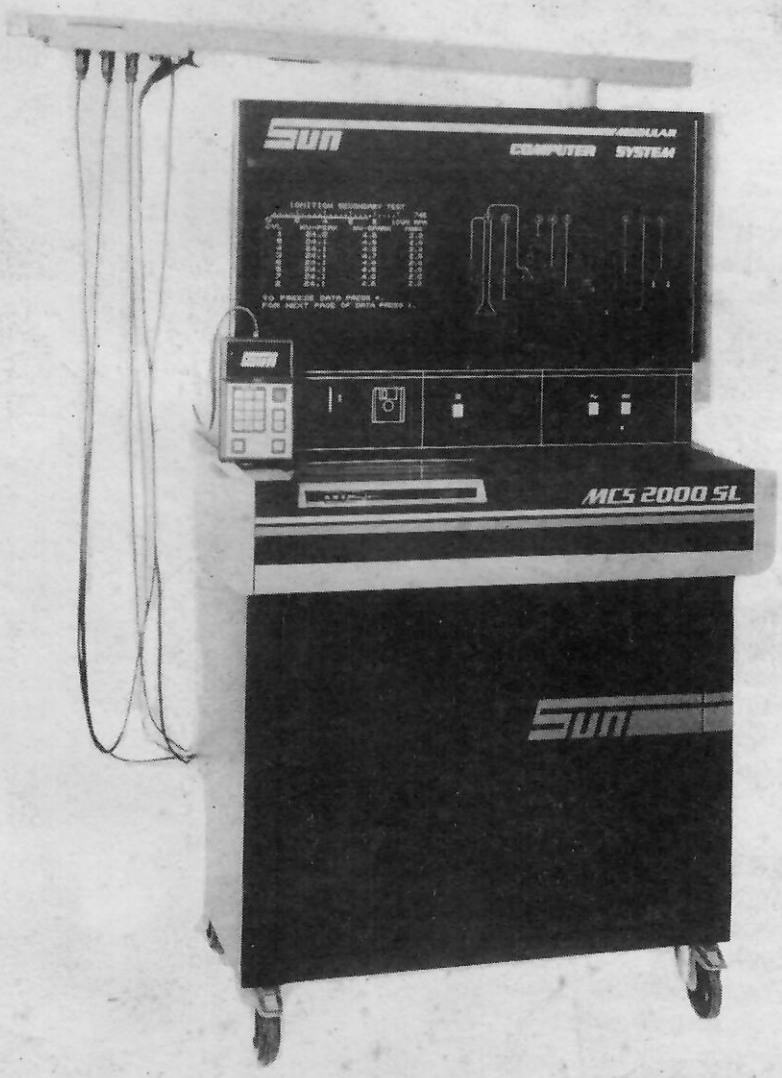
OPERATORS MANUAL



MCS 2000

CONTENTS INDEX

CONTENTS INDEX

CONTENTS INDEX

SECTION ONE
INTRODUCTION

1.01 GENERAL

The Modular Computer System, MCS 2000, shown in figure 1 : 1 is a diagnostic engine analyser capable of testing and diagnosing virtually any domestic or import vehicle engine as well as many related vehicle systems. The system's operational programme and vehicle specification and diagnostic programme are contained on a single 3.5" floppy disk. The computer Analyser's primary modes of operation include those shown in figure 1 : 2.

* Complete Engine Test	* Scope Functions
* Multimeter Testing	* Pinpoint Testing
* Adjustment Sequence	
* Lead Connections	* On-Board Computers (with optional STL-2)
* Service Utilities	

FIGURE 1:2

The 'MCS 2000' is microprocessor controlled and electronically self-calibrating. Testing is accomplished through:

> A 19" 'VDU' displays all digital data and converts to a full data and lab oscilloscope to provide pattern waveforms for injection, alternator and injection systems.

> The 'VDU' displays plain language instructional messages which provide full assistance in the analyser operation.

> The hand remote control allows operation of both the Oscilloscope and 'VDU' from the driving seat or within the confines of the engine compartment.

Each of the analyser's features and functions are covered in detail within the following sections of this operator's manual. The Analyser's standard and optional test capabilities and hardware are shown in figures 1:3 and 1:4. Refer to "Accessories" for a listing with part numbers of standard and optional accessories.

MCS 2000 Test Capabilities

STANDARD

* RPM
* Dwell
* Strobe Timing
* Magnetic Timing
* Battery & Distributor Volts
* Scope volt/kilovolt/milliseconds
* Pinpoint volt/ohm
* CO:HC:CO^2:O^2 Emissions Module
* Amps and Vacuum
* Oil Temperature

OPTIONAL

* Measurement of Diesel RPM & Timing
* On-Board Computer Management Testing

FIGURE 1:3
Standard and Optional Test Capabilities

MCS 2000 Hardware

STANDARD

* Analyser Console
* Remote Control
* Test Lead Boom
* Serial I/O Port
* Leads, connectors and adaptors
* Four Gas Infra-red Exhaust Analyser
* High Speed 80 Column Printer

OPTIONAL

* Sun Test Link - STL/2
* Diesel RPM and Timing

FIGURE 1:4
Standard and Optional Analyser Hardware

1.02 SAFETY PRECAUTIONS

The following precautions must always be observed when conducting automotive testing

1. Exhaust gasses contain carbon monoxide which is an odourless and colourless lethal gas. Always work in a properly ventilated area.

2. Petroleum fumes are explosive. Do not smoke where petrol is present.

3. Wipe up petrol spills immediately and dispose of soaked rags in proper airtight containers. Always stop leaks and clean spills immediately.

4. Check the engine oil level and add oil if necessary before testing. A vehicle should not be tested if the oil level is low.

5. Check the coolant level before testing. A vehicle should not be tested if the coolant level is low. If the engine is hot, check the level on the overflow tank.

CAUTION: Do not open closed coolant systems while the fluid is hot.

6. Do not wear loose clothing or a necktie near an operating engine. Keep hands and hair away from moving engine parts, such as fan blades, belts or pulleys.

7. Be particularly careful not to operate the timing light too near the fans or belts. The timing light may have the effect of making the fan appear to "stand still". This is a dangerous optical illusion which may cause the operator to contact the fan.

8. Safety goggles should be used when working on a vehicle to protect eyes from acid, dust, petrol or other objects which may fly off moving parts.

9. Ear mufflers should be worn when using your English Analyser in conjunction with a high speed rolling road. All other precautions advised with the rolling road should be carried out.

10. Never look directly into the carburettor venturi when cranking or running an engine. Backfiring may cause severe burns.

11. Never wear wrist watches, rings or other jewellery when working on a vehicle. Such items may catch on moving components or cause electrical short circuits, burning the wearer.

12. Avoid contact with hot surfaces, such as exhaust manifolds and pipes, silencers, catalytic converters, radiators and hoses.

13. Do not lay tools or equipment on the battery. Accidental earthing of the battery terminals may cause shocks or burns, damage to wiring or damage to the battery itself. Battery acid can damage clothing and burn skin or eyes. If you contact battery acid, wash with as much water as possible and use a weak soda (such as baking soda) to neautralize the acid. If acid enters the eyes, consult a doctor immediately.

SAFETY PRECAUTIONS (continued)

14. Hydrogen gas is produced by automotive batteries. Flame or sparks near the battery may cause it to explode.

15. A fire extinguisher should always be kept in the work area. The extinguisher should be suitable for a range of uses, including, petrol, chemical and electrical fires.

16. Extremely high voltage is present in the secondary side of the ignition system. Always use insulated pliers when handling ignition system components whilst the engine is running.

17. Always ensure that the vehicle gearing is neutral or park and place wheel chocks in front of and at the rear of the drive wheels before testing a vehicle.

1.03 OVERVIEW

Operator VDU Messages

The MCS 2000 operates entirely through individual display screens, called "pages", which appear on the Video Display Unit, commonly referred to as a 'VDU'. A "menu" page contains a list of options from which the operator is prompted to make selections. To make menu selections, and to advance from page to page, the operator follows the prompt messages which appear on two lower lines of the 'VDU'. Prompt messages usually ask the operator to make an entry using the remote control or to alter testing arrangement such as 'Crank Engine' or 'Increase Engine Speed'.

Programme Menu

The analyser's primary menu is the 'PROGRAMME SELECTION' page (Figure 1:5), which contains six options. Brief descriptions of each option's purpose and principle features appear in the following sections and paragraphs. The 'PROGRAMME SELECTION' page can be reached at any time by pressing the [P] key once or twice, depending where you are in the programme. To select an option on the Programme Menu, press the cursor [>] key on the hand control a sufficient number of times to align with the selected line on the menu command. Alternatively, press the [+/—] key to operate the cursor in the reverse direction.

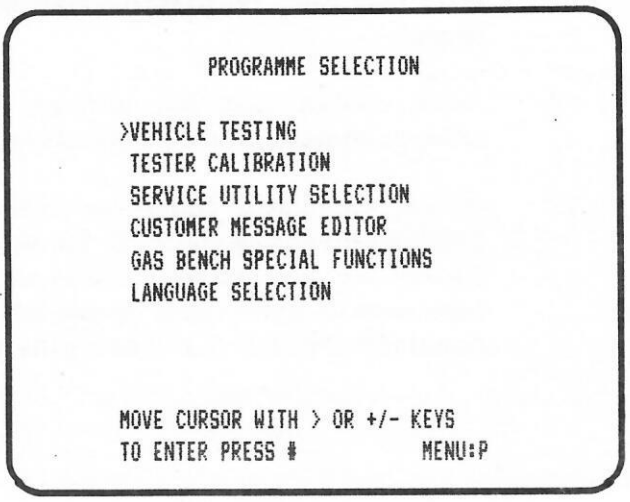


FIGURE 1:5
Programme Selection Menu

SECTION TWO
HAND CONTROL

2.01 GENERAL

The 'MCS 2000' is totally operational from the wired hand control (Figure 2:1), and all forms of operator entry on the computer are performed by using the key commands. The better acquainted you become with the command keys, the more proficient you will become in using the computer and conducting vehicle testing.

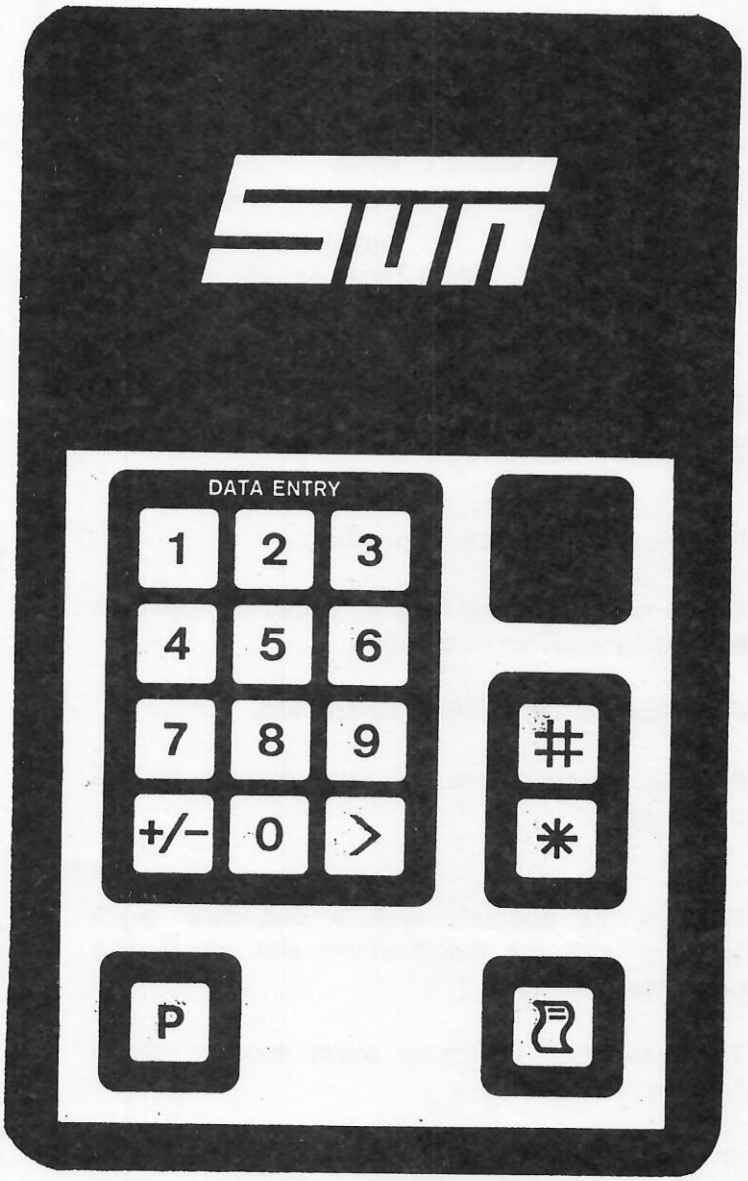


FIGURE 2:1
Hand Control

The hand control is powered from the 'MCS 2000' and therefore will not require separate battery power.

Keyboard Commands

[P] Programme Select Key

[>] Cursor Key

[#] Proceed Key

[*] Hold/Freeze Key

[0] to [9] Function/Data Entry Keys

[+/–] Repeat Key

[/=/] Print Key

[ ] Engine Kill Key

During vehicle testing and dependent on the test programme selected, the 0-9 function/data keys serve as functional information keys. Depressing Key No. [2] will always show a help page for the operator. Different help messages will be shown depending on the area of programme being used.

Key Definitions

The following are the definitions of the Function/Data keys (0-9) whilst using "Vehicle Testing" programme.

The on-screen menu shown in Figure 2:2 is available by pressing the (0) key.

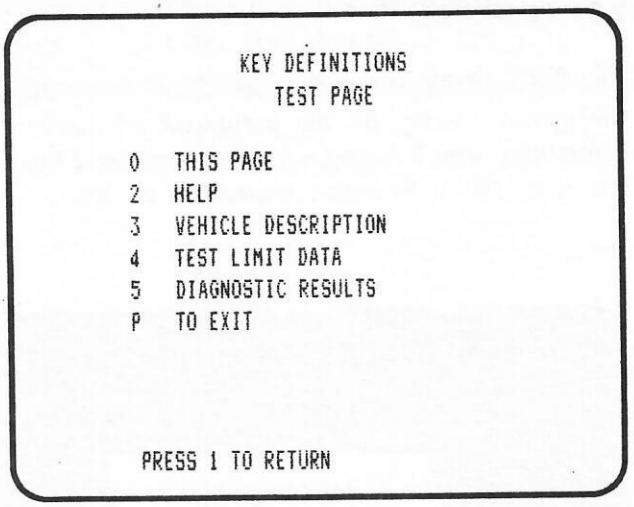


FIGURE 2:2
Vehicle Testing Key Definitions

(0)	This page.	By pressing (0) whilst using the "Vehicle Testing" programme, the screen will show the menu, figure 2:2.
(1)	Test Data.	Returns to the test page in question.
(2)	Help.	Shows on screen any help messages applicable to the testing sequence in question.
(3)	Vehicle Description.	Provides detail of the vehicle under test.
(4)	Vehicle Limit Data.	Provides specifications of the selected vehicle under test.
(5)	Diagnostic Results.	Provides the operator with a diagnostic guide together with the specifications and actual data under test.
(P)	Abort Test.	To discontinue testing or select another vehicle for test.

Scope Function (Running Mode)

The following are the definitions of the Function/Data keys (0-9) whilst using the "Scope Function" in 'Running' mode. (Figure 2:3).

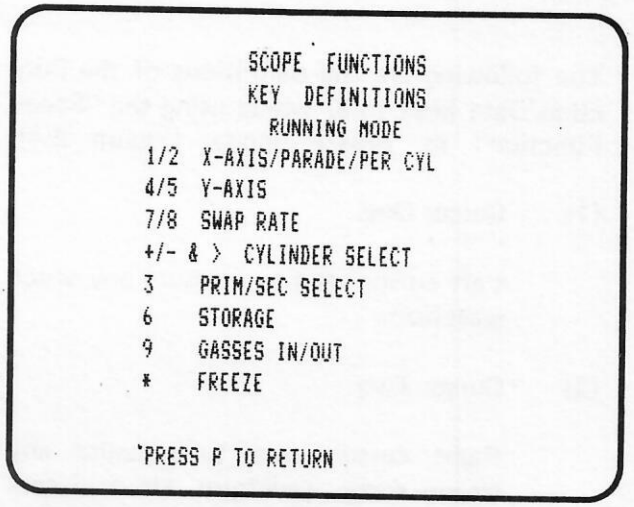


FIGURE 2:3
Running Mode Key Definitions

(1) X-axis (Increase Scale)

Alter the horizontal scale to higher voltage range for Primary and Secondary testing.

(2) X-axis (Decrease Scale)

Alter the horizontal scale to lower voltage range for Primary and Secondary testing.

(3) Primary or Secondary

Secondary automatically selected, pressing once will select primary scale, pressing again reselects secondary scale.

(4) Y-axis (Decrease Scale)

Alter the vertical scale to longer time scale for Primary and Secondary testing.

(5) Y-axis (Increase Scale)

Alter the vertical scale to shorter time scale for Primary and Secondary testing.

(6) Storage

Pressing this button will store up to a maximum of 32 oscilloscope patterns from the selected testing area. Thes patterns may then be reviewed at leisure for intermittent misfires or similar. To recall the stored oscilloscope patterns, press the key marked (*).

(7) Swap Rate

To select each cylinder for speed of viewing. The mode will automatically select continuous, pressing once will pause each cylinder for one second. Pressing a second time will pause each cylinder for two seconds. Pressing a third time will return to continuous rotation.

(8) Swap Rate

As number seven but in reverse.

(9) Gasses In/Out

Pressing once will display live exhaust gas data in the top right of the oscilloscope. Pressing again deletes exhaust gas data from the screen.

(*) Freeze

Freezes the display in any scope testing mode.

Scope Function (Freeze Mode)

The following are the definitions of the Function/Data keys (0-9) whilst using the "Scope Function" in 'Freeze' mode. (Figure 2:4).

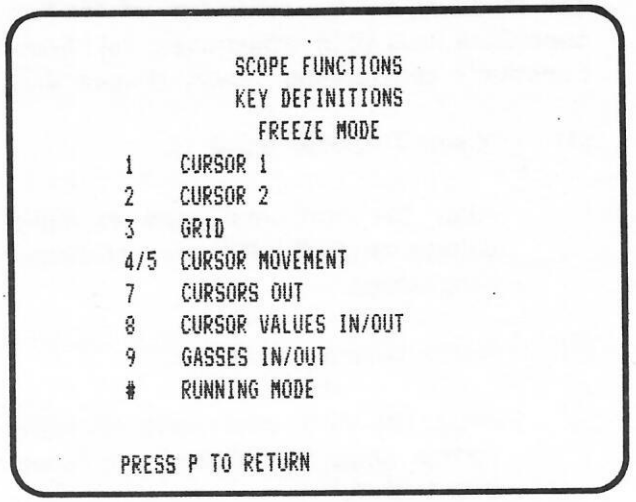


FIGURE 2:4
Freeze Mode
Key Definitions

(1) Cursor One.

Left cursor used to measure any scope waveform.

(2) Cursor Two.

Right cursor used to measure any frozen scope waveform. Used in conjunction with cursor one as measurements required are usually between the two cursor positions selected.

(3) Grid. Pressing this key displays a grid on the oscilloscope to assist with measurement.

(4) Left Cursor Movement. Moves either cursor one or two to the left.

(5) Right Cursor Movement. Moves either cursor one or two to the right.

(6) No operation in this mode.

(7) Cursors Out. Deletes the cursors from the oscilloscope.

(8) Cursor Values In/Out. Pressing this key once will display the difference between the cursor measurements in the top right of the oscilloscope. Pressing a second time deletes the measurements.

(9) Gasses In/Out. Pressing once will display stored exhaust gas data in the top right of the oscilloscope. Pressing again deletes exhaust gas data from the screen.

(#) Running Mode. Returns the oscilloscope to the running mode. This will also cancel any cursor measurement or gas data shown in the top right of the oscilloscope.

2.02 OVERVIEW OF HAND CONTROL

	FUNCTION or DATA ENTRY	VEHICLE TESTING	SCOPE RUNNING	SCOPE FREEZE
1	1	Return to Previous Page	Increase 'X' Axis	Enter Left Cursor
2	2	Help	Decrease 'X' Axis	Enter Right Cursor
3	3	Vehicle Description	Primary or Secondary	Scope Grid In/Out
4	4	Vehicle Limit Data	Increase 'Y' Axis	Move Cursor to Left
5	5	Diagnostic Results	Decrease 'Y' Axis	Move Cursor to Right
6	6		Pattern Store	
7	7		Swap to Faster Rate	Delete Cursors
8	8		Swap to Slower Rate	Cursor Values In/Out
9	9		Gasses In/Out	
0	0	Key Definition Menu		
P	Return to PreviousTest	Abort Test	Return to PreviousTest	
#		Continue to Next Section		Unfreeze Scope
*		Hold or Save Data	Freeze Scope	
>	Menu Selection Down		Select Next Cylinder	
+/-	Menu Select Up	Cancel and Retest	Select Last Cylinder	
/=/	Print Screen			
	Kill Ignition			

SECTION THREE
BASIC INSTRUCTIONS

3.01 GENERAL

Section two contains information and instructions which are used throughout the analyser's operation. Information presented here may be used as often as you wish. You should become familiar with these ground rules so that when you begin actual vehicle testing, you can proceed quickly and confidently.

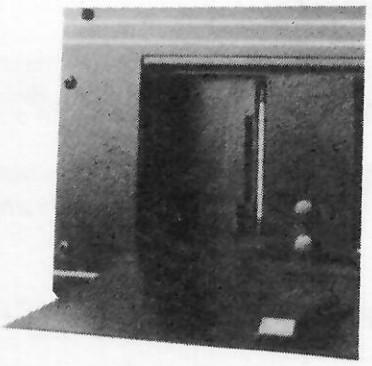


FIGURE 3:1
MCS 2000 Disk-Drive

Getting Started

After providing power to the "MCS 2000" by connecting the power cable to a correctly earthed electric socket, turn on the Computer, pressing the main power switch located on the front panel of the tester.

Booting the System

To prepare the 'MCS' for operation, you must first install the main system software disk in the standard 3.5 inch disk drive located behind the tester front door panel to the left of the tester front panel (Figure 3:1). The main system software disk should be inserted vertically with the drive label to the right until latching into position. The 'VDU' will show on the bottom line the instruction, "INSERT DISK AND PRESS ANY KEY". This will cause the computer system to cycle and load the operating programme in to the 'MCS 2000' memory. The loading process or "booting" of the 'MCS 2000' will take a few moments and various computer control readings will be shown on the 'VDU' until completion takes place.

When the computer finishes the loading process, the 'VDU' will shown 'TESTER WARM UP" page (Figure 3:2) together with "TESTER READY" information. A countdown clock will show the duration of time left for the infra-red exhaust analyser to reach normal testing efficiency. This instruction should always be obeyed when switching on for the first time each day. If the computer has been temporarily switched off, for example, to move to another test bay area, then you can if desired press the proceed [#] key after a countdown of two minutes.

TESTER WARM UP

TESTER READY IN 15:00 MIN.

COPYRIGHT (C) 1989
SUN ELECTRIC EUROPE BV
ALL RIGHTS RESERVED

FIGURE 3:2
Tester Warm-Up

The computer will automatically enter a calibration routine after the expiry of fifteen minutes (or pressing [#]) and the operator should ensure that the computer's harness and leads are not connected to the vehicle for this operation. An instruction on the 'VDU' will prompt the operator to ensure that all leads are disconnected.

After the computer has been successfully powered-up and the disk correctly installed, other basic instructions are necessary before performing vehicle testing.

Floppy Disks

Floppy disks should be kept clean and dry, and should be stored in the disk compartment located to the right of the main disk drive (Figure 3:1).

CAUTION: *Magnetic materials, such as magnetised screwdrivers, electric motors, coils, HEI distributors, etc., should be kept away from all disks to prevent damage.*

Every reasonable precaution has been taken to ensure the accuracy of the information stored in this system, but no responsibility can be accepted by SUN ELECTRIC for any inaccuracies.

3.02 DATA PRESENTATION

Data is primarily collected through the test leads with the 'VDU' being the communication between you and the 'MCS 2000'. Data is displayed on the screen in a format which resembles a page. Therefore, displayed data on the 'VDU' is also called a "page". A test which is more than one page long is called a "test sequence" because of its sequence of events.

The data for each page or test sequence is collected under different conditions and pages are titled according to the different test conditions (i.e., Cranking, High Cruise, Idle, Secondary, Cylinder Comparison etc.). In all 'VDU' displays, graphics play an important part to convey information to the operator which can be easily distinguished at a glance. When testing using the MCS 2000 with vehicle limits, the test results will have adjacent to them graphics such as; ; = ; ^ ; ;. The symbol ' = ' indicates immediately to the operator that the test result is within the given specification or tolerance normally quoted by the manufacturer. Should the test result show ' ^ ' this would show the result as being above specification and correspondingly the ' ' would indicate that the result is below specification.

Do not forget that if the display shows either ; ^ ; ;, by pressing key [5] will give a diagnostic result for the detail of specification and by pressing key [4] will display the specifications of the vehicle in question.

Display Format Features

1. All pages are titled according to the type of test being performed.

2. Bar graphs are located at the top of many test pages. The bar graph is labelled (i.e., RPM or VOLTS etc.). The specific tolerance range is defined with high and low specifications. This range is referred to as a "window" and will be indicated on the bar graph as:

" . ! . > . . ! . < . . ! . "

(See Figure 3:3).

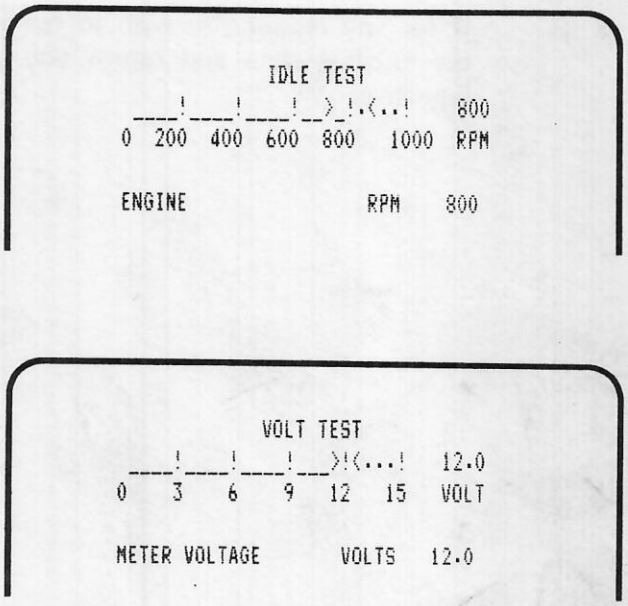


FIGURE 3:3
Sample of Upper VDU Bar Graphs Showing RPM & Volt Scales

3. The limits page (key [5]) shows "Min/Max" specifications. If no minimum or maximum specification exists, then the area will be left blank.

4. In some instances, the results during test will not be displayed until the data is collected by pressing key [*].

5. Out of limit results will be displayed with an indicator up/down arrow as mentioned in 'Data Presentation'. If the data has already been frozen, pressing key [+/—] will unlock the page and allow adjustments to be executed. Once adjustments correctly executed, the up/down arrow will change to ' = '. By pressing key [*], the updated results will be saved and any diagnostic messages previously shown will be cancelled.

6. All types of ignition timing will be recorded whether using the timing light or magnetic principle.

Note: When operating in the magnetic timing mode, the timing signal will be over-ridden by the timing light if used.

7. In test sequences where the engine is running, the results will be updated every few seconds. This process is continuous until you either press freeze the data or continue to the next test area, key [*]. During the updating process, the data is curent and therefore considered 'live'.

8. When performing some tests, the prompt will advise you to press key [1] for further information. This is a test sequence, and in most cases will show 'live' data until you are prompted to press key [*].

9. If for any reason you wish to re-run any test page, press key [+/—] which will clear the existing data and return you to the beginning of that particular test page or sequence.

