CONTENTS

1. DESCRIPTION AND FEATURES

Gastester Professional is a combined exhaust gas CO analyzer, tachometer, dwell meter and voltmeter with many uses in motor car maintenance. Though primarily intended for multi-cylinder car engines the instrument may be used on motorcycles and single cylinder engines.

As received, the carton should contain the following items:

Gastester Professional unit Exhaust probe complete with plastic pipe and 2 retaining springs. Handbook

Dwell data leaflet

Features:

DISPLAY	Large 15 mm Light Emitting Diode display showing 31/2 digits (i.e. maximum scale reading 1999, minimum scale reading -1999). Over-range is indicated by 1 in the LEFT display only, and zero by 000. Decimal points are added, appropriate to the scale selected.
FUNCTION SWITCH	Used to select the required function: exhaust CO measurement, Voltage, Engine RPM (high), Engine RPM (low), Dwell degrees, Dwell percent.
CYLINDERS SWITCH	for setting the number of cylinders, this switch is effective on RPM and DWELL ANGLE ranges.
CALIBRATE KNOB	Only used in CO measurement, for initial calibration of the instrument, by setting the display to read 2.00 with the exhaust probe in air.
PULSE PUMP	This is a non powered pump driven by pressure fluctuations in the exhaust to give a consistent gas flow in the analyzer.
GASINLET	For connection of the exhaust probe.
GAS OUTLET	Exhaust gas outlet, (do not restrict).
GAS VENT	Exhaust gas outlet, (do not restrict)
WATER DRAIN	At the rear of the instrument. Ejects water drained from the exhaust gas.
RED & BLACK LEADS	These leads provide power from the car battery.
BLUE LEAD	Pickup, used in RPM, Dwell and Volts measurements.
EXHAUST PROBE	The metal pipe is for insertion into the exhaust pipe, and is retained in position by the metal springs which press against the INSIDE of the exhaust pipe.

2. CO MEASUREMENT

1. PREPARATIONS BEFORE USE

Any service maintenance such as air filter renewal, valve adjustment, carburetor maintenance, ignition maintenance including ignition timing, should be carried out before setting the carburetor or fuel injection mixture adjustment. Fuel mixture setting should be the FINAL ADJUSTMENT in any engine tuning work.

Carbon monoxide is an EXTREMELY POISONOUS gas. ANY work on the car with the engine running should therefore ALWAYS be carried out IN THE OPEN AIR. The user should take are NOT TO BREATHE IN exhaust gas when using Gastester near the exhaust pipe with the engine running.

The car should be thoroughly warm before the tests begin. It is not enough to leave the car to warm while parked. The car should be taken for a drive, and the tests not started until water temperature, engine, and exhaust system are thoroughly heated, and are at normal running temperature. If a spare battery is to be used, the instrument may usefully be warmed up during this period.

Study the workshop manual for the particular car (or consult the information given later in this booklet) to identity the correct adjustment screws that control the mixture strength and the idle speed. Identify the direction to turn the screws to achieve the desired effect (i.e. mixture richer or weaker, idle speed faster or slower). If in doubt, make a note of the initial position of the adjustments before starting work, so that in case of difficulty, or if the wrong adjustment is changed, the setting can be restored to its original position.

Check the manual for the correct CO and IDLE RPM values. Have to hand the correct tools or making the necessary adjustments.

2. INSTRUCTIONS FOR USE

(a) Ensure that the car is thoroughly warm as mentioned above, that it is parked in a convenient position in the open air, with the hand brake applied. Note: THE INSTRUMENT SHOULD NOT BE PLACED DIRECTLY IN THE EXHAUST STREAM. CLEAN AIR IS REQUIRED IN THE REFERENCE CELL FOR ACCURATE READINGS.

Note: Bright sunlight on the instrument will make visibility of the LED display difficult

(b) Place the Gastester Professional on a convenient flat surface close to the vehicle's exhaust pipe outlet. Switch off the engine temporarily while making connections. Connect the RED and BLACK clips to the vehicle's 12 V battery (RED to +, BLACK to -), and the BLUE pickup lead to the COIL NEGATIVE terminal to obtain RPM readings.

THE PROBE SHOULD BE FITTED TO THE INSTRUMENT BUT DO NOT INSERT THE EXHAUST PROBE INTO THE EXHAUST PIPE AT THIS STAGE.

(c) Restart the engine and allow a period of 8 minutes for the instrument to warm up with the probe in air. Observe the display for a further 2 minutes to ensure that the reading has stabilized.

IF NOT, ALLOW A FURTHER PERIOD BEFORE SETTING THE CO CALIBRATION

During the warm up period other ranges will give accurate readings and it is therefore useful to check and adjust engine IDLE RPM.

(d) Switch to the CO range with the probe in air. DO NOT INSERT THE EXHAUST PROBE INTO THE EXHAUST PIPE AT THIS STAGE. Use the rotary calibration control to carefully set to the CALIBRATE reading of 2.0% CO. Having set the CALIBRATE condition do not move the instrument, or move to a different location during subsequent CO tests. (NB The CALIBRATE position represents what the instrument should register when the probe is in air. It is coincidental that air should measure the same as exhaust gas with 2% CO. When the probe is subsequently inserted into the exhaust pipe, the pointer of the instrument may move down or up from the CALIBRATE condition, depending on whether the exhaust has less than, or more than. 2% CO).

(e) Ensure that the engine is set to the IDLE RPM stated by the manufacturer. NOW INSERT THE PROBE INTO THE VEHICLE EXHAUST PIPE, to a minimum of 3/4 of its length, i.e. 8" or 20cm. In order for the automatic water drain to function, the probe pipe should fall continuously from the exhaust end to the inlet end to allow water droplets to run down. Otherwise the water will collect at the lowest point and will have to be drained manually.

(f) Wait for a period of 15 seconds for the meter to respond and a further 1 minute to stabilize. Make a note of the reading of the CO level on the meter display. If the reading is not between the manufacturer's recommended maximum and minimum, or below that specified as a legal requirement, then adjustment if the carburetor or fuel injection system will be required.

(g) If the indicated CO reading is too high or too low, then make a small adjustment to the mixture screw, and correct the idle speed by adjusting the idle speed screw (or throttle bypass screw if fitted - see section). Do this repeatedly in small increments, allowing approximately one minute for the reading to stabilize at each mixture setting.

