# ELECTRONIC DIAGNOSTICS!

**How to trace faults in electronic engine management systems**

***Part 11:*** *Under the spotlight this month is Rover MEMS, as found on the latest Rover 820 16v. Chris Graham reports.*

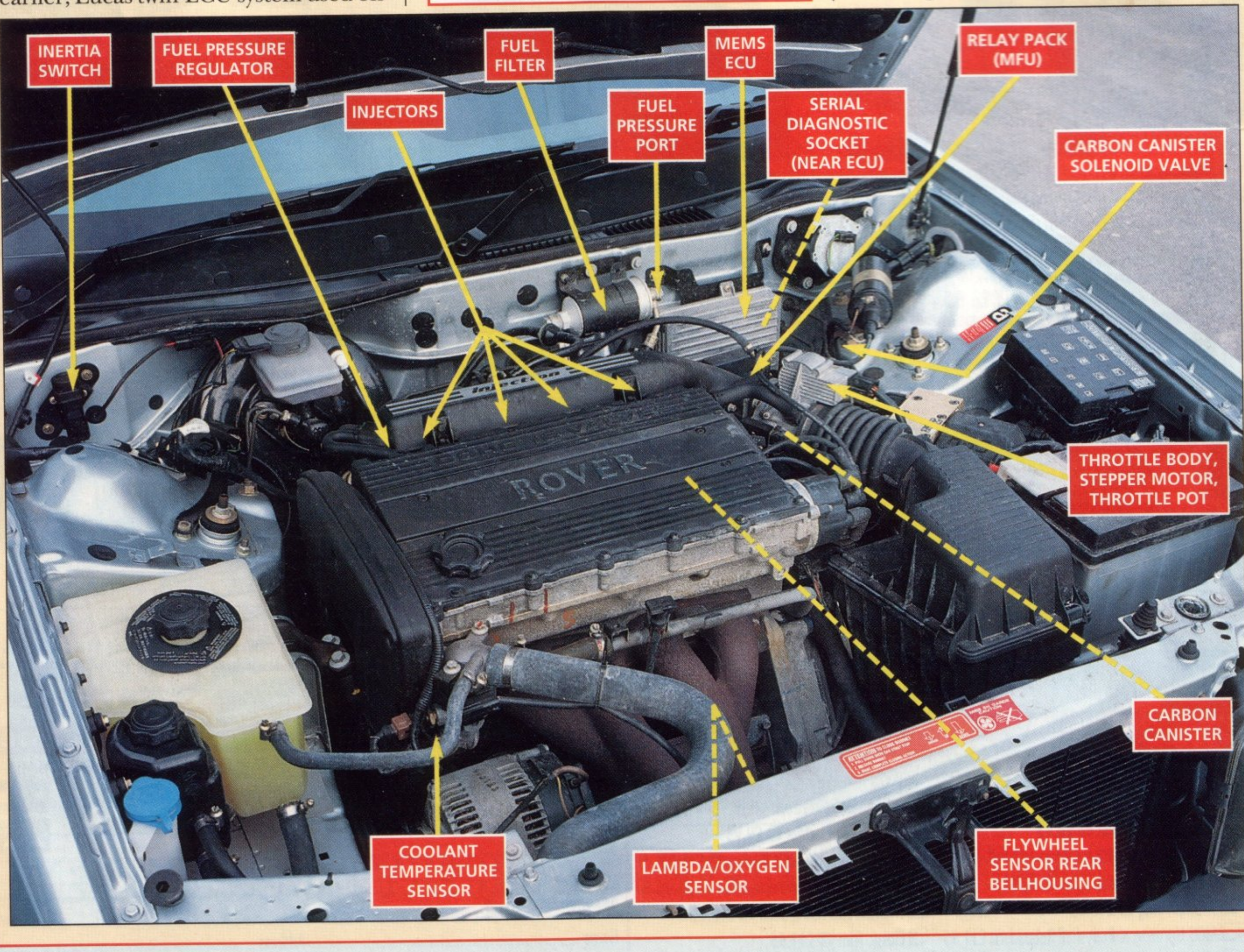
The Rover modular engine management system (MEMS) first appeared in May 1991. It is a system that was jointly developed by Rover and Motorola and is found on 200 and 400 Rovers as well as on the 800 series cars.