3.03 MENUS

Another operational function you will use frequently in virtually all phases of analyser operation is a Menu. The menu's are presented in three forms:

1) Main Menu — PROGRAMME SELECTION

2) Sub Menu — VEHICLE TEST SELECTION

3) Test Menu — WORKSHOP TEST SELECTION

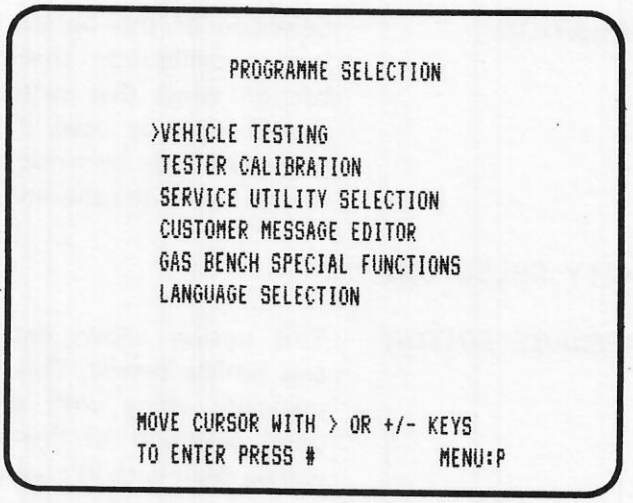


FIGURE 3:4
Programme Selection Menu

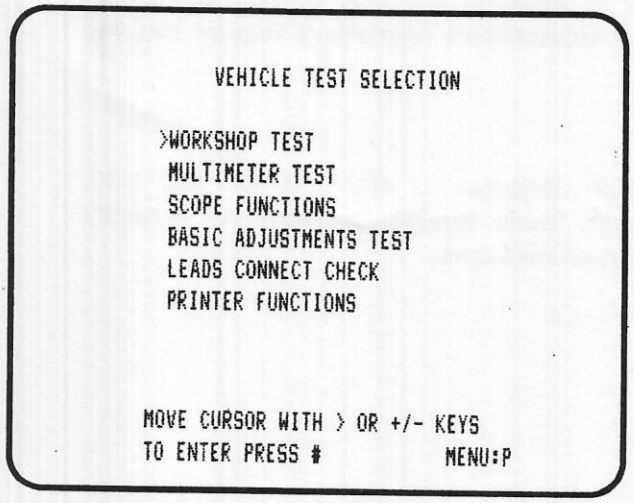


FIGURE 3:5
Vehicle Test Menu

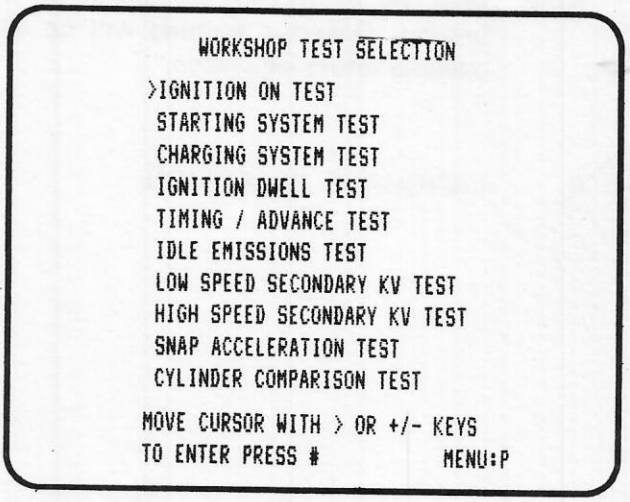


FIGURE 3:6
Workshop Test Menu

3.04 PROGRAMME SELECTION

Programme Selection (Figure 3:4) is the primary list of tester operations from which you may choose any one, of the test sequences available to you. The "PROGRAMME SELECTION" Menu should be the starting point of any test sequence you choose.

1. VEHICLE TESTING

Selection of this option gives the operator a secondary menu with a choice to select a vehicle by model, or whether to select a vehicle by code number, or simply to test a vehicle not using any specifications at all. In essence, this option gives access to all parameters of engine testing and will be dealt with under paragraph heading "Vehicle Test Selection".

2. TESTER CALIBRATION

Selection of this option enters the computer into a calibration check as the initial calibration when first switched on. This option should also be used if the initial warm-up procedure was over-ridden thus not allowing the gas bench to calibrate.

3. SERVICE UTILITY SELECTION

4. CUSTOMER MESSAGE EDITOR

This option allows data entry of customer and vehicle details. This will be printed automatically along with any diagnostic report upon selection of Printer Functions, which will be dealt with in a subsequent section.

5. GAS BENCH SPECIAL FUNCTIONS

This option is for Service use only and should not be selected. If inadvertently selected, press key [P] to return to Programme Menu.

Note: Incorrect adjustment invalidates gas bench information and may prevent tester calibration. Operator training will be given if Government regulations require this for possible future legislation.

6. LANGUAGE SELECTION

English language is standard for the U.K. market. Some foreign languages are available as option packages.

Vehicle Testing

If "VEHICLE TESTING" is selected from the main menu (Figure 3:4), this will generate a secondary menu of the same name, "VEHICLE TESTING" (Figure 3:7) and ask the operator three further questions:-

1.	VEHICLE SELECTION	Choice of this option allows the operator to choose from various lists, the details of the vehicle presented for test. (i.e., Make, Model, Year, c.c., etc.).
2.	VEHICLE CODE NUMBER ENTRY	Choice of this option allows the operator to enter a code number applicable for the vehicle presented for test.
3.	VEHICLE ENTRY WITHOUT LIMITS	This choice is an identical programme to selection one or two but does not operate to any vehicle specification.

After choosing one of the above options, the computer will ask for a specified disk relating to the vehicle under test. Once the disk has been inserted in the disk drive, the computer will continue with the message on screen, 'Tester Loading Vehicle Data'.

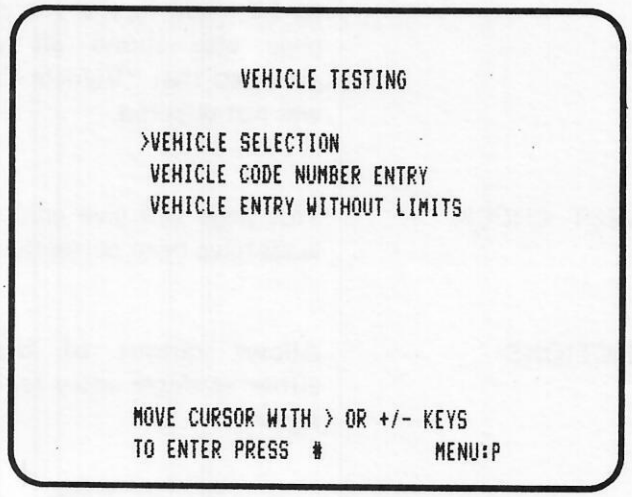


FIGURE 3:7
Vehicle Testing Menu

Vehicle Test Selection

Having selected the choice of vehicle presented for diagnosis, the computer will issue one further menu, "WORKSHOP TEST SELECTION" (Figure 3:6) and this now gives the operator a choice of single area testing to a full diagnostic test.

1.	WORKSHOP TEST SELECTION	This choice will be divided in to ten engine test areas (Figure 3:6). The operator may choose any one of the ten, in any order, but it should be understood that if a full diagnostic test is to be carried out, then the order of menu is the order of testing priority.
2.	MULTIMETER TEST	This will give the operator all 'live' functions spread on three pages. Page one shows mainly electrical current and ignition coil. Page two shows timing and emission and finally page three leaves the operator with a full volt/ohm meter for assorted pinpoint testing.
3.	SCOPE FUNCTIONS	Places an oscilloscope on screen with fully functional primary, secondary, alternator and lab scope.
4.	BASIC ADJUSTMENTS TEST	Allows adjustment of all basic engine functions to be made in the correct logical order. This page also shows all vehicle specifications provided that "Vehicle Entry Without Limits" was not selected.
5.	LEADS CONNECT CHECK	This page will give guidance whether the test leads have been correctly connected.
6.	PRINTER FUNCTIONS	Allows output of diagnostic information either as single entry reports or full diagnostic reports.

Workshop Test Selection

On all pages during the "WORKSHOP TEST SELECTION" (Figure 3:6), continuous monitoring of RPM and engine oil temperature will take place.

1.	IGNITION ON TEST	Measures parameters to ensure that battery and ignition supply are in good order and capable of continuing with further tests.
2.	STARTING SYSTEM TEST	Measures battery and starter circuits under load and continues to update ignition supply under cranking conditions. Also checks compression electronically and checks to see if enough fuel is available to supply engine requirements.
3.	CHARGING SYSTEM TEST	Measures output from alternator and generator under load together with regulator voltages.
4.	IGNITION DWELL TEST	Measures dwell angles and movement between idle and cruise speeds to indicate excess wear in distributor base plates and drive arrangements.
5.	TIMING/ADVANCE TEST	Measures base timing with mechanical and vacuum advance curves, including vacuum retard systems where applicable.
6.	IDLE EMISSIONS TEST	Measures three exhaust gasses and compares results between idle and cruise settings.
7.	LOW SPEED SECONDARY KV TEST	Captures secondary KV readings at idle and compares with exhaust gas analysis.
8.	HIGH SPEED SECONDARY KV TEST	Captures secondary KV readings at cruise speed and compares with test seven to diagnose any defects in secondary ignition system.
9.	SNAP ACCELERATION TEST	Checks fuel enrichment and spark plug and HT wire condition under load.
10.	CYLINDER COMPARISON TEST	Checks each cylinder individually for power performance together with changes to RPM and unburnt fuel readings.

Example:

If it was felt necessary to check only the High Tension circuit of an engine under test, as it is obvious that a misfire is occurring in this area, then whilst selecting key [8] would provide information it would be prudent to start vehicle testing at key [7] which would automatically continue through [8] and [9] upon completion of each test. With these three tests complete, by pressing key [5] a diagnosis would appear on screen with a valuation of any repair necessary to overcome the misfire problem. After initially selecting key [7], try pressing key [2] (Help). The information contained on screen will advise the operator of the minimum connections required to conduct the test and how the test should be conducted.

3.05 LAB SCOPE

Finally, one further menu will come to light when using the lab scope (Figure 3:8). The list of options allow for easier access to the different parameters of test and sets up both the X-axis and Y-axis to the most ideal settings for the given test requirement.

1.	STANDARD SETTING	This will give a standard setting on which to base any lab-scope test. Both X and Y axis with trigger slopes can be altered.
2.	DUTY CYCLE	Use this page for testing idle speed control valves.
3.	INJECTOR	Use this page for testing opening periods of all electronic fuel injectors.
4.	IDLE MIXTURE CONTROL	Use this page for testing idle speed control valves.
5.	INTEGRATOR VOLTAGE	
6.	LAMBDA SENSOR	Use for checking correct operation of Lambda Sensors.
7.	AIR FLOW SENSOR	Use for checking smooth operation of air flow valves.
8.	INDUCTIVE SENSOR	Use for checking.
9.	HALL EFFECT SENSOR	Use for checks on trigger modules.
10.	CRANKSHAFT POSITION SENSOR	Check position of crankshaft sensors for timing settings etc.

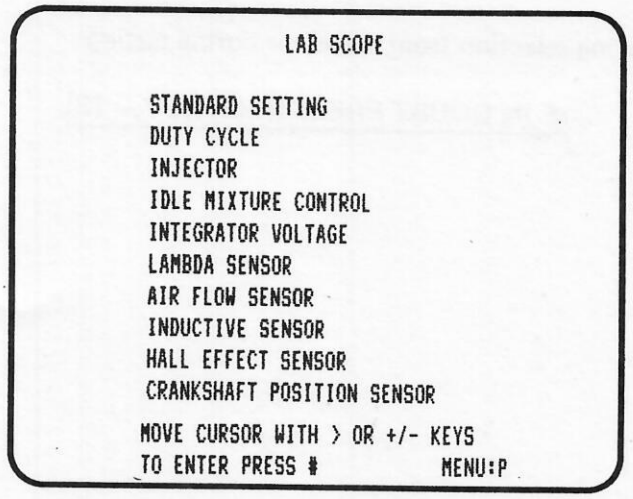


FIGURE 3:8
Lab Scope Menu

3.06 OPERATIONAL AIDS

To assist in learning the quickest and most appropriate way to complete the 'MCS 2000' procedures, visual messages, called prompts, will be displayed on the 'VDU' in all operational display pages. In addition to these procedural prompts, you may receive information messages regarding conditions or warnings. Additional help during any operation is also available by pressing the help key "[2]".

Prompt Messages

Prompt messages are displayed along the bottom line of the 'VDU' to guide you through testing and set-up procedures. The messages will normally end by directing you to press a key to advance to the next stage of testing sequence.

Informational Messages

These messages are used to present conditions and data which directly relate to the test. An example of a data message could be "Low Flow" which indicates the twin filtration system for exhaust gas measurement is fouled.

Other messages may be seen from time to time are:

REVERSE CURRENT PROBE	The amp clamp has been incorrectly fitted to the battery lead.
ENGINE KILL	The ignition circuit will be interrupted if the hand control or front panel switches are activated.
LOW FLOW	The exhaust emmission measurement system is unable to calculate a sufficient gas sample. Check for blocked primary and secondary filter or sample pipe and probe.

Help Messages

Finally, at any time during selection from menus or during testing

IF IN DOUBT PRESS HELP KEY – [2]

SECTION FOUR
PRE-TEST SET-UP

4.01 GENERAL

The information in this section explains the pre-test procedures that prepare the 'MCS 2000' for vehicle testing. The set-up procedures include vehicle identification, vehicle set-up, visual inspection, lead check, tester connections and engine warm-up. All vehicle testing will require either a code number entry or a specific vehicle selection to identify a vehicle. At the very least, input of basic information, such as firing order together with idle speed and CO specifications will be necessary.

When 'VEHICLE TESTING' is selected from the 'Programme Selection' main menu, you will be prompted to complete a sequence of pre-test pages for all the above items.

The sub-section 4.03 shows three different ways to enter details of any vehicle for test. Each variation will lead to a test and diagnosis result but depending on the initial information given, diagnosis will vary due to the specification parameters.

Vehicle Testing Menu Overview

VEHICLE SELECTION	This selection will, upon correct completion of all necessary data entry, give universal specifications for the vehicle presented for test. This method is usually employed if a vehicle is not listed with a 'SUN' code from the code book supplied with the 'MCS 2000'.
VEHICLE CODE NUMBER ENTRY	This selection will, upon correct entry of the 'SUN' code, give specifications dedicated to the vehicle presented for test. This method is much quicker with loading the specifications, and access to diagnostic messages are identical to the above, given the same parameters.
VEHICLE ENTRY WITHOUT LIMITS	This method will request only minimal vehicle data, such as firing order, timing, idle speed etc., and therefore can only give limited diagnostic information upon completion of test sequences.

4.02 PRE-TEST PROCEDURE

Follow the instructions for switching on the 'MCS 2000' and booting the system in Section Two, sub-section 3.01. Once the 'MCS 2000' is booted, the warm-up page for calibration will be displayed.

Each time the analyser is switched on, an automatic self calibration check of the internal circuitry and emission equipment is performed. When each part of the system is calibrated, a message is displayed against each checked component (Figures 4:1 and 4:2).

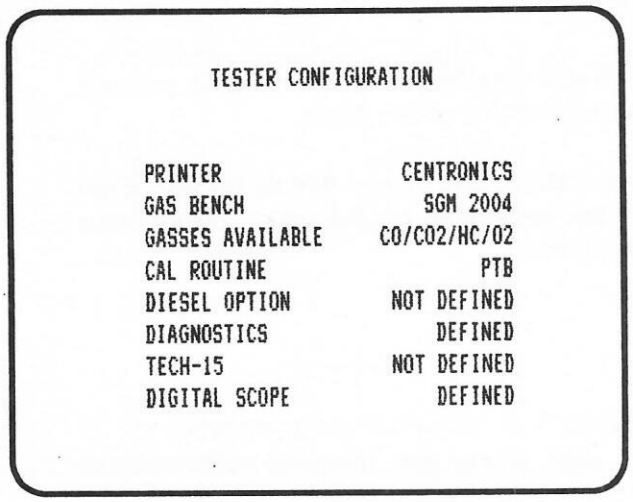


FIGURE 4:1
Tester Configuration Screen

The 'VDU' will display a fifteen minute count-down timer (Figure 4:3) to allow the emission test bench to reach correct operating temperature. Calibration of the exhaust gases will not activate until fifteen minutes* has elapsed after switching the 'MCS 2000' on.

When all systems show "PASS", press continue '[↵#]' or '[P]' to advance to the main 'Programme Selection' menu, shown in previous sections. You may return to the calibration page at any time by selection from the 'Programme Selection' menu.

*Two minutes if already warm.

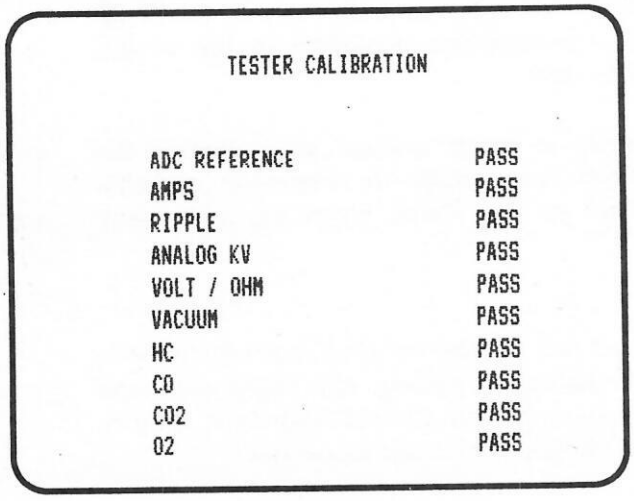


FIGURE 4:2
Tester Calibration

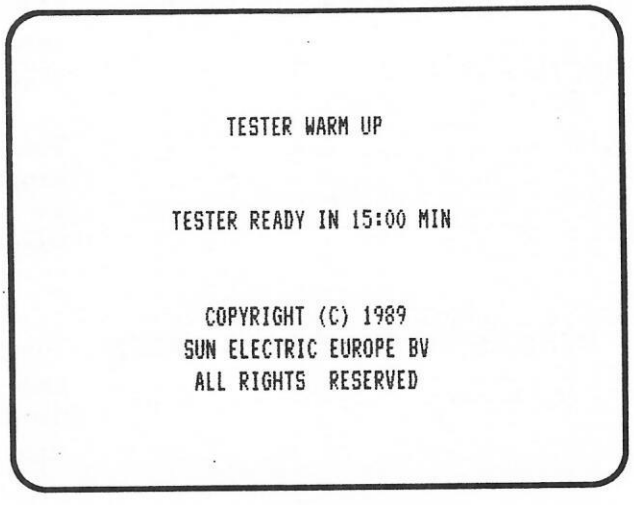


FIGURE 4:3
Tester Warm-Up

4.03 VEHICLE IDENTIFICATION

Generic Disk

Insert a generic disk into the disk drive and press any key on the hand control. At this point a message will advise the operator that the tester is loading the vehicle data and that the disk should not be removed during this process.

From the 'Programme Selection' menu, select "VEHICLE TESTING", by aligning the cursor [>] and pressing [#]. The 'VDU' will change to show a further menu of the same name as selected, i.e. "VEHICLE TESTING" (Figure 4:4). From this menu, re-align the cursor to select "VEHICLE SELECTION".

Vehicle Selection

After selection from the menu, "VEHICLE SELECTION", several further menu's will allow for data entry of the vehicle presented for test. From the options given, choose those applicable to the vehicle by aligning the cursor and confirming the decision by pressing the proceed [#] key.

At all times the operator will be prompted by a message on the bottom two lines of the 'VDU' as to the next action to take.

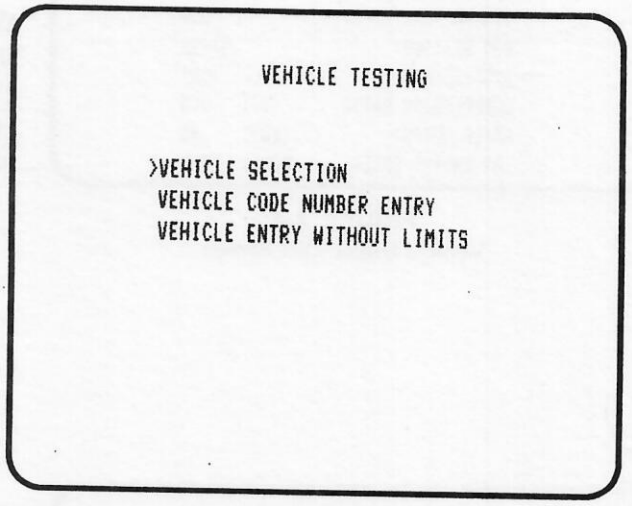


FIGURE 4:4
Vehicle Testing Menu

All these specifications will build universal data required to conduct a vehicle test, and the analyser will display an on-screen message advising the operator that the data entered will be of a universal nature only. (Figure 4:5).

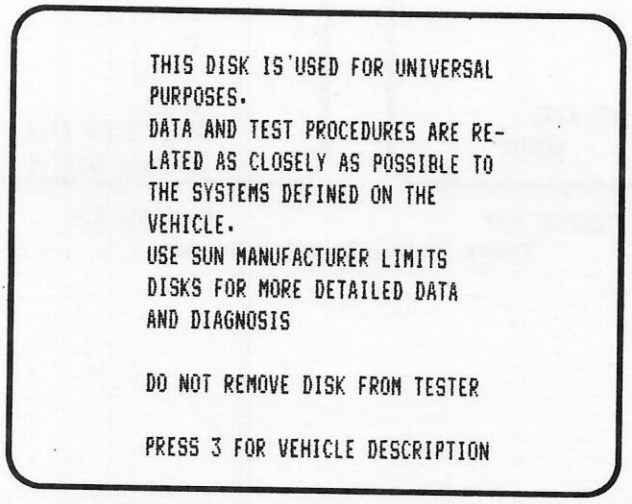


FIGURE 4:5
Generic Disk Information

Specific Disk

Insert desired specific disk (e.g. Ford, Honda, etc.) into disk drive and press any key on the hand control. At this point a message will advise the operator that the tester is loading the vehicle data and that the disk should not be removed during this process.

```
        VEHICLE UNDER TEST
SUN CODE NUMBER:          18500122
MANUFACTURER:                FORD
MODEL NAME:        SIERRA/SAPPHIRE
LIMITS VALID FROM:       02.87- >>
ENGINE ID:                     LS
CHASSIS CODE:               HK- >>
IGNITION TYPE:      TRANSISTORISED
FUEL SYSTEM TYPE:      CARBURETTOR
FIRING ORDER:              1-3-4-2
TIMING MARK OFFSET:            0.0
RON SETTING:                 94-95
DISPLACEMENT                  1597
COMPRESSION RATIO         1 :  9.5
RATED OUTPUT           (KW):    55
 AT ENGINE SPEED       (RPM):  5300
```

FIGURE 4:6
Vehicle Under Test Screen

Two methods of data entry may be employed using a specific disk, firstly, the same procedures should be adopted as if using the generic disk as described on page 4:3, but the computer will ask for more specific information on the 'VEHICLE SELECTION' menu's before loading the dedicated information to conduct vehicle diagnosis.

When the details have been loaded in to the 'MCS 2000', you may press key [3] to review the details of the 'VEHICLE UNDER TEST' (Figure 4:6). The screen details may differ slightly to figure 4:6 dependent on the vehicle.

```
        VEHICLE SELECTION
SELECT MODEL:
 FIESTA
 ESCORT/ORION
 CAPRI
 TAUNUS/CORTINA
 SIERRA/SAPPHIRE
 GRANADA
 SCORPIO/GRANADA


MOVE CURSOR WITH > OR +/- KEYS
TO ENTER PRESS #          MENU:P
```

FIGURE 4:7

```
        VEHICLE SELECTION
SELECT ENGINE ID:
 B4              RE
 JC              YY
 LC
 LS
 N4
 NE
 NR
 NY
 PR
 PR(CH)
 PR(S)
MOVE CURSOR WITH > OR +/- KEYS
TO ENTER PRESS #          MENU:P
```

FIGURE 4:8

Typical 'Vehicle Selection' Screens

Code Number Entry

Insert desired dedicated disk (e.g. Ford, Honda, etc.) into disk drive and press any key on the hand control. At this point a message will advise the operator that the tester is loading the vehicle data and that the disk should not be removed during this process.

To use this method of entry, select from the 'VEHICLE TESTING' menu (Figure 4:4), 'VEHICLE CODE NUMBER ENTRY' and enter the appropriate code number as prompted by the computer.

Code number entry is used from the code book supplied with your 'MCS 2000' and data will be just as detailed as the description of 'Specific Disk' given on page 4-4. The advantage of using a code number, gives the manufacturers precise specifications to the applicable vehicle presented for test. Details are immediately loaded to the computer without the need to select other identification such as, engine size, chassis numbers etc.

When the code number has been loaded (Figure 4:9) in to the 'MCS 2000', you may press key [3] to review the details of the 'VEHICLE UNDER TEST' (Figure 4:6), in the same way to that of the previous method. The screen details may differ slightly to figure 4:5 dependent on the vehicle.

In all examples to load vehicle data, following loading, a page will now be presented (Figure 4:10) for the input of customer name and address together with further vehicle detail such as registration number and mileage etc. The procedure to input the alphanumeric detail is described in detail in section ??, sub-section ??.

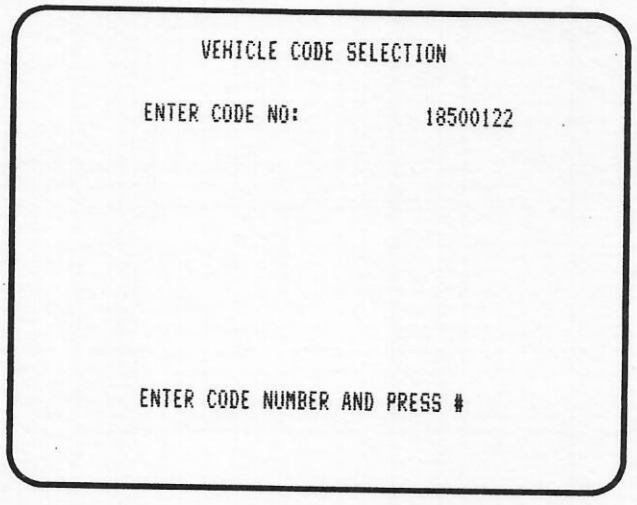


FIGURE 4:9
Vehicle Code Selection Screen

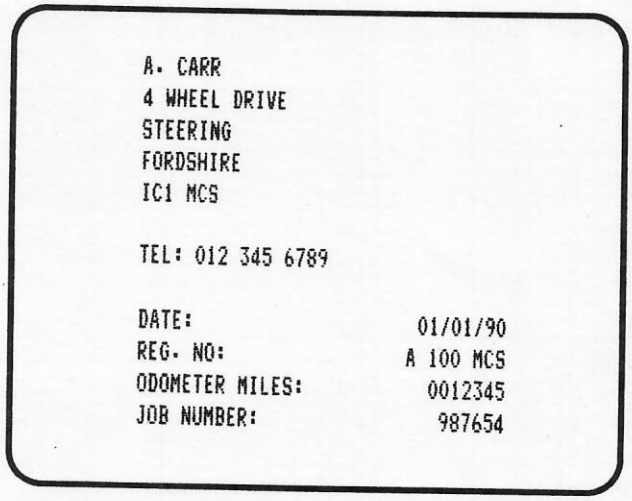


FIGURE 4:10
Customer Information Screen

Entry With No Limits

Entry with no limits (Specifications) is confined to one page where the operator will be asked to enter the number of cylinders and the firing order of the vehicle presented for test. Other minor information may be requested before the engine may be tested.

By using the "VEHICLE ENTRY WITHOUT LIMITS", the tester is unable to give any diagnosis guide after completion of testing. This is available only with 'VEHICLE SELECTION' and 'VEHICLE CODE NUMBER ENTRY'.