3. FURTHER INFORMATION

It should be noted that an engine, even in good overall condition, will show a fluctuation in idle CO over a period of time, of typically 0.5%. Bearing in mind this fluctuation, and also errors and drift in the instrument, the user should aim to set the average CO reading to be midway between the limits set by the manufacturer, or at a reasonable margin below the prescribed legal limit. Periodically, during the tests, examine the lowest point of the transparent plastic pipe to see if it contains water to a degree that might impede the flow of gas. If it does, remove the pipe at the instrument gas inlet end and clear the pipe by allowing the water to drain out, then reconnect the pipe and carry on with the tests. If the transparent pipe falls continuously from the exhaust to the pump the automatic drain should operate and keep the pipe clear of water. NOTE; Operation of the pulse pump will usually be audible as the pulsation’s in the exhaust cause the internal
diaphragm to vibrate. If the instrument ceases to respond to changes in mixture setting or the sound from the pulse pump becomes irregular, check the sample pipe for collected water. See also SECTION 6. MAINTENANCE

The calibration of the instrument may be checked at any time. Simply remove the exhaust probe and wait at least five minutes, or ten minutes in still air, for the exhaust gas to disperse from the collector box. If necessary, the calibration may then be adjusted using the calibration control knob. The user is advised to periodically check the calibration of the instrument during particularly extended tests.

Some motor car engines will not readily "tick over" at idle speeds for long periods. The speed may become erratic, and engine misfiring may occur. With the prolonged testing of such engines, it may be necessary to occasionally "purge" the engine by, for instance, increasing the speed to 2000 rpm - 3000 rpm for 15 seconds. This may be done at any time during the tests but the exhaust probe should preferably be removed beforehand.

If the exhaust pipe has a curved inlet it may be necessary to slightly bend the metal exhaust

probe to give better fit. This should be done very carefully using slight bends in several places rather than a single big bend in order not to kink the pipe. FULL INSERTION IS ESSENTIAL FOR ACCURATE READINGS. See section 6 MAINTENANCE and APPENDIX 2 (5).

Engine fuel systems are usually designed so that the mixture automatically becomes weaker at speeds above idle, except under rapid acceleration when the mixture is enriched (see also Section 1 introduction). Gastester is designed to work at engine idle speeds, however it will also give a reliable reading at higher engine speeds. VIOLENT FULL THROTTLE ACCELERATION TO HIGH ENGINE SPEED SHOULD BE AVOIDED WHILE THE PROBE IS IN THE EXHAUST PIPE AS THIS MAY DISPLACE THE PULSE PUMP DIAPHRAGM CAUSING IT TO MALFUNCTION.

To test mixture weakening at higher RPM, increase the engine speed in increments of approximately 300 RPM to 400 RPM up to a maximum of 2500 to 3000 rpm, observing the reading between each adjustment. (Remember that the instrument may take 15 seconds to respond to a particular adjustment, and a further 1 minute to stabilize). The CO level should fall progressively and low during the speed increase.

The mixture enrichment for acceleration (accelerator pump/air valve damper) can be tested by rapid opening and immediate release of the accelerator. Opening to half throttle should be sufficient. Within a few seconds of this operation the Gastester CO indication should increase before returning to its previous setting. The degree of increase will vary according to how this procedure is carried out also with the type of fuel system. A fixed choke carburetor with accelerator pump will usually a more pronounced increase than a variable choke carburetor or fuel injection system.

Use only a 12 volt car battery in good condition as power supply. Smaller batteries (or a faulty or flat car battery) may not be able to supply adequate current to the instrument (Gastester Professional draws about 0.8 amps), resulting in errors in use and difficulty in calibration. If the vehicle has a 6v or 24v battery, use an external battery, such as the battery of a nearby car.

If a separate battery is used (i.e. not the battery fitted to the car), it is necessary to connect the positive terminal of the vehicle battery to the negative of the power battery, to give a common ground before connecting the blue lead. This will enable the rpm voltage and dwell ranges to function.

3. TACHOMETER

1. GENERAL INFORMATION

Two ranges are provided. RPM (low) measures RPM directly in the range 0 to 1999 RPM, and is intended for tests at or around idle speed. RPM (high) measures RPM in the range 0 to 999, and covers the whole operating speed range of all engines. RPM high is displayed in thousands, and so the figure displayed needs to be multiplied by 1000 for the correct reading. For instance, a display reading of 3.25 represents 3,250 RPM.

The principle of operation of the measuring circuit is to measure the rate of ignition pulses in low tension (LT) winding of the ignition coil. This instrument is therefore only suitable for coil irk ignition systems, but it can equally be used on conventional "points" and electronic ignition systems, since both types of ignition system utilize an ignition coil. However, it can not be used on magneto or and some capacitive discharge systems that are occasionally used in racing engines. The calibration of the display assumes a 4-stroke engine (i.e. one firing stroke per 2 revolutions of the engine per cylinder, and a single ignition distributor shaft, The display can be read directly for all such engines which have 2, 4, 5 or 6 cylinders, as set by the cylinders switch. For use with other types of engine and ignition system, see APPENDIX 5.

It is acceptable, indeed often desirable, to switch to RPM measurement while measuring exhaust gas CO. In this case, the instrument should be placed on the ground at the rear of the car, and not moved after it has been calibrated, for CO measurement.

If the instrument is not required for simultaneous CO measurement, then it is acceptable to move the instrument closer to the engine bay for RPM measurement, if preferred for convenience.

2. INSTRUCTIONS FOR USE

(a) Set the FUNCTION switch to position RPM (low) or RPM x 1000 (high), depending on the range of RPM to be measured.

(b) Set the Cylinders switch to the number of cylinders of the engine.

(c) Connect the BLACK lead to the car battery (-) terminal, and the RED lead to the car battery (+) terminal.

(d) Connect the BLUE lead to the (-) low tension (LT) terminal of the ignition coil. If the low on terminals are not clearly marked determine the correct one by trial and error as NO damage) can occur if this connection is made to the (+) terminal. However, it is important NOT to connect the BLUE lead to the High Tension output of the coil (i.e., the spark plug lead connection) as this would age the internal circuitry of Gastester Professional, which is not protected against spark voltages.

(e) Ensure that all leads are clear of moving parts, and that Gastester Professional is in a safe place Start the engine and read the engine RPM on the display, remembering to multiply the scale reading by 1000 if RPM (high) has been selected. Gastester Professional can be used directly with 2, 4, 5 and 6 cylinder "conventional" engines, simply using the CYLINDERS switch set to the appropriate number of cylinders and reading the I or DWELL ANGLE directly from the display. "Conventional", meaning 4 stroke engines with a e set of points/electronic trigger and not "wasted spark".