It should not be confused with the earlier, Lucas twin-ECU system used on the M20 engine – the two are completely incompatible. According to Frank Massey, proprietor of Preston-based Fuel Injection Services (Tel: 01772 201597), MEMS is typical of the new generation of engine management systems. It's very code reader-friendly with plenty of useful information being available from serial communicator interrogation.

## TYPICAL FAULTS

1. **Misfires and hesitation**
2. **Poor hot starting**
3. **Over-rich fuelling**

*Car kindly supplied by Dutton-Forshaw Blackpool, Vicarage Lane, Marton, Blackpool, Lancs. FY4 4XL, Tel: 01253 767811.*



## Testing times

Before starting any tuning or diagnostic work, Frank considers it vital to ensure the following: make certain that the spark plugs are in good condition, the vacuum pipes are secure and free from leaks, that the throttle operates fully (from the pedal), that the breather hoses are secure and leak-free and that the loss-motion gap (throttle cable adjustment) is set correctly (through serial communications).

Although it's not possible to make any purely mechanical adjustments with MEMS, a serial communicator can be used to very good, practical effect. The fuel pump can be energised and tested in conjunction with a voltmeter and/or pressure gauge. The indexed stepper motor can be driven which is important because it has to be parked in a certain position (at 25 indexes) for the base idle speed to be adjusted. Serial communication will do this as part of the tune-up procedure. With the stepper correctly parked the idle should be as specified – if not the button-headed bolt on the throttle quadrant must be adjusted accordingly.

The ignition coil may be fired so the function of the HT system can be assessed. The injectors can be triggered too, but bear in mind that this action will deliver fuel which can be bad news for a hot catalyst. Consequently, Frank suggests that this test only be made with a cold engine and for the shortest time possible.

The heating element in the oxygen sensor can be driven. This is a four-wire component which is preheated to bring it up to operating temperature more quickly. Both cooling fans can also be driven as can the over-run fuel cut-off function.

During component testing with serial communication the engine speed (rpm) can be displayed which will help to confirm whether the flywheel sensor input is active and operating – without this rpm will not be calculated. It is also possible to display the manifold absolute pressure (no other way of testing the MAP sensor). This should be about 30k/pascals at idle and 100k/pascals or so with the engine off, at atmosphere. The transition between the two should be a linear one (without glitches).

The coolant temperature sensor is displayed as a temperature rather than a voltage (although volts can be measured at the component) and it should be noted that hot idle is not reached until the coolant temperature reaches 82 degrees C. Tune-up functions are actually locked out until this temperature is reached – no idle speed adjustment is possible until this is achieved.

When in 'limp home' mode the ECU sets the coolant temperature default at around 60°C. So if you have a car that seems to operate at a fixed temperature, it's probably in 'limp home' mode.

The fuel temperature sensor in the fuel rail will display the temp in degrees and the ECU will set a default of about 35° for this during 'limp home'. Note that on automatic models this value is fixed.

The battery voltage can be displayed which is important because the ECU has a default programme guarding against battery voltage changes, particularly for the effects of voltage drop and the driving of injectors and stepper motor. If the voltage falls sufficiently the ECU will compensate by increasing injector duration. Quite often a battery or alternator fault can be the simple cause of what appears to be a serious ECU or input error.

The throttle potentiometer voltage test is best performed with the engine off so that the full travel and progression of the throttle can be tested. It's vital that the increase from fully shut to fully open is smooth. The range is approximately 0.5V to 4.0V.

Testing the Lambda sensor voltage output is another interesting one because, although effectively no fuel adjustment is possible, this does not mean that fuelling errors cannot exist. Using the serial communicator it is possible to examine the switched output of the Lambda sensor which will operate between about 0.2V and 0.8V. When the cat. is up to working temperature the sensor should be switching completely between 0.2 and 0.8V, indicating a correct mixture. The frequency of this switching should ideally be between once and three times per second (hertz). Quicker switching is OK but if it's slower then all is not well. A 'lazy' switch, or one that is fixed at one or other end of the output scale, will affect fuelling.