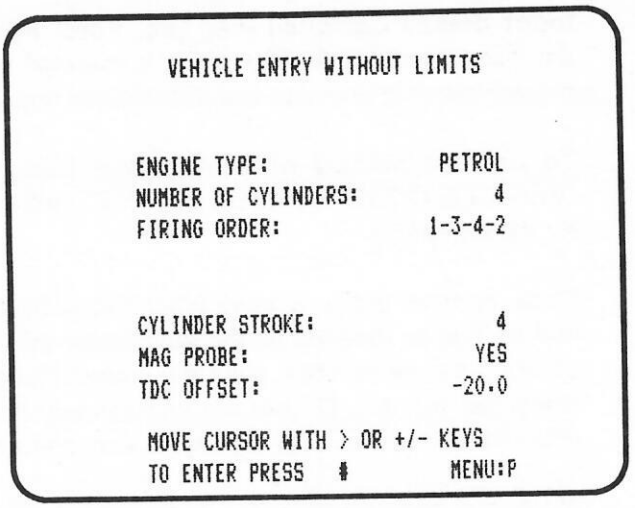


FIGURE 4:11
Vehicle Entry Without Limits

4.04 TESTER CONNECTIONS (Hook-Up)

CHROME SECONDARY CLAMP*: Clamp to main coil/distributor HT lead to measure Secondary Voltage and provide an External Trigger.

On some later vehicles, special adaptors will be necessary to connect this lead. Please consult your local representative or contact Sun Electric UK Ltd., who will be able to supply the necessary adaptors.

RED TRIGGER CLAMP*: Clamp on number one spark plug HT lead as near to the distributor cap as possible to provide a secondary signal for cylinder identification.

GREEN AMMETER CLAMP*: Clamp around negative battery earth cable with indication arrow on side of clamp pointing away from the battery to measure Starter Current Draw, Charging Circuit Output, Amps per Cylinder and Current Flow.

GREEN PINCH CLIP*: Connect to Negative/CB/KL1 terminal of the ignition coil to measure Dwell, Distributor Resistance and supply a further trigger for RPM.

YELLOW PINCH CLIP: Connect to Positive/SW/KL15 terminal of the ignition coil to measure Coil Voltage and supply a method of cylinder shorting for power balance tests.

RED PINCH CLIP: Connect to Battery Positive Terminal to measure Battery Voltage and Alternator Ripple.

BLACK PINCH CLIP: Connect to Battery Negative Terminal to measure Battery Voltage and supply earth for other test areas.

VACUUM HOSE: Connect to vacuum source at mainifold to measure engine vacuum (not distributor advance/retard).

MAGNETIC TIMING PICK-UP: Connect to appropriate manufacturers socket, where fitted, to measure all ranges of timing curves.

VOLT/OHM TEST LEADS: Used for pinpoint and lab scope testing.

OIL TEMPERATURE PROBE: Measure to length of dipstick and set stop before inserting in to crankcase via dipstick tube to measure engine oil temperature.

EXHAUST SAMPLE PROBE: Insert in to vehicle tailpipe ensuring that at least half of the probe is used to provide exhaust gas sample and measure against specifications.

DIESEL TEST LEAD (Option): Connect correct size Piezo transducer to clean area of number one diesel injector pipe with black wire to suitable earth and measure RPM, timing and start of fuel delivery.

* **These inputs will be continuously monitored by the tester on pages where they are of prime importance. Should a faulty connection be detected, a corresponding 'VDU' message will be displayed.**

4.05 LEADS CONNECTION CHECK

Once all data information has been entered, whichever choice from the 'VEHICLE TESTING' menu, the computer analyser will require connection to an engine and the operator will receive an instruction on-screen to connect all test leads (Figure 4:12).

If help is required to ensure that the correct connections are made, press key number [2] whilst at this point of pre-test set-up and a list of the connections to the vehicle will be displayed.

Pressing key [#] after connections are made will instruct the operator to start the engine whereby the computer analyser will display a list of all connections with a pass or fail remark (Figure 4:13).

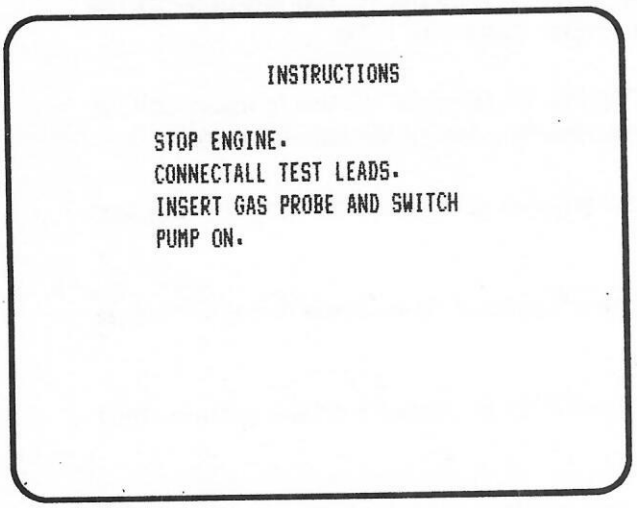


FIGURE 4:12
Instruction Screen

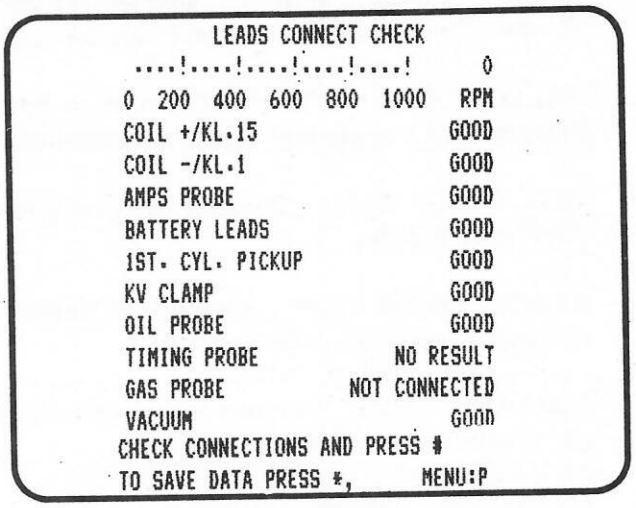


FIGURE 4:13
Engine Connection Check

Should any lead or connection fail to connect, during leads connect check, this will be prompted to the operator to recheck the connection and relocate where necessary. The example displayed at Figure 4:13 shows that no signal has been received from the Timing Probe and the Gas Probe has not been connected, therefore no results will be transmitted to 'MCS 2000'. In this case, the vehicle being tested was not equipped with a timing probe connector and the timing light should be used. The Gas Probe should be inserted in to the vehicle tail pipe, ensuring the exhaust system is in sound condition with no leaks.

In both these examples, and others if confronted by similar messages, the prompt at the bottom of the screen requests the operator to check the connection and press the proceed [#] key, when the computer will recheck the connections and display an updated message.

When all connections are satisfactory, press the [*] key to save the data. Saving this data will be necessary to ensure satisfactory diagnostic results.

SECTION FIVE
COMPLETE TEST

5.01 GENERAL

This section will deal with engine testing, completing all sections of the entire 'WORKSHOP TEST' menu (Figure 5:1). The following descriptions of use may be made applicable to non-start engines as well as engines with misfires, whether at idle or cruise speeds.

The flow of testing has been designed in a chronological order to assist with any diagnostic decisions and ensure that minor problems are notified prior to any of a major nature. It should also be noted that each item listed on the menu may be carried out as an individual test. It is not necessary to begin with 'ignition on test' if the only requirement, for example is to conduct tests on 'idle emissions'.

For the purpose of explanation in this section each area of test listed on the 'WORKSHOP TEST' will be taken in listed order to retain continuity. During the initial stages of tester use, it would be advised to follow this principle until the operator becomes more con versant with use.

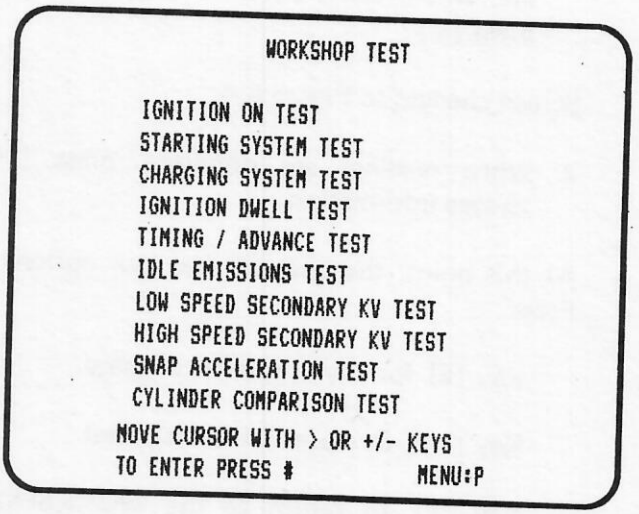


FIGURE 5:1
Workshop Test Menu

Throughout the entire test procedures, prompts will show on the two lower lines of the VDU to assist the operator with the next operation.

Refer to section 3, sub-section 3.02, 'Key Definitions', to recap what facilities are available during the testing sequence, but in basis, if the zero key [0] is pressed at any time, the menu reproduced in figure 5:2 will guide the operator to any of the listed items, expecially the 'Diagnostic Results' by pressing key number [5]. Please note that keys [3]-[4]-[5] will not be active if 'VEHICLE ENTRY WITHOUT LIMITS' was selected during pre-test set-up.

When a test page is saved by pressing [*] each result will have one of three visible indications. If an equal '=' is shown adjacent to the test result, this is agreed by the computer to be within specification to the programme used. Should the indication be an arrow shown facing upward ' ' or downward ' ', this indicates the result to be above or below the set specification. If key [5] is pressed, a diagnostic message will be shown if any parameter meets this criteria.

The 'MCS 2000' should be made ready for operation and pre-test set-up operations completed as described in previous sections of this manual.

5.02 WORKSHOP TEST

Ignition On Test

Measures all vehicle components through ignition circuit without engine running.

Screen should be at stage shown in Figure 5:3.

1. Switch off all current consumers, such as heated screens, radios and carphones etc. When ready, switch on ignition, then press [#].

Screen changes to Figure 5:4.

2. When readings are stabilised, press [*] to save information.

At this point, the operator has four options - Press:

Key [5] for any diagnostic message.

Key [+/-] to repeat the current test.

Key [P] to return to the 'WORKSHOP TEST' menu where another random test may be selected.

Key [#] tester will advance automatically to the next test in chronological order.

These options are available after completion of all ten test areas therefore future explanation in this section will continue by pressing [#] after each test to automatically advance to the next sequence of test.

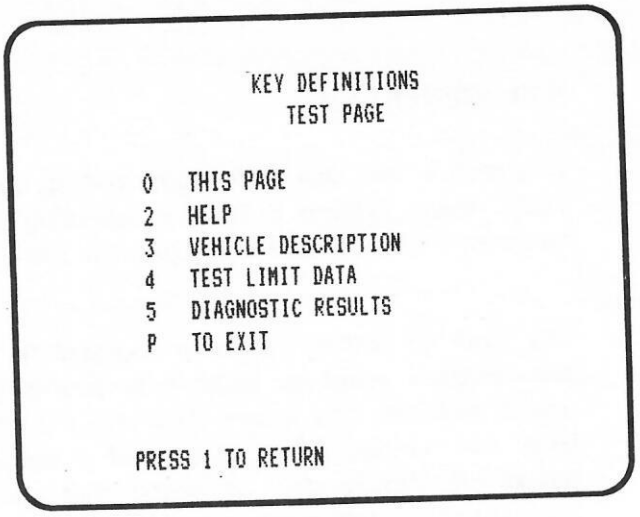


FIGURE 5:2
Vehicle Testing Key Definition

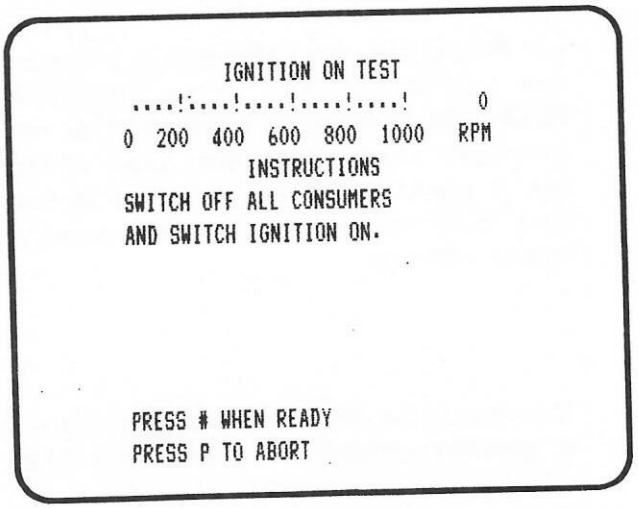


FIGURE 5:3
Ignition On Test (1)

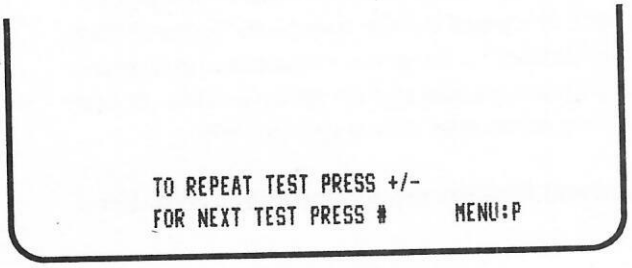


FIGURE 5:4a
Prompt After Pressing (*)

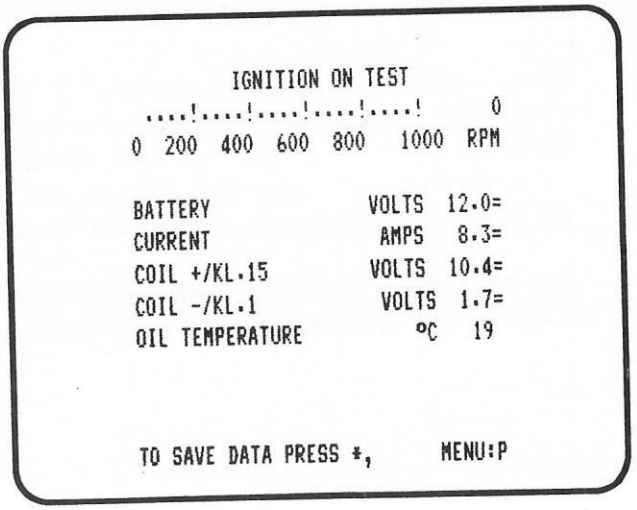


FIGURE 5:4
Ignition On Test (2)

Starting System Test

Measures loads to all ancillary equipment such as battery and starter motor in addition to checks to ignition circuitry and relative engine compression.

If previous 'Ignition On Test' has been carried out, the 'Starting System Test' will now be automatically selected. Alternatively, select the 'Workshop Test' menu, move the cursor to 'Starting System Test' and press [#].

The 'VDU' will now display a screen as shown in figure 5:5.

1. Switch off all current consumers, such as heated screens, radios and carphones etc.

   The Analyser will also offer the message that any reference to cylinder numbers will equal the vehicle firing order. If this message is not shown, usually when testing without any limits, (specifications) then the cylinder numbers shown do not necessarily refer to the actual cylinder under test.

Press [#] when ready and screen will change to that shown in figure 5:6.

2. At this point the operator will be instructed to 'Crank Engine' and this should now be carried out without interruption until engine starts, normally about 15 seconds. If the engine will not start, crank engine until screen shows 'Test data Saved' on the top screen line.

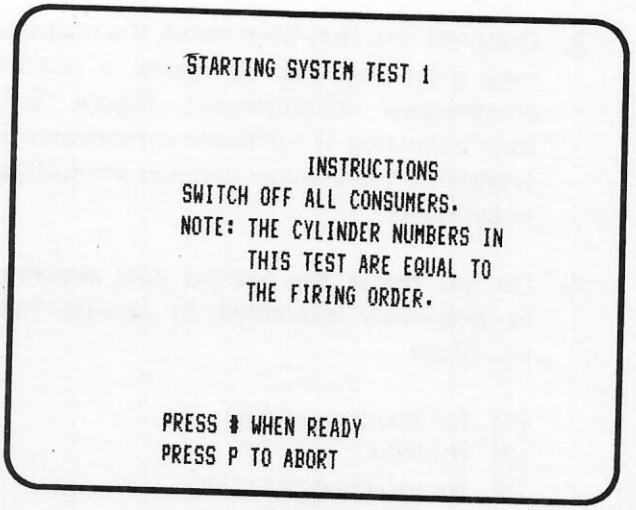


FIGURE 5:5
Starting System Message

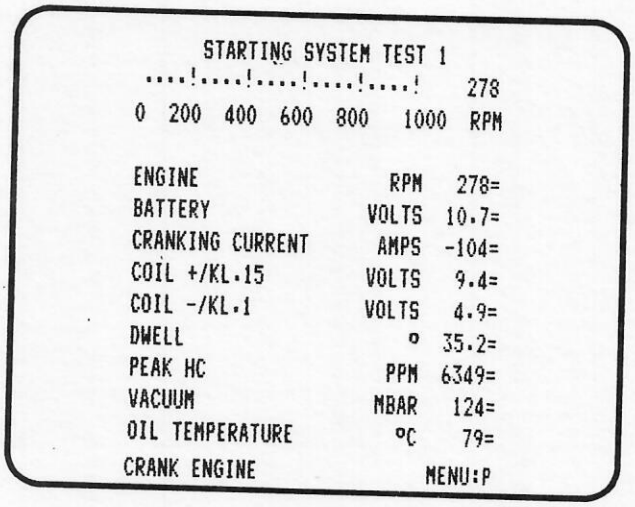


FIGURE 5:6
Starting System Test

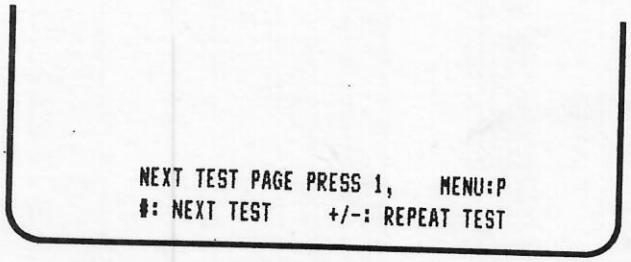


FIGURE 5:6a
Prompt After Test Complete

3. Once the data has been saved, the operator may press key [1] to review a relative compression measurement (figure 5:7) thus indicating if sufficient compression is available on any single cylinder or multiple of cylinders.

4. Do not forget the options now available, as previously explained in section two. i.e., press:

   [1] for test page review.
   [2] for help.
   [3] for vehicle description.
   [4] for limits/specifications.
   [5] for diagnostic messages.

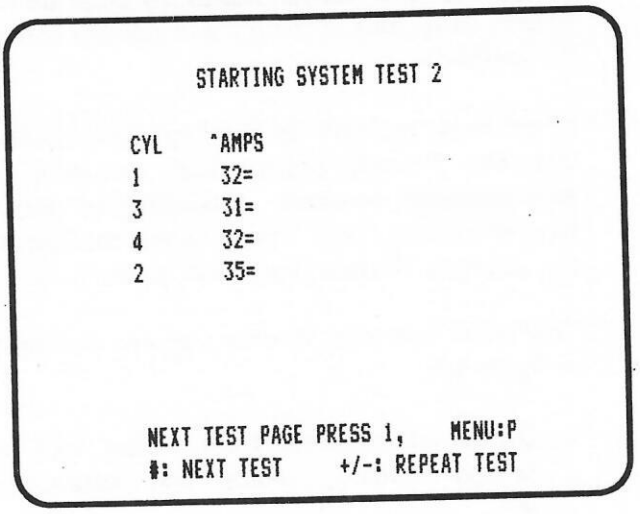


FIGURE 5:7
Relative Compression

Charging System Test

This test measures all parameters associated with the vehicle electrical system and reports on any malfunction.

Using the cursor, select from the 'WORKSHOP TEST' menu 'CHARGING SYSTEM TEST' or this will automatically have been selected if continuing from the previous test. (Figure 5:8).

1. Switch on current consumers, it is usually sufficient to switch on the heated rear screen and headlights. Once the test has been completed, the analyser will remind the operator to switch off those items used to conduct the test.

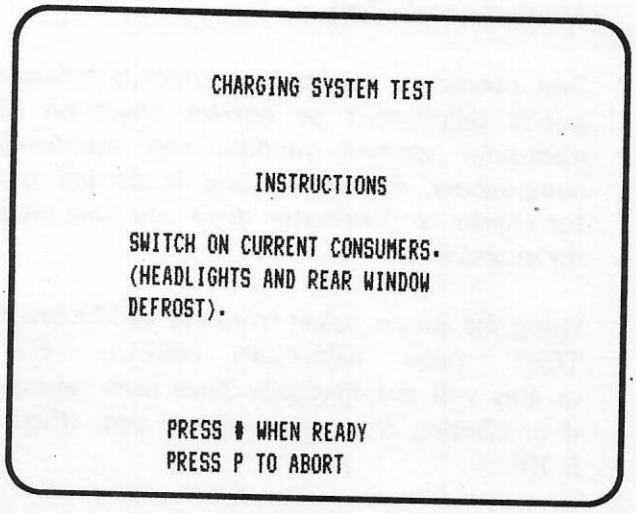


FIGURE 5:8
Charging System Message

Screen changes to figure 5:9 after key [#] is pressed.

2. On the graph shown at the top of the screen, note cursor symbols " > " and/or "<" with an instruction to 'BRING ENGINE RPM IN > < . Ensure that the engine rpm is above the " > " and below the " < " symbols and press the [*] key to save the information at the specified speed, usually idling above 600 rpm.

3. The prompt on the lower screen will now change and request the operator again to 'BRING ENGINE RPM IN > < ', this time at a higher rpm range.

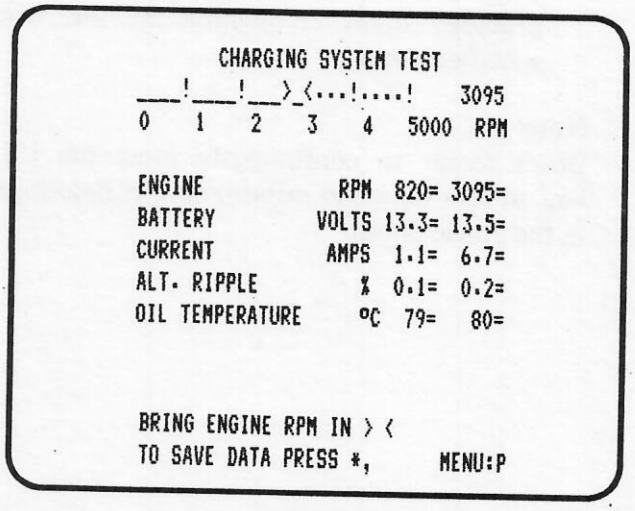


FIGURE 5:9
Charging System Test

If the [*] key is continuously pressed and the engine throttle opened and released to pass through the specified rpm range, usually between 2400 and 2600 rpm the results will be saved on screen. Note the top bar-graph will automatically change scale to allow for higher speeds.

The procedure of opening and closing the throttle with the hold [*] key depressed to save data may be used throughout the following tests with the exception of the timing tests when it is necessary to check timing adjustment prior to saving information.

Ignition Dwell Test

Test procedure checks for correct distributor points adjustment or correct operation of electronic ignition module and associated components. Further testing is carried out for checks to distributor drive and base plate for excess wear.

Using the cursor, select from the 'WORKSHOP TEST' menu 'IGNITION DWELL TEST' or this will automatically have been selected if continuing from the previous test. (Figure 5:10).

1. This test is conducted in a similar way to the previous 'Charging System Test'. Two columns of information will be provided upon completion of the two specified pages.

Note:
Don't forget to continuously press the [*] key to save data and information, as described in the previous test.

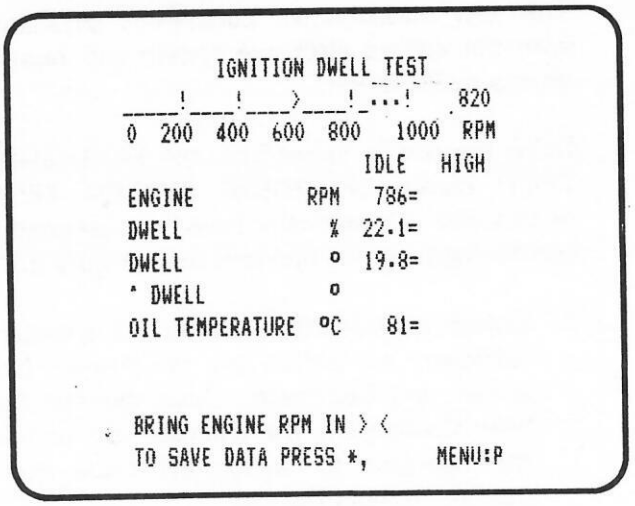


FIGURE 5:10
Ignition Dwell Test (Idle)

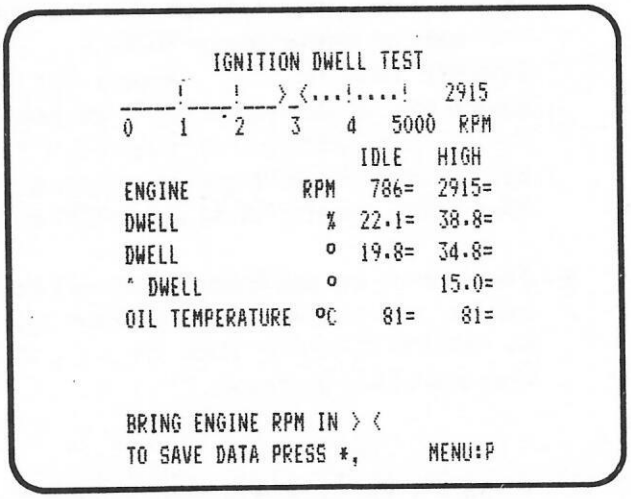


FIGURE 5:11
Ignition Dwell Test (Cruise)

Ignition Timing Test

This test procedure will ascertain whether timing curves throughout the engine rpm range are correct. The test will be conducted in five steps, starting with base strobe timing, following on through three mechanical advance checks with the vacuum supply disconnected and finally checking the timing with the vacuum reconnected.

Note: The above procedure is generalised and the steps may vary slightly according to specification and depending on the vehicle presented for test. The screen will always prompt the operator to conduct this test in correct sequence.

Using the cursor, select from the 'WORKSHOP TEST' menu 'TIMING/ADVANCE TEST' or this will automatically have been selected if continuing from the previous test. (Figure 5:11).

1. Disconnect and plug vacuum pipes where instructed.

   The analyser will remind the operator that timing will be checked using the timing light utilising the variable timing advance unit. If the alternative method of checking ignition timing via a diagnostic harness plugged in to the vehicle system, the message will be displayed accordingly.

   Timing, using the timing light may also be checked using either 'TDC' marks or 'Actual Timing Marks' and the analyser will also guide the operator as to which type of check is necessary.