3. POWER BALANCE TEST

This is a useful test, widely used in the motor trade, to detect or confirm the presence of a fault which is affecting one cylinder more than the others. Such faults include: faulty spark plug, poor cylinder compression, faulty petrol injector, air leak on the inlet manifold affecting one cylinder etc.

In order to perform this test accurately and without risk of high voltages tracking, (if plug leads are removed) we recommend the following method.

1. Place a thin piece of un-insulated wire under each plug lead connection, preferably at the distributor cap, leaving a short length exposed.

2. Connect a jumper lead to a reliable earth nearby and the free end to an insulated screwdriver. is for shorting the exposed wires to earth in turn and can be handled with safety as it provides a preferred path to ground.

3. Start the engine (the engine should be warm and may need to be set just above normal idle speed, e.g. 1 000 rpm.)

4. Short each spark plug lead in turn to earth, using for instance a well insulated plastic-handled screwdriver to bridge between each of the un-insulated wires and earth, and observe the reduced rpm. Allow a period of approximately five seconds per cylinder with sufficient "recovery" time between.

WHEN SHORTING A WIRE REMEMBER TO KEEP HANDS ETC. WELL CLEAR OF THE OTHER SHORTING WIRES EMERGING FROM THE DISTRIBUTOR CAP AS THE HT MAY ARC APPROXIMATELY 10MM! (NEARLY 1/2 INCH!)

Compare the rpm readings for each cylinder. Readings should be within 50 rpm of each other if all cylinders are producing equal power. Note: a poor cylinder will show LESS OF A DROP in rpm and shorting a cylinder which is doing no work will result in NO speed change.

4. DWELL METER

1. GENERAL INFORMATION

The dwell function is used for observation of Electronic Ignition and Fuel Injection system operation and the setting up of contact breaker points.

Scales for dwell are calibrated in PERCENT (%) and ANGLE IN DEGREES. Dwell PERCENT is the percentage time that current flows in the ignition coil or the injector is open. Dwell ANGLE is the degrees of distributor cam rotation during which current flows in the ignition coil.

Either of the two alternative methods of specification, degrees or percent, may be used in vehicle manuals. For correct degrees measurement the cylinder switch must be set appropriately as dwell is on a O' - 90' scale for 4 cylinder engines or 0 - 60 degrees for 6 cylinder engines. Dwell percent is ALWAYS on a 0% to 1 00% scale.

If the dwell period is too small, then the current in the ignition coil primary winding does not have time to build to the full value before another spark is demanded, which results in a weak spark, or no spark, at high engine speed. The car may start and idle OK, but the user may notice reduced performance or misfire at high RPM. If the dwell period is too great, failure of ignition components may result. With contact breaker systems (with points) other problems will arise such as engine misfire. It is for these reasons that modern electronic systems have variable dwell of for example 1 0% at low rpm and 50% at high rpm.

Ignition systems with contact points generally have a fixed dwell which is constant no matter how engine RPM is varied. In practice, there may be some small variation of dwell with engine speed, which may be ignored.

The points gap should be set to the dwell recommended by the vehicle manufacturer. Note: If considerable distributor shaft wear has taken place points gap may not then be as prescribed.

INCREASING THE POINTS GAP REDUCES THE DWELL.

REDUCING THE POINTS GAP INCREASES THE DWELL.

2. INSTRUCTIONS FOR DWELL MEASUREMENT

(a) Set the FUNCTION switch to position DWELL PERCENT (%) or alternatively DWELL ANGLE (degrees) depending on the range to be measured.

(b) Set the Cylinders switch to the number of cylinders of the engine if using the DWELL ANGLE range.

Connect the BLACK lead to the car battery (-) terminal, and the RED lead to the car battery (+) terminal.

(c) For measurement of ignition system dwell, connect the BLUE lead to the (-) low tension (LT) terminal of the ignition coil. If the low tension terminals are not clearly marked determine the correct one by trial and error as NO damage will occur if this connection is made to the (+) terminal. However, it is important NOT to try to connect the BLUE lead to the High Tension output of the coil (i.e. the spark plug lead connection) as this would damage the internal circuitry of Gastester Professional, which is **NOT** protected against spark voltages.

(d) Ensure that all leads are clear of moving parts, and that Gastester Professional is in a safe place. Start the engine and read the DWELL on the display in either percent or degrees.

For dwell measurement on other circuits remember that the display will indicate the relative period that NO VOLTAGE is present at the position where the blue lead is connected. Dwell is therefore correctly displayed when the ground lead of a coil or injector is sensed as this has a voltage present when ground is open circuit and none when the circuit is closed. This does not apply when the SUPPLY lead is switched. Also for positive ground vehicles read the meter backwards. For example: an indicated dwell of 40 degrees on a 4 cylinder (0 to 90 degrees) scale is actually 50 degrees.

3. FUEL INJECTION TESTS

These tests can only be made on cars which have the modern pulsed or Intermittent petrol Injection system. Systems of this type Include the following: Bosch L/LE/LH Jetronic, Bosch Motronic, Luca, Weber, VAG, Rover, Nissan, Toyota, Honda, Mazda, Subaru, Suzuki, Renix, Mitsubishi, Isuzu. NOT BOSCH K/KE JETRONIC, NOT TRIUMPH/LUCAS PI.

However, it should be cautioned that as this is an area of rapidly advancing technology, Gunson are unable to guarantee operation on all intermittent systems.

Before carrying out tests on a car, some understanding is necessary of the principle of operation of the particular petrol injection system being tested. This is the user's responsibility to make reference to the technical manual of the particular car belong tested. In general, the following notes apply to most cars:

One fuel injector is provided for each cylinder, and this injects a single squirt of gas once per engine revolution into the inlet manifold at a point near the inlet valve. All injectors (4 for a 4 cylinder car), operate at the same instant in time. (It follows that some injectors are injecting at a time when the inlet valve Is not open). Some cars have a slightly different system, where each injector operates twice per revolution below a particular RPM (e.g. Toyota).

The engine management system computes the petrol required, and opens each injector for a fixed time per revolution. The injection pressure with respect to the inlet manifold is constant, therefore it follows that the amount of gas injected per revolution Is proportional to the time that the injector is open. Injectors are closed by a spring, and are opened and held open by an electrical voltage applied to a solenoid incorporated in the injector. Each injector has an electrical connector with two pins. One of these Is generally hold at live (12 Volt), and the other carries the signal to open the injector. i.e. It is connected to ground in a series of timed pulses.

