —Proceed with test.

THE IMPORTS

HONDA
- —Disconnect oxygen sensor.
- —On fuel injected engines, disconnect and plug the fuel pressure regulator vacuum hose.
- —Proceed with test.

NISSAN
- —Disconnect and plug fuel pressure regulator vacuum hose.
- —Disconnect oxygen sensor.
- —Seal off idle air regulator hose.
- —Proceed with test.

944 PORSCHE
- —Disconnect and plug both fuel pressure regulator vacuum hoses.
- —Disconnect oxygen sensor.
- —On 1985 models, use jumper wire to connect terminals "C" and "B" of the capped plug by the left shock tower between the shock tower and the fire wall.
- —Proceed with test.

TOYOTA
- —Disconnect and plug fuel pressure regulator vacuum hose.
- —Disconnect oxygen sensor.
- —Use a jumper wire to short out plug for initial timing. Refer to underhood decal.
- —Proceed with test.

VOLKSWAGEN WITH BOSCH C.I.S. LAMBDA OR KE-JETRONIC (CIS-E) FUEL INJECTION
- —Pinch off hose going to the idle speed air valve, on KE-JETRONIC.
- —Disconnect oxygen sensor.
- —Proceed with test.

Dwell Bar Graph

When you test dwell, ignition or electronic fuel system, you are measuring the amount of time that current passes through a closed switch, such as ignition contact points or the internal switch in an ignition control module.

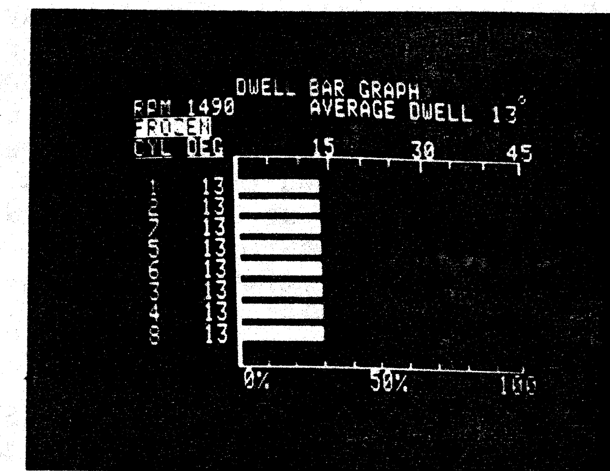


Fig. 8-1

The dwell bar graph screen (example: Fig. 8-1) displays engine RPM and average degrees of dwell. It lists the test engine's cylinders in the firing order sequence and displays individual cylinder dwell in digital and bar graph form. The number of bar graphs and the degrees of dwell scale, located above the bar graphs, vary in accordance to the engine data entered. A bar appears for each engine cylinder and full scale varies in accordance to the number of cylinders displayed (8 cyl. - 0 to 45°, 6 cyl. - 0 to 60°, and 4 cyl. - 0 to 90°). A 0 - 100% duty cycle scale, divided into ten 10% segments, is displayed below the bar graphs for testing fuel system duty cycle, or ignition dwell when the specification is given as a percentage. Note: A convenient percentage to degrees/degrees to percentage conversion chart is also provided. Conversions are calculated as follows:

Converting % to °

$$\% \text{ specification} \times \frac{360}{\text{number of cylinders}} = {}^\circ$$

Converting ° to %

$$\frac{{}^\circ \text{ specification}}{360 \div \text{number of cylinders}} = \%$$

Ignition dwell specifications are almost always given in degrees (°). Fuel system dwell specifications may be given as a percentage (%) of duty cycle or in degrees of dwell, and are most commonly read directly from a 6 cylinder dwell scale. However, there are exceptions, and therefore it is necessary to look up the recommended procedure and specification and to adapt this information for use with the MT1665; example: some manufacturers of import vehicles equipped with the oxygen sensor feedback system by Bosch (Lambda CIS) give a dwell specification that is to be taken from a 4 cylinder dwell scale (90° scale instead of 60°).

When the manufacturer specifies a degrees of dwell scale for fuel system testing other than the one appearing on the screen, use the following conversion chart and convert as follows:

Note the degrees reading on the screen.

Locate that degrees reading, or approximate reading, in the scale column (# of cyl) for the engine being tested.

Go to manufacturer's specified scale (# of cyl) on same line for conversion.

Example: You are testing an 8 cyl engine and manufacturer specifies a 0 - 60° scale (6 cyl). The dwell reading on the screen reads 27°. Locate 27° in the 0 - 45° column (8 cyl), then look across to the 0 - 60° column (6 cyl) on same line for conversion, which is 36°.

PERCENTAGE & DEGREE SPECIFICATION CONVERSION CHART

Percentage (%) Specification or Reading		Degrees (°) Scales 0° - 90° (4 cyl)	0° - 60° (6 cyl)	0° - 45° (8 cyl)
5%	=	4.5	3.0	2.25
10%	=	9.0	6.0	4.5
15%	=	13.5	9.0	6.75
20%	=	18.0	12.0	9.0
25%	=	22.5	15.0	11.25
30%	=	27.0	18.0	13.5
35%	=	31.5	21.0	15.75
40%	=	36.0	24.0	18.0
45%	=	40.5	27.0	20.25
50%	=	45.0	30.0	22.5
55%	=	49.5	33.0	24.75
60%	=	54.0	36.0	27.0
65%	=	58.5	39.0	29.25
70%	=	63.0	42.0	31.5
75%	=	67.5	45.0	33.75
80%	=	72.0	48.0	36.0
85%	=	76.5	51.0	38.25
90%	=	81.0	54.0	40.5
95%	=	85.5	57.0	42.75
100%	=	90.0	60.0	45.0

Ignition System Dwell Testing

<u>CAUTION</u>: When testing ignition dwell do not allow the yellow test lead clip to touch ground. Damage to the electronic ignition module could result.

On most electronic ignition systems the dwell cannot be adjusted as it can be on breaker point systems. On a breaker point system, dwell is checked against and adjusted to a specification. The dwell test on electronic systems is basically a check to see if dwell responds to engine speed variations as it is supposed to.

It is important to know the proper operation of the different electronic systems. When engine speed is increased dwell may increase, remain constant, or decrease. An improper dwell response indicates a faulty ignition control module. Refer to the following examples of proper dwell response to an increase in engine speed.

Dwell increases with increase in engine speed:

AMC & IH - Prestolite BID

Chrysler Corp - Hall Effect w/ESC

FMC - Dura Spark I, EEC III, EEC IV TFI

GMC - HEI, HEI ESC, HEI ESS, HEI EMR, HEI EST, HEI EST w/ESC, HEI EST w/Hall Effect Switch

Dwell remains constant with increase in engine speed:

Chrysler Corp - Hall Effect w/EIS

FMC - SSI, Dura Spark II, EEC I & EEC II.

Dwell decreases with increase in engine speed:

Chrysler Corp - EIS (domestic), ELB, ESC

TEST

1. Refer to manufacturer's procedures and specifications.

2. With Start-Up & Engine Data Entry Procedure (Pg. 2-1) completed and the test leads connected as shown on pages 3-1 or 3-2, start the engine.

3. <u>Breaker point ignition systems:</u>

   Check average dwell reading against manufacturer's specification. If it is not within specs, make adjustment.

   Compare individual cylinder dwell for variations.

   If they are within about 3° of each other (5° on distributors with side-pivot breaker plate), dwell variation is acceptable.

   If variations exceed 3°, distributor wear problems are indicated, such as: worn distributor shaft and/or bushings or distributor plate wobble (Fig. 8-2 on pg. 8-4); worn cam lobe (if only one reading varies - Fig. 8-3); stretched or loose timing chain (indicated by momentary alignment of bars when throttle is quickly opened).

   <u>Electronic ignition systems:</u>

   Increase engine speed and check for the proper dwell response (increased, constant, or decreased dwell). An improper dwell response indicates a faulty ignition control module.

Fuel System Dwell Testing

Fuel system dwell/duty cycle signals from GM electro-mechanical carbureted engines or Bosch Lambda systems can be monitored on the dwell bar graph screen. Fuel system duty cycle and ignition dwell as a percentage (°) can be read directly from the screen. The Dwell degrees (°) readings may be used directly when testing some vehicles, such as when the engine is a 6 cylinder and the manufacturer's specification is to be taken from the 0 - 60° scale. Refer to the conversion chart on pg. 8-2 when the manufacturer specifies a scale other than that appearing on the screen.

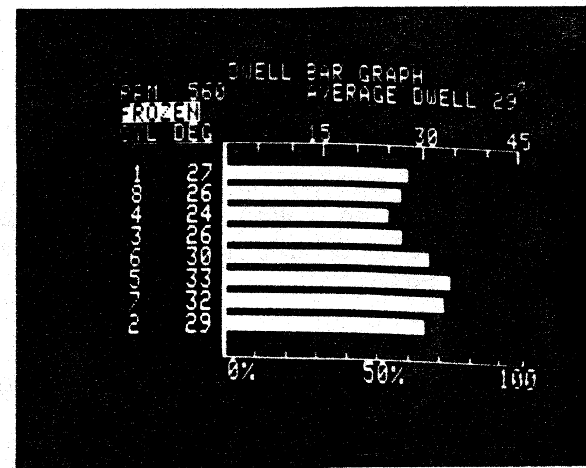


Fig. 8-2

GM Computer Command Control (3 C's) System

The Electronic Control Module (ECM) is the "brain" of the 3 C's system. It monitors engine operating conditions through many input sensors, and controls numerous functions through output devices.

Fuel control, one of the outputs, is accomplished as follows. The ECM monitors an output voltage signal from the oxygen sensor and sends a command signal to the Mixture Control Solenoid (M/C). The M/C varies the air/fuel ratio within a precalibrated range through the use of an electrically operated metering rod(s) and an idle air bleed valve. The M/C is cycled (turned on and off) 10 times per second to control the fuel flow. This resulting lean-to-rich and rich-to-lean action is monitored by the Counselor.

On an engine at normal operating temperature, the duty cycle reading at idle and part throttle should be between 16% - 83%, or 10° - 50° degrees of dwell using the 6 cylinder scale (0 - 60° scale). The reading should vary. The amount that it varies

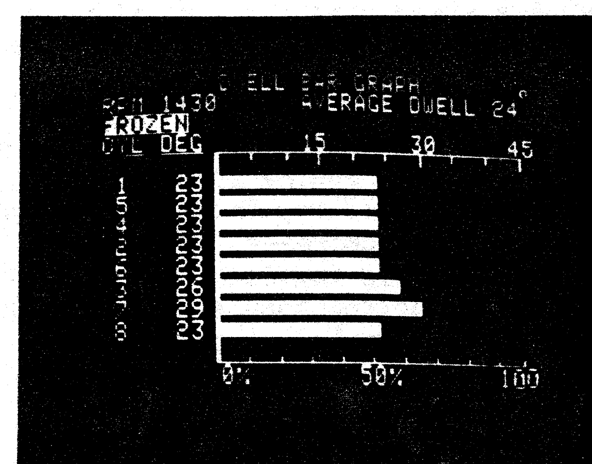


Fig. 8-3

does not matter; only the fact that it does vary. This is called "closed loop" operation, which means that the duty cycle or dwell reading is being varied by the ECM. A low reading (about 10% or 6°) indicates the ECM is signaling a rich command to the M/C solenoid, while a high reading (about 90% or 54°) would indicate a lean command signal.

Under certain operating conditions, such as wide open throttle or when the engine or oxygen sensor is cold, the duty cycle or dwell percentage will remain stable. This is known as "open loop" operation.

There are three ways to distinguish "open loop" operation from "closed loop":

1. A varying duty cycle or dwell reading will only occur while in the "closed loop."

2. Restrict intake air at the carburetor. "Closed loop" is indicated if the reading increases.

3. Remove a vacuum hose (PCV, power brake, etc.). "Closed loop" is indicated if the reading decreases.

NOTE: Oxygen sensors may cool off at idle and cause the duty cycle to change from varying to fixed. If this occurs, run the engine at fast idle to return to "closed loop" operation.

Bosch Lambda (CIS)
Fuel Injection System

Electronic Control Unit & Frequency Valve:

Based on signals from the oxygen sensor, the electronic control unit continually corrects the air/fuel mixture. It sends a series of electrical pulses to a frequency valve located in the fuel line that connects the upper and lower halves of the fuel distributor.