The 0.8V output provides a 'go lean'

# ENGINE MANAGEMENT

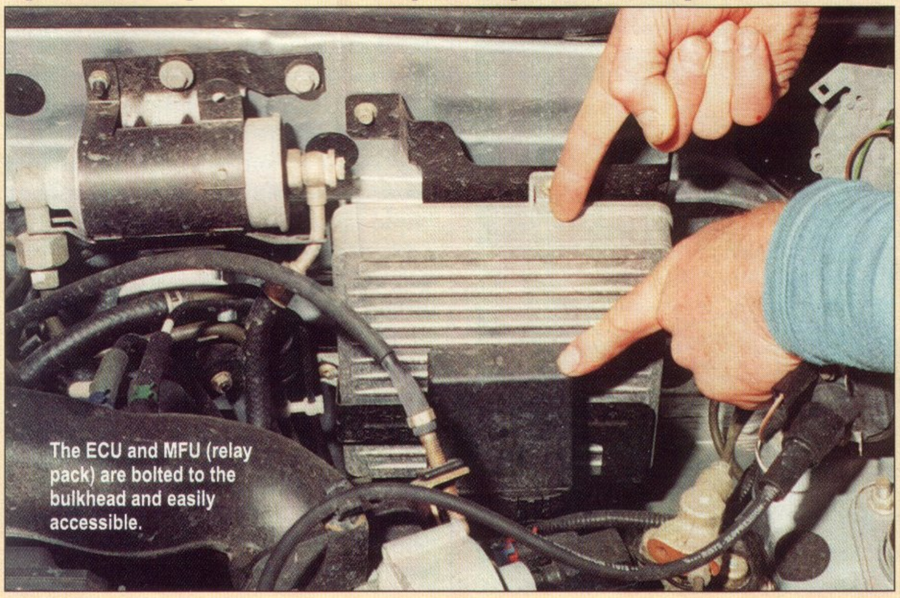
The MEMS system fitted to the Rover 820i 16v operates in conjunction with a catalytic converter. No mixture adjustments are possible and idle speed can only be controlled, through the stepper motor, via serial communications using a code reader.

Basic components of this system include: a throttle body incorporating a stepper motor; a potentiometer mounted on the throttle spindle; an air temperature sensor mounted in the air intake plenum chamber; a coolant temperature sensor fitted in the thermostat housing; a knock sensor at the rear of the engine block in the coolant water jacket; a multifunction unit (MFU) relay pack mounted next to the ECU in the engine bay – rear n/s of the bulkhead; a self-inductive flywheel sensor; four fuel injectors and a Lambda/oxygen sensor in the exhaust downpipe.

In addition there is: a diagnostic socket near the ECU (protected by a rubber boot); a fuel pressure regulator – o/s end of the fuel rail; a carbon canister solenoid chamber just beneath the ECU (to draw hydrocarbon fumes from the fuel tank – there is no open vent any more); a fuel filter towards the n/s on the bulkhead together with a fuel pressure measuring port (adapter required) and an inertia switch – rear o/s corner of the engine bay.

As with all injection systems, the three most important inputs are related to engine speed, load and temperature. Information on speed comes from the flywheel sensor while load input is from a MAP sensor – a direct vacuum pipe runs straight into the ECU from the induction manifold.

This Rover MEMS system also features several failsafe and 'limp home' functions which allow a number of key components to fail without causing the engine to stop.