To check the operation of a fuel injection system, the following procedure should be used:

a) Set the FUNCTION switch to position DWELL percent.

b) Connect the BLACK clip to the car battery NEGATIVE terminal (indicated by -, neg. or black).

Connect the RED clip to the car battery POSITIVE terminal. (indicated by + , pos. or red).

5. **VOLTAGE (O- 20.00 volts dc.)**

This range is for measuring battery voltage during charging, starting etc and may also be used to indicate terminal voltage of ancillary electrical equipment. Because the blue lead connection has a high impedance it may be used without loading a circuit and will therefore not load or damage electronic circuits. Note however that the GASTESTER PROFESSIONAL continuously draws approx. 0.8 Amps from the POWER SUPPLY to the CO analyzer, i.e. the RED and BLACK clips.

1. **BATTERY CHARGE: GENERAL INFORMATION**

A 12 volt lead acid battery has a nominal voltage of 12.6 volts. A battery which never reaches the "fully charged' stage, even after prolonged charging, can be said to be aging. It may continue to give good service - but a considerably reduced capacity for charge should be viewed with suspicion, particularly if there are other symptoms of a suspect battery, such as poor engine starting. On the other hand, it is entirely possible for a battery to "fail" while in the fully charged state, or at least all except one cell to be fully charged, and this mode of failure is quite common. A measurement taken immediately after having a battery on charge, or in a car with the engine running, will show approx. 0.5 volts higher than the normal 12.6 volt reading due to the accumulation of "surface charge' that is removed by the first modest current draw on the battery. A battery takes several hours to settle down to a completely stable state, even following a period of discharge, and is preferably left, say, overnight, However, a reasonably accurate measurement of the state of battery charge can be obtained by switching on the car headlamps for 1 minute then taking a measurement with the headlamps off.

2. INSTRUCTIONS FOR VOLTAGE MEASUREMENT.

(a) Connect the RED lead to battery (+) and the BLACK lead to battery

lb) Connect the blue lead to the battery (+) to read battery voltage, and refer to the following section for information on values.

3. INSTRUCTIONS - ALTERNATOR AND REGULATOR TEST

Before carrying out this test, ensure that the battery has been recently fully charged

(a) Connect RED lead to battery (+), BLACK lead to battery coil negative so that RPM may be set.

(b) Ensure that leads are clear of moving parts. Start engine, and set engine RPM to a speed of approximately 2000 RPM or a figure recommended in manufacturers data.

(c) Carefully move the BLUE lead to the battery positive connection.

(d) **NO LOAD TEST.** With all electrical loads off, observe the meter reading.

(e) **LOAD TEST.** Turn on as many electrical loads as possible (e.g. headiamps, rear screen heater, windscreen wipers, heater tan, etc.). Vary the engine speed. The meter reading should remain within specification at all engine speeds except slightly above idle, when it may fall.

FURTHER NOTES

Battery voltage: New, fully charged 12.6V (to 13.4V Inc. surface charge.) Old, fully charged 12.2V (to 13.OV inc. surface charge.)

Typical alternator charging voltage 13.4 V to 13.6 V minimum UNDER LOAD.

Typical alternator charging voltage 13.9V to 14.2V maximum NO LOAD.

5. **VOLTAGE (O- 20.00 volts dc.)**

This range is for measuring battery voltage during charging, starting etc and may also be used to indicate terminal voltage of ancillary electrical equipment. Because the blue lead connection has a high impedance it may be used without loading a circuit and will therefore not load or damage electronic circuits. Note however that the GASTESTER PROFESSIONAL continuously draws approx. 0.8 Amps from the POWER SUPPLY to the CO analyzer, i.e. the RED and BLACK clips.

1. **BATTERY CHARGE: GENERAL INFORMATION**

A 12 volt lead acid battery has a nominal voltage of 12.6 volts. A battery which never reaches the "fully charged' stage, even after prolonged charging, can be said to be aging. It may continue to give good service - but a considerably reduced capacity for charge should be viewed with suspicion, particularly if there are other symptoms of a suspect battery, such as poor engine starting. On the other hand, it is entirely possible for a battery to "fail" while in the fully charged state, or at least all except one cell to be fully charged, and this mode of failure is quite common. A measurement taken immediately after having a battery on charge, or in a car with the engine running, will show approx. 0.5 volts higher than the normal 12.6 volt reading due to the accumulation of "surface charge' that is removed by the first modest current draw on the battery. A battery takes several hours to settle down to a completely stable state, even following a period of discharge, and is preferably left, say, overnight, However, a reasonably accurate measurement of the state of battery charge can be obtained by switching on the car headlamps for 1 minute then taking a measurement with the headlamps off.

2. INSTRUCTIONS FOR VOLTAGE MEASUREMENT.

(a) Connect the RED lead to battery (+) and the BLACK lead to battery

lb) Connect the blue lead to the battery (+) to read battery voltage, and refer to the following section for information on values.

3. INSTRUCTIONS - ALTERNATOR AND REGULATOR TEST

Before carrying out this test, ensure that the battery has been recently fully charged

(a) Connect RED lead to battery (+), BLACK lead to battery coil negative so that RPM may be set.

(b) Ensure that leads are clear of moving parts. Start engine, and set engine RPM to a speed of approximately 2000 RPM or a figure recommended in manufacturers data.

(c) Carefully move the BLUE lead to the battery positive connection.

(d) **NO LOAD TEST.** With all electrical loads off, observe the meter reading.

(e) **LOAD TEST.** Turn on as many electrical loads as possible (e.g. headiamps, rear screen heater, windscreen wipers, heater tan, etc.). Vary the engine speed. The meter reading should remain within specification at all engine speeds except slightly above idle, when it may fall.

FURTHER NOTES

Battery voltage: New, fully charged 12.6V (to 13.4V Inc. surface charge.) Old, fully charged 12.2V (to 13.OV inc. surface charge.)

Typical alternator charging voltage 13.4 V to 13.6 V minimum UNDER LOAD.

Typical alternator charging voltage 13.9V to 14.2V maximum NO LOAD.

For precise data refer to the particular vehicle service manual.

Note that alternators fitted to some older vehicles may not quite be able to carry the full electrical load of the vehicle. In such cases refer to the alternator's rated specifications.

4. INSTRUCTIONS - ENGINE CRANKING TEST

The voltage range can be used to diagnose the presence of a faulty battery, to give a strong guidance in the detection of starter motor faults, and to lead the user to more specific tests for the other items of the starter cranking circuit such as the solenoid and battery terminals. Before carrying out this test, ensure that the battery has been recently fully charged.