When the frequency valve is closed, fuel pressure to the injector is determined by the fuel distributor's pressure regulating valves. When the frequency valve is open, fuel pressure decreases in the lower half of the distributor and tension on the spring is relieved allowing more fuel into the cylinder. The electronic control unit opens and closes the frequency valve many times per second to ensure smooth regulation of fuel pressure and mixture.

On a cold engine the valve opened to valve closed ratio is about 50%. After the engine warms up, the voltage produced by the oxygen sensor is monitored by the computer to determine the amount of time that the frequency valve is opened or closed. This ratio is monitored by the Counselor.

TEST

Observe the average dwell reading (upper right hand corner of screen) when testing fuel system dwell. Disregard the individual cylinder dwell readings and bar graph movement. They will vary when dwell varies and remain relatively stable when dwell is fixed.

1. Refer to manufacturer's procedures and specifications.

2. With Start-Up & Engine Data Entry Procedure completed, connect all leads, except the YELLOW LEAD, as shown on page 3-1 or 3-2.

   Connect YELLOW LEAD as follows:

   On GM vehicles equipped with electro-mechanical carbureted engines, connect YELLOW LEAD to the M/C dwell terminal (green harness connector usually located near the carbuetor) as shown in Fig. 8-4 on page 8-6. On tranverse mounted engines thE M/C dwell terminal is located by the passenger side fender well (Fig. 8-5 on page 8-6).

   On Bosch systems the YELLOW LEAD is connected at the frequency valve duty cycle electrical connector. Consult shop manual for exact location of lead connection for vehicle being tested.

3. Follow test procedure as outlined by manufacturer.

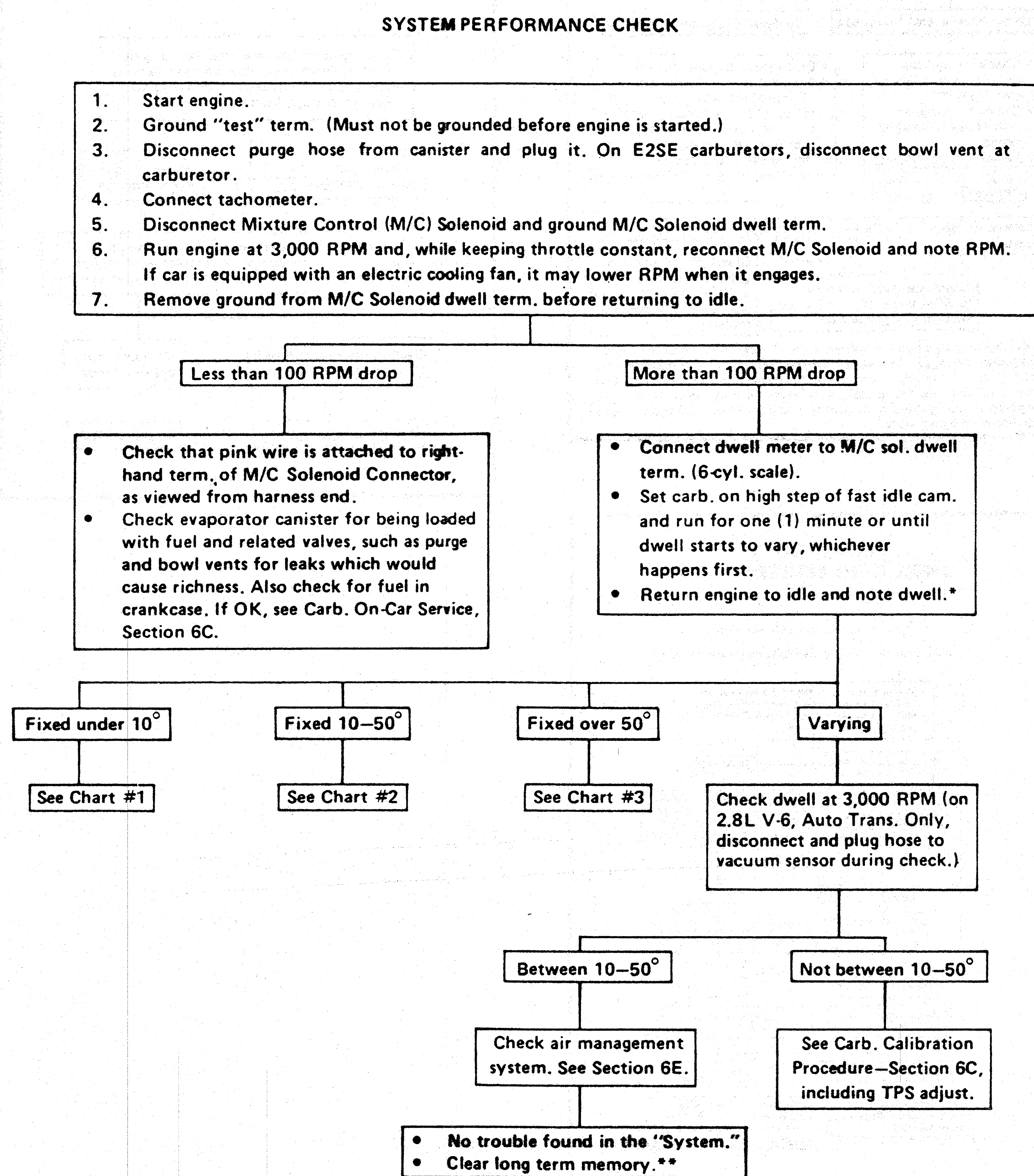
   For Bosch refer to Lambda Control System Operation Check.

   For GM refer to System Performance Check (SPC). A sample of the GM SPC and Charts 1, 2, & 3 are provided for your convenience on the following pages.

Fig. 8-4

Fig. 8-5

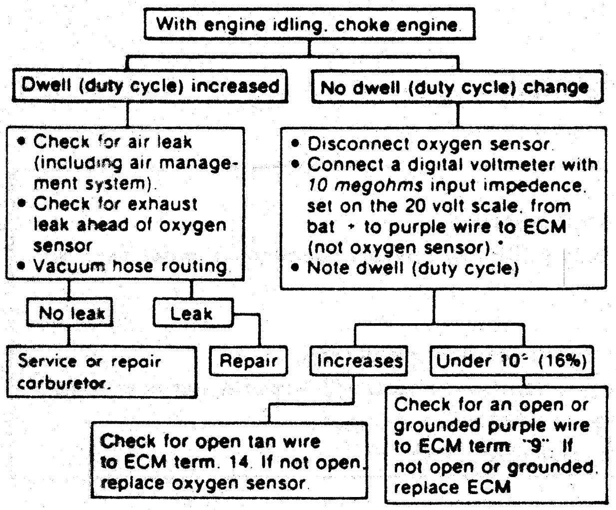
Copy of a GM System Performance Check and Charts 1, 2 & 3



*Oxygen sensors may cool off at idle and the dwell change from varying to fixed. If this happens, running the engine at fast idle will warm it up again.

**See Code(s) Clearing Procedure.

CHART NO. 1
DWELL FIXED UNDER 10°



**Do Not* use an ordinary voltmeter or jumper in place of the digital voltmeter because they have too little resistance. A voltage source of 1.0V to 1.7 V (such as a flashlight battery) can be connected with the Pos term to the purple wire and the neg term to ground instead of using the digital voltmeter as a jumper. If the polarity is reversed, it won't work.

CHART NO. 2
DWELL FIXED BETWEEN 10-50°

(Open Coolant or Oxygen sensor circuit)

Check for sticking TPS plunger and adjustment and low coolant

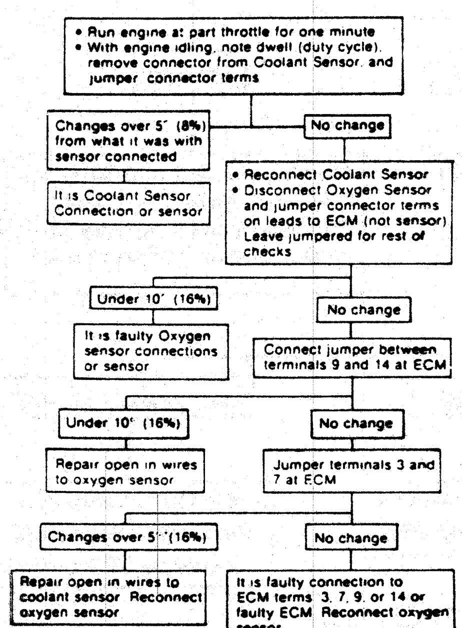
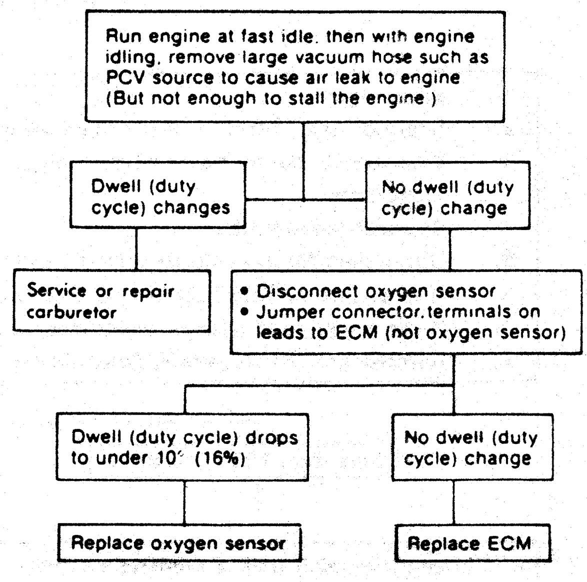


CHART NO. 3
DWELL FIXED OVER 50°



Alternator Pattern Waveform Screen

TESTING TIPS

1. For the most accurate alternator test results, the test vehicle should have a fully charged battery. An open circuit voltage test can be performed with the Counselor to check the battery's state-of-charge.

2. Do not polarize an alternator. Never disconnect alternator or battery leads when engine is running. Reverse polarity or excessively high voltage can severely damage the charging system.

3. Always make sure that test leads are hooked-up correctly. Voltage reading and waveform are monitored with the black and white leads. For an RPM reading the inductive pick-up must be connected.

4. "OVERRANGE" will appear on the screen if the voltage being monitored is not within the Counselor's -28 volt to +28 volt test range.

5. If an alternator has a severe internal defect (stator damage, multiple diode problems or field circuit damage), its waveform pattern may appear as just a straight line across the screen at a particular voltage level.

The alternator pattern waveform screen (Fig. 9-1) displays alternator output voltage and an alternator voltage waveform for testing the alternator for proper operation. The screen also displays engine RPM.

Fig. 9-1

The voltage reading is used to check the charging system's regulated voltage, to see that it is within the manufacturer's specification. It can also be used for other specific alternator tests, such as terminal voltage tests for the GM Delcotron SI Series.

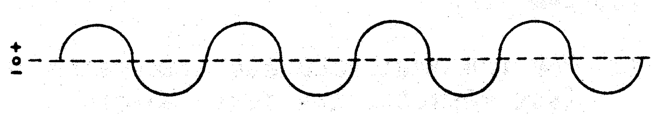
Waveform patterns are analyzed to determine the condition of the alternator's diodes and stator windings. Shorted and/or open diodes and stator windings are some of the more common internal alternator problems. If any of the stator windings or diodes are bad, they will effect the "normal" waveform pattern for an alternator with good stator windings and diodes.

A malfunction in this area may only reduce the alternator output by about 10%, and therefore it would not show up on the vehicle's charge indicator light or be detected during a current output or voltage regulator test. If this type of problem goes uncorrected it may lead to more extensive damage and possibly cause the failure of other electrical components on the vehicle.

The Alternator Waveform

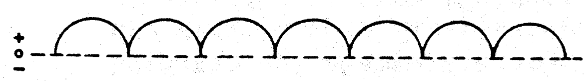
Within a group of stationary windings (stator) the alternator rotor (field) rotates. This produces a 3-phase alternating current (AC).