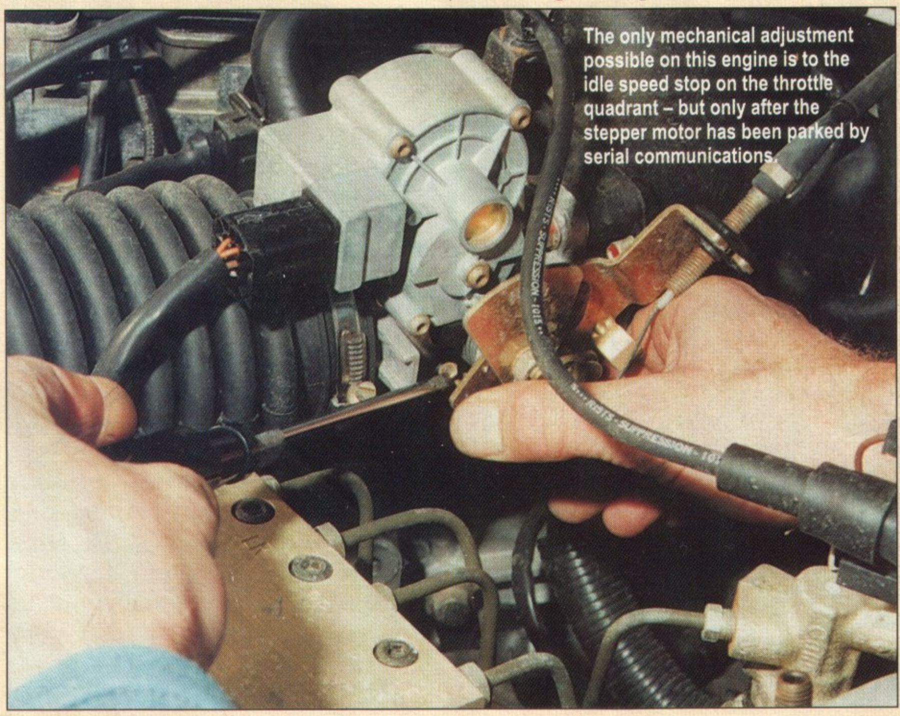
The ECU and MFU (relay pack) are bolted to the bulkhead and easily accessible.

signal for the ECU, to compensate for a mixture that is too rich. It can be triggered by any number of factors including defective ECU input, a fuel pressure variation, blocked injectors, air leaks, fuel pipe obstructions etc. Frank says that it's important not to blame the Lambda switch itself straightaway – the other possible causes mentioned should all be checked first. Also you should use a serial communicator to check that the 'limp home' mode hasn't been engaged because this will affect the switching performance too.

Usefully, the car can be driven while using the serial communicator to test the action of the Lambda sensor under normal operating conditions. This sensor only has an influence on fuelling while the engine is cruising with fixed throttle. Under hard acceleration and at idle it has little or no influence.

In 'limp home' mode there is a function which fixes the Lambda sensor output to a default – the fuelling is set slightly rich to guard against engine overheating.

It's also possible to carry out useful diagnostic work in the more conventional way using multimeter and oscilloscope. Components which are easily tested in this way include the flywheel sensor. Attaching an oscilloscope across its terminals generates a pure sine wave and the amplitude of this will be three to five volts peak-to-peak. Problems will be highlighted by variations in the output amplitude – under normal circumstances this should remain constant.


The only mechanical adjustment possible on this engine is to the idle speed stop on the throttle quadrant – but only after the stepper motor has been parked by serial communications.

## TECHNICAL SPECIFICATIONS

| | | |
|---|---|---|
| Throttle pot. | 0.5V at idle | 4.5V full load |
| Coolant sensor | 3.0V cold | 0.5V hot |
| Ambient air sensor | Supply – 5V | |
| | Output – 3.5V cold | 2.5V at 80+°C |
| Oxygen sensor | Switches between 0.2 and 0.8V at a frequency of 1-3Hz | |
| Flywheel sensor | 5V at idle | 3V cranking |
| Idle stepper motor | Supply – Battery voltage<br>Output – ECU switched to ground | |
| Fuel pressure | Max. – 5.0+bar<br>Delivery rate 60lt/hr + | Regulated – 3bar ±0.5bar |
| Injector duration | 2.5ms (hot) | 4.0ms (cold) |
| Coil | Output – approx 40,000+V | |
| Plug voltages | 12Kv at idle, load voltage 17-18,000Kv max. | |
| Voltage regulator | 13.5-14.5V | |
| Ignition timing | 12° at idle (if in 'limp home' retarded by 10°) | |

***(Before checking exhaust emissions the catalyst must be warmed to above 300°C – cruise engine for five minutes at about 3,000rpm to ensure this)***

| | |
|---|---|
| CO | 0% at idle<br>0% at cruise |
| HC | 0ppm at idle<br>0ppm at cruise |
| $CO_2$ | 14+% at idle<br>14+% at cruise |
| $O_2$ | 0.5% at idle<br>0.5% at cruise |

The voltage output of the coolant temperature sensor can also be tested in the old fashioned way. It's a 5V component and should be checked for an earth of 0.25V or better during cranking. The output voltage can also be monitored (see table). The ambient air temperature sensor can be checked in the same way.