(a) Put car out of gear and apply the handbrake.

(b) Disable the ignition by shorting the COIL HT lead to earth.

(c) Connect the BLACK lead to battery (-) and the RED lead to battery (+) and the BLUE lead to battery positive (+).

(d) Crank the engine (using Gunson's **Remotastart** if available). In bursts of 10 seconds for a total of 1 minute.

(e) Observe the scale. A good battery, fully charged, will maintain specified values of voltage for at least I minute, even under freezing conditions. On the other hand, a faulty battery, even when recently charged, will fail to hold these for more than a few seconds. See APPENDIX 6.

Connect the BLUE lead to the

6. MAINTENANCE

PULSE PUMP

The pulse pump SHOULD BE AUDIBLE during use at idle rpm as it reacts to pressure fluctuations in the exhaust. Response to mixture changes should occur within 15 seconds if sample

flow is normal. Should correct operation not be achieved check that the probe is being fully inserted in the vehicle tailpipe.

If a baffled silencer with no tailpipe is fitted, as on some motorcycles,temporary restriction of the exhaust outlet or temporary fitting of a tailpipe extension may be the only way to achieve pulse pump operation and acceptable results.

If faulty operation of the pulse pump is suspected check also that the pump is not filled with water. then that the diaphragm is flat (and therefore correctly seated). If necessary re-seat the diaphragm by twisting the cap of the pump several times. Obtain a replacement pump if these measures are not successful or alternatively return the complete instrument to Gunson Service Department if other faults are suspected

CALIBRATION

With extended frequent usage or impact while hot the GASTESTER PROFESSIONAL may develop a shift in the "CALIBRATION" setting position in air so that the 2% setting is not obtained at mid position of the calibration control

Note: Unless this drift is severe inaccuracies in the CO measurement are unlikely.

Under extreme circumstances this shift may prevent initial calibration being carried out, the product should then be returned for service .

For rectification or charge details please contact our service department with full details of product model and fault description. NOTE. An extra charge may be made for replacement of SEVERELY soiled external parts.

APPENDIX 1 EXHAUST GAS ANALYSIS

Carbon monoxide (chemical symbol CO) is a colorless, odorless, but extremely poisonous gas that is present in the exhaust gas of gas-engined vehicles. The amount of carbon monoxide in the exhaust gas is an accurate indicator of the air/fuel mixture strength being supplied to the engine, and for this reason motor manufacturers use the measurement of carbon monoxide in the engine exhaust as the recommended method for setting the air/fuel mixture strength on carburetors and fuel injection systems. The recommended percentage of carbon monoxide in the exhaust at engine idle is usually specified in the engine maintenance handbook for each vehicle.

Manufacturers typically specify a CO level somewhere within the range 0.5% to 3.5% by volume, and often give an upper and lower limit for the recommended setting, for example, a manufacturer may specify 0.5% to 1.5% CO. Alternatively, the data may be given in the for 2% + .5% CO (which means between 1.5% and 2.5%). Less commonly (and less exactly) a manufacturer may simply specify a maximum limit e.g. below 3.5% CO.

Carbon monoxide only amounts to a relatively small percentage of the total volume of exhaust gas. The bulk of exhaust gas comprises nitrogen (N_2), carbon dioxide (CO_2), water vapor (H_20). Hydrogen (H_2) is also present, particularly in association with carbon monoxide. Oxygen (0_2) can be present either due to a weak mixture, or due to engine misfiring. Very small amounts of other substances are also present in exhaust gas, such as unburned or partially burnt fuel (generally referred to as hydrocarbons) and also some oxides of nitrogen. The way that the composition of exhaust gas varies with petrol/air mixture strength is illustrated in Figure 5.

It can be seen from Figure 5 that at a particular air/fuel mixture ratio (somewhere near 14.7: 1 for petrol engines) the amount of oxygen present in the air that is entering the engine is exactly that required to completely burn all the petrol to carbon dioxide and water. There is therefore very little carbon monoxide in the exhaust, and no free oxygen. This particular ratio of air and petrol is known as the stoichiometric ratio. At this ratio, the percentage of carbon dioxide in the exhaust is at a maximum, and the percentage of carbon monoxide is very low.

In mixtures richer than the stoichiometric ratio (i.e. more fuel, or less air), there is insufficient oxygen in the air to burn all the carbon in the fuel completely to carbon dioxide. Some carbon therefore exists in the form of carbon monoxide, and the richer the mixture the more carbon monoxide and the less carbon dioxide there is in the exhaust. It can be seen from Figure 5 that motor manufacturers generally specify a mixture strength at idle that is slightly richer than the stoichiometric ratio. Under some conditions, such as starting an engine from cold, or during acceleration, very much richer mixtures are used.

In mixtures weaker than the stoichiometric ratio (i.e. less fuel, or more air), there is more oxygen in the air than required for complete combustion of the petrol, and the surplus oxygen appears in the exhaust gas. The level of carbon monoxide is very low, since virtually all the carbon in the petrol is completely burnt to carbon dioxide. There is however a smaller percentage of carbon dioxide present in the exhaust than at the stoichiometric ratio of air and fuel, simply due to the diluting effect of the extra air passing through the engine. Engines are commonly designed to run with such weak mixtures under light load driving conditions, though not at idle.

An engine will run, indeed run quite well, at mixtures that are richer or weaker than those specified by the motor manufacturer. However, at settings richer than the manufacturer recommends, there is a loss in economy, and at very rich settings, typically 8% to 10% CO, the onset of poor running occurs, characterized by the particular engine sound that is known as "hunting".

At settings weaker than the manufacturer recommends there is poor engine performance and 'flat spots", and at very weak settings, typically 2% to 4% oxygen, the engine will not run at all. Note that at very weak settings it is inappropriate to speak of the CO level, since CO reaches a very low level below which it hardly changes for further weakening of the mixture and some other indicator of mixture strength must be used, such as oxygen.

It has already been mentioned that motor manufacturers specify a CO level at a particular engine idle RPM, but that the CO level under other engine running conditions will generally be different from this. A richer mixture is used when starting the engine from cold, a weaker mixture when driving under light power, a richer mixture when accelerating, etc. However, the user does not need to be aware of this. It is simply necessary to set the mixture strength at idle as specified by the motor manufacturer, and the carburetor or fuel injection system then automatically sets the mixture right at other engine conditions.