Example of single phase AC voltage:



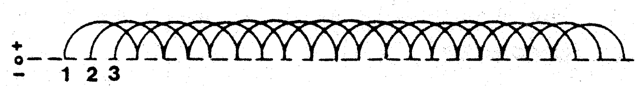
However, the vehicle's battery, ignition system and other electrical components require direct current - DC. To change the AC to DC the alternator uses a series of diode rectifiers (one-way electrical check valves). The diodes rectify the negative portion of the AC allowing only positive portions (DC) to flow through the alternator output wire.

Example of single phase DC voltage:



The waveform of 3-phase DC voltage, with a battery in the circuit to stabilize the electrical system, is a "slightly" rippled horizontal line. The 3-phase output is smooth enough to be considered a non-varying DC voltage.

Example of three phase DC voltage:



The waveform for 3-phase DC voltage is illustrated as it will appear on the screen in step 6 of the test. It is the first example of a waveform for an alternator with "good" stator windings and diodes.

TEST

1. Refer to any applicable manufacturer's procedures and specifications.

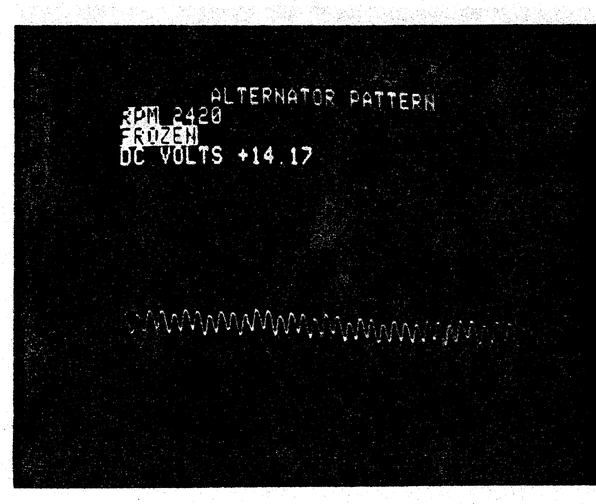
2. With the Start-Up and Engine Data Entry Procedure completed, press ALT & FUEL INJ key for the alternator, fuel injection and voltage waveform pattern selection screen. Then press the 1 key to select the alternator pattern waveform screen.

3. Connect the test leads as shown in Fig. 3-1 or Fig. 3-2 (capacitive/HEI pick-up not required). NOTE: Connecting the white lead to the alternator output terminal will result in a larger waveform pattern.

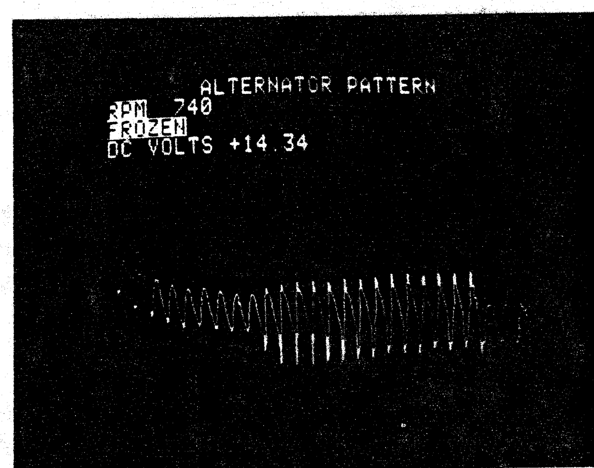
4. With the engine running, observe the voltage reading and waveform pattern at idle and at about 2000 RPM.

5. Compare the voltage reading to the manufacturer's specification. If the reading is not within specification, check the waveform to see if it is normal for a good alternator, as described next in step 6. If the waveform shows good, suspect a faulty voltage regulator.

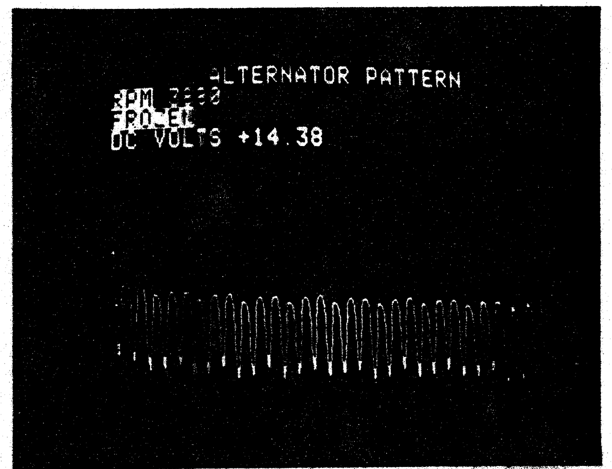
6. Refer to the following three illustrations. They are examples of normal alternator waveform patterns. NOTE: These are basic patterns. Patterns will vary somewhat in size and shape with changes in alternator speed and current output.



A normal alternator test pattern - regularly spaced, even ripples, all about the same height.



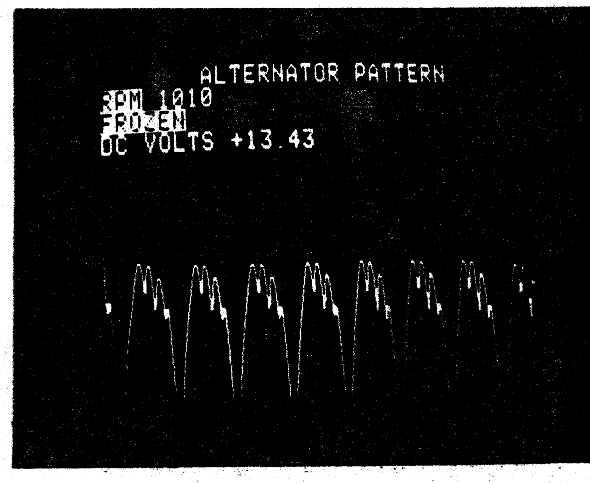
A normal alternator test pattern with some peaks and spikes. These are usually observed under light-load conditions. They are the result of ignition and voltage regulator operation. Solid state voltage regulators control the alternator's output voltage by switching on and off at very high frequency rates. The result is inductive peaks and spikes on a normal wave form pattern.



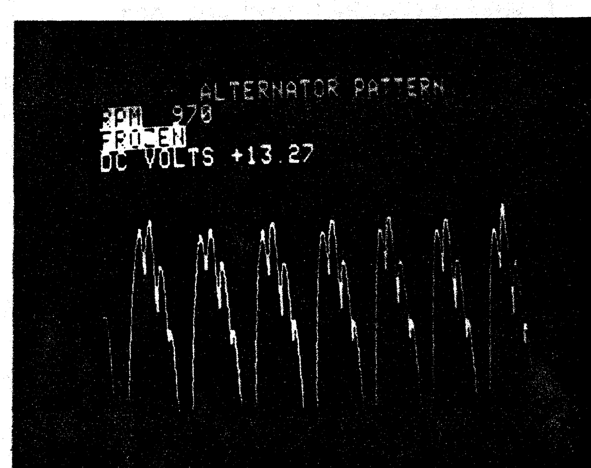
A normal alternator pattern - slightly larger and smoother pattern resulting from an increase in the load on an alternator, such as headlamps on.

7. Refer to the following illustrations for examples of abnormal alternator waveforms. An abnormal pattern indicates that further bench testing is required, and that the alternator will have to be repaired or replaced.

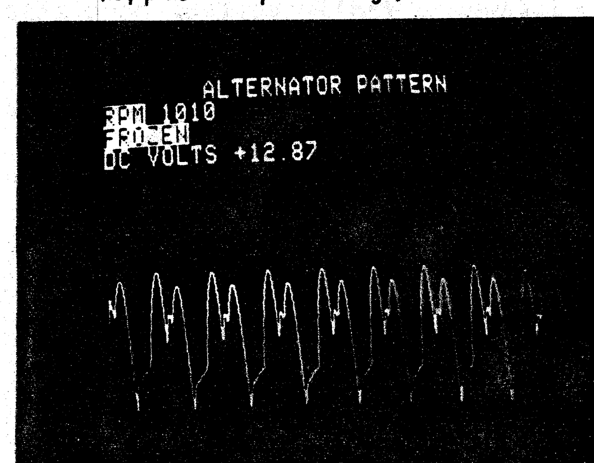
Note: Waveform patterns for malfunctioning alternators can vary significantly from those shown. Although they depict actual problems, they are only intended to be representative samples of how typical alternator problems may appear on the oscilloscope.



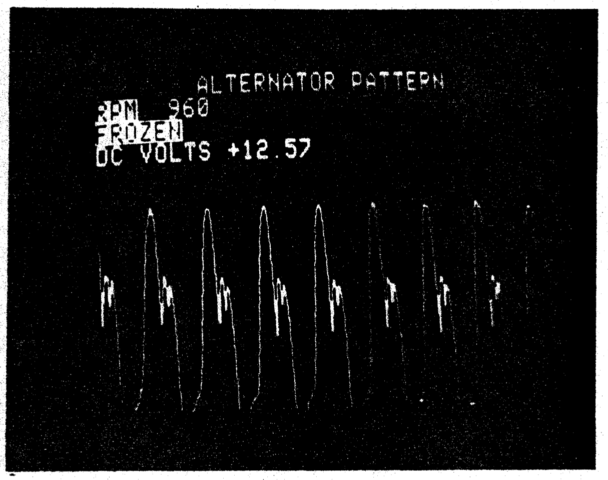
1 open diode (pos. or neg.)



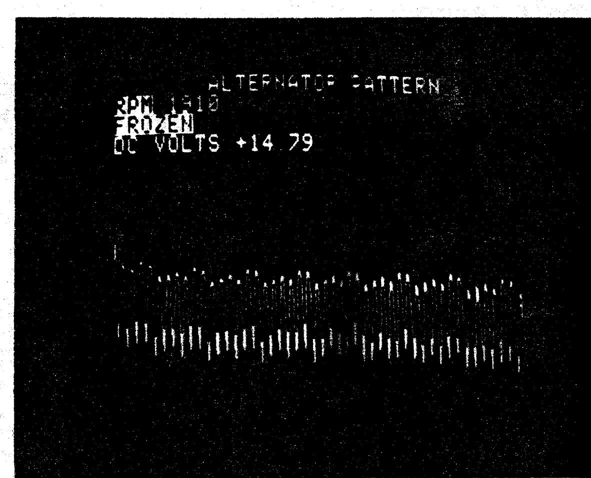
1 open and 1 shorted diode (opposite polarity)



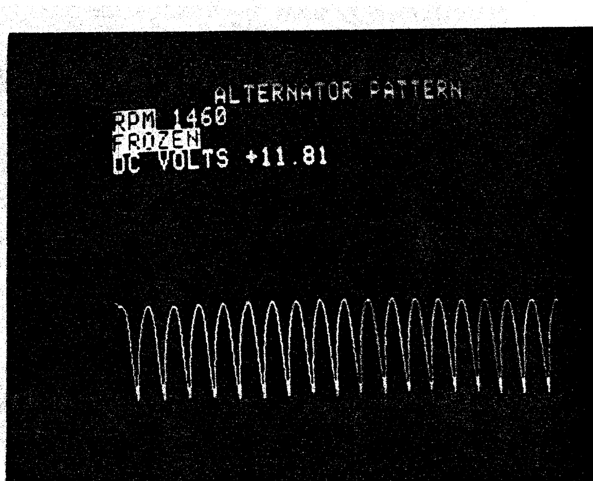
1 shorted diode (pos. or neg.)