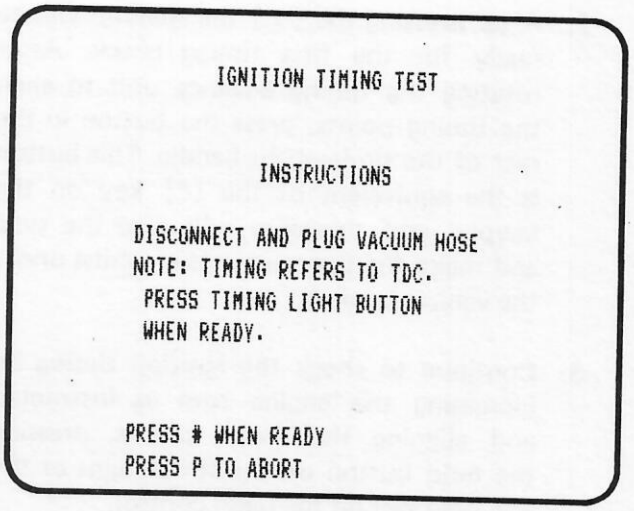


FIGURE 5:12
Ignition Timing Test Message

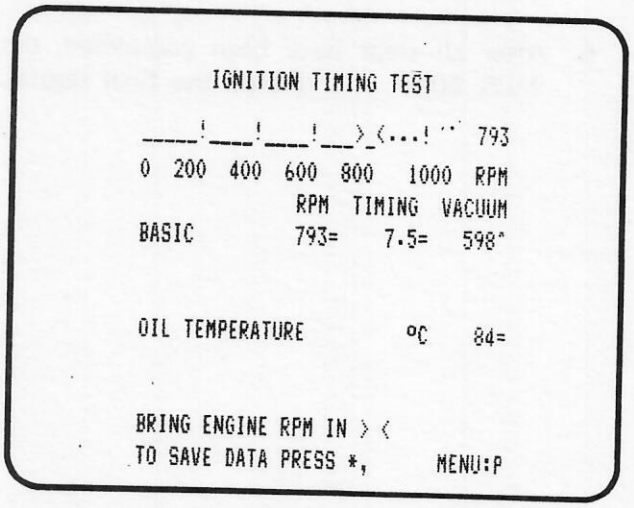


FIGURE 5:13
Basic Timing Results

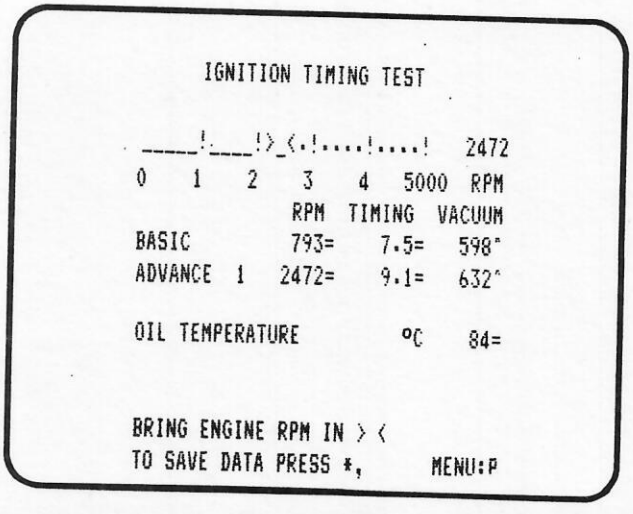


FIGURE 5:14
Mechanical Advance (1) Result

Ignition Timing Test (Continued)

2. After pressing the [#] the analyser will be ready for the first timing check. After rotating the timing advance unit to align the timing points, press the button in the rear of the timing light handle. This button is the equivalent of the [*] key on the keypad and therefore will save the data and make the operation easier whilst under the vehicle bonnet.

3. Continue to check the ignition timing by increasing the engine rpm as instructed and aligning the timing points, pressing the hold button on the strobe-light or the [*] hold key on the hand control.

4. Prior to the final timing check, the 'MCS 2000' will ask the operator to reconnect any vacuum hoses previously disconnected.

5. After all steps have been completed, the 'MCS 2000' will display the final results.

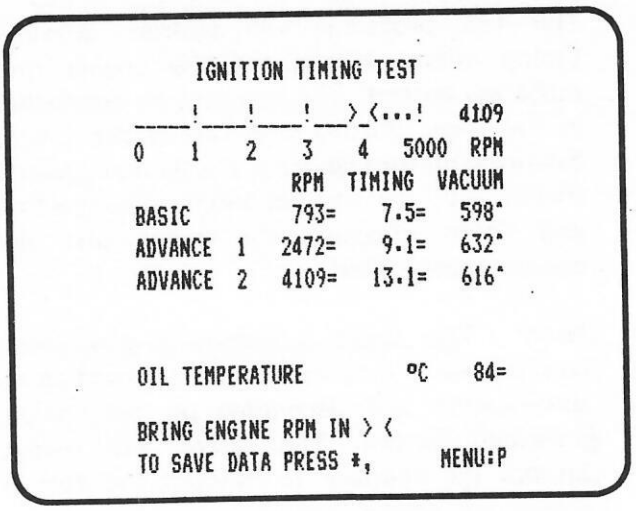


FIGURE 5:15
Mechanical Advance (2) Result

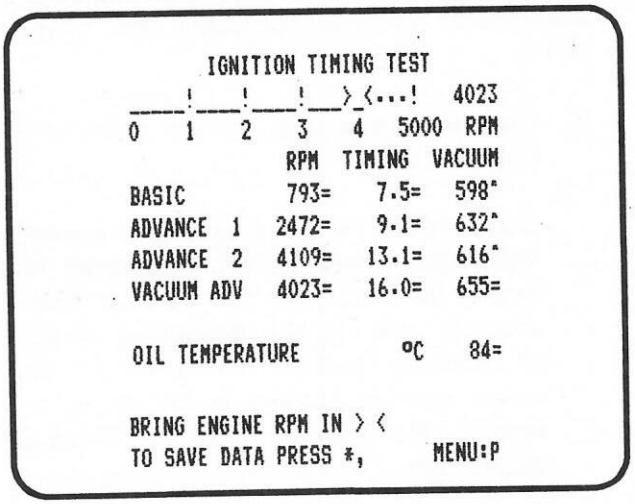


FIGURE 5:16
Vacuum Advance Results

Idle and Emissions Test

This procedure tests all engine idle functions using four exhaust gas measurement complemented with Lambda and Air/Fuel Ratio calculations.

Using the cursor, select from the 'WORKSHOP TEST' menu 'IDLE/EMISSIONS TEST' or this will automatically have been selected if continuing from the previous test. (Figure 5:17).

NOTE:

It is very important, both at idle and cruise that all exhaust gas readings stabilise before pressing the [*] key.

1. The procedure for this test is similar to that of the Charging System and Ignition Dwell tests and will result in two columns of data. One at idle and one at cruise speed.

   Disconnect or turn off any Air Conditioning, Pulse Air, Air Pumps and Exhaust Gas Recirculation devices where applicable.

   A reminder will be given to re-instate these devices after the test has been completed.

2. When ready, press [#] and the screen will change to show figure 5:18. Ensure that readings have stabilised and press the [*] key to save this data.

3. Increase engine speed to the specified rpm window, allow to stabilise and press the [*] key.

```
IDLE / EMMISIONS TEST

INSTRUCTIONS

IF PRESENT, DISABLE:
 - PULSE AIR
 - AIR PUMP
 - AIR CONDITIONING


PRESS # WHEN READY
PRESS P TO ABORT
```

FIGURE 5:17
Idle/Emission Message

```
IDLE / EMISSIONS TEST
    ____!___!___!__>_<...!  797
0  200  400  600  800  1000  RPM

ENGINE            RPM   797=
CO                  %  1.36=
HC                PPM   161=
CO2                 % 13.66=
O2                  %   1.5=
LAMBDA CALCULATED      1.02=
AIR FUEL RATIO    :1  14.9=
OIL TEMPERATURE   °C    86=

TO SAVE DATA PRESS *,      MENU:P
```

FIGURE 5:18
Idle/Emissions Test at Idle

```
IDLE / EMISSIONS TEST
____!___!>__<!....!....!   2510
0   1   2   3   4   5000  RPM

ENGINE            RPM   797= 2510=
CO                  %  1.36=  0.7=
HC                PPM   161=  102=
CO2                 % 13.66= 14.1=
O2                  %   1.5=  1.0=
LAMBDA CALCULATED      1.02=  1.0=
AIR FUEL RATIO    :1  14.9= 14.7=
OIL TEMPERATURE   °C    86=   87=
TO REPEAT TEST PRESS +/-
FOR NEXT TEST PRESS #,     MENU:P
```

FIGURE 5:19
Idle/Emissions Test at Cruise

Low Speed Secondary KV Test

This test checks all secondary KV equipment at idle, starting at the coil tower and proceeding through the wiring via the distributor cap and finishing at the spark plug. Secondary KV should be considered very closely as this can give considerable clues as to the condition of not only the ignition area but also to mechanical problems together with fuel system distribution faults.

Using the cursor, select from the 'WORKSHOP TEST' menu 'LOW SPEED SECONDARY KV TESTS' or this will automatically have been selected if continuing from the previous test. (Figure 5:20).

1. Press the proceed key [#] after observing any messages shown on the VDU.

   To monitor overiding problems that may affect KV readings, two test pages are available for this test, the first one being similar to figure 4:18 showing exhaust gas readings.

   Pressing number [1] key will display the second of the test pages (Figure 5:21) to monitor actual KV.

   Allow engine to stabilise and save the data by pressing the [*] key.

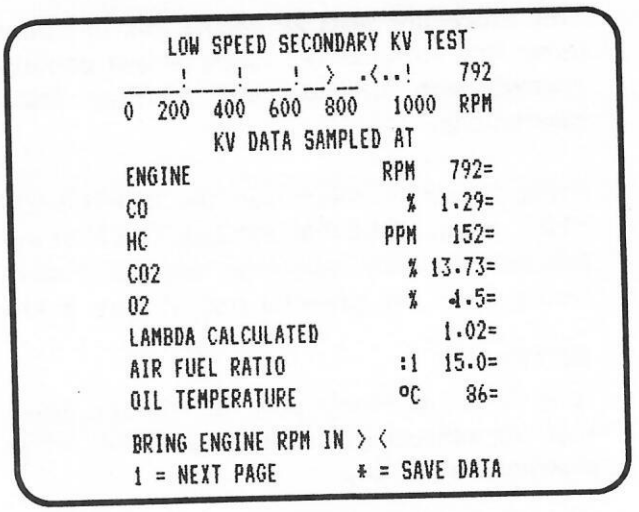


FIGURE 5:20
Low Speed Secondary KV Monitor

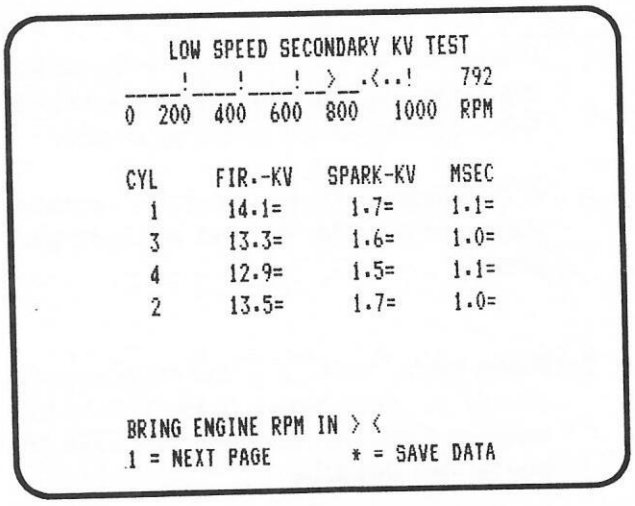


FIGURE 5:21
Low Speed Secondary KV Test

High Speed Secondary KV Test

This test checks all secondary KV equipment at high speed or cruise speed in the same way as the previous test.

Using the cursor, select from the 'WORKSHOP TEST' menu 'HIGH SPEED SECONDARY KV TEST' or this will automatically have been selected if continuing from the previous test. (Figure 5:22).

1. This test also comprises of same two test pages and to conduct this test, use the procedure as the previous test. Follow the instruction for the higher rpm test speed. (Figure 5:23).

Note:

It is possible with this test to hold the [*] key and raise and lower the rpm through the test speed window to quickly save the data.

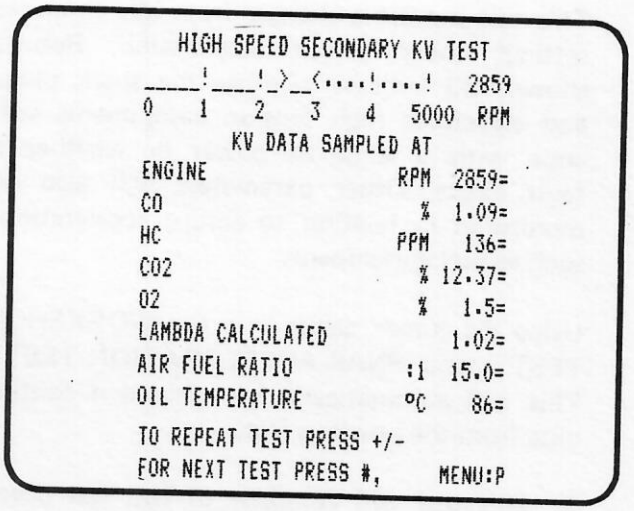


FIGURE 5:22
Emissions Monitor at Cruise

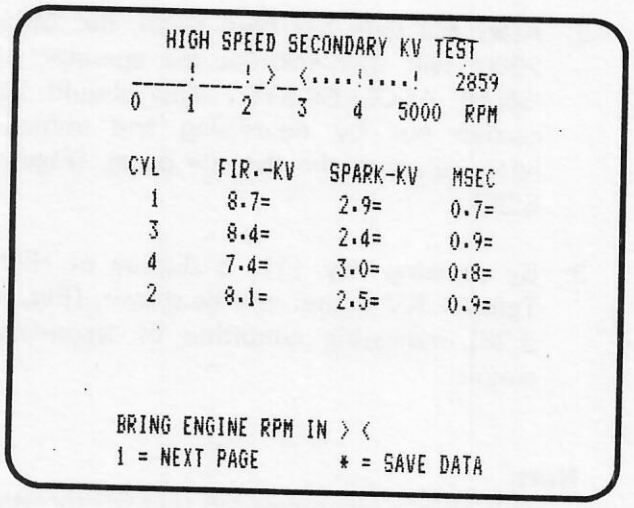


FIGURE 5:23
High Speed Secondary KV Test

Snap Acceleration Test

This test monitors changes from idle to cruise settings under abrupt acceleration. Results shown will indicate whether the spark plugs and associated high tension components will cope with a surge of power or whether a fault exists. Other parameters will also be monitored in relation to abrupt acceleration, such as fuel enrichment.

Using the cursor, select from the 'WORKSHOP TEST' menu 'SNAP ACCELERATION TEST'. This will automatically be selected if continuing from the previous test.

1. This test will comprise of two test pages to monitor high tension and measure fuel enrichment. Initially, the 'MCS 2000' will ask the operator to stabilise the engine and save data by pressing [*]. (Figure 5:24).

2. After the data has been saved, the 'MCS 2000' will then instruct the operator to 'SNAP ACCELERATE'. This should be carried out by depressing and immediately releasing the throttle pedal. (Figure 5:25).

3. By pressing key [1], a display of High Tension KV action will be shown, (Figure 5:26) indicating condition of secondary circuit.

Note:

It is always recommended that the throttle pedal is used rather than the under bonnet linkage. This will ensure that any engine management system fitted will react to throttle movement. The action should consist of a firm and positive movement using one foot in the exact same way as one would accelerate when overtaking.

```
        SNAP ACCELERATION TEST
____!___!___!___!_...!    814
0  200  400  600  800  1000  RPM
        CAPTURED READINGS
BASE: ENGINE              RPM  814=
      CO                    %  1.34=
      HC                  PPM  182=
CO INCREASE               %
OIL TEMPERATURE           °C   86=


BRING RPM IN >(, ALLOW GAS VALUES
TO STABILISE, PRESS * TO START
```

FIGURE 5:24
Snap Acceleration Test (Start)

```
        SNAP ACCELERATION TEST
____!___!__..!....!....!  2310
0    1    2    3    4   5000  RPM
        CAPTURED READINGS
BASE: ENGINE              RPM  2310=
      CO                    %  3.39=
      HC                  PPM  210=
CO INCREASE               %  2.05=
OIL TEMPERATURE           °C   86=


BRING RPM IN >(, ALLOW GAS VALUES
TO STABILISE, PRESS * TO START
```

FIGURE 5:25
Snap Acceleration Test (End)

```
        SNAP ACCELERATION TEST
____!___!__..!....!....!  2310
0    1    2    3    4   5000  RPM
CYL      BASE FIR.-KV  *FIR.-KV
  1          14.1=       2.3=
  3          14.7=       0.9=
  4          13.8=       2.1=
  2          13.0=       1.0=


TO REPEAT TEST PRESS +/-
FOR NEXT TEST PRESS #,     MENU:P
```

FIGURE 5:26
Snap Acceleration Test (KV)

Cylinder Comparison Test

Cylinder Comparison Test compares all cylinders by interupting the ignition spark in firing order sequence. Checks are made for individual distribution to each cylinder of fuel, energy and compression. Diagnosis of these results, either by the operator or the 'MCS 2000', can indicate problems with mechanical areas, such as tight or loose valve clearances, inlet manifold leaks and injection or carburation conditions.

Using the cursor, select from the 'WORKSHOP TEST' menu 'CYLINDER COMPARISON TEST'. This will automatically be selected if continuing from the previous test.

1. The first display screen will instruct the operator to 'BRING VEHICLE IN POWER BALANCE CONDITIONS' (Figure 5:27). This generally means setting the engine speed to approximately 1500 RPM and ensuring the electric cooling fan is bridged (if fitted) to operate throughout the entire test. If key [2] is pressed at this stage, the display will offer help pages to assist with correct function of this test according to the vehicle presented for test.

2. With the initial procedure now set, press the [#] key to change to the display screen shown in figure 5:28, allow the data to stabilise and press the [*] key which will activate the test.

3. If key [1] is now pressed, the screen will display data as it is recorded (Figure 5:29). Cylinder number one will not display its data until completion of the other cylinders under test.

```
CYLINDER COMPARISON TEST

INSTRUCTIONS
NOTE: THE CYLINDER NUMBERS IN
      THIS TEST ARE EQUAL TO
      THE FIRING ORDER.
BRING VEHICLE IN POWER BALANCE
CONDITIONS.



PRESS # WHEN READY
PRESS P TO ABORT
```

FIGURE 5:27
Cylinder Comparison Message

```
CYLINDER COMPARISON TEST
____!)_(!....!....!....)  1518
0   1   2   3   4  5000  RPM
BASE: ENGINE          RPM  1518=
CRANKING CURRENT      AMPS  -100=
BASE: CO                 %  0.62=
      HC                PPM    74=
      CO2                %  14.20=
      O2                 %   1.8=
LAMBDA CALCULATED           1.07=
AIR FUEL RATIO           :1  15.7=
OIL TEMPERATURE          °C    89=
BRING RPM IN )(, ALLOW GAS VALUES
TO STABILISE, PRESS * TO START
```

FIGURE 5:28
Cylinder Comparison Set-Up

```
CYLINDER COMPARISON TEST
____!__..!....!....!....!  1520
0   1   2   3   4  5000  RPM
CYL    *AMPS     *RPM     *PPM
  1     32=      169=    2363=
  3     31=      188=    2240=
  4     32=      175=    2314=
  2     35=      177=    2245=




NEXT TEST PAGE PRESS 1,   MENU:P
```

FIGURE 5:29
Cylinder Comparison (Complete)

Cylinder Comparison Test (Continued)

4. Upon completion of the Cylinder Comparison Test, the tester will instruct the operator to reset all systems in to normal function mode. (Figure 5:30). At this point the operator should reset the engine idle speed and reconnect the temperature switch to the cooling fan. Further reset instructions should be carried out as originally instructed.

5. With all tests now completed, pressing key [.#] will show the 'VEHICLE TEST SELECTION' menu and 'PRINTER FUNCTIONS' may be selected to print the diagnostic results.

Printing of the data and results is described in section six.

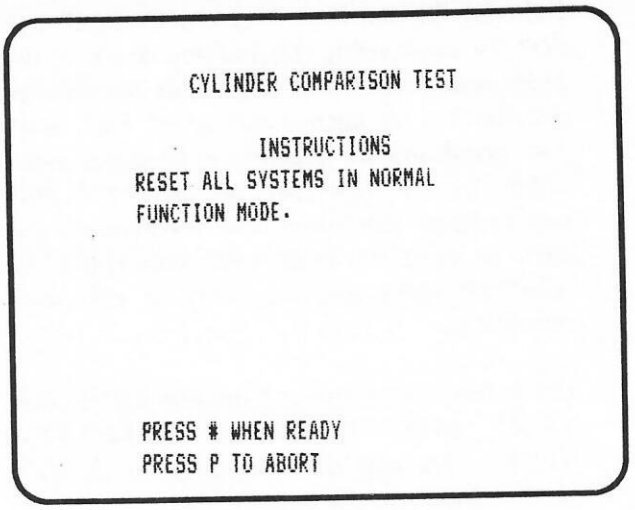


FIGURE 5:30
Cylinder Comparison Message

SECTION SIX
PRINTER

6.01 GENERAL

The 'MCS 2000' uses an eighty column high speed printer (Figure 6:1) housed under a protective acrylic cover to the left of the tester work area. Care in design has ensured that dirt and contamination in the printer area is minimal but nevertheless, the operator should take care not to allow ingress of foreign matter which may result in damage to the printer head or components. Such damage will render the printer warranty void.

The printer requires standard 'Computer A4' tractor feed fanfolded paper and is housed under the printer itself. Access to the paper compartment is gained by releasing the crosshead screw to the right corner of the printer table and then tipping the printer back to an angle of 45°. Fresh paper should be loaded with the first sheet fed through the printer table to the underside of the printer and located on the printer tractor spools. Finally wind paper through to align with top of access cover. Refit retaining screw and replace acrylic cover.

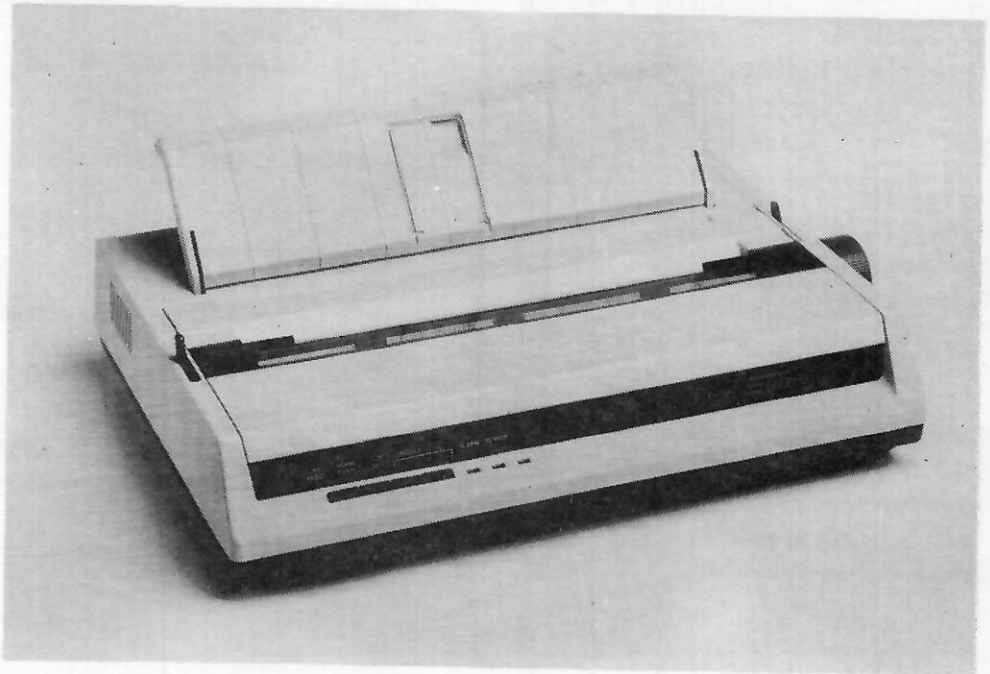


FIGURE 6:1
HSP 1080 Printer

The printer on/off switch is located horizontally on the lower right side rear corner and when switched on should display two green lights on the printer front panel. To assist with paper alignment, especially where perforation take place, press the 'Select' switch on the printer front panel to extinguish the 'Select' green light. Press the 'Form Feed' switch and the paper will feed through to the position required for the end of a full sheet. Re-align the top of the paper with the top cover and depress the 'Select' switch again and ensure the green 'Select' light is on.

NOTE: The green 'Select' light must be on at all times for the printer to be in the operate mode.

6.02 PRINTER OPTIONS

The 'MCS 2000' has six different options to enable printer output for display to either the Technician, Customer or Records. The operator may also request output from the printer for all the completed tests or for any one individual test. Availability is also provided to print details of the 'BASIC ADJUSTMENTS TEST'.

Information may only be printed provided that a test sequence has been completed. Any areas of test left incomplete will be ignored by the diagnostic computation although the screen display will list confirmation of all areas not completed.

Using the cursor, select from the 'VEHICLE TEST SELECTION' menu 'PRINTER FUNCTIONS' (Figure 6:2).

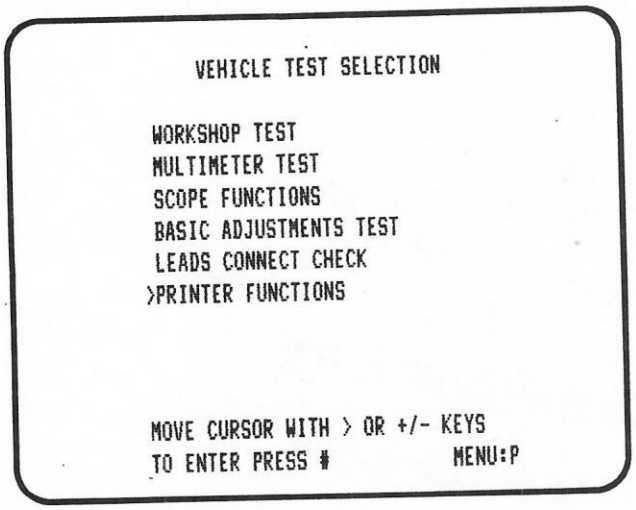


FIGURE 6:2
Vehicle Test Selection Menu

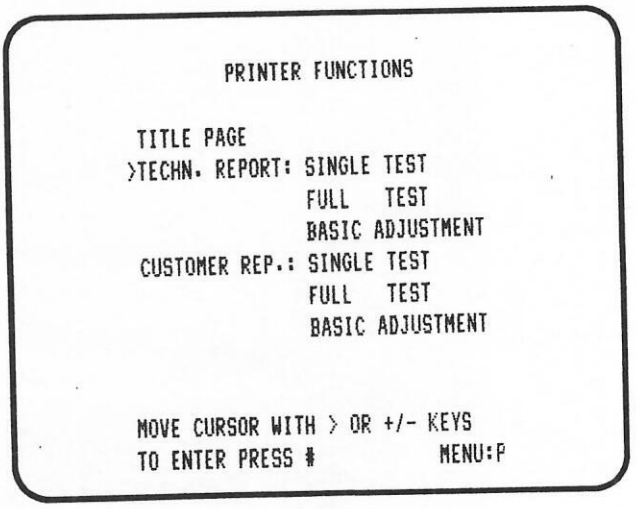


FIGURE 6:3
Printer Functions Menu

The screen display will now show six different options to print (Figure 6:3). After selection of print option, the printer will automatically activate. The next paragraphs will deal with each print seperately.

6.03 PRIMARY PAGE

The first page of every report is reserved for information (Figure 6:4) of the garage and customer, together with details of the vehicle presented for test.

```
=======================================
|  WELL EQUIPPED GARAGE PLC           |
|  2000 SUN WAY                       |
|  UPYOUR STREET                      |
|  NEAR PERFECT                       |
|  MCS 2000                           |
|                                     |
|  ALL CARS CATERED FOR               |
|                                     |
|  DATE:                   01/01/90   |
|  JOB NUMBER:            MISC 1234   |
|  ODOMETER MILES:            10234   |
=======================================

              VEHICLE UNDER TEST

=======================================
|  SUN CODE NUMBER:         18500122  |
|  MANUFACTURER:                FORD  |
|  MODEL NAME:       SIERRA/SAPPHIRE  |
|  NUMBER OF CYLINDERS:            4  |
|  LIMITS VALID FROM:        02.87->>  |
|  IGNITION TYPE:     TRANSISTORISED   |
|  FUEL SYSTEM TYPE:     CARBURETTOR   |
|  IDLE SPEED       RPM:     750-850  |
|  CO VALUE           %:   1.25-1.50  |
|  BASIC TIMING       °:   11.0-13.0  |
=======================================
```

FIGURE 6:4
First Page Print Format

6.04 PRINT REPORTS

Technician Report: Single Test

By selection of the 'TECHN. REPORT: SINGLE TEST' (Figure 6:3), the 'WORKSHOP TEST' menu will be displayed prior to printing. The operator may now move the cursor to the selected test and press the [#] continue key and printing of the selected single test will commence.

The report below shows the technician the printed result of the 'Ignition Timing Test', conducted in "section 5, pages 5 - 7 and 5 - 8". Whilst for the purpose of illustration the 'Ignition Timing Test' is shown. Alternative choices may be made from any one of the ten test areas offered from the 'WORKSHOP TEST MENU'.