Gastester is an exhaust gas analyser that works on the "Hot Wire" or "Thermal Conductivity " principle. According to this principle, the thermal conductivity of exhaust gas varies in proportion to the amount of carbon monoxide present.

APPENDIX 2 COMMON PROBLEMS

(1) The car does not drive well with the correct idle mixture setting. This is a common complaint (it may even occur to a small extent on a new vehicle when the mixture is set to the lowest of the manufacturers stated CO tolerance). On older vehicles the cause is likely to be a fuel system fault which creates a weak mixture just above idle speed.

Remedy: Clean the idle jet and idle air bleed jet on fixed choke carburetors. Check for needle/jet wear on variable choke carburetors (above 40,000 miles). These are available as replacement parts. Check operation of acceleration enrichment device.

(2) The correct mixture setting cannot be achieved

Setting is continually too rich.

Remedy: Clean the idle air bleed jet and air passage on fixed choke carburettors. Check for severe needle jet wear on variable choke carburettors. Check for high fuel level in the float chamber. Check cold start device.

Setting is continually too weak.

Remedy: Clean the idle jet on fixed choke carburettors. Check needle and jet for disengagement from adjusting device or sticking on variable choke carbureftors. Check foair leaks.

(3) The engine misfires at idle with the correct mixture setting.

Remedy: Check for general engine condition - compression pressures, sparking plugs etc. Check for air leaks, these may cause severe variation in mixture between cylinders. Investigate mixture quality i.e. fuel air mixture may not be finely atomized due to partially blocked air jets or prematurely feeding main jet system causo6d; by high float chamber level etc.

(4) The mixture setting drifts

Remedy: Check for leaking float chamber needle valve if CO level steadily increases with prolonged idle. Check for high float chamber level. Check Gastester CALIBRATION in air. slight drift will occur during extended operation. Good stability should be obtained over a period of five minutes or more. A variation of, for example 0.5% CO at 2.0% CO is not uncommon on an engine which is in good working order.

(5) Gastester does not respond to mixture changes

Remedy: Check for water in the probe pipe, adequate insertion of the probe (essential for accurate readings, 8 inches/20 cm). If a baffled silencer with no tailpipe is fitted, as on some motorcycles, temporary restriction of the exhaust outlet or temporary fitting of a tailpipe extension may be the only way to achieve acceptable results. NOTE: In use the pipe from the exhaust probe should preferably slope down continuously to the Pulse Pump/Wate(r Trap so that water runs down and may be automatically expelled from the drain pipe. Operation of the pulse pump is normally audible as the internal diaphragm vibrates with pulsations from the exhaust, If response is obtained at higher than idle speeds only, Pulse Pump may need replacement. (Alternatively twist the pump cap on the body to re-seat the diaphragm).

If the pump is working, the vehicle mixture adjustment may be ineffective.

(6) Gastester Professional cannot be set to the Calibration Condition in air after warm-up.

Remedy: First check that the unit is switched correctly to CO RANGE and is used in a horizontal position (the unit will not operate correctly if instrument is significantly inclined or if the instrument angle is changed after calibration). Ensure that the unit is connected to a car battery (a 12v dry cell battery, or a faulty car battery can not provide enough current and are unsatisfactory). Ensure that the unit is correctly warmed up (allow at least 10 minutes). Ensure that the unit is being calibrated to the 2% CO condition, NOT at zero). Ensure that the probe is in air, not in the exhaust pipe. If these checks do not resolve the problem, it is possible that the instrument has "drifted", generally due to collector box contamination or damage due to impact (the instrument is more susceptible to damage when warm and in use).

APPENDIX 3 MULTIPLE CARBURETTORS

Where two separate carburetors are fitted, (not to be confused with a twin choke carburetor) two extra complications arise. Firstly the air flow through the carburetors must be accurately balanced before any mixture setting can be undertaken. This can be done using Gunson's Carbalancer, or less accurately with a tube to listen to the air intake hiss.

Secondly there will be separate **mixture** adjustments which must be synchronized. In the unlikely event that cylinders fed by each carburetor have totally separate exhaust, CO can be checked in each exhaust to set the respective carburetor. When the exhaust is common to all cylinders another method must be used. One method is to count the turns of the mixture adjusting screws from the fully closed position (or jet flush with the bridge for variable venturi types) and then ensure that the screws are kept to the same number of turns throughout adjustment. An alternative (and better) method is to use Gunson's Colortune to set the mixture strengths equal at some point, then to ensure that the screws are turned the same amount during subsequent adjustments.

APPENDIX 4 CARBURETTOR A[IJUSTMENTS

1 GENERAL INFORMATION

There are literally hundreds of different types of carburetor in use today, and finding the appropriate screws that control idle mixture strength and idle speed can pose quite a problem. Wherever possible, the user is advised to consult a detailed workshop manual for the particular car, but the following notes are provided for use when such information is not available.

Firstly it should be mentioned that it is a legal requirement that all carburetors have either a method of sealing the adjusting screws, or require the use of a special tool to enable adjustments to be made. In some ways this has been a retrograde step, it may stop "tinkering" by an unskilled owner but wear of the various parts takes place during the life of the car, and mixture adjustment is frequently ignored until it becomes troublesome in terms of starling, performance or economy. Seals are usually thin metal or plastic plugs which are destroyed on removal, and are usually removed using a sharp screwdriver bit or short self-tapping screw. Other types offer a limited adjustment which can be increased by removal of a cap, and some cover seals have a removable center section allowing access to the adjustment. The vehicle manufacturer will invariably recommend that the seals are renewed after adjustment, but this is frequently ignored by the service trade or vehicle owner, particularly after the service warranty has expired. In some countries, particularly the USA and Japan, this would be an offence.

2. IDLE CIRCUITS

Carburetor types can be divided into those that have a separate fuel circuit for idle. and those without a separate idle circuit. Figure 6 shows a typical arrangement of separate idle circuit. The mixture is made richer (i.e. CO higher by screwing the screw out)

Carburetors without a separate idle mixture circuit are typified by the SU and CD horizontal variable

3. SINGLE FIXED VENTURI TYPE

This is one of the simpler forms of carburetor with a single air inlet and throttle plate, with a variety of air and fuel metering jets and channels. The main jet and associated main air jet an emulsion tube etc., provide an aerated “emulsion” which is fed to the venturi at speeds above idle. This already aerated fuel and air mixture breaks down further in the airstream.