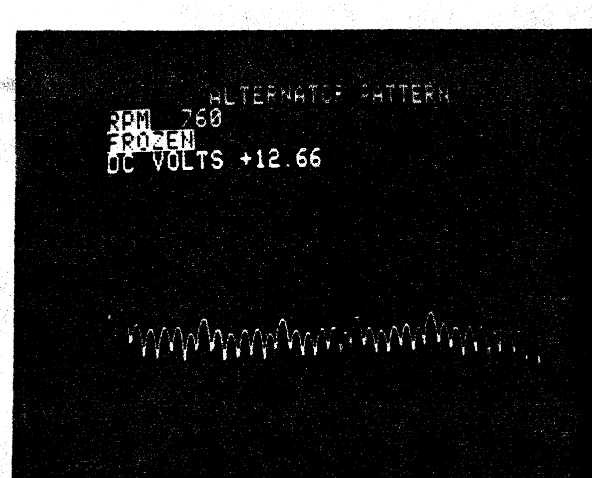
1 open and 1 shorted diode
(same polarity)



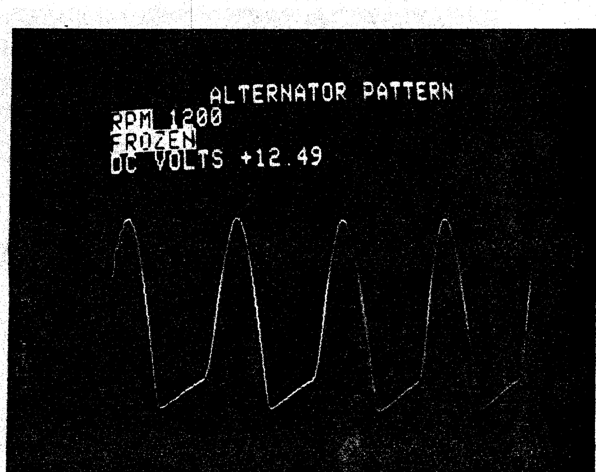
diode trio (1 open diode)



Shorted stator winding



diode trio (2 open diodes)



Open stator winding

Note: A faulty voltage regulator or varying alternator speeds/loads can also cause waveform patterns similiar to the two shown above. Refer to Diode Trio Tests on next page to determine if diode trio is the problem.

DIODE TRIO TESTS

If a diode trio (tri-diode or exciter diode) is suspected of being faulty, perform either of the following test procedures to determine the condition of the diode trio.

Diode Trio Test A

1. While testing the alternator output as previously instructed in alternator test section (white booted lead connected to the alternator output terminal), note the alternator's output voltage and waveform pattern.
2. Reconnect the white booted lead at the alternator as follows:
   GM Delcotron - #1 terminal
   Bosch - D+ terminal
   Motorola - regulator terminal
3. Using the same test RPM, compare waveform pattern and voltage reading to previous results.
4. Determine condition of diode trio.

   Diode trio good - voltage reading within one (1) volt of reading received at the alternator output terminal and the waveform pattern appears similiar.

   Diode trio bad - significant drop in voltage reading and waveform expanded beyond screen capacity (Fig. 9-2).

Diode Trio Test B

1. Complete steps 1 & 2 of Diode Trio Test A.
2. Switch to the Voltage Waveform Pattern Screen and then perform step 3 of Diode Trio Test A.
3. Determine condition of diode trio.

   Diode trio good - Voltage reading within one (1) volt of reading from at the alternator output terminal, and waveform appears similiar to that in Fig. 9-3.

   Diode trio bad - a square wave pattern (Fig. 9-4) is displayed on screen and alternator output voltage is significantly lower. Note: Square wave pattern indicates presence of alternating current.

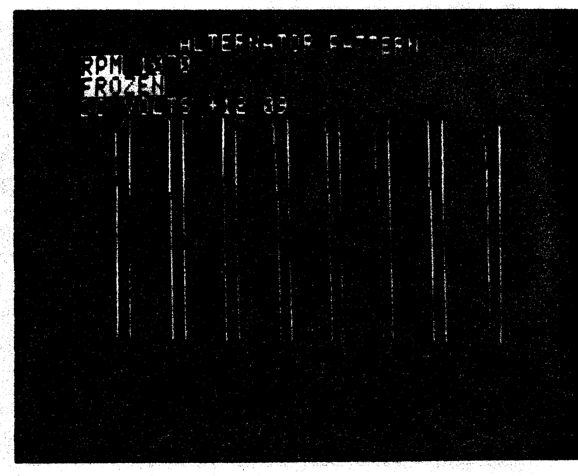


Fig. 9-2

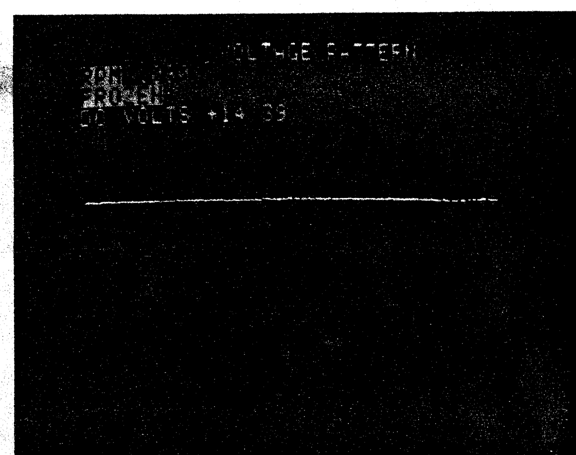


Fig. 9-3

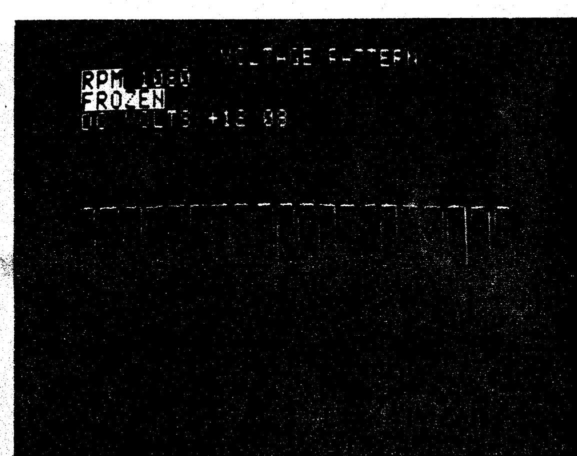


Fig. 9-4

Fuel Injector Pattern Waveform Screen

The fuel injector pattern screen (Fig. 10-1) is used to monitor fuel injector voltage waveforms. A voltage waveform indicates that the fuel injector is receiving a voltage signal from the electronic fuel control module; the signal is a command to deliver fuel. The waveform can be expanded, frozen, and then measured with the mSEC Cursor to determine the amount of time the injector is being commanded to deliver fuel. The frequency of the injection pulses can also be measured. The screen provides engine RPM to assist you in testing.

The fuel command period is referred to as "pulse width," and the frequency as "pulse rate" (Figs. 10-2 & 10-3, and 10-4 & 10-5 next page). The pulse width and rate commands that the injector receives from the control module are based on information the module receives from input sensors such as: engine speed, load or manifold absolute pressure (MAP); barometric pressure ((BARO), engine coolant temperature (CTS), throttle position (TPS), oxygen content (O_2 sensor), manifold air temperature (MAT), mass of incoming air (air flow sensor - MAF), etc. The overall "objective" is the optimum balance of maximum performance and efficiency, while maintaining minimum emission pollutants. This is accomplished by providing accurate fuel metering for all operating conditions.

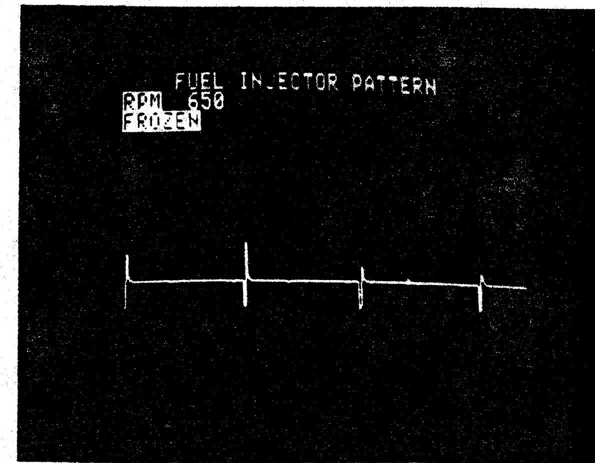


Fig. 10-1

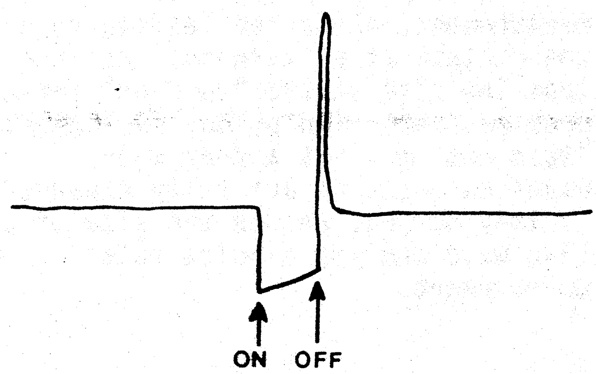


Fig. 10-2 - injector waveform A

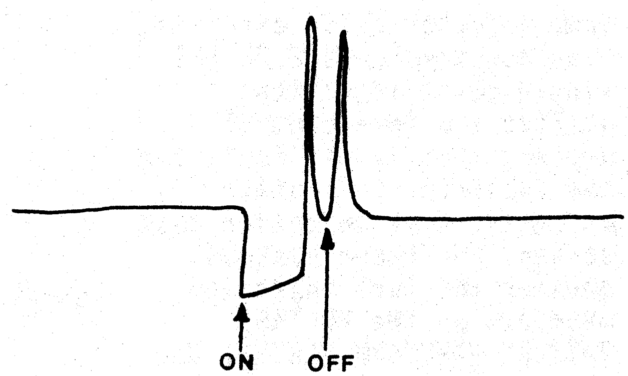


Fig. 10-3 - injector waveform B

Injector waveforms A and B (above) are representative of two types of injector drive circuitry. Type A activates the injector at one current level to achieve the desired pulse width (one voltage spike). Type B activates the injector at two different current levels (open mode and hold mode) to achieve the desired pulse width (two voltage spikes, Fig. 10-6).

A pulse width mSec measurement is made by aligning the leading edge of the mSec cursor curtain at "turn-off," and the trailing edge of the curtain at "turn-on." For a pulse rate measurement, align the leading edge of the curtain at a "turn-on," and the trailing edge at the "turn-on" for the previous injection pulse. Two injector "turn-ons" may not appear when waveform patterns are fully expanded. If they do not, reduce the size of a live waveform for a pulse rate measurement.

Testing Tips:

Some injector drive circuits, such as Chrysler's 2.2L EFI single point injection, utilize a unique control process that is difficult for the Counselor to monitor using the fuel injection test screen. For these systems monitor the fuel injection waveform on the VOLTAGE PATTERN WAVEFORM SCREEN. Use the white and black booted leads.

An injector waveform pattern may appear upside down on the voltage screen when the injector is activated by "feed side" instead of "ground side" control. Use the same procedure to measure upside down fuel injection patterns.

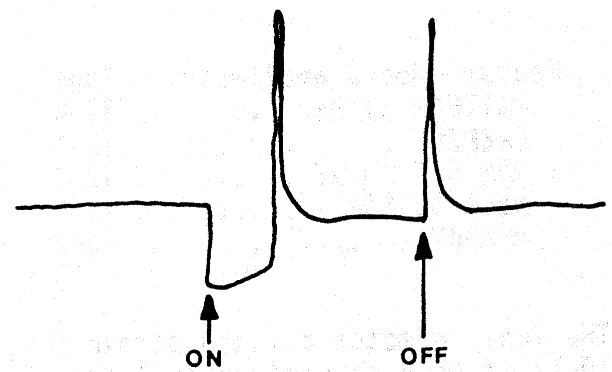


Fig. 10-4

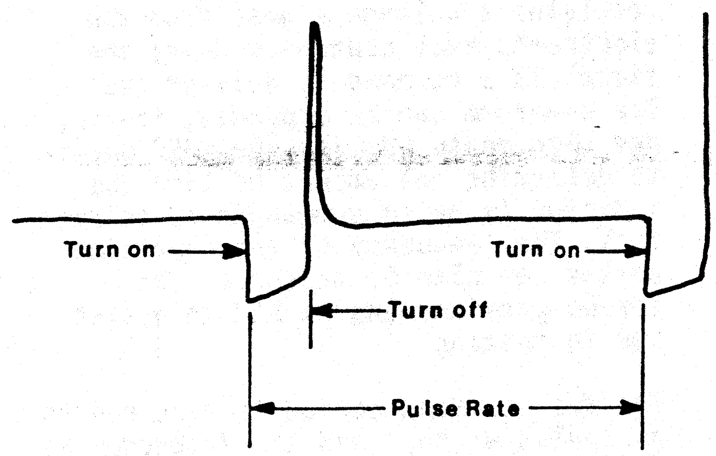


Fig. 10-5

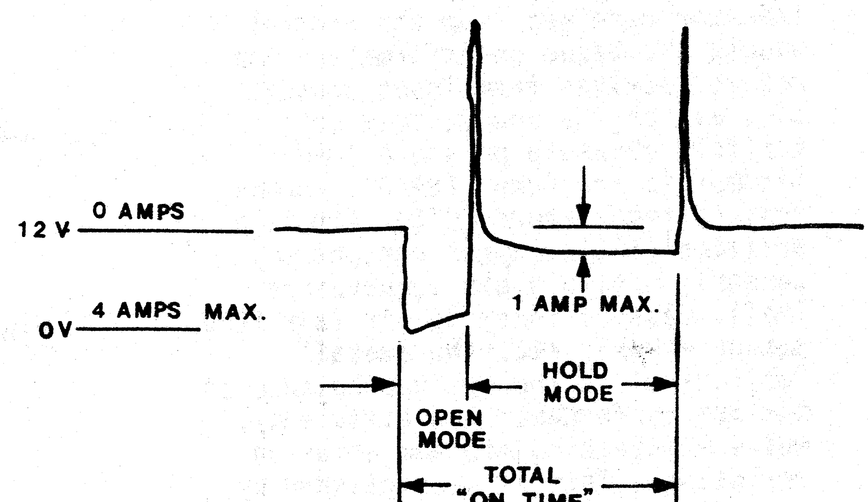


Fig. 10-6

TEST

1. Refer to any applicable manufacturer's procedures and specifications.

2. With Start-Up & Engine Data Entry Procedure completed, press ALT & FUEL INJ key for the alternator, fuel injector and voltage waveform patterns selection screen. Then press the "2" key to select the fuel injector pattern screen.