IGNITION TIMING TEST

TEST DATA				DIAGNOSIS
	RPM	TIMING	VACUUM	Basic vacuum:: high!
BASIC	793=	7.5=	598"	Probable cause:
ADVANCE 1	2472=	9.1=	632"	-vacuum advance active.
ADVANCE 2	4109=	13.1=	616"	Check:
VACUUM ADV.	4023=	16.0=	655=	-if vacuum advance hose has been disconnected properly.
OIL TEMPERATURE	°C	84=		Repeat test to check remaining timing settings.

LIMIT DATA		MIN./ MAX.
BASIC TIMING		
ENGINE SPEED	RPM	700/ 1000
BASIC TIMING	°	4.0/ 8.0
VACUUM	MBAR	0/ 70
ADVANCE 1		
ENGINE SPEED	RPM	2350/ 2650
TIMING ADVANCE	°	3.0/ 11.0
VACUUM	MBAR	0/ 70
ADVANCE 2		
ENGINE SPEED	RPM	3800/ 4200
TIMING ADVANCE	°	9.0/ 16.0
VACUUM	MBAR	0/ 70
VACUUM ADVANCE		
ENGINE SPEED	RPM	3800/ 4200
TIMING ADVANCE	°	14.0/ 20.0
VACUUM	MBAR	280/ "
OIL TEMPERATURE	°C	75/ 115

End of Diagnostic Messages.

FIGURE 6:5
Typical Diagnostic Report (Single Test)

Technician Report: Full Test

Using the cursor, select from the 'PRINTER FUNCTIONS' menu 'FULL TEST' and press the [#] continue key. Printing of a full report will commence at this point.

The format of the printed output will follow the same pattern as with the single report, i.e., name and details on the first page, followed by a full diagnostic report. Instead of just one as shown on page 6 - 4, the 'MCS 2000' will print out all ten test areas as listed on the 'WORKSHOP TEST' menu (Figure 6:6).

Each area of test will print its report, irrespective of any fault being apparent. On the test areas showing no faults, the diagnostic report will still print all 'Test Data' and 'Limit Data' but the 'Diagnosis' will confirm that no problems have been found. (See Figure 5:7).

```
                WORKSHOP TEST

  IGNITION ON TEST
  STARTING SYSTEM TEST
 >CHARGING SYSTEM TEST
  IGNITION DWELL TEST
  TIMING / ADVANCE TEST
  IDLE EMISSIONS TEST
  LOW SPEED SECONDARY KV TEST
  HIGH SPEED SECONDARY KV TEST
  SNAP ACCELERATION TEST
  CYLINDER COMPARISON TEST
 MOVE CURSOR WITH > OR +/- KEYS
 TO ENTER PRESS #          MENU:P
```

FIGURE 6:6
Workshop Test Menu

CHARGING SYSTEM TEST

TEST DATA			DIAGNOSIS
ENGINE	RPM	3095=	Test result: No problems found.
BATTERY	VOLTS	13.5=	
CURRENT	AMPS	6.7=	
ALT. RIPPLE	%	0.2=	
OIL TEMPERATURE	°C	80=	
LIMIT DATA	**MIN./**	**MAX.**	
ENGINE SPEED	RPM	2800/ 3200	
CHARGING VOLTAGE	V	12.4/ 14.5	
CHARGING CURRENT	A	1.0/ 15.0	
ALTERNATOR RIPPLE	%	0.0/ 3.0	
OIL TEMPERATURE	°C	20/ 115	

FIGURE 6:7
Typical Diagnostic Report

Technicians Report: Basic Adjustment

The 'Basic Adjustment' report (Figure 6:8) retains the same format as previous printed output and displays all data and results together with any diagnostic guide. The 'Basic Adjustment' test sequence is primarily offered to conduct service adjustments rather than actual diagnosis.

BASIC ADJUSTMENTS TEST

TEST DATA			DIAGNOSIS	
ENGINE TIMING SPEED	RPM	810=	CO reading:	high!
DWELL	°	19.8=	HC reading:	high!
INITIAL TIMING	°	12.0=		
			Probable cause:	
			-incorrect idle mixture setting	
			Set emissions to specifications	
			and adjust idle speed; repeat	
ENGINE IDLE SPEED	RPM	815=	test.	
CO	%	2.34*		
HC	PPM	594*	End of Diagnostic Messages.	
CO2	%	14.4=		
O2	%	1.4=		
LAMBDA CALCULATED		0.97=		
AIR FUEL RATIO	:1	14.2=		
OIL TEMPERATURE	°C	89=		

LIMIT DATA		MIN./ MAX.
OIL TEMPERATURE	°C	80/ 115
TIMING WINDOW		
ENGINE SPEED	RPM	700/ 900
IGNITION DWELL	°	10.0/ 45.0
TIMING ADVANCE	°	11.0/ 13.0
EMISSIONS WINDOW		
ENGINE SPEED	RPM	850/ 950
HYDROCARBONS	PPM	100/ 300
CARBON MONOXIDE	%	1.5/ 2.0
CARBON DIOXIDE	%	10.0/ 15.0
OXYGEN	%	0.0/ 2.0
LAMBDA CALC.		0.95/ 1.15

FIGURE 6:8
Basic Adjustments Report

Customer Report: Single Test

Print reports selected from the 'Printer Functions' menu for the customer, refer only to checks that have been made together with a simplified diagnosis.

Using the cursor, select from the 'PRINTER FUNCTIONS' menu, 'CUSTOMER REPORT.: SINGLE TEST' (Figure 5:2).

Select from the 'WORKSHOP TEST' menu (Figure 5:6), the test area to be printed and to begin printing, press the [#] key.

The report shows the customer the printed result of the 'Ignition Timing Test', conducted in "section 4, pages 4 - 7 and 4 - 8". Whilst the illustration below shows 'Ignition Timing Test', alternative choices may be made from any one of the ten test areas offered.

IGNITION TIMING TEST

TEST DATA	DIAGNOSIS
THIS TEST CHECKS: - BASIC TIMING SETTING - ADVANCE (MECHANICAL AND/OR ELECTRONIC) - VACUUM ADVANCE (IF PRESENT) - VACUUM RETARD (IF PRESENT)	Basic vacuum:: high! Probable cause: -vacuum advance active.

FIGURE 6:9
Typical Customer Report (Single Test)

To see the actual differences between the 'Customer Report' and the 'Technician Report' the customer report shown in figure 5:9 is the same diagnosis as the technician report shown in figure 6 - 5.

Customer Report: Full Test

In a similar manner to printing the 'Technician Full Test', the 'Customer Full Test' is dealt with in the same manner. Figure 5:10 shows just the first test report of ten.

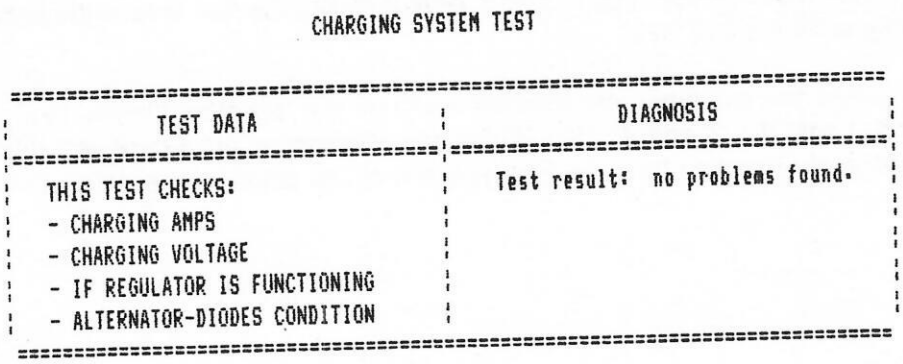


FIGURE 6:10
Typical Customer Report

Figure 6:10 shows the customer version of the technicians report previously shown at figure 6:7.

Customer Report: Basic Adjustment

This report is also dealt with in the same way as previosuly described in the 'Technicians Basic Adjustment' procedure. Figure 5:11 shows the customer version of the report previously shown at figure 5:8.

BASIC ADJUSTMENTS TEST

TEST DATA	DIAGNOSIS
THIS TEST CHECKS:	CO reading: high!
- BASIC DWELL SETTING	HC reading: high!
- BASIC TIMING SETTING	
- IDLE SPEED SETTING	Probable cause:
- IDLE MIXTURE (CO) SETTING	-incorrect idle mixture setting

FIGURE 6:11
Basic Adjustments Report

6.05 PRINTER MAINTENANCE

General

The 'MCS 2000' is equipped with a 'HSP 1080' high speed, eighty column, dot matrix printer for hard copy output of virtually any report whether complete from the printer menu or simply by pressing the print button to print screen page information only.

The printer has internal factory set switches that must not be altered or reset in any way. The rear cover of the printer should NOT be removed.

The 'HSP 1080' printer requires standard size, perforated, tractor feed, fanfolded, computer 'A4' paper measuring (9.5" x 11") available from most High Street stationery suppliers.

Printer Controls

Three indicator lights on the printer front panel (Figure 6:12) provide the operator with the following information:

POWER: This light indicates that electric power is switched on to the printer.

ALARM: This light glows when the paper supply runs out or if the paper becomes jammed or distorted in the tractor feed. Printing will stop until the paper supply is replenished.

SEL: The 'SEL' light indicates that communication with the 'MCS 2000' is available. **This light must be on for the printer to operate.**

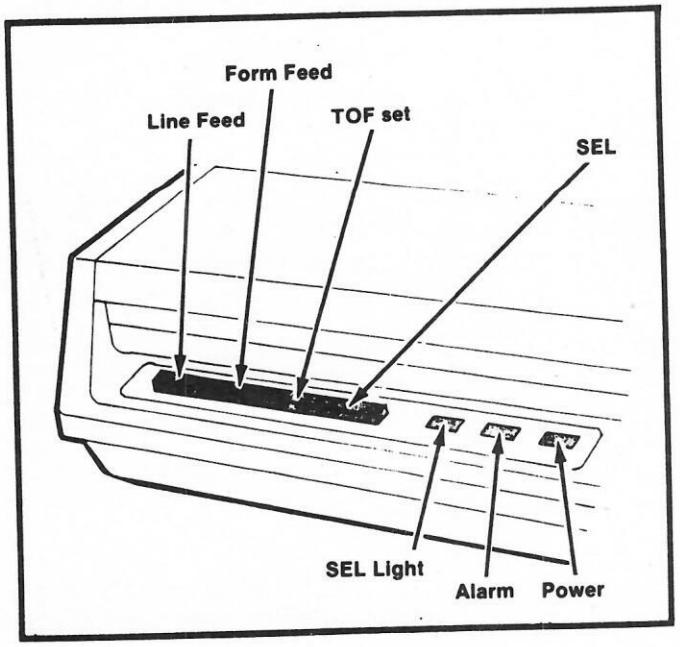


FIGURE 6:12
Printer Front Panel

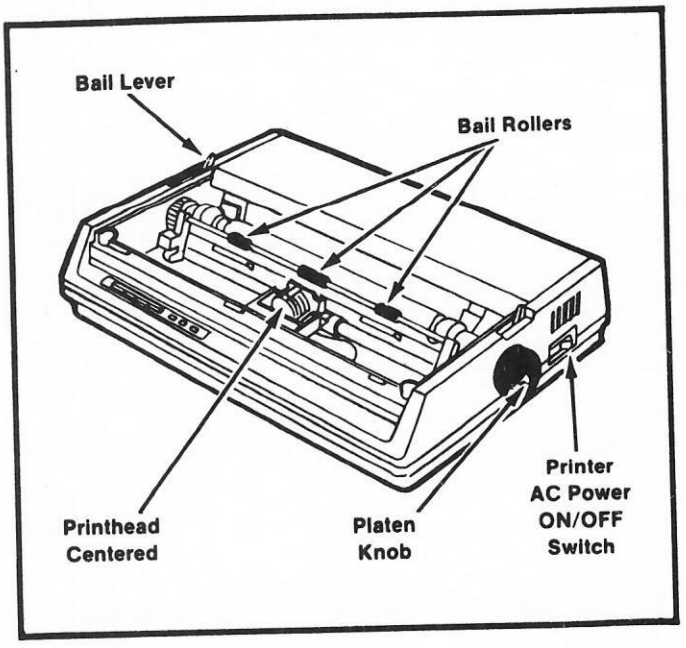


FIGURE 6:13
Location of Controls

Paper Loading

1. Turn the printer off at the power switch (Figure 6:13).

2. Remove the top access cover by lifting off.

3. Place a stack of fanfolded paper in the compartment below the printer.

4. Pull forward both the bail and paper levers, located left and right of the printer platen. (Figure 6:14).

5. Take the first sheet of paper and feed it through the bottom of the printer and into the paper guides shown in figure 6:15.

6. Align and mount the holes of the paper with the corresponding pins on the left and right pin feeds (Figure 6:15).

Note: Adjustable pin feeds should always be set to accommodate 9.5" width print paper. If for some reason, pin feed width is disturbed, reset by pushing the pin feed adjustment levers (located just to the outside of each set of tractor pins) forward and slide both mechanisms to the correct width. Push adjustment levers back into place to lock mechanism to new position. (Figure 6:15).

7. Lower the bail and replace the access cover.

8. Turn the printer power switch on, ensure 'SEL' light glows.

9. Press the print key [/=/] and keep depressed for three seconds and paper will automatically advance.

10. When paper stops advancing, turn up the paper manually using the platen knob until a perforation is lined up with the edge of the printer access cover.

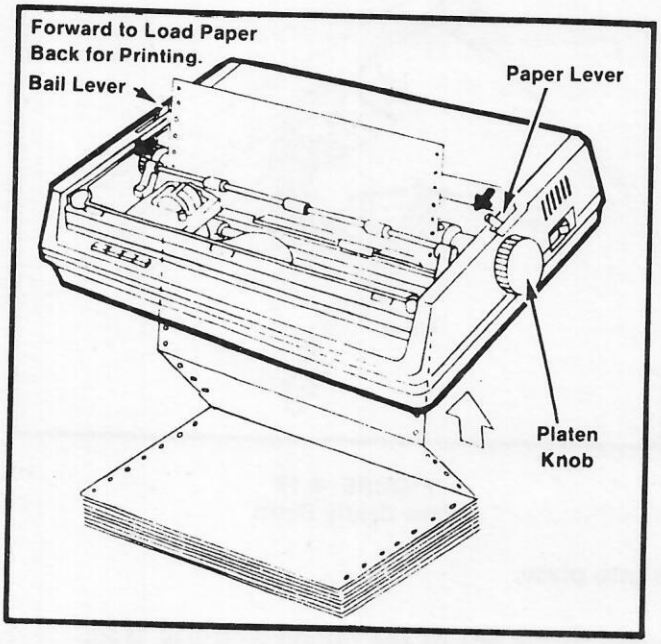


FIGURE 6:14
Bottom Paper Feed Loading

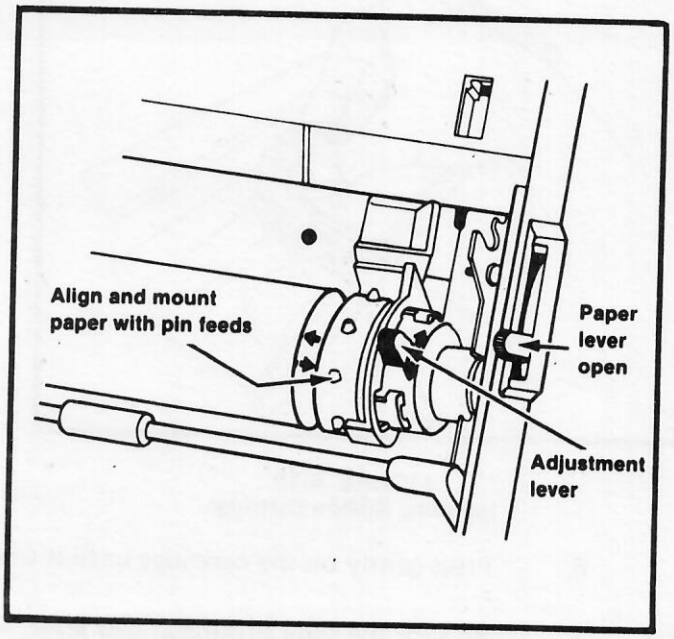


FIGURE 6:15
Adjustable Pin Feed

Ribbon Cartridge Replacement

1. Turn the printer off at the power switch. (Figure 6:13).

2. Remove the top access cover by lifting off.

3. Slide the printhead to the middle of the printer. (Figure 6:16).

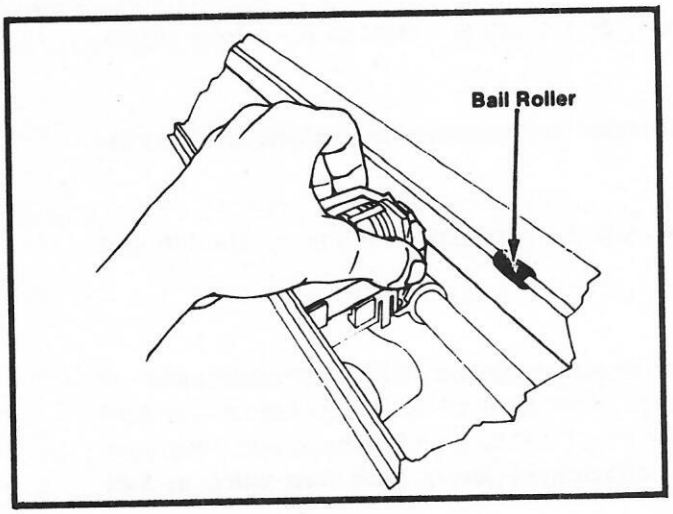


FIGURE 6:16
Grasp Cartridge and Lift

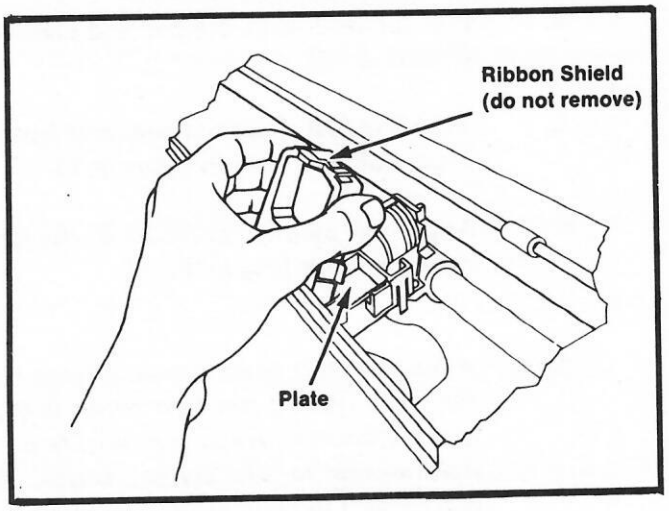


FIGURE 6:17
Installing Ribbon Cartridge

4. To remove old ribbon cartridge, grasp on either side of the cartridge and lift up. (Figure 6:17).

5. Install a new black ribbon cartridge by tilting the side of the cartridge opposite the ribbon shield so that a portion of the cartridge slides on to the front of the printhead plate. Lower the top of the cartridge containing the side with the ribbon shield over the printhead (Figure 6:18). DO NOT REMOVE THE RIBBON SHIELD. A tab on each side of the cartridge will align perfectly with inserts on the printhead plate.

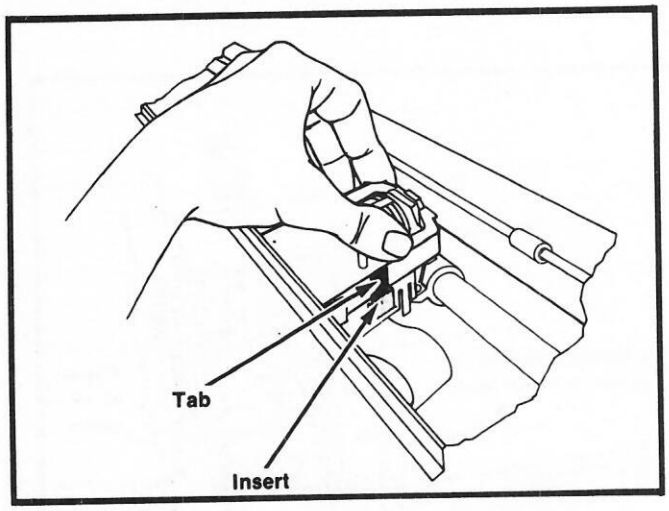


FIGURE 6:18
Installing Ribbon Cartridge

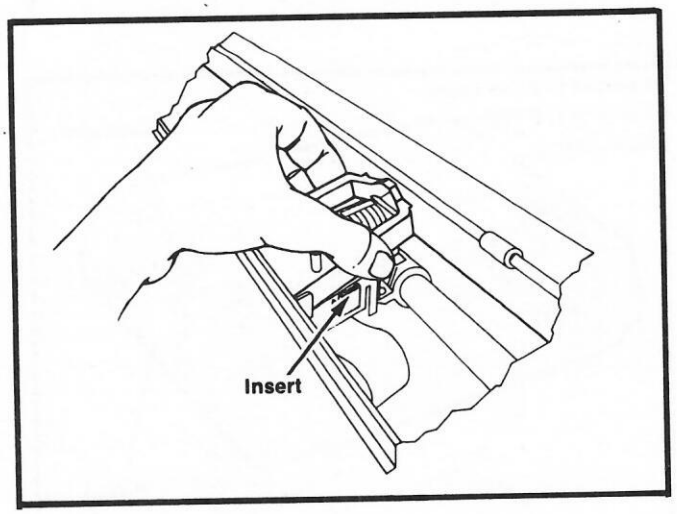


FIGURE 6:19
Press Gently Down

6. Press gently on the cartridge until it snaps into place.

7. Be sure the blue printhead gap lever, located to the left of the ribbon cartridge, is set in the number 1 (one) position.

Routine Maintenance

For trouble free operation, the printer should be cleaned as follows at least once a month or after 300 hours operation.

DO NOT APPLY ANY LUBRICANTS TO THE PRINTER

1. Turn power off to the 'MCS 2000' and remove paper stack.

2. Remove the printer access cover.

3. Using a clean dry soft cloth, dust the area around the carriage shaft, platen and paper sensor. Remove any loose paper particles or other debris.

4. With the nozzle attachment of a vacuum cleaner, vacuum the carriage shaft and paper feed areas very carefully to remove any accumulated dust. **Do not use a compressed air supply.**

5. Re-load paper (See Paper Loading) and replace access cover.

SECTION SEVEN
SYSTEM TESTING

7.01 GENERAL

The 'MCS 2000' in addition to the comprehensive full testing facilities already covered, incorporates several other features to assist with the accurate diagnosis of various other systems found on all ranges of motor vehicles. These include:

MULTIMETER TEST: A high specification multimeter, containing three screen pages of information to facilitate quick reference checks of service adjustments, basic diagnosis or full volt/ohm-meter checks.

BASIC ADJUSTMENTS TEST: Two screen pages of live data complete with specifications with any adjustments to be made in chronological order to assist in final tuning of the engine.

LEADS CONNECT CHECK: A facility to ensure that one or all connections have been correctly connected to the engine and confirm that no diagnostic faults are attributable to operator error.

Any of the above are selected by pressing key [P] until the 'PROGRAMME SELECTION' menu (Figure 7:1) is shown. Select from this menu, 'VEHICLE TESTING' and then select from the 'VEHICLE TEST SELECTION' menu (Figure 7:2) either 'MULTIMETER TEST' or 'BASIC ADJUSTMENTS TEST' or 'LEADS CONNECT CHECK'.

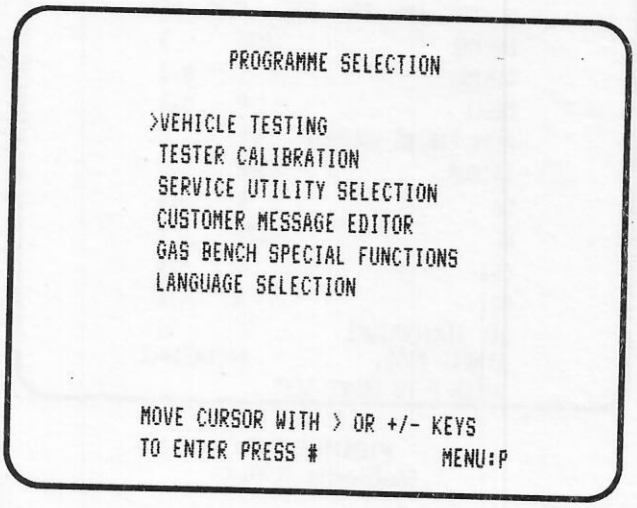


FIGURE 7:1
Programme Selection Menu

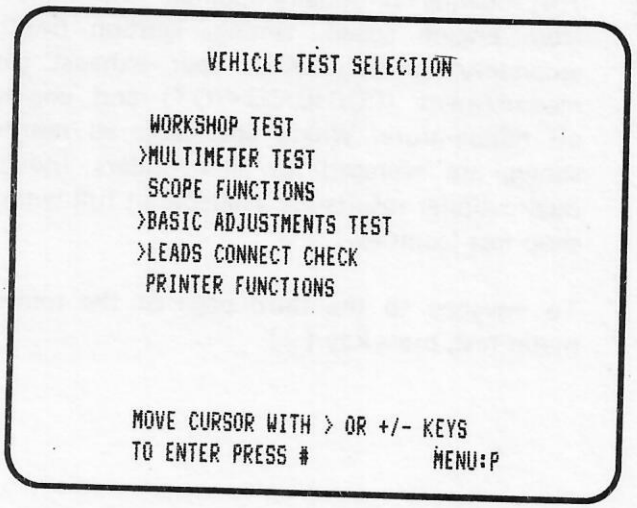


FIGURE 7:2
Workshop Test Selection Menu

7.02 MULTIMETER TEST

Multimeter 1 Test

Upon selection of the Multimeter, the first screen page will be displayed (Figure 7:3) showing continually updated information from engine speed, battery, primary ignition, secondary ignition (KV), unburnt fuel level (HC) and oil temperature. Where applicable, all results shown are averaged for all cylinders. Individual cylinder results are available in full workshop test facilities.

To advance to the second page of the multimeter test, Press key [#].

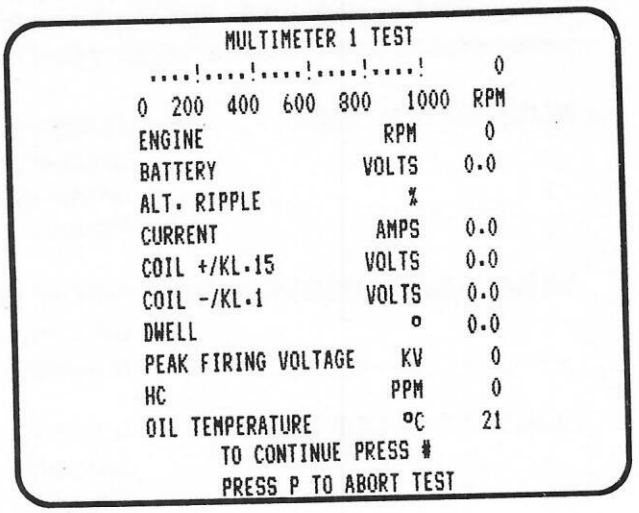


FIGURE 7:3
Multimeter 1 Test

Multimeter 2 Test

After pressing key [#], the second screen page of the multimeter is displayed (Figure 7:4) showing continually updated information from engine speed, timing, ignition dwell, secondary ignition (KV), four exhaust gas measurement ($CO/HC/CO^2/O^2$) and engine oil temperature. Where applicable all results shown are averaged for all cylinders. Individual cylinder results are available in full workshop test facilities.

To advance to the third page of the multimeter test, press key [#].