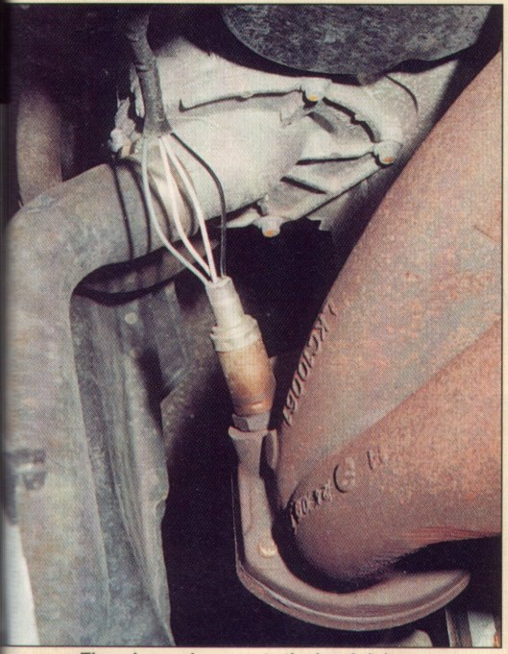
The knock sensor is used to retard individual cylinders when pinking is detected. It will reinstate them progressively once the knocking has been stopped. This component is potentially a difficult one to check because the voltage tends to be low. Ideally a good oscilloscope is required but you can carry out a useful test with an engine analyser. Set the machine on 'scope' function to observe 'coil primary' and tap the block lightly with a hammer. If all is well you will see that dwell control is activated.

The inputs to the four-wire stepper motor can be checked using an oscilloscope, as can injector duration and the oxygen sensor. A serial communictor will monitor the $O_2$ accurately but a voltmeter or oscilloscope can provide useful confirmation. It's also important to establish that the oxygen sensor is powered-up. This has a fused supply via the battery and Lambda control relay in the MFU.