3. Disconnect the injector harness from the fuel injector. Select the proper adaptor. Connect the adaptor to the harness connector and the injector. NOTE: Use the color codes when connecting adaptor for GM TBI system.

4. Connect all the test leads, except the yellow lead, as shown in Fig. 3-1 or Fig. 3-2. Connect the yellow test lead to the yellow connector on the adaptor.

5. With engine running a voltage pattern should appear if (1) leads are connected correctly and (2) the injector is activated by ground side control. Three or four injector waveform pulses should appear across the screen. If so, continue with Step # 6. A horizontal line without any voltage spikes means you are not receiving a fuel injector signal. Continue with the following procedure until pattern appears:

   Disconnect the end of the adaptor that connects to the injector harness. Reverse the connection (except on GM TBI).

   Reverse the black and yellow lead connections to check if injector is feed side controlled (example: 1975 - 80 Cadillac).

   Reverse the adaptor connection at the injector harness again (to its original position).

   Reverse black and yellow lead connections again (to their original positions).

   NOTE: If injector waveform still does not appear, an injector signal may not be present at that injector indicating a control signal or wiring problem.

6. Expand waveform as required for pulse width and/or pulse rate measurements, and using FREEZE or RPM SET POINT, freeze the waveform for measurement with the mSEC CURSOR.

7. Compare results against any available manufacturer's specifications. If no specifications are available, refer to the following general guidelines:

   Pulse width at idle or at any steady engine speed (light load or no load) typically will be from .6 to 3.0 mSec.

   At maximum fuel demand, such as accelerating with a heavy load, 8.0 mSec may easily be achieved.

   At sudden deceleration a near 00.00 mSec reading may occur for an instant.

   To evaluate pulse rate it is necessary to know the operation of the particular system being tested.

NOTE: An injector waveform that checks good indicates satisfactory control to the injector. It does not eliminate the possibility of a mechanical fuel system problem.

8. If port-type injection system, test at another injector from a different control group. Injectors may be grouped in many combinations. Only one injector of a group need be tested to verify the control signal if control is not individual to each injector. A wiring schematic should be referenced to determine (1) the number of injector groups, (2) the number of injectors to a group, and (3) which injectors are controlled by which injector groups.

Voltage Pattern Waveform Screen

TESTING TIPS

CAUTION: When performing voltage tests, be careful to avoid lead contact with secondary ignition components (distributor cap, coil wire, plug wires, etc.). To do so could cause personal injury and/or possible damage to this test instrument.

1. The voltmeter is polarity sensitive. It is connected with the positive (white) lead towards the power source and the negative (black) lead towards ground. A "-" (negative) voltage value will be displayed when monitoring negative voltage.

   If the leads connections are reversed a positive voltage value will be displayed with a "-" sign, and a negative value will be shown as a positive.

2. "OVERRANGE" will appear on the screen if the voltage being monitored is not within the Counselor's -28 volt to +28 volt test range.

Available voltage, voltage drop, continuity, and electronic ignition pick-up coil tests can be performed using the voltage pattern waveform screen.

The voltage pattern waveform screen (Fig. 11-1) displays a voltage reading, voltage waveform pattern, and RPM reading.

NOTE: The voltmeter portion of the Counselor is a high impedance voltage tester that meets automobile manufacturers' criteria (10 megohms minimum input impedance) for testing vehicles equipped with computerized engine control systems.

When the voltage pattern is called up (black & white test leads not connected) a straight horizontal line will appear across the screen. When the test leads are connected to positive voltage the line will move upward on the screen. The line moves downward for negative voltage. No upward or downward movement indicates no voltage present in circuit under test. The waveform pattern may remain straight, which indicates a constant steady voltage, or it will show a pattern that is representative of voltage changes. Pattern variations are caused by varying voltage levels and intermittent (on/off) voltage.

NOTE: When the voltage signal is discontinued (shut off or leads disconnected) the horizontal voltage line will return slowly to its starting point. This characteristic is

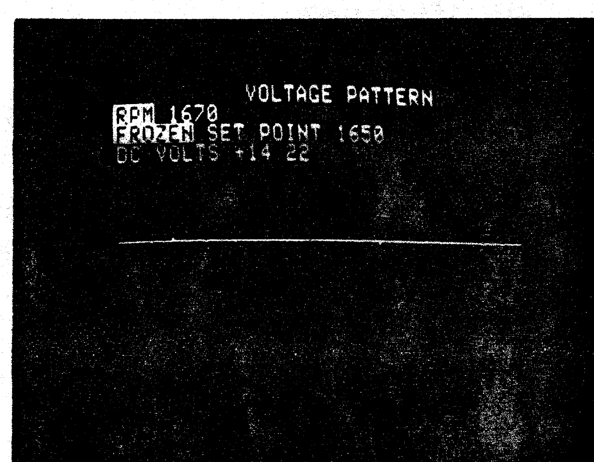


Fig. 11-1

designed into the Counselor to provide a better voltage waveform.

Voltage Testing

Voltage tests are performed to determine whether or not voltage is present in a circuit and/or to measure the amount of a voltage to see if it is within specifications.

Two basic voltage tests are performed with the Counselor - voltage available and voltage drop.

Voltage available tests are performed with no current flow (open circuit - the consumer, such as a bulb, electric motor, etc. not operating). This test is performed to determine if there is voltage available, and measures the amount of voltage available.

Voltage drop tests require current flow (closed circuit - consumer operating). This test measures the amount of voltage "lost" in the portion of the circuit between the test points.

VOLTAGE AVAILABLE TEST

1. Refer to any applicable manufacturer's procedures and specifications.

2. With the Start-Up & Engine Data Entry Procedure completed, press ALT & FUEL INJ key for the alternator, fuel injection and voltage waveform patterns selection screen. Then press the "3" key to select the voltage pattern waveform screen.

3. Make sure there is no current flow.

4. Connect the test leads. Only the black and white booted test leads are required. Connect as follows:

   Black lead to ground.

   White lead to positive test point(s).

5. Compare reading(s) to specifications.

VOLTAGE DROP TEST

1. Complete steps 1 and 2 of VOLTAGE AVAILABLE TEST.

2. Connect the black and white booted test leads at the desired test points. Both leads may be connected in the positive (insulated) side of the circuit or in the negative (ground) side, or they can be connected with a lead in both sides.

3. With current flow (consumer operating) in the circuit, take the reading from the display and compare it to specifications.

Continuity Testing

Continuity testing is performed to determine if the conductive path of a circuit, a section of a circuit or a specific electrical component, is continuous (continuity) or interrupted (open). It is an efficient means of troubleshooting circuits to isolate problem areas and/or locate a specific fault(s).

Voltage must be present in the circuit to test for continuity with a voltmeter. Continuity is checked using the black and white booted leads hooked up in series with the circuit as shown in Fig. 11-2 (next page). In this example, continuity is being checked from test point 3, through the source and ground path, to test point 2.

TEST

1. Complete steps 1 and 2 of VOLTAGE AVAILABLE TEST.

2. Connect black and white leads in series to the circuit or portion of the circuit being tested - black lead in the ground path and white at test point in the insulated portion of the circuit.

3. Check voltage reading. Any reading in excess of "00.00" indicates continuity.

Electronic Ignition Pick-Up Coil Testing - for "No-Start" Condition

The electronic ignition pick-up coil test is an ignition system troubleshooting test performed on engines in a "no-start" condition. It is done to determine if the pick-up coil is good.

Primary ignition current on/off time is regulated by the ignition control module. On/off time is based upon a signal voltage the module receives from the electronic ignition distributor. The signal is provided by a triggering device in the distributor. The most common triggering device is the magnetic pulse generator type. NOTE: Other triggering devices use breaker points, metal detection, optical or light detection, etc. All do the same job.

The signal from the magnetic pulse generator type triggering device is induced in the pick-up coil (stator) as the nonmagnetic teeth of a rotating triggering wheel (reluctor, armature, timer core, etc.) approach, align with, and move away from the pole piece of a permanent magnet. The low reluctance of the trigger wheel causes the magnetic field to expand as a tooth approaches alignment. The field collapses as the tooth moves away. This magnetic flux motion induces a signal voltage in the pick-up coil that can be monitored by the Counselor (Fig. 11-3).

TEST

1. Complete steps 1 and 2 of VOLTAGE AVAILABLE TEST.

2. Disconnect the two wires (GM - green & white, Ford - purple & orange, Chrysler - both black) that come off the pick-up coil at the connector(s) located closest to the pick-up coil. NOTE: On GM systems

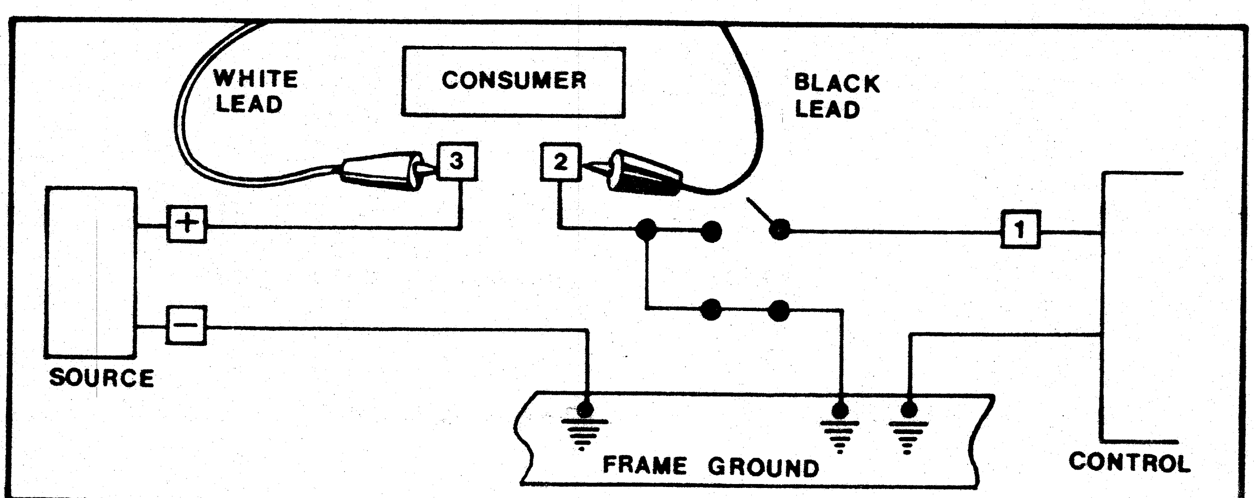


Fig. 11-2

remove the distributor cap for access to wires.

3. **Connect the black and white booted** test leads to the pick-up coil's connector terminals. NOTE: Test leads may be reversed for this test. Make sure that they do not touch ground as this can effect test results.