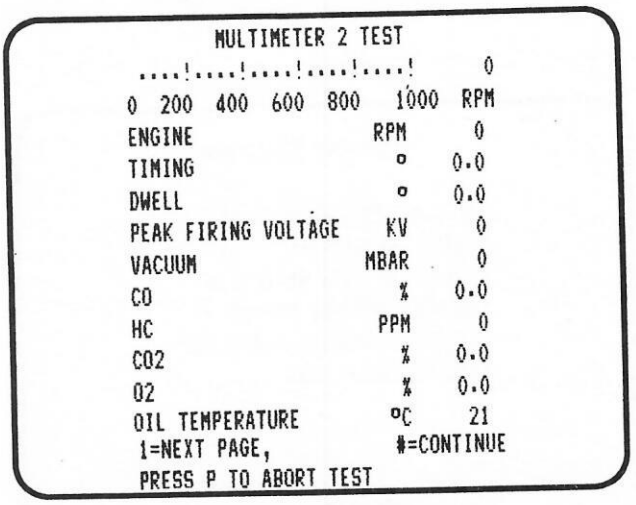


FIGURE 7:4
Multimeter 2 Test

Multimeter 3 Test

All measurements using the volt/ohms meter are carried out using the separate twin leads from the Computer overhead boom. The leads have interchangeable ends incorporating pointed probes or pinch clips.

After pressing key [#], the third screen page of the multimeter is displayed (Figure 7:5) and will automatically, select voltage range. If resistance (Ohms) is required, press the cursor [>] to change.

The ohm-meter has two ranges, one variable and one fixed. To alternate between these choices press [*] for the fixed range or key [+/-] to reset to variable.

To finish with the multimeter facilities, press key [P] to return to the main menu.

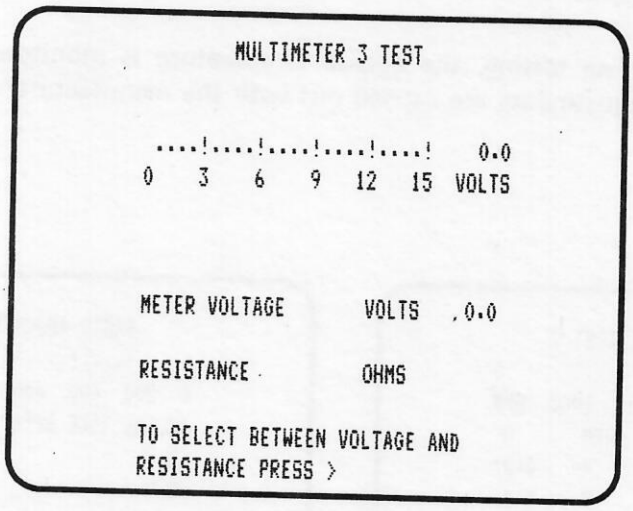


FIGURE 7:5
Multimeter 3 Test (Volts Range)

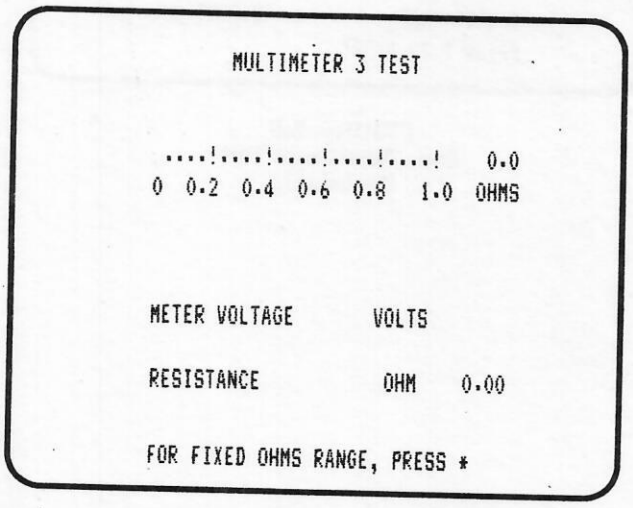


FIGURE 7:6
Multimeter 3 Test
(Variable Range Ohms)

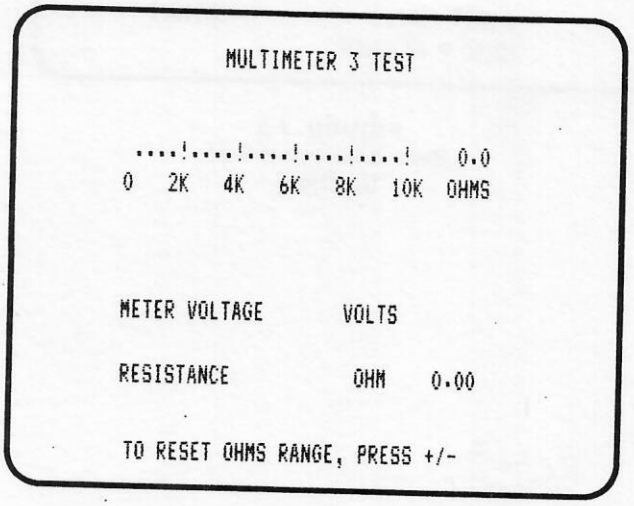


FIGURE 7:7
Multimeter 3 Test
(Fixed Range Ohms)

7.03 BASIC ADJUSTMENTS TEST

As the 'BASIC ADJUSTMENTS TEST' is decisive and therefore will indicate whether the results are within specification, details of the vehicle presented for test must be loaded in to the 'MCS 2000'. Refer to Section 4, for details on loading the computer with vehicle limits.

Select the 'BASIC ADJUSTMENTS TEST' as described on page 7.1 and if applicable to the vehicle limits, various reminder messages will be displayed. As each instruction is completed, press key [#] as instructed on the prompt line.

The first (Figure 7:8) of two screen pages of live engine data will be displayed and adjustments may be carried out. The page is arranged so that all adjustment sequences are conducted in chronological order to minimise on duplicated work.

After completion of timing and dwell on the first screen page, press key [1] to proceed to the next screen page (Figure 7:9) to make final adjustments to exhaust emission.

Note: At all times during testing, the engine temperature is monitored and care should be taken that adjustments are carried out with the manufacturers temperature specifications.

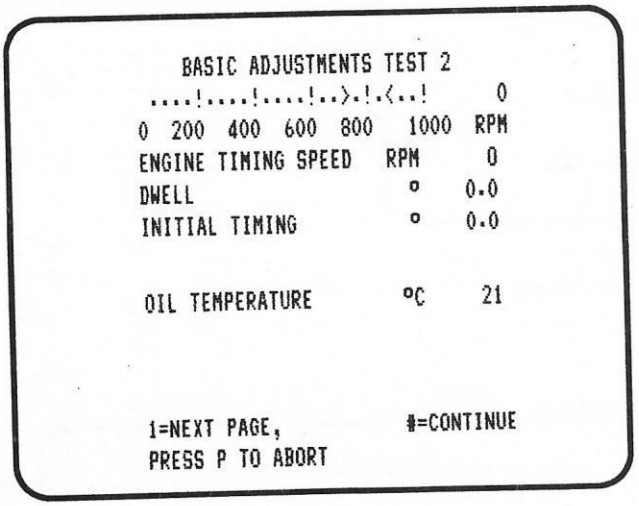


FIGURE 7:8
Basic Adjustment Test
(Ignition)

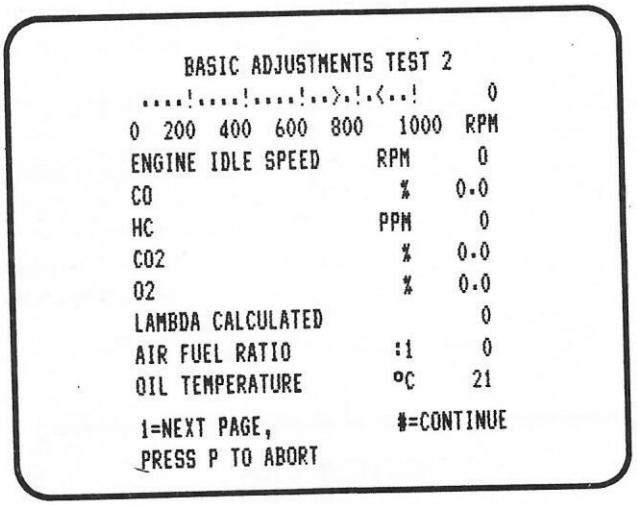


FIGURE 7:9
Basic Adjustment Test
(Emission)

7.04 LEADS CONNECT CHECK

A check of all lead connections is always carried out as part of the initial set-up to a vehicle and therefore full instructions have already been included in Section 4.05 on page 4-8.

'LEADS CONNECT CHECK' may be carried out at any time during use of the 'MCS 2000' should a recheck be necessary.

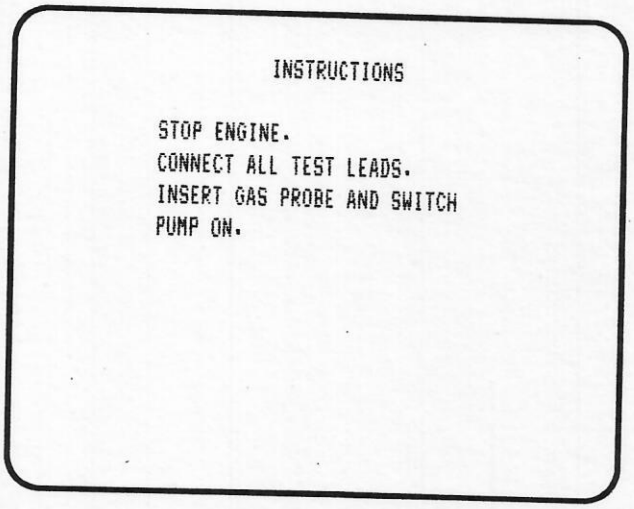


FIGURE 7:10
Instruction Screen

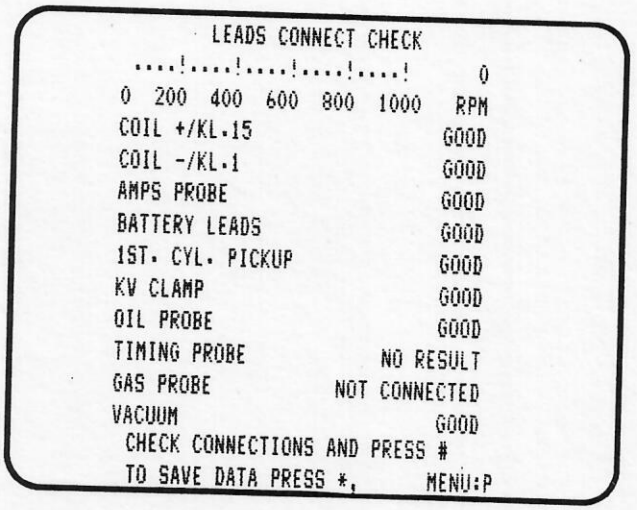


FIGURE 7:11
Engine Connection Check

SECTION EIGHT
OSCILLOSCOPE FUNCTIONS

8.01 GENERAL

The oscilloscope fitted to the 'MCS 2000' is a digital scope and therefore has more flexibility to save and store various test sequence patterns than its counterpart, the anologue oscilloscope. The more common waveform test areas of secondary and primary ignition testing are still incorporated, but additional facilities to produce test waveforms from engine management components in addition to fuel injection equipment are more accessible with the versatility to freeze, print or save correct and incorrect patterns. Furthermore, using the freeze or store facility, the operator is able to view problem areas without unnecessary running of a faulty engine.

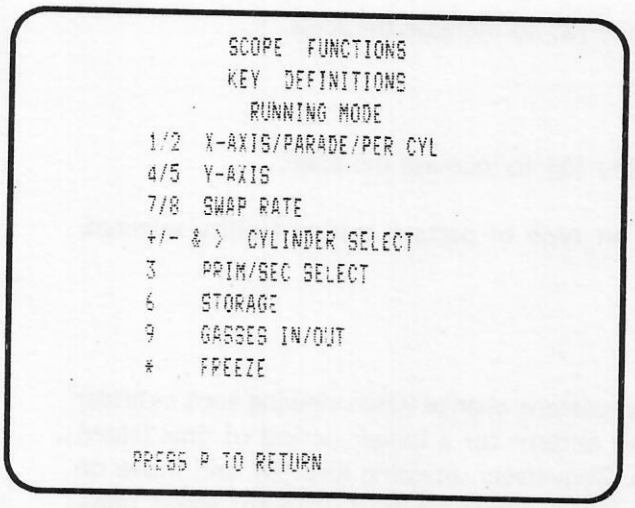


FIGURE 8:1
Running Mode
Key Definitions

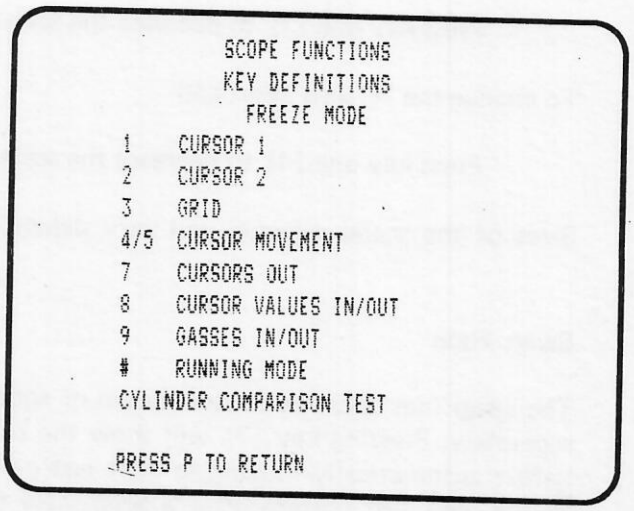


FIGURE 8:2
Freeze Mode
Key Definitions

8.02 OPERATIONS IN SCOPE RUNNING MODE

At any time during use of the oscilloscope, pressing key [0] will display a menu (Figure 8:1) assisting the operator with various key functions whilst the scope is used in the running mode.

Scale Changing

Alteration to the oscilloscope Horizontal scale (X axis) and Vertical scale (Y axis) is permissable to allow the operator to choose the largest possible view of waveforms within the scope.

To change the 'X' axis: (Horizontal)

Press key one [1] to decrease the scale or key [2] to increase the scale.

To change the 'Y' axis (Vertical)

Press key one [4] to decrease the scale or key [5] to increase the scale.

Sizes of the scales selected will vary dependent on type of pattern testing facility selected.

Swap Rate

The swap rate operates to slow down or speed up pattern change when viewing each cylinder seperately. Pressing key [7] will show the selected pattern for a longer period of time (slow) before automatically moving to next test pattern. Conversely, pressing key [8] will move on to the next test pattern after a brief view time (fast). There are four different speed rates, pressing either key [7] or [8] consecutively will show all four rates.

Cylinder Select

Cylinder select shows the operator a continuous pattern from a particular cylinder of operation. By pressing key [>] the next pattern in firing sequence will be displayed. Pressing key [+/-] will display the previous pattern in firing sequence.

All patterns on display will stay locked on screen until a further key stroke is made.

Primary/Secondary Select

By pressing key [3], the oscilloscope will change from Primary to Secondary waveform testing. To revert back to the first pattern, toggle on key three [3].

Pattern Store

Pressing key [6] will put into computer memory a sequence of firing patterns from any of the available modes of testing. To discontinue storing patterns, press key [6] again.

To review the patterns, whether the engine is running or not, press the [>] key to scroll forward and the [+/–] to scroll backwards.

Whilst review takes place, the operations of the scope will be as if the freeze mode is used and therefore if a defective pattern is displayed, the cursor measurement facility may be used. (Cursor measurement is described later in this section).

Exhaust Gas Display

It will be of use to view the four exhaust gas data readings during various test areas. This facility is available by pressing key [9], whereby live update of emission data is shown overlayed in the upper right section of the oscilloscope. To cancel the exhaust gas data, press key [9] again.

Freeze

To Freeze any waveform, press [*]. To release Freeze, press [#].

NOTE:

Refer to Section 2; Page 5 for complete overview of hand control.

8.03 OPERATIONS IN SCOPE FREEZE MODE

Cursor Measurement

Two cusors are employed to show measurements in time, displayed as milliseconds (MS) and frequency, displayed as Hertz (HZ).

To use the cursor measurement facility, the scope must be in the freeze mode. A menu (Figure 8:2) is available when key [0] is pressed.

Pressing key [1] places the first cursor, depicted as a vertical line, on the screen. Pressing key [4] will move the cursor line to the left and pressing key [5] will move the cursor line to the right. If either key [4] or [5] is continually pressed the cursor line will move steadily in the direction selected.

Pressing key [2] places the second cursor, also depicted as a vertical line, on the screen. Pressing either key [4] or [5] operates in the same manner as the first cursor.

Having placed the cursors on measurement points, the upper right of the oscilloscope will display the measurement data in 'MS' and 'HZ' if key [8] is selected. Pressing key [8] again de-selects measurement data.

The cursor measuring facility is convenient for measurement checks to injection duration, spark duration and any system of operation concerning pulse and timebase.

To cancel all cursor positions, press key [7].

Oscilloscope Grid

A further aid to measurement can be placed on screen in the form of a grid, evenly placed both vertically and horizontally assisting the operator to quickly check duty cycles etc. Pressing key [3] places the grid on screen. Pressing key [3] again returns the screen to original setting.

Exhaust Gas Display

Similarly as with the scope running mode, the four exhaust gas data readings may need to be monitored. This facility is available by pressing key [9], whereby frozen emission data is shown overlayed in the upper right section of the oscilloscope. To cancel the exhaust gas data, press key [9] again.

Running

To re-run any waveform, press [#]. To Refreeze, press [*].

8.04 IGNITION PATTERNS

Secondary Waveforms

Secondary patterns are waveforms generated from the engine ignition system and in the main contain information concerning the spark output from the coil tower and distributed to the spark plugs. Certain criteria governs the principle of the pattern such as when and for how long a switching method operates.

i.e. A set of ignition points or transistor pack etc.

It should also be borne in mind that should a fault show in an oscilloscope pattern, certain mechanical factors also exist to influence the result.

i.e. Weak fuel mixtures will show high plug voltage lines.

NOTE:

The following pages show typical secondary patterns displayed on the 'MCS 2000'. In general, these patterns are printed to describe the use of the hand control with cursor features and scale changes. The patterns do not imply any problems existing in either the ignition or mechanical areas of the engine, but the patterns being taken from an actual running engine may show small areas of wear or malperformance.

Illustrated below is a standard secondary scope ready for use, set to a horizontal scale (X-axis) of 100% to 0% and a vertical scale (Y-axis) of 0 KV to 50 KV, also shown is exhaust gas data in the top right of the screen.

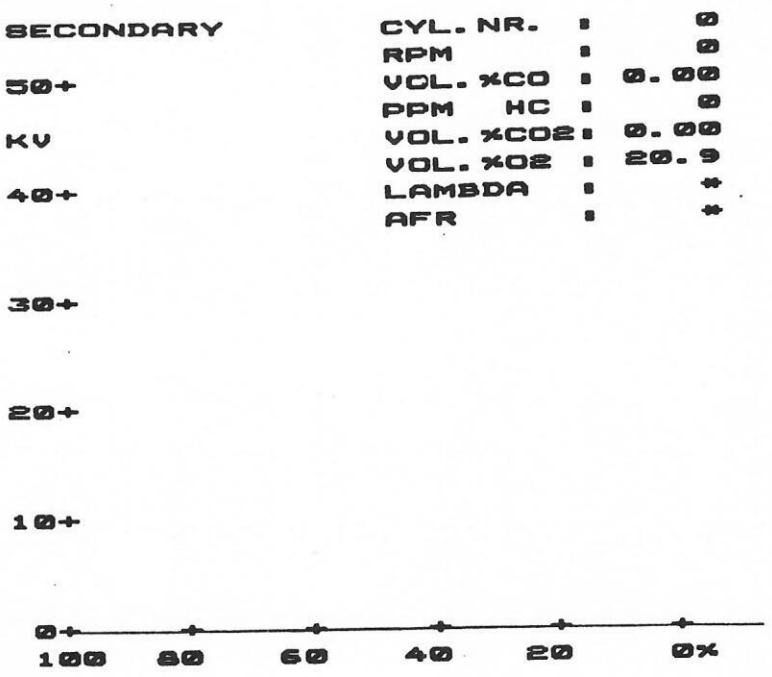
Change horizontal scale by pressing keys [1] or [2].

Scales available:
- Blank (No Scale)
- 100% to 0%
- 0 MS to 5 MS
- 0 MS to 100 MS

Change vertical scale by pressing keys [3] or [4].

Scales available:
- 0 KV to 5 KV
- 0 KV to 10 KV
- 0 KV to 25 KV
- 0 KV to 50 KV

Press key [9] to hide or display exhaust gas data.



Illustrated below is a typical secondary pattern in the running mode showing a cylinder firing section with the horizontal scale (X-axis) set at 0 MS to 5 MS and a vertical scale (Y-axis) of 0 KV to 25 KV, also shown is exhaust gas data in the top right of the screen.

Change horizontal scale by pressing keys [1] or [2].

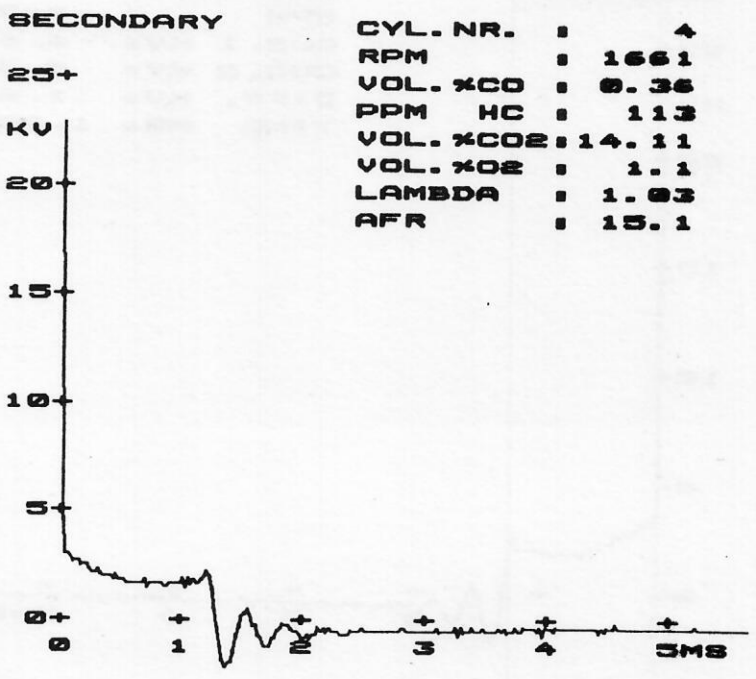
Scales available:
- Blank (No Scale)
- 100% to 0%
- 0 MS to 5 MS
- 0 MS to 100 MS

Change vertical scale by pressing keys [3] or [4].

Scales available:
- 0 KV to 5 KV
- 0 KV to 10 KV
- 0 KV to 25 KV
- 0 KV to 50 KV

Press key [9] to hide or display exhaust gas data.

Press key [*] to freeze scope trace.



Illustrated below is a typical secondary pattern in the freeze mode showing a cylinder firing section with the horizontal scale (X-axis) set at 0 MS to 5 MS and a vertical scale (Y-axis) of 0 KV to 25 KV. Note that the top right of the scope now displays data from use of the cursors.

Install first cursor by pressing key [1]

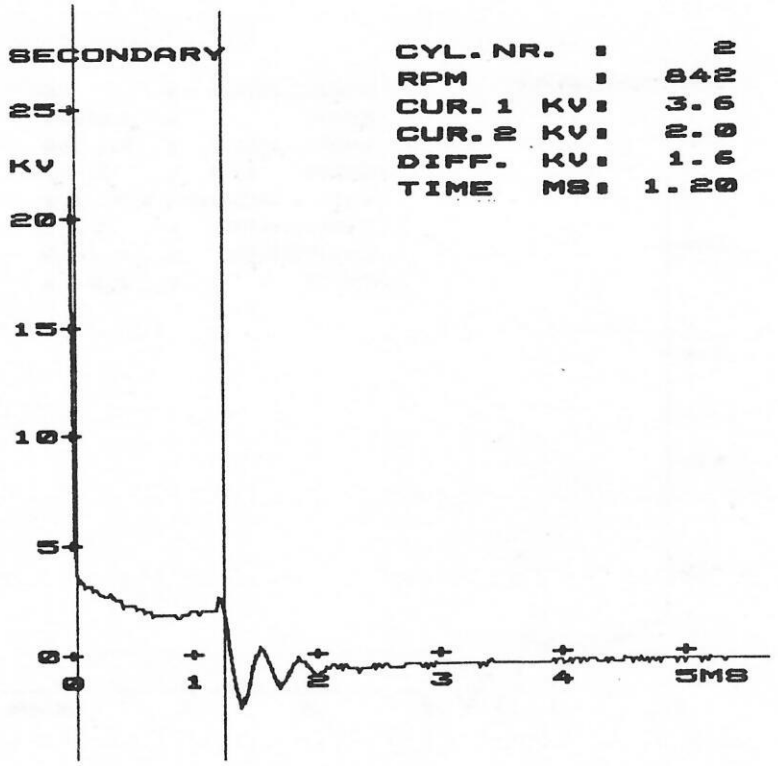
Move cursor left: key [4]
Move cursor right: key [5]

Install second cursor by pressing key [2]

Move cursor left: key [4]
Move cursor right: key [5]

Press key [9] to hide or display cursor data.

Press key [#] to return to running scope trace.



Primary Waveforms

Primary patterns are waveforms generated from the engine ignition system and in the main contain information concerning the operation and input of low voltage from the battery via the ignition switch and to the coil. As with the secondary patterns, certain criteria can influence the pattern.

The primary waveforms displayed on the following pages may be manipulated in exactly the same manner as the previous test for secondary waveforms. The functions of the keyboard have identical values to freeze, use cursors and data or cursors in/out.

NOTE:

The following pages show typical primary patterns displayed on the 'MCS 2000'. In general, these patterns are printed to describe the use of the hand control with cursor features and scale changes. The patterns do not imply any problems existing in either the ignition or mechanical areas of the engine, but the patterns being taken from an actual running engine may show small areas of wear or malperformance.

Illustrated below is a typical primary pattern in the running mode showing all cylinders firing, with the horizontal scale (X-axis) set at 0 MS to 5 MS and a vertical scale (Y-axis) of 0 V to 500 V.

Change horizontal scale by pressing keys [1] or [2].

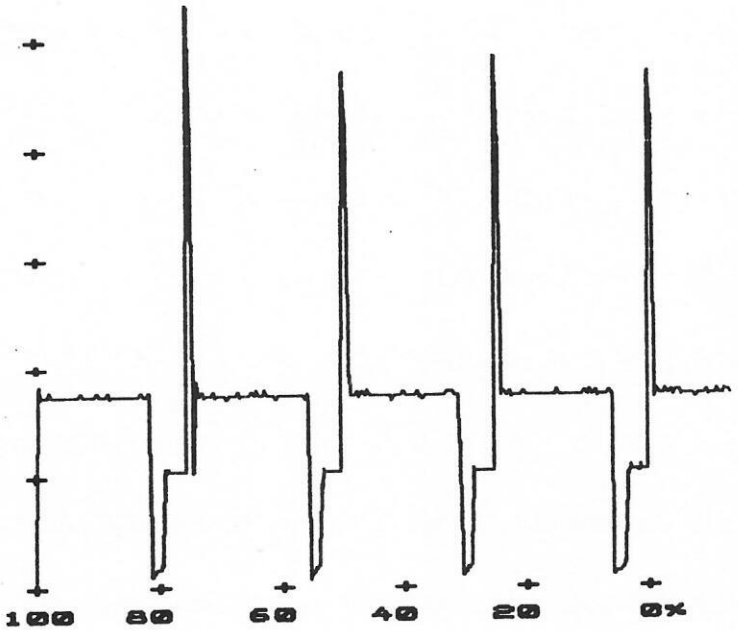
Scales available:
- Blank (No Scale)
- 100% to 0%
- 0 MS to 5 MS

Change vertical scale by pressing keys [3] or [4].

Scales available:
- 0 V to 25 V
- 0 V to 50 V
- 0 V to 250 V
- 0 V to 500 V

Press key [9] to hide or display exhaust gas data.