The idle circuit is separate and also has a fuel and an air jet which feed an aerated mix to a drilling downstream of the throttle plate, further drillings are found in the area of the throttle plate. Just above the idle drilling would be found "progression" holes which are progressively uncovered by the movement of the throttle plate and increase the fuel flow when exposed to the manifold depression (or vacuum). This supplements idle fuel flow until the main fuel discharge in the venturi is well established. All of these fluid circuits are fed from a small reservoir of fuel whose level is controlled by a float and needle valve.

4. SINGLE VARIABLE VENTURI TYPE

This type of carburetor consists of a single air inlet (but more than one carburetor is sometimes fitted), a throttle plate (or butterfly), and an air valve or a piston which closes off the air inlet to which is attached a tapered fuel metering needle. This needle runs inside a fuel jet which draws mixture from a small reservoir of fuel. The level of fuel is controlled by a float and valve.

At idle, when the throttle is nearly closed, the air valve is almost completely closed and the tapered needle which is attached to it restricts the flow of fuel to a great extent. As the throttle is opened the air valve is drawn upwards allowing more air to enter and the needle is drawn out of the jet allowing more fuel to flow. If the throttle is opened fully at low RPM the air valve rises about halfway. As the engine speeds up and draws in even more air the air valve will continue to rise. Thus the top half of the needle governs part throttle mixture and the lower half (slim end) governs full throttle mixture.

Mixture enrichment during acceleration is achieved using an oil filled damper which reduces the rate at which the air valve can rise.

Two types of needle are fitted:(a) a rigidly fixed needle which should not touch the jet. In some cases after stripping the carburetor it is necessary to centralize the needle and jet during re-assembly (this is a very early type).

(b) A needle which is spring loaded against the side of the jet; when in good condition this type gives improved accuracy of fuel metering. (Replace at 50,000 miles/80,000 km intervals).

Note: the needle housing should not be rotated as the direction of spring loading will be affected. Fuel metering needles are manufactured to within .0025mm (.0001 ") and should be handled carefully.

SU type HIF and Stromberg CDSE types have a temperature compensating device fitted, but other SU and Stromberg CD types should be set when the carburetor is warm to the touch but not hot, to achieve maximum selling accuracy.

IDLE ADJUSTMENT

The idle speed screw generally acts on the throttle spindle to which the accelerator linkage is connected; this will give very fine adjustment of the throttle. The mixture screw (also affecting mixture at high speeds) is located in different positions on different types.

SU TYPE

On early versions this is generally a hexagon nut underneath the carburetor and is screwed up to weaken (clockwise looking from underneath). Other types, HS8, HD, etc., have a screw which raises and lowers the jet through a system of levers. HIF types have a screw, which is located behind a removable plug in the right hand side of the carburetor; screwing in clockwise enriches the mixture.

Occasionally adjustment is on the left (one left, one right on twins).

CD TYPE

On early versions there is, generally underneath the carburetor, either a large slotted screw or, in later types, a castellated bush, which requires a special tool for easy adjustment. It is screwed up to weaken (clockwise looking from underneath). Other types (adjustable needle) are plugged underneath and have a slot in the air valve (piston) guide rod. Remove damper and look inside to check for this. (The slot is across the smallest tube, which is visible). An adjusting tool is also required here.

5. TWIN VENTURI CARBURETTORS (TWIN CHOKE) PROGRESSION TYPE

On this type two venturis are incorporated in the same casting. One throttle plate opens before the other (observe while operating the throttle linkage). At low speeds and for idle mixture adjustment this type can be considered similar to the single choke type, all adjustments being carried out on the barrel which opens first.

The Pierburg 2E3 shown in Figure 7 has a diaphragm operated second barrel and the idle adjustment is by the throttle stop screw and idle mixture screw shown.

On the G.M. Varajet carburettor shown in Figure 12 the secondary barrel is of variable venturi design. This has no bearing on the idle setting, which is of the by-pass type. Idle speed is adjusted on the throttle by-pass screw.

6. TWIN VENTURI CARBURETTOR SIMULTANEOUS TYPE

On this type the two venturis are incorporated in the same casting and both throttle plates operate at the same time. There is usually no need to balance the air flows through the two barrels, they are often linked by a single throttle spindle. Balancing of the two mixture screws is obtained by setting to the same number of turns open.

7. FUEL INJECTION SYSTEMS

Modern fuel injection systems can be either of the continuous type (e.g. Bosch K & KE-Jetronic), or intermittent type (e.g. Bosch L, LE, LE2-Jetronic, Motronic, Lucas LH etc) Adjustment screws are provided for idle mixture (CO). In some versions idle speed is not mechanically adjustable. The manufacturer's instructions should be carefully followed for particular models. The illustrations below show examples of types of adjustments.

Some older types of system (e.g. Triumph PI) used separate throttle plates per cylinder and a common idle mixture screw. With this type it is essential to obtain an accurate balance through each throttle plate before any mixture setting is undertaken. This can be done using Carbalancer or Colortune as mentioned in APPENDIX 3. Where separate control screws are provided for each cylinder, adjustment should remain synchronized, by using the same turns for each screw during adjustments.

APPENDIX 5 TACHOMETER, DWELL and DISTRIBUTORLESS IGNITION

(1) Conversions for other types of engine.

Gastester Professional can be used directly with 2, 4, 5 and 6 cylinder "conventional' engines, by simply using the CYLINDERS switch set to the appropriate number of cylinders, and reading the RPM or DWELL ANGLE directly from the display. "Conventional", meaning 4 stroke engines with a single set of points/electronic trigger and not "wasted spark",

For other engines it is necessary to multiply or divide the reading shown on the scale. In most cases, the multiplication or division is 2, and can be done by mental arithmetic.

The circuits of Gastester Professional measure RPM by measuring the rate of ignition pulses (i.e. sparks) in the low tension (LT) winding of the ignition coil. The assumption is 1 impulse (i.e. 1 opening of the points, or one spark), per 2 revolutions of the engine, per cylinder (i.e. corresponding to the 4 stroke

combustion cycle). There are 4 positions of the Function switch, corresponding to 2. 4. 5 and 6 cylinders, and therefore Gastester Professional assumes:

2 Cylinder setting:	2 impulses per 2 revolutions
4 Cylinder setting:	4 impulses per 2 revolutions
5 Cylinder setting:	5 impulses per 2 revolutions
6 Cylinder setting:	6 impulses per 2 revolutions

For engines with other numbers of cylinders, the scale reading can be readily calculated. For instance, A SINGLE CYLINDER 4 STROKE ENGINE has one spark per 2 revolutions. Gastester Professional therefore receives 1 impulse per 2 revolutions. With the Function switch set to 2 cylinders, the scale reading should therefore be multiplied by 2. ie. if the scale shows 1000 RPM. actual speed is 2000 RPM.