4. Crank the engine and observe the waveform.

   Anything other than just a **straight line** appearing across the screen indicates that the pick-up coil is good. Fig. 11-3 shows a typical waveform for a **good pick-up coil.**

   Just a straight line on the screen indicates a bad pick-up coil.

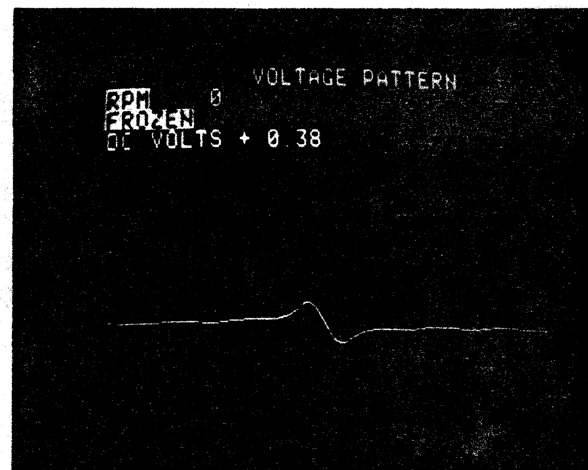


Fig. 11-3

Counselor Feature Modes

FREEZE

The FREEZE mode will freeze any live bar graph or waveform pattern screen for analysis, including expanded waveform patterns. "FREEZE" will appear in upper left hand portion of screen (Fig 12-1).

Press FREEZE to freeze a live screen. Press FREEZE again to return to a live screen.

When a primary or secondary waveform pattern is frozen, the waveform patterns for all cylinders are frozen simultaneously. View the frozen patterns of other cylinders by pressing the keys that correspond to the cylinder numbers.

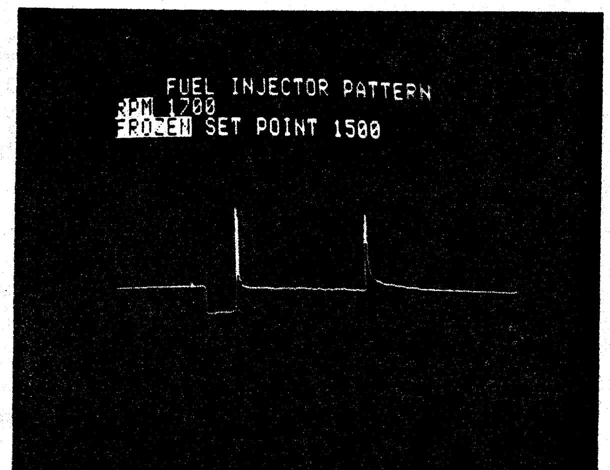


Fig. 12-1

m/SEC CURSOR

The m/SEC CURSOR measures in milliseconds (1/1000 second) the time period of any section of a frozen waveform (Fig. 12-2).

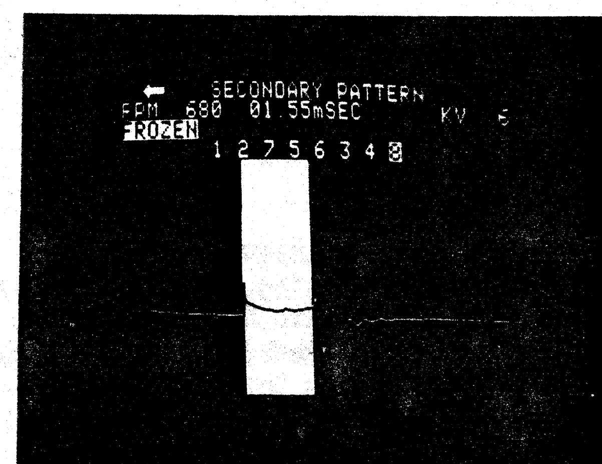


Fig. 12-2

To make the time measurement:

1. With the waveform pattern frozen, press ➡ to move the leading (right) edge of the cursor curtain to the right edge of the portion of the waveform pattern to be measured.

   An arrow will appear in the upper right hand corner of the screen when ➡ is pressed. It signifies that the arrow keys will control the movement of the leading edge of the cursor curtain.

2. Press ENTER.

   When ENTER is pressed, the arrow in the upper right hand corner of the screen is removed and an arrow appears in the upper left hand corner of the screen. It signifies that the trailing edge of the curtain will be controlled by the arrow keys

3. Press ➡ to move the trailing edge of the curtain to the left edge of the portion of the waveform being measured. Read the time measurement.

MEMORY

A frozen screen is automatically stored in MEMORY. The Counselor can retain in MEMORY one frozen waveform pattern and a screen for all three bar graphs (Example: Fig. 12-3). In the Shorting Bar Graph mode, either test screen (cylinder power balance or carburetor balance) may be stored into MEMORY.

When a primary or secondary pattern is in MEMORY, waveform patterns for all cylinders can be called up individually by pressing their cylinder numbers.

To recall any function screen from MEMORY during testing, the screen must be accessed from another screen in a FROZEN or MEMORY mode, or by pressing RESET, 1, and then the desired screen's function key.

If a function screen is called-up when the screen appearing on the scope is not in a FROZEN or MEMORY mode, the requested screen will come up live. If the requested screen is a waveform pattern and there is a waveform pattern in MEMORY, the wave form in memory will be lost. If the requested screen is a bar graph, a bar graph in MEMORY in that function will not be lost unless the screen is unfrozen and then refrozen.

Pressing keys RESET - 2 - RESET clears all function screens from MEMORY.

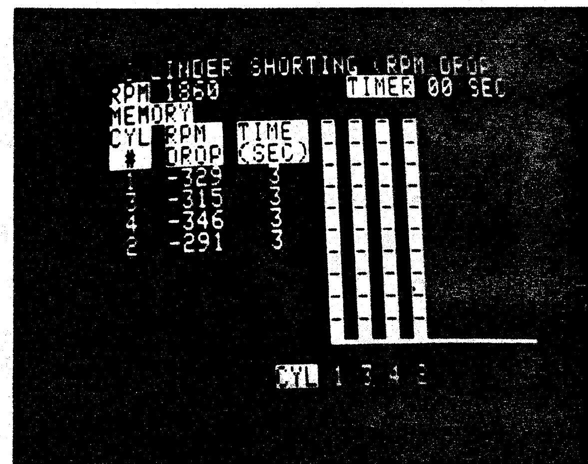


Fig. 12-3

The Counselor will retain frozen screens in MEMORY for at least three (3) days after power (AC or DC) has been turned off.

RPM SET POINT

RPM SET POINT will freeze all live screens, except DWELL and CYLINDER SHORTING bar graphs, at or above any specified engine rpm.

To freeze a screen using the RPM SET POINT:

1. While in a live screen, press RPM SET POINT. RPM SET POINT will appear in upper middle portion of screen (Fig. 12-4).

2. Using the numbered keys, enter the rpm set point. (Numbers entered shift from right to left on display during entry.)

   NOTE: "Keying in" the set point too rapidly can cause a computer entry error. If this occurs screens may be frozen at rpms significantly above or below the set point displayed. Reenter set point if this is observed.

   A set point can be changed prior to pressing ENTER by reentering a new set point.

   Pressing RPM SET POINT prior to pressing ENTER will exit the RPM SET POINT mode.

3. Press ENTER.

   To exit from the RPM SET POINT mode at this point, press RPM SET POINT.

4. Increase the engine rpm. The screen will freeze at or above the specified rpm (Fig. 12-5).

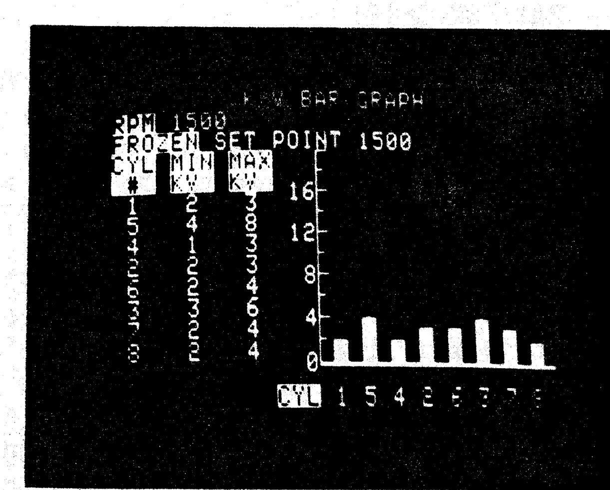


Fig. 12-4

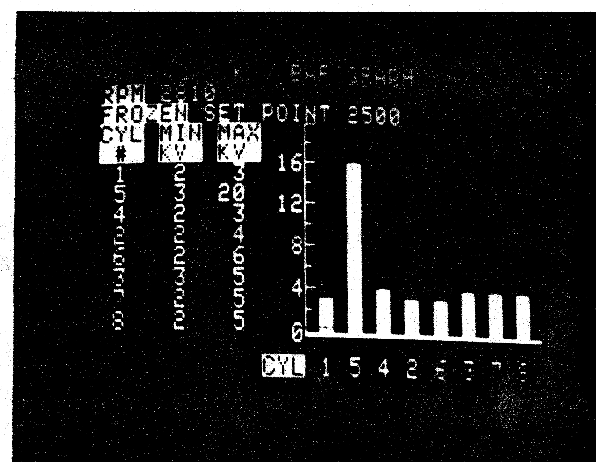


Fig. 12-5

NOTE: The slower you accelerate, the closer you will come to freezing the screen at the specified rpm.

Press FREEZE to return to a live screen; RPM SET POINT will remain, and increasing engine speed to specified rpm will freeze screen.

Exit from RPM SET POINT while in live screen by pressing RPM SET POINT.

PATTERN SHIFT

PATTERN SHIFT repositions the firing section of a primary or secondary waveform pattern from towards the center of the screen to the left side and vice versa (Figs. 12-6 & 12-7).

To shift a waveform pattern "TRIG" must appear in the upper left hand portion of the screen. If "EXPAND" appears in the upper left hand portion of the screen, press ENTER for "TRIG." The STD TRIG key shifts the firing section of the waveform pattern to the left side of the screen and the SPCL TRIG shifts it towards the center.

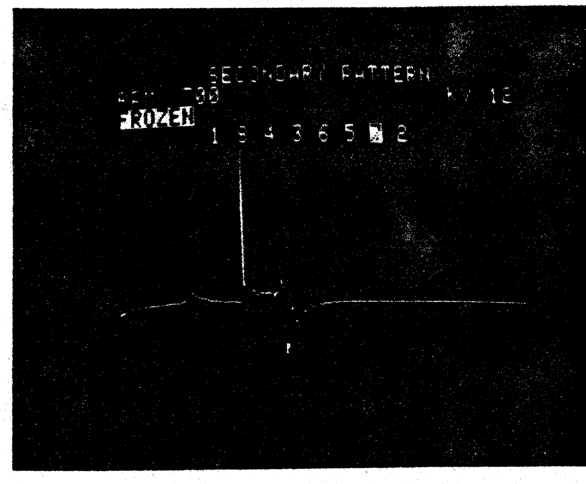


Fig. 12-6

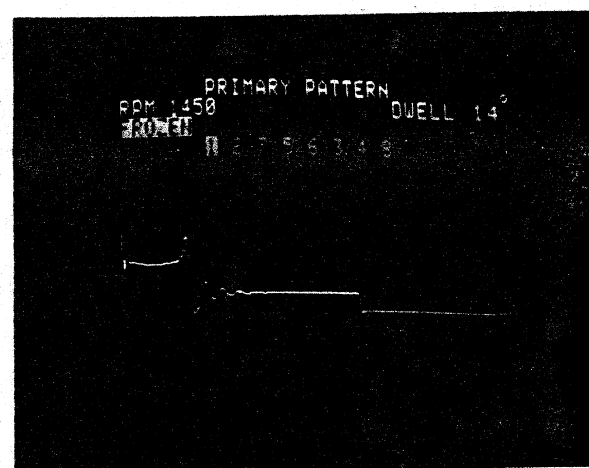


Fig. 12-7

PATTERN EXPAND

PATTERN EXPAND enlarges any waveform pattern for easier viewing (see Figs. 12-8 & 12-9) and/or mSEC time measurements. Only live patterns can be expanded. Expanded patterns can be frozen.