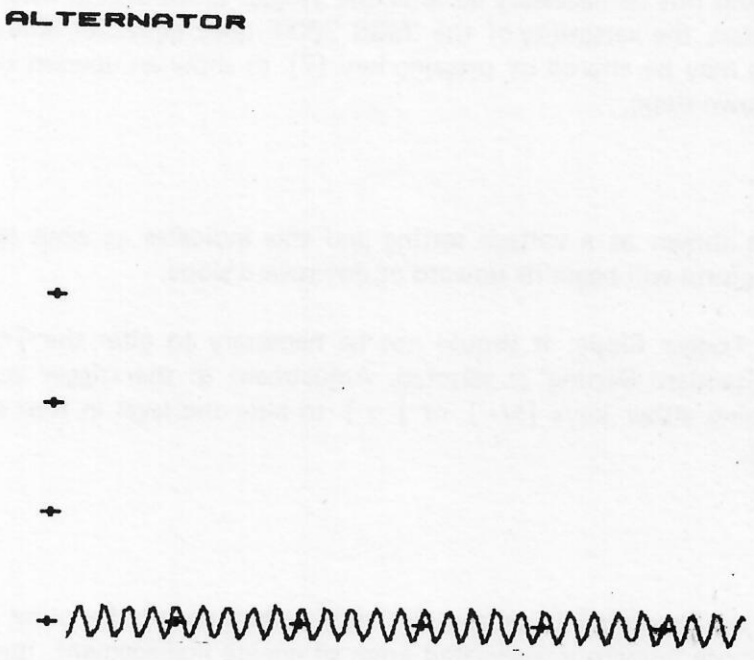
Press key [*] to freeze scope trace.



8.05 ALTERNATOR PATTERNS

The following pattern shows a typical alternator waveform, in serviceable order. Patterns may differ slightly depending on the manufacture of the alternator or whether the charging system has a load applied such as the headlights or heated screen are switched on. In general the pattern should be consistent and of an even height.

Usually, breakdown of an alternator diode interrupts the waveform with a high volt spike and is quite noticeable on screen.



8.06 LAB SCOPE

Trigger Level and Mode

When the lab scope is selected, ten options are on menu for easy choice and set up of the scope for particular area testing.

Each of the ten screens will show two important items:

1. **Trigger Slope**

   Trigger Slope is shown using an arrow symbol either up [^] or down [v]. This simply means that the first section of the waveform, starting on the left of the scope, will either rise or fall in the direction the arrow indicates.

   Although it should not be necessary to alter the Trigger Slope except when 'Standard Setting' is selected, the versatility of the 'MCS 2000' does allow for adjustment and the trigger slope may be altered by pressing key [7] to show an upward slope or key [8] to show a down slope.

2. **Trigger Level**

   Trigger Level is shown as a voltage setting and this indicates at what level on the 'Y' axis the waveform will begin its upward or downward slope.

   Similar to the Trigger Slope, it should not be necessary to alter the Trigger Level except when 'Standard Setting' is selected. Adjustment of the trigger level may be altered by pressing either keys [+/–] or [>] to alter the level in four steps. (0.5v : 3v : 10v : 20v).

Lab Scope Patterns

Lab Scope waveforms are generated from any electrical system usually by pulse and can be used to verify and diagnose numerous associated areas of engine management, fuel injection, sensors, amplifiers to name just a handful.

NOTE:

The following pages show typical lab scope patterns displayed on the 'MCS 2000'. In general, these patterns are printed to describe the use of the hand control with cursor features and scale changes. The patterns do not imply any problems existing in either the ignition, mechanical or management areas of the engine, but the patterns being taken from an actual running engine may show small areas of wear or malperformance.

Lab Scope Pre-Set Scales

Each of the ten listed areas on the lab scope menu will be defined with pre-set information, most suitable to test the component selected.

In addition to the pre-set information, each test area may, if required, be altered within the parameters listed below. Therefore information given on this page will be applicable to all ten lab-scopes tests.

Change horizontal scale by pressing keys [1] or [2].

Scales Available:
- Blank (No Scale)
- 100% to 0%
- 500 MS to 0 MS
- 100 MS to 0 MS
- 25 MS to 0 MS
- 5 MS to 0 MS

Change vertical scale by pressing keys [3] or [4].

Scales Available:
- 0 v to 100v
- 0 v to 40 v
- 0 v to 20 v
- 0 v to 5 v
- 0 v to 2 v
- 0 v to 1 v

Change Trigger Slope by pressing keys [7] or [8].

Scales Available:
- 0.5 v
- 3.0 v
- 10.0 v
- 20.0 v

Change Trigger Level by pressing keys [+/–] or [>].

Scales Available:
- Arrow pointing upward
- Arrow pointing downward

Press key [9] to hide or display exhaust gas data. (Running Mode).

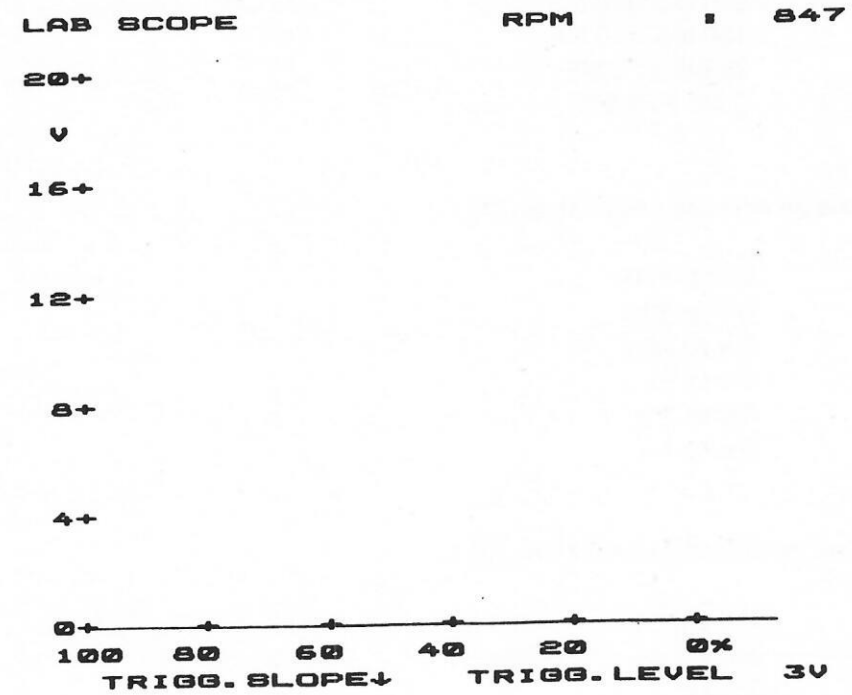
Press key [8] to hide or display cursor data. (Freeze Mode).

Standard Setting

Illustrated below is 'Standard Setting' lab scope selected from the menu and ready for use.

Pre-Set Scales:-

Horizontal (X-Axis)	:	Oms to 25ms
Vertical (Y-Axis)	:	0v to 40v
Trigger	:	Internal




```
FREQ. HZ :   0.0
RPM      :     0
VOL. %CO :     *
PPM  HC  :     *
VOL. %CO2:     *
VOL. %O2 :     *
LAMBDA   :     *
AFR      :     *
```

Duty Cycle

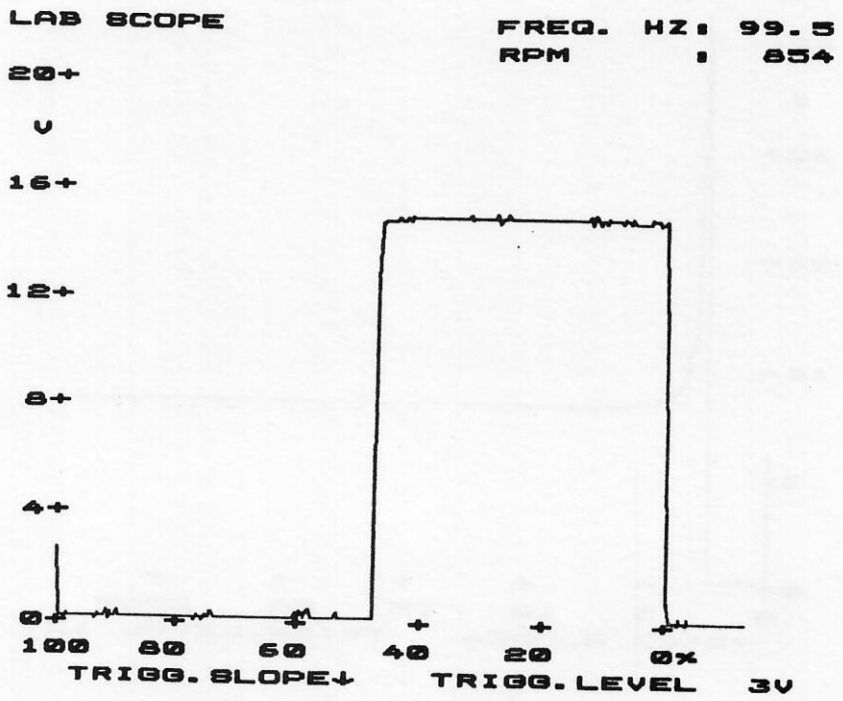
Illustrated below is the 'Duty Cycle' lab scope selected from the menu and showing a waveform from an Idle Speed Control.

Pre-Set Scales:-	Horizontal (X-Axis)	:	100% to 0%
	Vertical (Y-Axis)	:	0v to 20v
	Trigger Slope	:	Down
	Trigger Level	:	3v

Use Pinpoint Leads:- Black to engine earth.
Red to pulse terminal.

NOTE:

The waveform illustrated is a sample of an 'Idle Speed Control', but it must be remembered that this pattern can vary in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



Injector

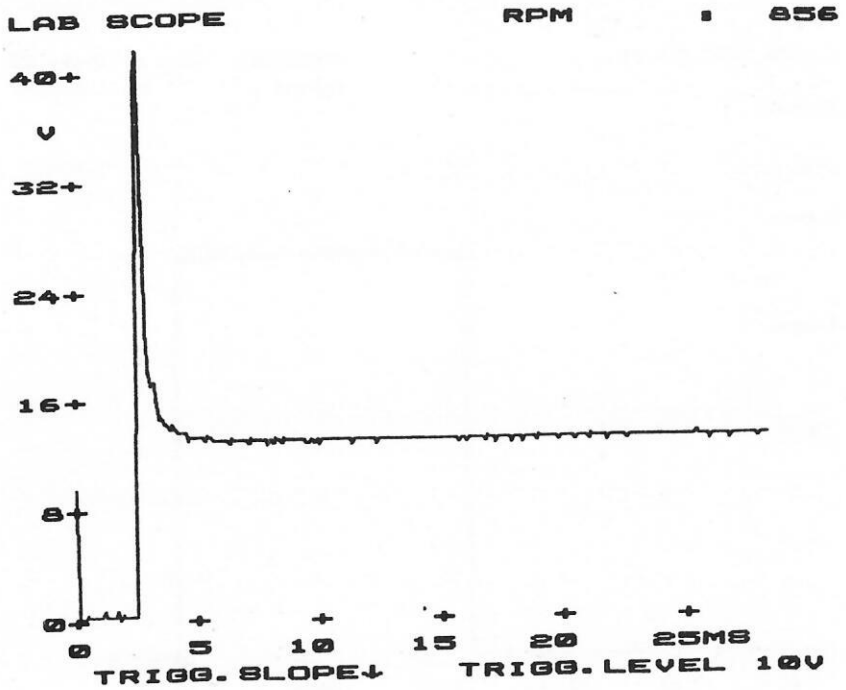
Illustrated below is an 'Injector' lab scope selected from the menu and showing a waveform of an electronic fuel injector.

Pre-Set Scales:-	Horizontal (X-Axis)	:	0ms to 25ms
	Vertical (Y-Axis)	:	0v to 40v
	Trigger Slope	:	Down
	Trigger Level	:	10v

Use Pinpoint Leads:- Black to engine earth.
Red to injector switching terminal.

NOTE:

The waveform illustrated is a sample of an 'Electronic Fuel Injector', but it must be remembered that this pattern can vary in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



Idle Mixture Control

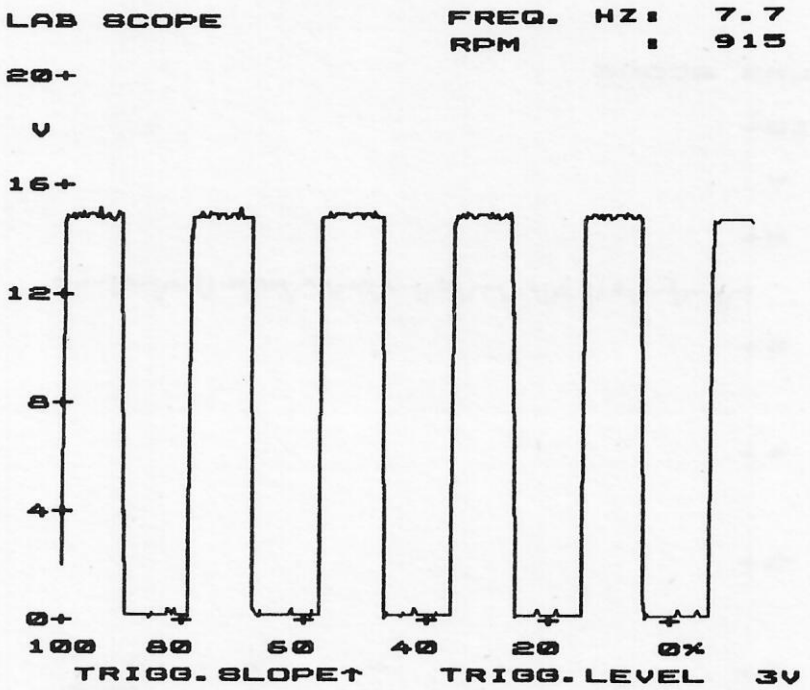
Illustrated below is the 'Idle Mixture Control' lab scope selected from the menu and showing the waveform of an Idle Mixture Control.

Pre-Set Scales:-	Horizontal (X-Axis)	:	100% to 0%
	Vertical (Y-Axis)	:	0 v to 20 v
	Trigger Slope	:	Up
	Trigger Level	:	3v

Use Pinpoint Leads:- Black to engine earth.
Red to Pulse terminal.

NOTE:

The waveform illustrated is a sample of an 'Idle Mixture Control', but it must be remembered that this pattern can very in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



Integrator Voltage

Illustrated below is the 'Integrator' lab scope selected from the menu and showing the waveform from LU-Jetronic ECU.

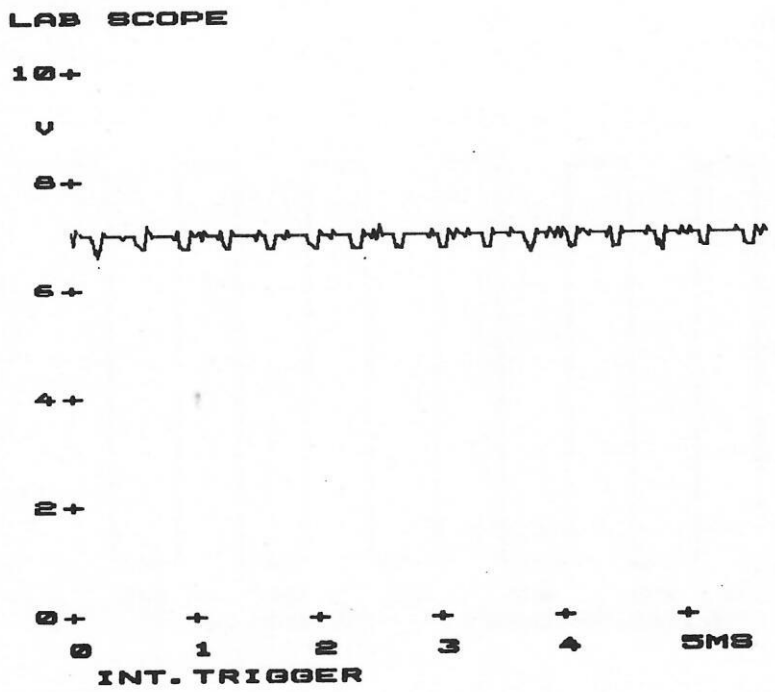
Note: The signal shown will fluctuate between voltage levels.

Pre-Set Scales:	Horizontal (X-Axis)	:	0ms to 5ms
	Vertical (Y-Axis)	:	0v to 10v
	Trigger	:	Internal

Use Pinpoint Leads:- Black to engine earth.
Red to terminal integrator lead.

NOTE:

The waveform illustrated is a sample of an 'LU-Jetronic ECU', but it must be remembered that this pattern can vary in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



Lambda Sensor

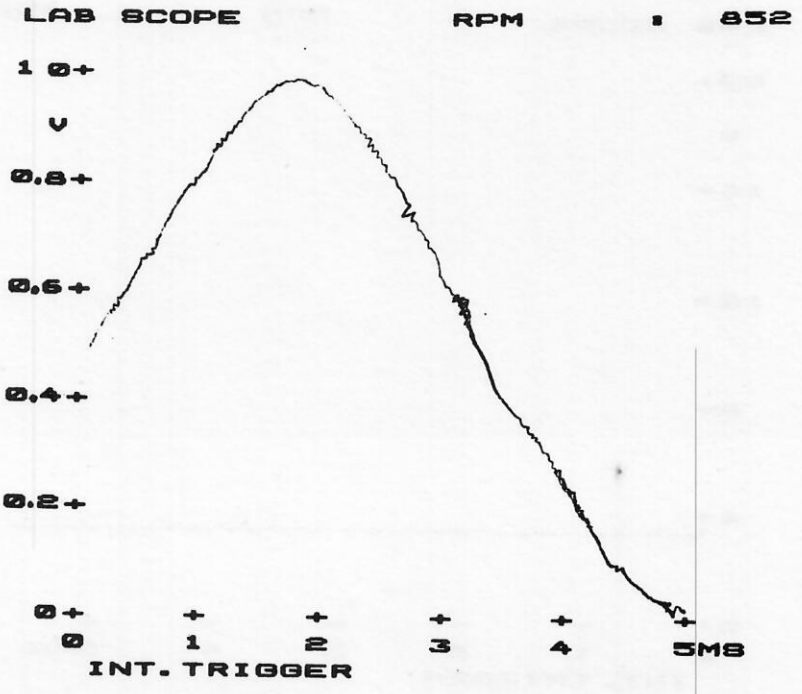
Illustrated below is the 'Lambda Sensor' lab scope selected from the menu and showing the waveform of a Lambda Sensor at idle.

Pre-Set Scales:-	Horizontal (X-Axis)	:	0ms to 5ms
	Vertical (Y-Axis)	:	0v to 1v
	Trigger	:	Internal

Use Pinpoint Leads:- Black to engine earth.
Red to Sensor output terminal.

NOTE:

The waveform illustrated is a sample of an 'Lambda Sensor', but it must be remembered that this pattern can vary in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



Air Flow Sensor

Illustrated below is the 'Air Flow Sensor' lab scope selected from the menu and showing the waveform from an Air Flow Sensor.

Pre-Set Scales:-

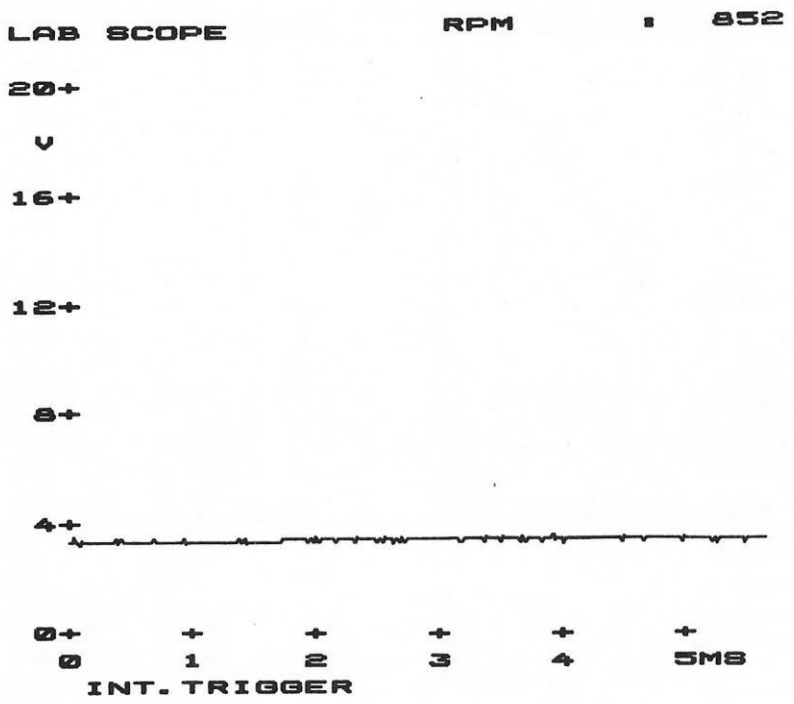
Horizontal (X-Axis)	:	0ms to 5ms
Vertical (Y-Axis)	:	0v to 20v
Trigger Slope	:	Internal

Use Pinpoint Leads:-

Black to engine earth.
Red to output terminal.

NOTE:

The waveform illustrated is a sample of an 'Air Flow Sensor', but it must be remembered that this pattern can vary in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the compenent under test.



Inductive Sensor

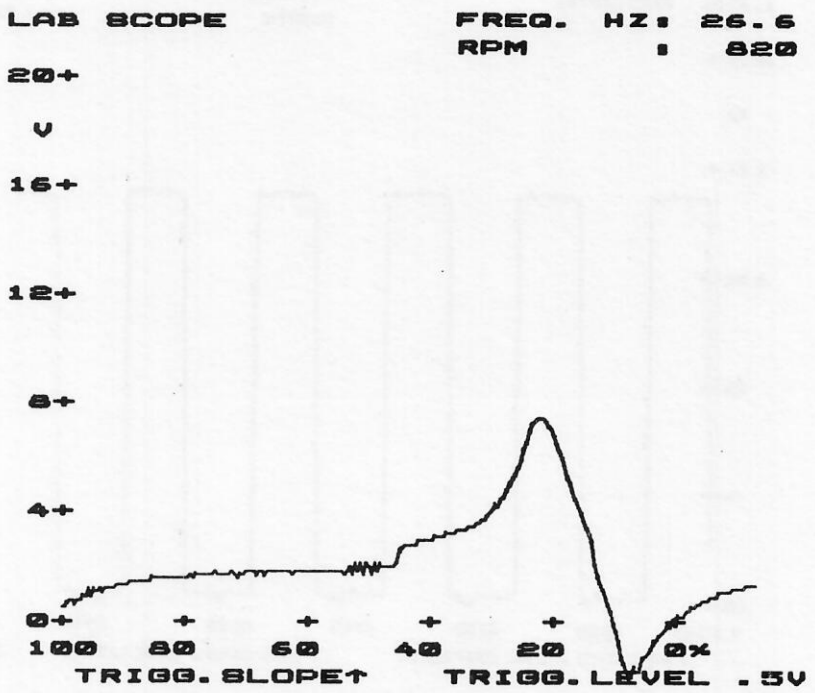
Illustrated below is the 'Inductive Sensor' lab scope selected from the menu and showing the waveform from a Distributor Inductive Sensor.

Pre-Set Scales:-	Horizontal (X-Axis)	:	100% to 0%
	Vertical (Y-Axis)	:	0 v to 20 v
	Trigger Slope	:	Up
	Trigger Level	:	0.5 v

Use Pinpoint Leads:- Black to engine earth.
Red to Distributor terminal.

NOTE:

The waveform illustrated is a sample of an 'Distributor Inductive Sensor', but it must be remembered that this pattern can vary in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



Hall Effect Sensor

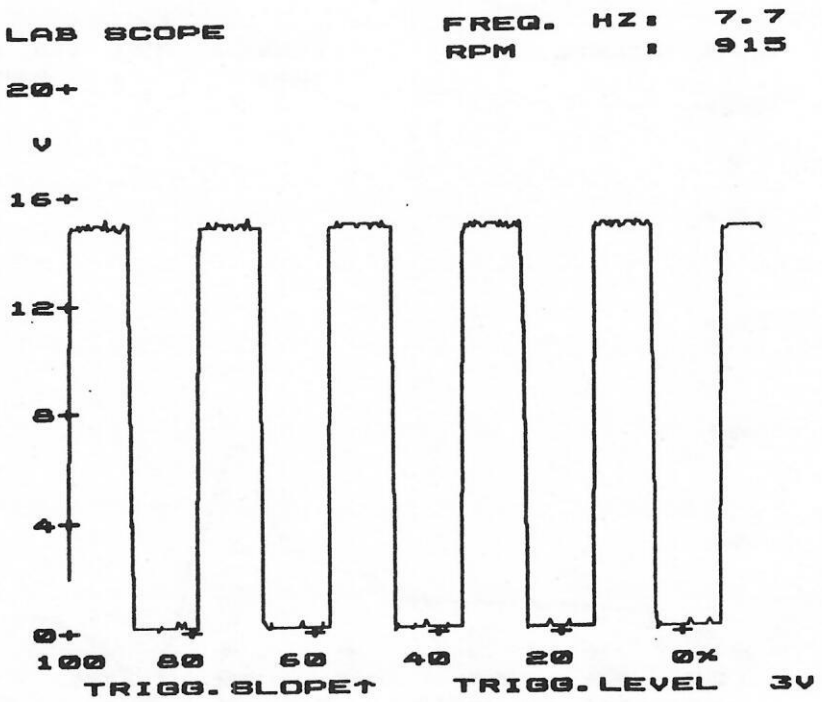
Illustrated below is the 'Hall Effect Sensor' lab scope selected from the menu and showing the waveform from a Distributor Hall Effect Sensor.

Pre-Set Scales:-	Horizontal (X-Axis)	:	100% to 0%
	Vertical (Y-Axis)	:	0 v to 20 v
	Trigger Slope	:	Up
	Trigger Level	:	3 v

Use Pinpoint Leads:- Black to engine earth.
Red to Distributor terminal.

NOTE:

The waveform illustrated is a sample of an 'Hall Effect Sensor', but it must be remembered that this pattern can very in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



Crankshaft Position Sensor

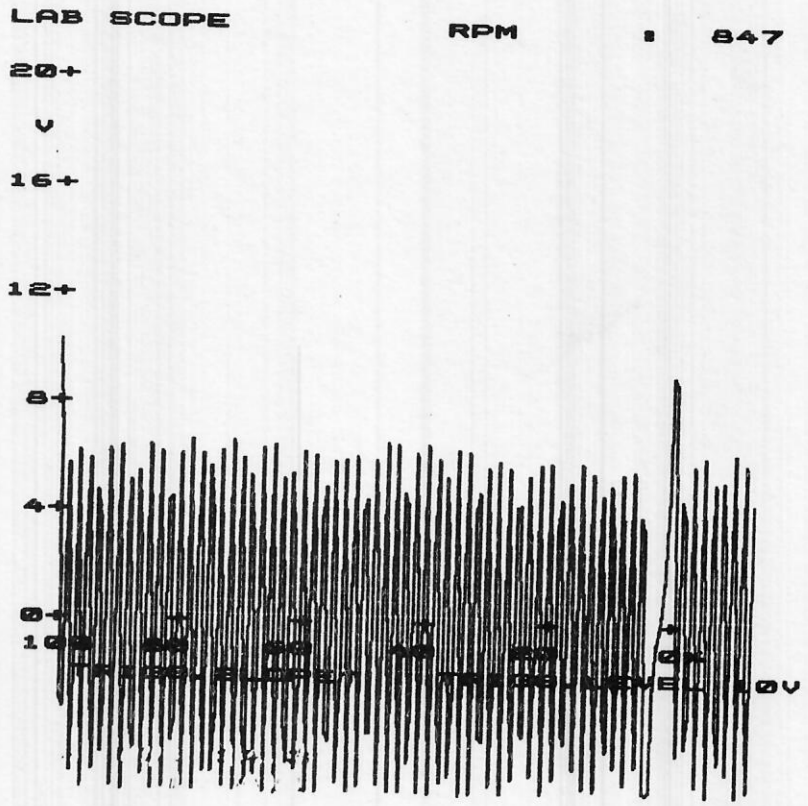
Illustrated below is the 'Crankshaft Position Sensor' lab scope selected from the menu and showing the waveform of a timing sensor positioned at the crankshaft.