This example is common on DISTRIBUTORLESS IGNITION SYSTEMS used on car engines (except the FORD system - see below), and also 4 stroke MOTORCYCLES where the ignition sensor is camshaft driven.

Note: It the above engine has an extra "WASTED SPARK" or if it is a two stroke engine (with twice the number of sparks per revolution) the reading would be correct on 2 cylinder setting. This "wasted spark" and 2 stroke example is common on motorcycle engines for any number of cylinders, as they often have a coil for each cylinder and a crankshaft driven ignition pickup/points cam.

The FORD Distributorless Ignition System (DIS) requires special consideration. In such systems there is one coil per 2 cylinders, a 4 cylinder car having 2 coils. The coils produce sparks every revolution (one wasted) and so the display gives a direct reading on the two cylinder range. (The Gastester Professional tachometer pickup is only connected to one of the coils).

Other car engines with DIS have one coil per cylinder and one spark per two rotations of the engine.

(2) Difficulty in connecting the Blue lead.

All vehicles that use spark ignition have a dc powered ignition coil excepting Magneto and CD ignition which is only used on some vintage cars and some motorcycles. The ignition coil has a primary winding or low tension which will generally have two visi6le connections to which are attached a cable of normal insulation thickness (2.5 mm). Following the plug leads back from the spark plugs will (except DIS systems) identify the distributor. Another thick lead of plug lead type (the "king lead"), will lead from the distributor to the coil. On the coil will be two connectors to the primary winding. In DIS systems, the plug leads go to the coil direct.

With some cars, the coil is covered by cowling or is enclosed within the engine management system. In such cases the user should refer to the workshop manual of the car for the location of the coil, and in particular to the location of the terminals of the primary winding to which Gastester Professional is connected. Some ignition coils are totally enclosed, or are virtually inaccessible. In these cases the user must examine the circuit diagram of the car to identify a wire or connector that a tachometer (or Gastester Professional blue lead) can be connected to.

Where an ignition coil has exposed "spade" type connections, it is easy to connect the crocodile clip of Gastester Professional directly. Where an ignition coil has an insulated plug-and socket arrangement, it may be necessary to improvise a suitable connection, such as by trapping a short length of fine wire (e.g. fuse wire) between the plug and socket. And making the connection to the short length of wire (taking care to remember to remove the wire at the end of the tests). Alternatively a piece of stiff wire can be pushed into the connector alongside the lead. Another useful improvisation for some connectors, particularly the type often used by Vauxhall, where the connector is a plastic covered plug, is to use a paper-clip trapped under the plug.

(3) Connection to a Distributorless Ignition System (DIS)

The connection to a DIS system is made to the primary winding of either of the coils. The coils are not always visible as separate coils, but there is invariably a cable which leads to the primary windings. In the Ford DIS system (used on Fiesta, Orion, Escort etc), the connection is to either of the outer connectors of the 3 way plug-and-socket mounted on the coil unit. These connectors are numbered 1 and 8. It may be more convenient to make the connection to the other end of the lead, which is to pin numbers 1 or 8 of the ECU multi-way plug. (See Figure)

(4) Difficulty in obtaining a reading.

Check the connections to the car battery, then remove the BLUE lead and connect to the other side of the coil.

If**,** for any reason, a 12V battery other than the car battery is used for the Red and Black leads of Gastester Professional, it will be necessary to connect a common earth between the battery earth and the earth of the car.

(5) **6V, 24V and positive earth systems.**

Gastester Professional will not give an accurate reading of RPM with a 6 Volt vehicle. Using that vehicle's battery. To use Gastester Professional to measure the RPM of a 6 Volt vehicle, connect the Red and Black leads to an external 12V battery, remembering to connect a common earth between the vehicle earth and the external battery, and connecting the Blue lead as described previously.

Gastester Professional should not be used on a 24V vehicle using that vehicles battery. To avoid damage to the meter's circuitry an external 12V battery should be used and a common earth connected between the vehicle and external battery as mentioned above.

APPENDIX 6 ALTERNATOR, STARTER AND BATTERY TESTING

Typical battery voltage during cranking HOT 10.5 to 11.5 volts (engine and environment hot, cranking at approx. 450 RPM).

Typical battery voltage during cranking COLD 9.5 to 10.5 volts (engine and environment cold. cranking at approx. 200 RPM).

When testing the starter motor cranking circuit, connect the blue lead to the battery post. followed by the battery connector, the solenoid connector and if available the starter motor connection. Compare these voltages (under cranking in each case) to detect a component with an excessive drop indicating a fault.

SPECIFICATION

Gastester Professional is a combined exhaust gas CO analyzer, tachometer, dwell meter and voltmeter.

Though primarily intended for multi-cylinder car engines the instrument may also be used on motorcycles and other engines including single cylinder engines with the following proviso:

(a) The CO range may NOT be used on TWO STROKE engines and on four stroke motorcycles a suitable exhaust tailpipe fitting is required for full insertion of the probe.

(b) For two stroke and four stroke motorcycle type engines see APPENDIX 5 (1) for cylinder switch setting for Tachometer and Dwell ranges, and APPENDIX 5 (5) for other than 12v applications.

TECHNICAL SPECIFICATION

CO FUNCTION
CALIBRATED RANGEO - 10% CO
(indicates uncalibrated to 20% CO)
ACCURACY +/- 0.5% CO Typical.
(Throughout the indicated range 0.5% CO to 6.5% CO)

BATTERY/ALTERNATOR VOLTAGE
INDICATED 0-20 V
ACCURACY at 12.0 V +/- 0.05 V

RPM LOW
INDICATED 0-1999 RPM
ACCURACY WITHIN - 2% OF READING PLUS 1 DIGIT (1 digit = I rpm)

RPM HIGH (x 1000)
INDICATED 0-19,990 RPM
ACCURACY WITHIN - 2% OF READING PLUS 1 DIGIT (1 digit = 10 rpm)

DWELL ANGLE DEGREES
INDICATED TO SUIT (Number of cylinders)
ACCURACY WITHIN - 1% OF READING PLUS I DIGIT (1 digit = 0. 1 degree)

DWELL PERIOD PERCENT
INDICATED 0-100%
ACCURACY WITHIN - 1% OF READING PLUS 1 DIGIT (1 digit= 0. 1 percent)