For any waveform pattern, other than a primary or secondary, press ➡ to expand the pattern and ⬅ to reduce an expanded pattern.

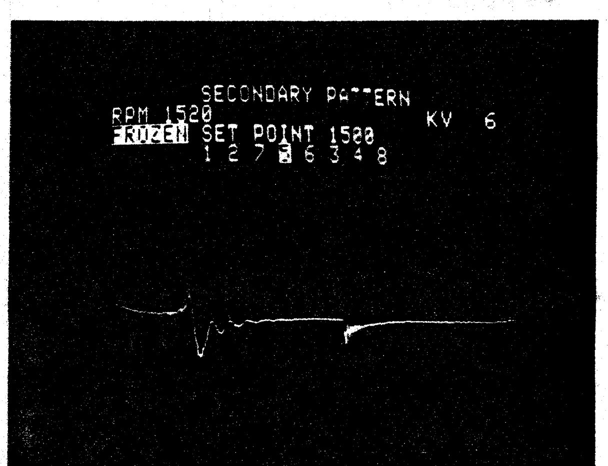


Fig. 12-8

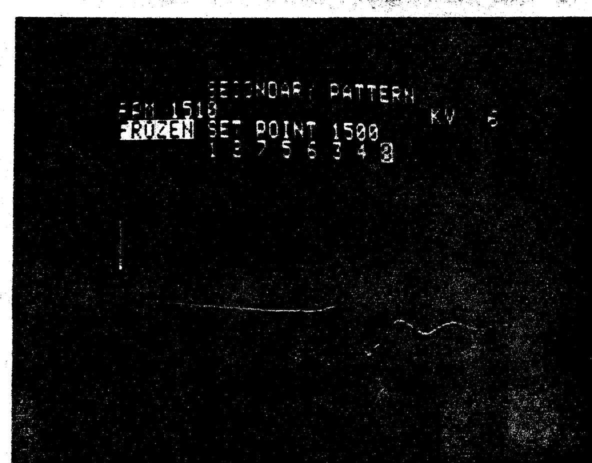


Fig. 12-9

Before a primary or secondary pattern can be expanded, "EXPAND" (not "TRIG") must appear in the upper left hand portion of the screen. Press ENTER to change from "TRIG" to "EXPAND." Then use the arrow keys to adjust the size of the waveform pattern.

CYLINDER SHORTING

While in a live PRI PATTERN or SEC PATTERN any cylinder can be shorted by pressing its number on the key board; "SHORTING" will appear on the screen (Fig. 12-10). The cylinder will be shorted for as long as the key is depressed. The waveform will indicate that the cylinder is being shorted and the rpm reading will normally decrease.

CAUTION: To protect the test vehicle from damages that can occur from improper cylinder shorting, and for best test results, read and follow the cautions listed under Cylinder Shorting Bar Graph (Pg. 7-2) before performing cylinder shorting.

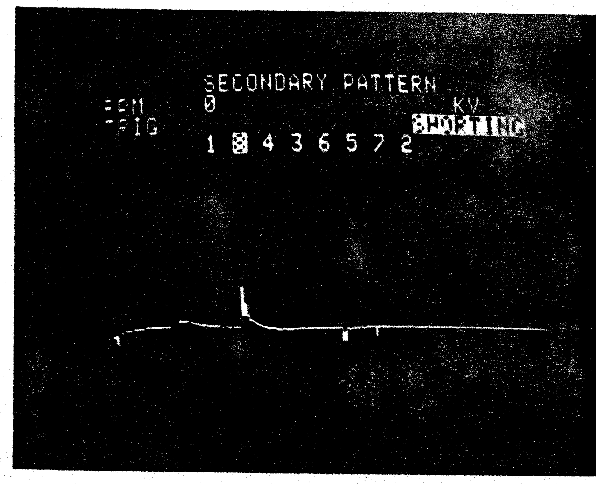


Fig. 12-10

MT1665 MAINTENANCE

ASSEMBLY	FREQUENCY	MAINTENANCE
Keyboard	As required	Clean keyboard using a mild detergent and soft cloth. Do not use cleansing agents such as acetone, benzene, carbon tetrachloride, gasoline, toluene, etc., which are damaging to the keyboard surface. Do not use abrasives which can scratch or mar the display area.
CRT Screen	As required	Same as above.
DC Power Leads	As required	If lead clips become corroded, remove corrosion with a wire brush. Corroded clips may prevent the unit from powering up.
Lead Sets and Pick-Ups	Periodically	Check for loose wires, damaged connectors, chafing of wires and any other damage. Replace damaged lead set or pick-up.
Top of Unit	As required	Wipe top of unit free of dust, dirt or liquids which could drain through the vents and impair the functioning of unit. Do not use the top of the unit as a shelf.
Auxiliary Terminals at back of unit	As required	Be sure terminals are able to make a good connection. Terminals should be free of dirt, rust or other substances which would prevent connection.

ASSEMBLY	FREQUENCY	MAINTENANCE
Inductive Pick-Up	Periodically	Clean core surfaces with CRC LECTRAMOTIVE 05018 CLEANER. Spray surface with plastic tube tip about 1" away. Dry with air nozzle from a distance of 6" or more.
Vent Holes	Periodically	Wipe both upper and lower vents clean of any material which would block air flow through the unit.

SYMPTOM	POSSIBLE CAUSE	CHECKS AND REMEDIES
Screen comes up blank	Intensity control turned down	Turn up intensity control to brighten screen.
	Power cord(s) not correctly attached	Check connection of power cord(s) to unit (back of unit); it should be securely snapped into the unit.
	Power leads not properly connected	If using AC, be sure lead is plugged into good source. If using DC, be sure leads are securely attached to the terminals, and that the polarities of the leads and terminals match.
	Power supply not correctly selected	Switch power supply switch to DC if unit is being powered from car battery. Switch power supply to AC if unit is being powered from wall outlet.
	On/off switch not activated	Trigger the on/off switch under the right front of the unit to the "ON" position.
	No power or improper power to unit	Check circuit breakers at top left of back of unit. AC line voltage must be within $\pm$10% of 120 VAC. DC power supply voltage must be at least 10.5 VDC. Press RESET key.
Waveforms, graphs do not show up on screen	Unit not receiving input signals	Check to see that lead set is correctly hooked up: Black clip to negative battery terminal or good ground. White clip to positive battery terminal, alt. terminal, or voltage test terminal.

(continued)

SYMPTOM	POSSIBLE CAUSE	CHECKS AND REMEDIES
Improper or erratic RPM readings	Bad spark plug wire	Connect inductive pick-up to different spark plug wire or replace wire.
	Inductive pick-up not functioning properly	Check that inductive core is clean (see maintenance). Check that inductive pick-up is fully clamped over wire. If this does not work, replace inductive pick-up.
	Improper engine data entered	Reenter engine data to proper number of cylinders and cycles.
A timing light or test equipment powered from auxiliary terminal will not work	Unit not powered by car battery, or AC power is used and DC power cord is not connected to car battery	Must connect power cord to car battery in order to use timing light. Connect timing light to auxiliary terminals at back of unit. Check inductive pick-up of timing light to be sure it is clamped properly over inductive loop at back of unit.
Screen appears dim or hard to see in direct sunlight	Intensity not properly adjusted	Set intensity control to the desired level for best viewing.
Waveform will not sync	No primary and secondary sync signals being received by scope	Check and reconnect primary lead and/or secondary lead to proper signal source.
Secondary waveform or KV readings are low	Secondary pick-up not clamped properly around wire (capacitive clothespin pick-up)	Make sure the pick-up closes fully around the wire.
	Secondary pick-up not secured or flush to integral coil on HEI distributor	Make sure the pick-up is secured flush to coil pack on HEI distributor.

Leadset continuity test

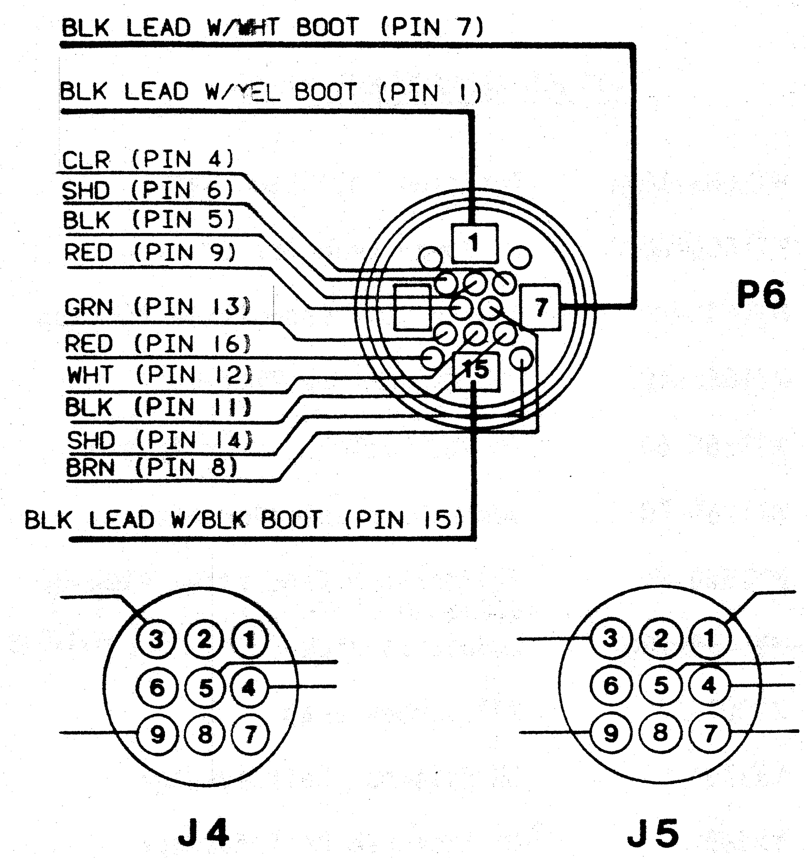
Inductive pick-up - there should be continuity between:
pin 9 of P6 and pin 5 of J4
pin 5 of P6 and pin 3 of J4
pin 4 of P6 and pin 4 of J4
pin 6 of P6 and pin 9 of J4 (shield)

Capacitative pick-up - there should be continuity between:
pin 8 of P6 and pin 4 of J5
pin 16 of P6 and pin 1 of J5
pin 13 of P6 and pin 7 of J5
pin 12 of P6 and pin 9 of J5
pin 11 of P6 and pin 3 of J5
pin 14 of P6 and pin 5 of J5 (shield)

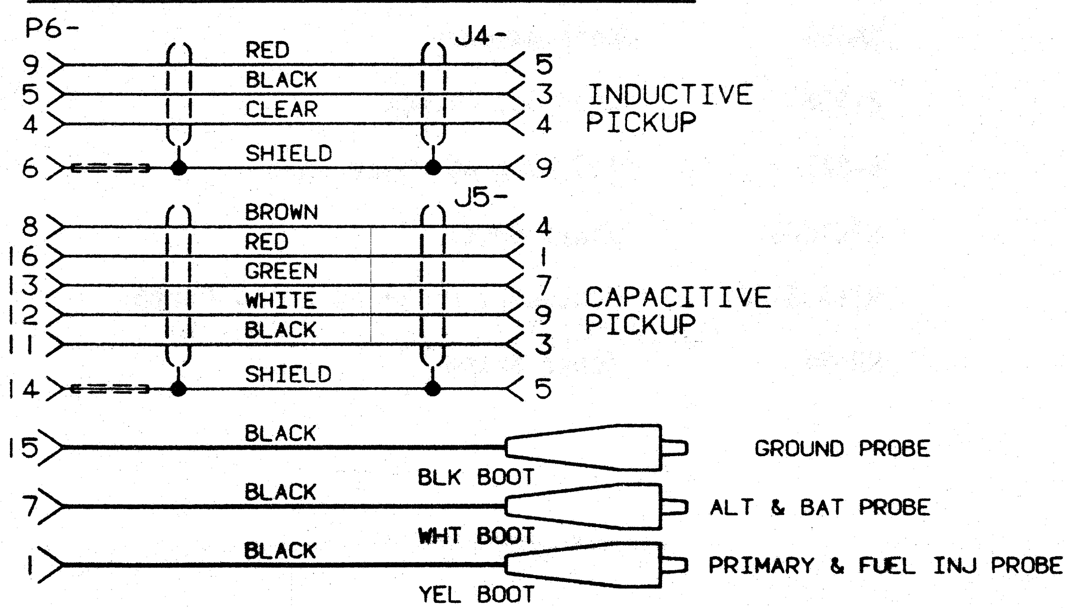
Groundprobe - continuity between pin 15 of P6 and clip in the black boot