Pre-Set Scales:-	Horizontal (X-Axis)	:	100% to 0%
	Vertical (Y-Axis)	:	0 v to 20 v
	Trigger Slope	:	Up
	Trigger Level	:	10 v

Use Pinpoint Leads:- Black to engine earth.
Red to sensor terminal.

NOTE:

The waveform illustrated is a sample of an 'Crankshaft Timing Position Sensor' but it must be remembered that this pattern can vary in voltage, frequency and cycle time dependent on the type of manufacture and operating conditions of the component under test.



SECTION NINE
CARE AND MAINTENANCE

9.01 GENERAL

The maintenance and service procedures for the 'MCS 2000' Modular Computer System presented in this section are those which the operator may perform. All other service operations should be performed by an authorised 'Sun' representative.

For details on Printer Maintenance, please refer to section 6, sub-section 6.05.

CAUTION: **Never use petrol, aerosol carburettor or brake cleaners, or any other solvent based cleaner. The use of highly volatile solvents may cause damage to the tester finish or its perspex components.**

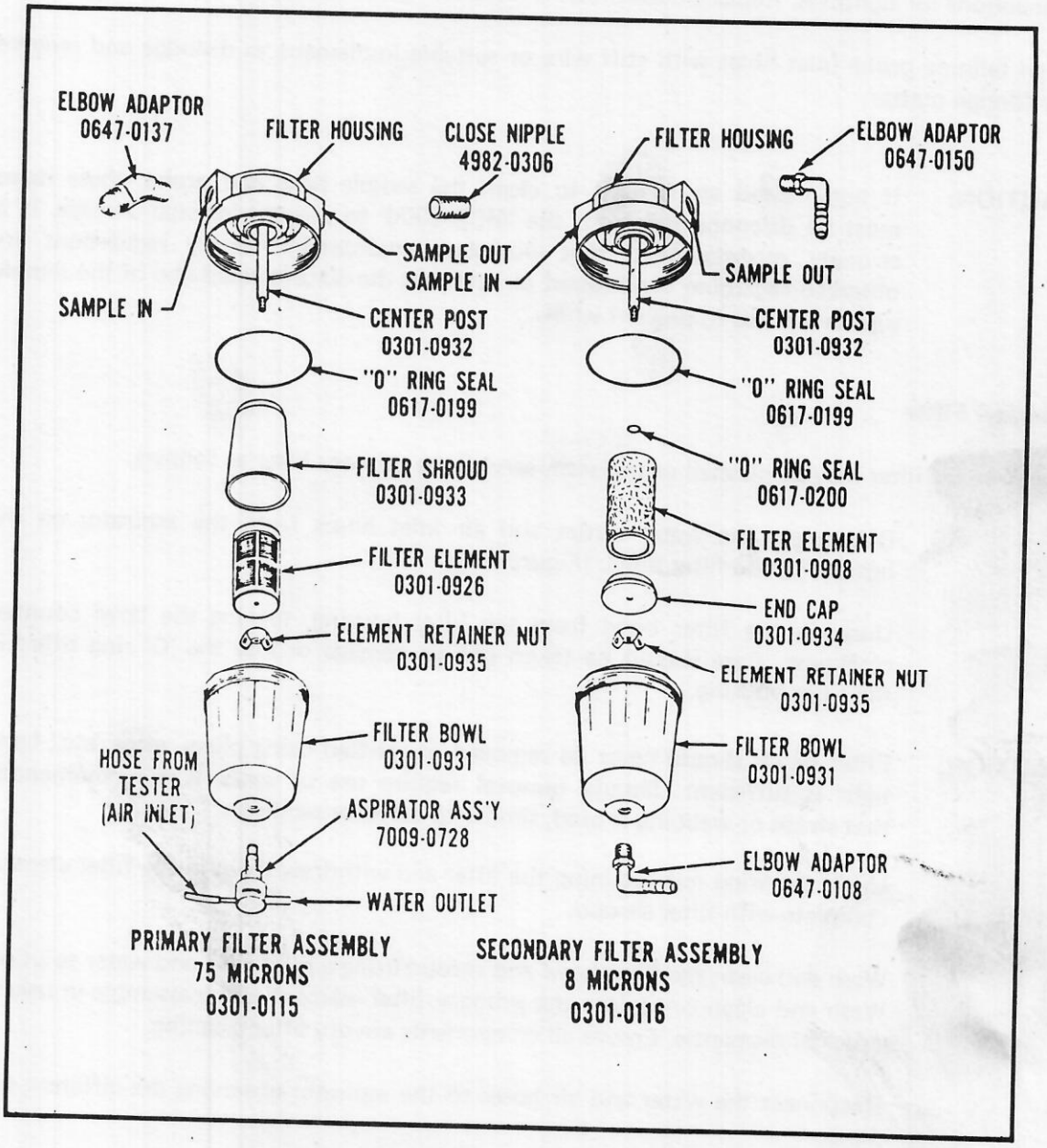


FIGURE 9:1
Sample Filter Arrangement

9.02 FILTER MAINTENANCE

The primary and secondary filters should be cleaned or replaced when the 'LOW FLOW' message flashes on the upper centre area of the 'VDU'. Whilst replacing or cleaning the filters, it is also recommended that the sample probe and hose is serviced and cleaned.

The response rate of the exhaust analyser is dependent on a clean filtration system and therefore it is important to ensure that filters and hose assemblies are regularly checked.

A label detailing filter maintenance and installation appears on the back panel of all testers.

Sample Hose and Probe

Periodically inspect both the sample hose and tail pipe probe for signs of damage such as cuts and kinks which allow ingress of air into the sampling system. Also check sample hose connections for tightness. Replace hose/probe if leaks are found or suspected.

Clean tailpipe probe inlet holes with stiff wire or suitable implement to dislodge and remove any foreign matter.

CAUTION: **If compressed air is used to clean the sample hose and probe, these items must be disconnected from the 'MCS 2000' to prevent internal damage. It is strongly recommended that workshop environment safety regulations are observed regarding compressed air and that the disconnected end of the sample pipe is secured to prevent whip.**

Primary Filter

The primary filter may be cleaned or replaced, service the primary filter as follows:

1. Disconnect the water outlet and air inlet hoses from the aspirator on the bottom of the filter bowl. (Figure 9:1).

2. Unscrew the filter bowl from the filter housing, turning the bowl counter-clockwise. Care should be taken not to damage or lose the 'O' ring fitted in the filter housing.

CAUTION: **Filter bowls should never be removed or refitted using pliers, grips, etc., hand tight is sufficient. Should removal require use of tools, it is recommended that straps or webbing is used, similar to oil filter removers.**

3. Undo the wing nut retaining the filter and withdraw the primary filter element complete with filter shroud.

4. Wash and clean the filter bowl and shroud using a mild soap and water solution. Wash and clean or replace the primary filter element and reassemble in reverse order of dismantle. Ensure all components are dry after cleaning.

5. Reconnect the water and air hoses to the aspirator observing the different size pipes.

Secondary Filter

The secondary filter must be replaced when it becomes dirty or clogged. Service the secondary filter as follows:

1. Disconnect the hose from the elbow adaptor on the bottom of the filter bowl. (Figure 9:1).

2. Unscrew the filter bowl from the filter housing, turning the bowl counter-clockwise. Care should be taken not to damage or lose the 'O' ring fitted in the filter housing.

CAUTION: Filter bowls should never be removed or refitted using pliers, grips. etc., hand tight is sufficient. Should removal require use of tools, it is recommended that straps or webbing is used, similar to oil filter removers.

3. Undo the wing nut retaining the filter and remove end cap. Withdraw and discard the secondary filter element.

4. Wash and clean the filter bowl using a mild soap and water solution and install new secondary filter element. Reassemble in reverse order of dismantling. Ensure all components are dry after cleaning.

5. Reconnect the hose to the elbow adaptor.

Air Filters

The 'MCS 2000' incorporates two cellulose sponge air intake filters in the body of the tester at the rear to circulate air across various internal components.

Withdraw the sponge from its housing, (No tools required) and wash in mild soapy water, dry and refit recess.

To ensure that the components are stabilised at a correct heat level, it is recommended that these filters are removed and cleaned monthly.

9.03 MAINTAINING APPEARANCE

The 'MCS 2000' Modular Computer System is finished with a stain resistant baked enamel and brushed aluminium. It is recommended that the painted and plated surfaces are polished with an automobile wax. Once this has been done, a periodic wipe down with a dry cloth will be sufficient.

Care should be taken not to damage the tester front screen panel when cleaning and therefore only a clean soft cloth should be used with a proprietary brand glass cleaner.

Test Lead Maintenance

Inspect all test leads weekly for cuts and abrasions and care should be taken when routing the leads across an engine that they do not foul rotating engine components or rest on hot exhaust manifold systems.

The test leads and mains power cable will retain a favourable appearance if they are cleaned regularly using a waterless hand cleaner and wiped dry.

Induction clamps fitted to the test leads should be kept free of oil, grease and contaminates and should be cleaned when necessary to minimise mistriggering situations.

Lubrication

Every sixty to ninety days, apply a light machine oil to the cabinet castors so that they will roll freely.

No other lubrication is required.

Miscellaneous Maintenance

It is recommended that the 'MCS 2000' is left switched on during the working day, but to prolong the life of certain items, it is advisable to switch off the exhaust analyser pump and timing light when not required.

9.04 DISK MAINTENANCE

Floppy Disks

Floppy disks should be kept clean and dry, and should be stored in the disk compartment located to the right of the main disk drive.

CAUTION: **Magnetic materials, such as magnetised screwdrivers, electric motors, coils, HEI distributors, etc., should be kept away from all disks to prevent damage.**

SECTION TEN
UNDERSTANDING FOUR GAS ANALYSIS WITH LAMBDA & AIR FUEL RATIO

10.01 GENERAL

This section is intended to be technical information rather than operation procedure for the 'MCS 2000'. In general, analysis and diagnosis of four exhaust gasses is relatively new in conjunction with the introduction of catalytic converters to the European Market.

The full value and benefits of understanding four-gas analysis will become apparent as you use your 'MCS 2000' to obtain data to diagnose engine problems and make necessary repairs.

10.02 IDEAL ENGINE

If wecould imagine the 'Ideal' Internal Combustion Engine, it would burn its fuel completely. The combustion by-products (the exhaust gas) of this theoretical ideal engine would be Carbon Dioxide (CO_2) and water vapour (H_2O).

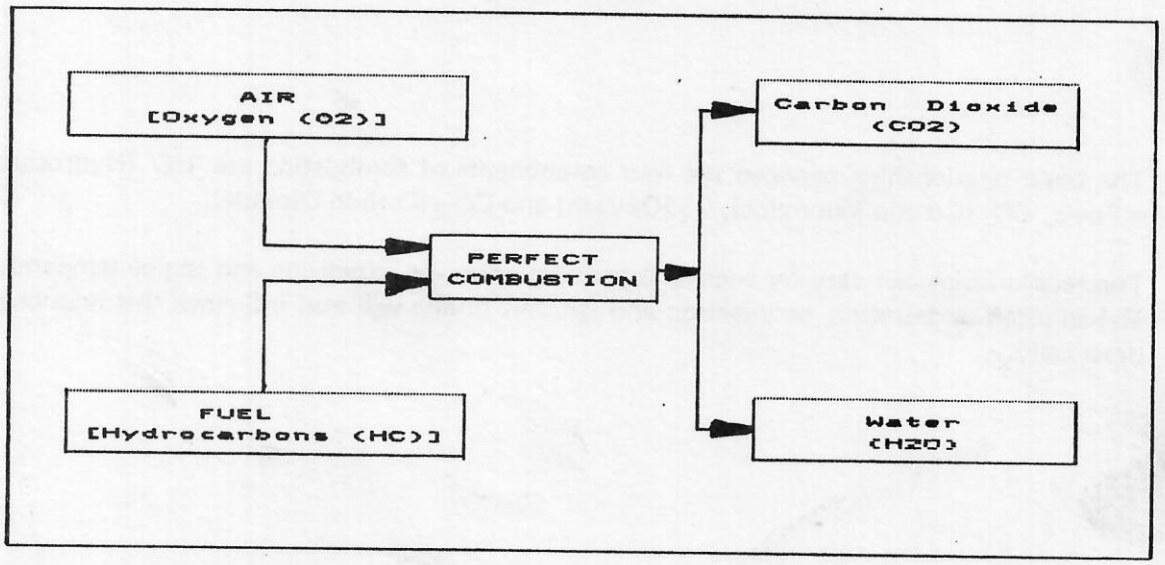


FIGURE 10:1
Ideal Engine

Unfortunately, nothing is perfect. In the real world engine, when the flame front is set off by the spark, hits the relatively cool cylinder walls, some of the fuel is quenched and incomplete combustion results. Also, if the carburettor or injection system is improperly adjusted, the 'Air Fuel' ratios are incorrect for complete combustion.

10.03 REAL-WORLD ENGINE

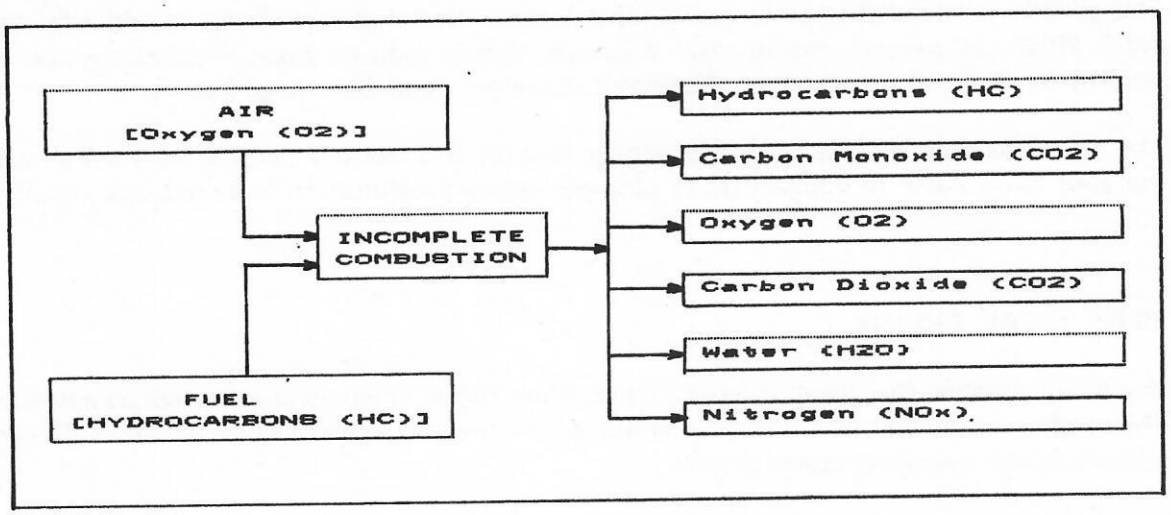


FIGURE 10:2
Real-World Engine

The basic relationships between the four components of combustion are 'HC' (Hydrocarbon = Fuel), 'CO' (Carbon Monoxide), 0_2 (Oxygen) and CO_2 (Carbon Dioxide).

The relationships can vary by engine, depending upon age, condition and engine temperature. Mal-adjusted carburation or injection and ignition timing will also influence this relationship drastically.

10.04 EXHAUST GASSES

Hydrocarbons

Hydrocarbons are unburnt or partly burnt fuel. High levels of hydrocarbons (Measured in Parts Per Million – PPM) in the exhaust gas are often related to problems in the ignition system, fouled plugs, poor ignition wires, improper timing or dwell, vacuum leaks or incorrect 'Air/Fuel' ratios all cause improper combustion and 'High HC' readings.

Garbon Monoxide

'CO' is formed when there is not enough oxygen present during combustion. High levels of carbon monoxide (Measured as a percentage '%' of the exhaust gas) can be caused by a too rich mixture, low idle speed, incorrect float level, blocked air filter, malfunction of the PCV valve or incorrectly adjusted carburettor or injection system. Low oxygen levels indicate that more fuel is present than can be consumed with the oxygen available. This could be called oxygen starvation. The solution is to reduce the amount of fuel.

Carbon Dioxide

'CO_2' (Measured as a percentage '%' of the exhaust gas) is an important diagnostic clue to the efficiency of the combustion process. Carbon Monoxide (One part Carbon to one part Oxygen) is the result of Too Little oxygen in the combustion process. Carbon Dioxide (One part Carbon to two parts Oxygen) is the result of more efficient combustion. The greater the percentage of 'CO_2' in the exhaust gas, the more efficient the engine is running. A reading of 13% to 15% is considered ideal, with CO and HC at or near zero and oxygen within 1% to 3%.

Oxygen

'O_2' (Measured as a percentage '%') indicates the accuracy of the carburettor setting. If the oxygen content is measured as the Air/Fuel ratio is adjusted from rich to lean, or lean to rich, a step jump in the reading of at least 0.5% shows the crossover point from rich to lean. 'O_2' measurement is also useful in detecting vacuum leaks and ignition problems causing a misfire and of course an incorrect sample because the exhaust probe is not correctly inserted and/or the exhaust system is leaking. Oxygen readings of 1.5% or less is considered ideal with 'HC' and 'CO' at or near zero and 'CO_2' within the range of 13% to 15%.

Oxides of Nitrogen

Nitrogen 'N' makes up approximately 80% of the air we breathe, the balance of approximately 20% is oxygen. An internal combustion engine uses the oxygen (O_2) to operate and exhaust the nitrogen. However, Oxides of Nitrogen (NOx) are formed when the combustion temperature exceeds 2500 degrees Fahrenheit.

Although 'NOx' compounds do not directly effect how the engine works, when the (NOx) combine with unburnt fuel (HC) in certain atmospheric conditions, they are the basis of SMOG. For this reason, 'NOx' (Measured in gramms per mile) are measured for the type approval test.

Part of the solution to controlling 'NOx' has been a device called an 'EGR' (Exhaust Gas Recirculation) valve, designed to lower combustion temperatures by recirculating exhaust gasses back to the combustion chamber. There is little that the Mechanic/Technician can do to control emissions except to make sure that the engine and the 'EGR' valve (on vehicle so equipped) are functioning correctly.

It is not practical to measure 'NOx' in the service workshop without the use of a dynomometer and the equipment used to measure this gas, normally chemiluminescent, is very expensive.

10.05 THE KEY – AIR/FUEL RATIO

The air/fuel ratio at which the fuel burns most efficiently is called 'Stoichiometric' point. This is also the point at which 'HC' and 'CO' emissions are lowest and 'CO_2' is highest.

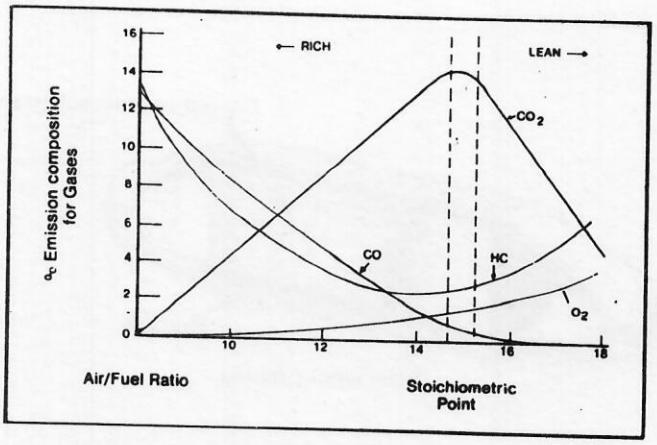


FIGURE 10:3
The Stoichiometric Point is 14.7 to 1 Air/Fuel Ratio
(At which the fuel mixture burns most efficiently)

As shown above, the point at which most efficient combustion (Low HC and CO, high CO_2) occurs is approximately 14.7:1 air/fuel ratio.

NOTE: *This point may vary slightly because of the difference in fuel composition.*

Testing of vehicles today, and tomorrow, with vehicles fitted with catalytic covertors and air management systems has made fuel system adjustments more difficult than before. The new computer engine management will maintain correct air/fuel ratios with very little error, but only if the system inputs are operating correctly.

Carbon Dioxide (CO_2) and Oxygen (O_2) are the keys to proper adjustment of today's electronic carburettors and fuel injection systems.

There is no compromise on modern engines for the correct settings. We are now in the era when all carburation, injection and ignition system settings are critical. It is only by using the four gas method of analysis that problems can be accurately diagnosed.

10.06 CATALYST

A Catalytic Convertor is a device, which resembles a silencer, and is fitted into the exhaust system between the manifold and the silencer. It consists of a chamber in which a chemical reaction takes place to change toxic and harmful gasses into less harmful ones. The most common use for emission control is a three-way catalyst which will change approximately 90% of the CO, HC and NOx from the engine into CO_2, N (Nitrogen) and H_2O (Water) at the tail pipe.

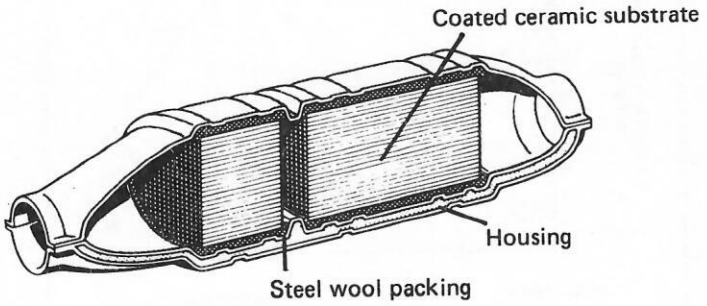


FIGURE 10:4
Typical Catalytic Convertor

A typical three-way catalytic convertor consists of a stainless steel outer layer with an inner honeycomb structure of ceramic material. This material is initially covered with a wash coat of aluminium oxide which has the effect of increasing the surface area of the material to approximately the size of three football pitches, the surface area is then covered with a small amount (2/3 gramms) of noble metals Platinum and Rhodium. Platinum accelerates the oxydisation of CO and HC whilst Rhodium reduces NOx.

A catalyst will only operate at maximum efficiency if the air/fuel ratio of the mixture being burnt is at stoichiometric (14.7:1) and the operating temperature of the catalyst is between 400 and 800 degrees centigrade. At temperatures below 300 degrees centigrade, the catalyst will not function and at 800 degrees centigrade to 1000 degrees centigrade, breakdown of the noble metals will occur. Over 1000 degrees centigrade, severe and rapid deterioration of the catalyst will take place.

Any severe engine malfunction, such as a misfire, could cause a temperature rise of up to 1400 degrees centigrade which would cause melting of the substrate material. The use of leaded petrol and excessive oil residue can also poison the catalyst.

In order to maintain the correct mixture strength (AFR), the majority of cars fitted with catalysts will be equipped with Electronic Fuel Injection or Electronic Carburettor Control. These systems may be 'Open Loop' with reliance being placed on a correctly tuned and maintained engine, or, 'Closed Loop' which uses a 'Lambda' sensor to provide information to the Electronic Control Unit (ECU) to maintain correct air/fuel ratio. Most vehicles will use Electronic Fuel Injection with a Closed Loop System.

10.07 LAMBDA

Lambda is a number which indicates in a simple way how much air is present in the fuel mixture being burnt. When 'Lambda' equals one (1.00) this means that there is just enough air for complete combustion of the fuel and no excess oxygen. Any reading over 1.00 indicates excess air (lean mixture) and a reading less than 1.00 indicates not enough air (rich mixture). Lambda is directly related to air/fuel ration with the ideal AFR (14.7:1) being Lambda 1.00.

$$\text{The sum of Lambda} = \frac{\text{ACTUAL AFR}}{\text{IDEAL AFR}}$$

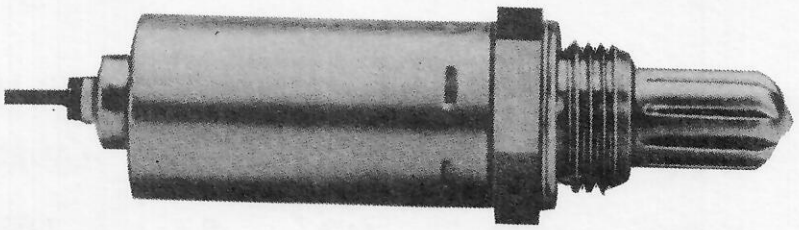


FIGURE 10:5
Lambda Sensor

A Lambda sensor is a ceramic device placed in the exhaust system on the engine side of the catalytic convertor. It consists of a body of ceramic material, the surface of which has porous platinum electrodes. One electrode is open to atmosphere and the other is in the exhaust stream. When the oxygen content on both sides of the electrodes is different, a voltage is created. Therefore the function of the Lambda sensor is to detect the amount of oxygen in the exhaust gas and to feed the resultant voltage generated to the Electronic Control Unit.

The ECU will evaluate the signal received from the Lambda sensor and will increase or decrease the quantity of fuel supplied in order to maintain the correct air/fuel ratio or Lambda 1.00.

The operation of this closed loop system take place at approximately ten cycles within the Lambda window of 0.97 to 1.03. The operating voltage is 0 to 0.8 volts with Lambda 1.00 being 0.5 volts.

The Lambda sensor will not operate below 250 degrees centigrade, before that temperature the system will operate under 'Open Loop' (No Control). In order to speed up the operation of the Lambda sensor, some are pre-heated. These are identified by three wires coming from the Lambda sensor instead of one.

10.08 USE OF LAMBDA MEASUREMENT

'Sun' now provide for both Lambda and AFR measurement on all four gas analysers. The method adopted for Lambda measurement is derived from the Spindt formula, which takes account of CO, HC, CO_2 and O_2. This formula has been adopted as it is the most comprehensive, and allows for Lambda (AFR) measurement both before and after the catalyst with the same result. It is expected that the majority of 'Open Loop' will have an exhaust tapping before the catalyst in order that fuel mixtures may be adjusted accurately to Stoichiometric. On 'Closed Loop' systems some manufacturers are fitting a tapping before the catalyst.

To test an engine fitted with a catalyst and/or a Lambda sensor, the engine should be run at 3000 rpm for approximately three minutes to ensure that it is at operating temperature. If monitoring exhaust gas you will see the change in values as the catalyst comes into operation.

TYPICAL READINGS WITH LAMBDA CONTROL (CLOSED LOOP)

	CO	HC	CO2	O2	LAMBDA	AFR
Before Catalyst	0.6	120	14.7	0.7	1.00	14.7
After Catalyst	0.2	12	15.3	0.1	1.00	14.7

You will note that the CO, HC and O2 will always reduce, whereas the CO2 will always increase. The Lambda/AFR will remain the same before and after the catalyst.

TYPICAL READINGS OF AN OPEN LOOP SYSTEM

TUNED	CO	HC	CO2	O2	LAMBDA	AFR
Before Catalyst	0.6	110	14.7	0.7	1.00	14.7
After Catalyst	0.1	15	15.2	0.1	1.00	14.7
RICH MIXTURE	**CO**	**HC**	**CO2**	**O2**	**LAMBDA**	**AFR**
Before Catalyst	2.5	300	12.4	0.2	0.96	14.2
After Catalyst	1.8	90	13.9	0.0	0.96	14.2
LEAN MIXTURE	**CO**	**HC**	**CO2**	**O2**	**LAMBDA**	**AFR**
Before Catalyst	0.15	185	12.9	4.2	1.10	16.1
After Catalyst	0.03	80	13.4	3.6	1.10	16.1

RANGE OF EMISSION VALUES WITH AND WITHOUT CATALYST

	WITH CATALYST	WITHOUT CATALYST
CO	0.05% to 0.5%	0.5% to 1.5%
HC	5ppm to 30ppm	50ppm to 350ppm
CO2	14.5% to 15.5%	13% to 15.5%
O2	0.1% to 2.0%	0% to 2.0%
LAMBDA	0.97 to 1.03	0.9 to 1.1
AFR	14.4/15.0 to 1	14.5/16.0 to 1

USING LAMBDA AS A DIAGNOSTIC AID

LAMBDA = 1.00

CO = Low
HC = High
CO2 = Low
O2 = High

= MISFIRE

LAMBDA = 1.00

CO = Low
HC = Low
CO2 = Low
O2 = High

= EXHAUST LEAK

LAMBDA = 0.80 to 1.00

CO = High
HC = High
CO2 = Low
O2 = Low

= RICH MIXTURE

LAMBDA = 1.00 to 1.20

CO = Low
HC = High
CO2 = Low
O2 = High

= LEAN MIXTURE