Alternator and battery probe - continuity between pin 7 of P6 and clip in the white boot

Primary and fuel injector probe - continuity between pin 1 of P6 and clip in yellow boot



REFERENCE WIRING DIAGRAM



MT1665 REPLACEMENT PARTS

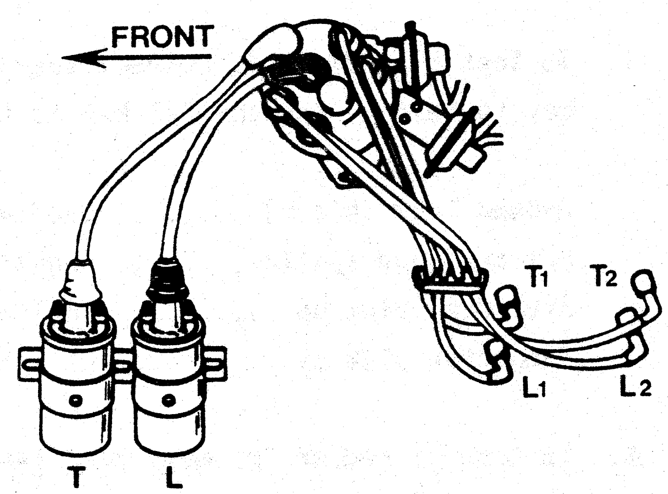
MT1665-10A	Ignition Test Lead Set
MT1665-20	DC Power Lead Set
MT1665-30	Remote Coil Capacitive Pick-Up
MT1665-40	HEI Capacitive Pick-Up
MT1665-60	GM-TBI Fuel Injector Adaptor
MT1665-70	Bosch Fuel Injector Adaptor
MT1665-90	Toyota/Nova Capacitive Pick-up
~~MT1480-100~~	Inductive Pick-Up MT60A08R
MT301-24	24" Jumper Lead
YA376	GM External Coil Adaptor
YA388	GM Micropak Coil Adaptor
YA3870	Ford TFI Coil Adaptor (E-Coil)
YA824A	Spark Plug Pliers
YA859	Coil Adaptor
2-5357	Lead Set Clamps
6-821	120 Volt AC Power Cord
MTC1665	Vinyl Cover
MT1665-300	Accessory Meter Mounting Plate
KR491	Scope Stand

MAZDA ROTARY ENGINES

THE FOLLOWING INFORMATION APPLIES ONLY TO 1974 THRU 1985 MAZDA ROTARY ENGINES. THESE ENGINES ARE EQUIPPED WITH AN IGNITION SYSTEM THAT USES ONE DISTRIBUTOR WITH TWO IGNITION COILS. THE TEST PROCEDURE ON THE BACK PAGE IS NOT INTENDED FOR CYLINDER SHORTING OR DWELL TESTING.

The Mazda Rotary engine is comprised of two sections, each contains a rotating triangular shaped rotor (piston), inside of an epitrochoid housing. Three complete crank revolutions (3 X 360° = 1080°) are completed for one rotor face (moving combustion chamber) to complete the cycle. There are four (4) "strokes" or phases per cycle. Therefore each phase is 1080 - 4 = 270 . Thus, each phase has half again as long a time to be completed as compared to a piston engine at the same RPM. The phases occur simultaneously on all three faces of the rotor.

All engine timing is expressed in crank angle degrees and is referenced to top dead center (TDC), which is minimum volume on the combustion (spark plug) side. This combustion side utilizes two (2) spark plugs for the front section (boot may be color coded blue) and two (2) spark plugs (boot may be color coded black) for the rear section. The bottom spark plugs are referred to as leading side (L) spark plugs and the top spark plugs are trailing side (T) spark plugs. The top front spark plug is T1 and the bottom front spark plug is L1. The top rear spark plug is T2 and the bottom rear plug is L2.



Two spark plugs per combustion chamber are required because of the physical length of the combustion chamber. The two plugs are used to fully ignite the compressed air/fuel mixture for best efficiency.

Two ignition coils are used, a leading coil (L) (boot may be color coded black) and next to it (possibly towards the front of the vehicle) the trailing coil (T). The distributor cap is arranged to allow the leading coil wire in the center and the trailing coil wire on the perimeter in a position that may appear to be like a spark plug wire cap tower. This arrangement is possible because of a multilevel split rotor inside of the distributor.

TO TEST MAZDA ENGINES:

1. Enter the following engine data:

   Cylinders 2
   Cycles 2
   Firing Order 12

2. Select test screen.

3. To test L1 and/or L2, connect test leads as described below. Press the "1" key to test L1 and the "2" key to test L2.

   Ground lead (black) .... good vehicle ground.
   Primary lead (yellow) ...... negative coil terminal of leading coil.
   Secondary pick up .... coil wire of leading coil.
   Inductive pick up .... L1 spark plug wire.

4. To test T1 and/or T2, move test leads as described below. Press "1" to test T1 and "2" to test T2.

   Primary lead (yellow) ...... negative coil terminal of Trailing coil.
   Secondary pick up .... coil wire of Trailing coil.
   Inductive pick up .... to coil wire of Trailing coil.

NISSAN/DATSUN ENGINES EQUIPPED WITH SPARK PLUG SWITCHING CONTROL

The Nissan Anti-Pollution System - Z type engine (NAPS-Z) with the Electronically Controlled Carburetor (E.C.C.) System is used on the Nissan/Datsun Pickup Truck, Stanza, and 200SX 4 cylinder models (except high altitude model at high altitudes and M.P.G. model). The spark plug switching control system is designed to change the ignition system from 2-plug ignition to 1-plug ignition during heavy load driving conditions in order to reduce engine noise.

The ignition system on these engines uses 8 spark plugs with a special distributor cap having 8 spark plug wire outlet terminals and 2 coil wire inlet terminals. Two (2) ignition coils are used, one for the 4 spark plugs on the exhaust side of the engine and one for the 4 spark plugs on the intake side.

Two types of switching control are used.

Type I, is used on Non-California 4WD and 2WD Manual Transmission vehicles. Inputs to the E.C.C. control unit are engine temperature, engine speed, transmission neutral position, clutch engaged/disengaged position. Output from the E.C.C. control unit is through a vacuum switch (detecting full throttle) and then to the Ignition Control (I.C.) unit for spark plug switching control.

Type II, is used on Non-California 2WD M/T Cab & Chassis and Automatic Transmission (A/T) and on all California models. Inputs to the E.C.C. control unit are engine temperature, engine speed, transmission neutral position, clutch engaged/disengaged position, and a vacuum switch detecting full throttle. Output from the E.C.C. control unit is directly to the Ignition Control unit for spark plug switching control .

Spark plug switching control changes from 2-plug operation to 1-plug operation if:

Neutral, clutch or inhibitor switch is OFF
Engine vacuum indicates cranking or full throttle
Engine temperature is over 70°C (158°F)
Engine speed is over 2,400 RPM

Other combinations are possible, to switch from 2 to 1 plug operation and back to 2 plug operation, depending on the engine operating conditions affecting the above four basic inputs.

Using the MT1665 on the Nissan/Datsun E.C.C. System

Two ignition coils are mounted at the right front corner of the engine compartment. The top ignition coil is the Exhaust side (EX) coil and the ignition coil just beneath it is the Intake side (IN) coil. Both ignition coil wires connect to the distributor cap at one side. The distributor cap has 8 spark plug wires, 4 cap terminals facing towards the passenger side of the vehicle labeled I1, I3, I4, and I2, from top to bottom. These 4 spark plug wires connect to the spark plugs towards the intake manifold side of the engine. The other 4 cap terminals face towards the driver's side of the vehicle and are labeled E1, E3, E4, and E2, from bottom to top. Rotor rotation is counter-clockwise.

Connect the MT1665 lead connections as with a standard remote coil application with the following exceptions:

Black to ground
White to battery positive
Yellow to ignition coil negative terminal ("EX" ignition coil)
#1 pick-up to #1 spark plug wire (on "E1" spark plug wire)
Secondary pick-up to coil wire ("EX" coil wire)

Connecting in this manner will allow the Primary and secondary circuits on the exhaust side to be examined .

To observe the Primary and Secondary circuits on the intake side connect as follows.

Black to ground
White to battery positive
Yellow to ignition coil negative terminal ("IN" ignition coil)
#1 pick-up to #1 spark plug wire (on "I1" spark plug wire)
Secondary pick-up to coil wire ("IN" coil wire).

To perform cylinder balance or cylinder shorting, connect a jumper wire from the negative terminal of one ignition coil to the negative terminal of the other ignition coil. Then connect:

Yellow lead to either one of the ignition coil negative terminals
Black to ground
White to battery positive
#1 pick-up to #1 spark plug wire (on "I1" spark plug wire)
Secondary pick-up to coil wire ("IN" coil wire).

Snap-on. Counselor® Update

When testing General Motors High Energy Ignition (HEI) systems with the MT1665, several abnormal screen conditions may occur:

1) No dwell number on the primary pattern screen.

2) No dwell numbers or bars on the dwell bar graph screen.

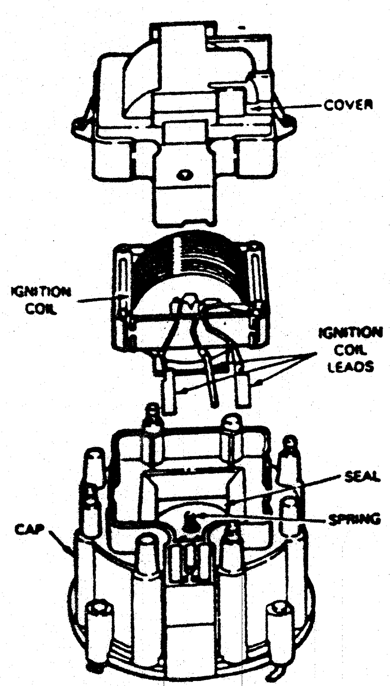
3) "Jittering" waveforms and/or bar graph screen.

4) Low readings on the kV Bar Graph screen.

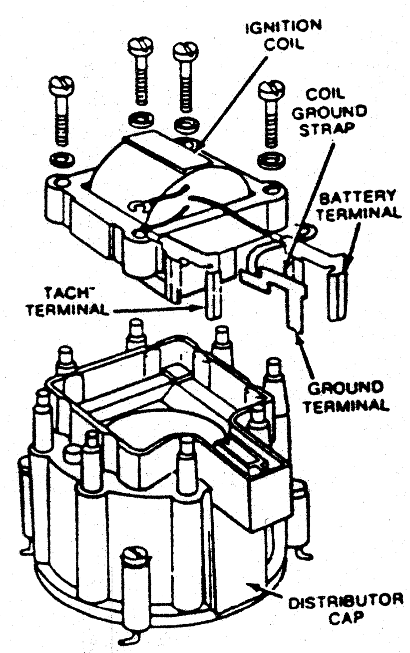
These conditions may be caused by an integral or remote ignition coil that is improperly grounded or with reverse polarity. This can occur when the ignition coil is improperly installed, connected, or with a disconnected or missing ground strap (integral coils only). This condition may be the result of an integral ignition coil that has been installed without the ground terminal (middle spade terminal of the three terminals) to the 3 wire harness connector in the distributor cap (access to this terminal may require ignition coil removal).

NOTE: With reversed coil polarity, waveforms will usually appear inverted or attempting to invert. Also, screen lock-up with a partial waveform may be displayed.

Correct the above condition(s) as necessary and check to see if the scope returns to proper operation. If not, press RESET. In some instances, it may be necessary to shut off the power switch (a short cool-down period may be necesary), and return it to the "ON" position.



When coil is in cap, remove screws, cap, and primary wires. Then, new coil can be installed in cap. Make sure wires are connected properly.



Properly Installed Coil Ground Strap

XX

X