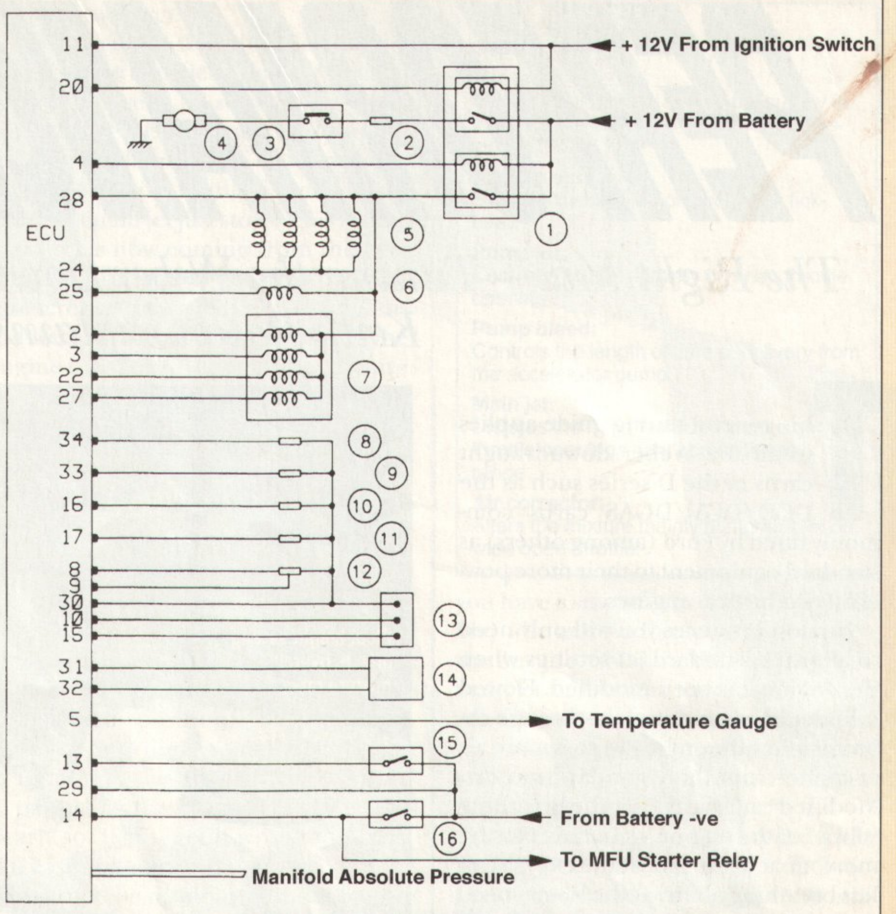
## Trouble-shooting

The first and most common problem with this application of MEMS concerns the distributor cap. It's a straightforward cap housing the rotor arm and is mounted on the end of the exhaust camshaft at the front of the engine. This can and often does suffer with the ingress of oil and other contaminants from the camshaft seal. The resultant build-up of deposits on the electrodes within the cap impair spark performance. This causes poor spark duration or internal tracking within the cap.

The problems of hesitation, misfires and flat spots caused by this will initially occur under heavy load conditions when demand is greatest. As it gets worse the misfire will become more generalised and will often be worse when the weather is damp. The solution is simply to remove the cap, clean it and replace any components necessary.



There is good access to the Lambda/oxygen sensor mounted in the exhaust downpipe at the front of the engine. Studying its switching performance provides very useful information about fuel mixture quality.




## ROVER MEMS MPI

1. Engine MFU
   (a) Fuel Pump Relay
   (b) Main Relay
2. Ballast Resistor
3. Inertia Switch
4. Fuel Pump
5. Injectors
6. Ignition Coil
7. Stepper Motor
8. Fuel Temp Sensor (Manual trans only)
   Resistor (5K4-8K2ohms) (Auto. trans only)
9. Coolant Temp Sensor
10. Inlet Air Temp Sensor
11. Knock Sensor
12. Throttle Potentiometer
13. Serial Diagnostic Link
14. Crank Sensor
15. Throttle Pedal Switch
16. Park/Neutral Switch (Auto. trans only)
    Shorting Link (Manual trans only)

*Diagram courtesy of FKI Crypton Ltd.*

Don't simply replace the cap without bothering to change the camshaft oil seal though.

Earlier cars suffered from a faulty rotor arm. The symptoms of this are much the same as for the cap problems but also sometimes include poor starting or no start at all. Such a problem can be picked up while testing coil output – sometimes will be as low as 15kV. Rover introduced a revised arm which can be identified by a bead of red compound along the blade.

Radio frequency under the bonnet is another common cause of these sorts of engine running problems and can be caused by dirty HT leads and poor spark suppression. In bad cases it can be sufficient to induce 'limp home' mode. To guard against this make sure that the leads are all clean, dry and in good condition. Always use the correct specification plugs and genuine O/E leads, distributor cap and rotor arm.

Poor hot starting, if not caused by HT problems, is often attributed to a faulty flywheel pick-up sensor. This component can be badly affected by dust and dirt but is also easily damaged by the careless removal and fitting of clutch and gearbox. It can be checked by serial comms. but unfortunately the actual output cannot be measured. Consequently, the code reader may well pronounce the component fit but its low output will be sufficient to prevent the engine from starting.

Ideally you will need an oscilloscope to check this one but a multimeter can be used. Remember, though, that multimeter outputs, measured in AC, are not necessarily the true peak value and so may appear initally low.

The third common problem encountered with this set-up is one of over-rich fuelling. When the manifold pressure changes from negative pressure to atmospheric, or even positive, then the mixture will go rich which is a normal function of the system. The pipe connecting the induction manifold to the ECU can fatigue, chafe, crack or split which, in the early stages, results in a slight drop in manifold pressure and an associated richening of the fuel mixture. Ultimately, however, this can lead to a total failure, at which point the 'limp home' facility will be engaged.

However, until the vacuum drops sufficiently low to be recognised by the ECU, a progressive richening of the mixture will be caused. To test for this problem attach a vacuum gauge at the ECU end of the pipe so that accurate measurements of the true manifold vacuum being applied can be taken. Blockage of the pipe with carbon deposits, fuel or even kinking are all possible causes.

Finally, Frank said bear in mind when carrying out routine exhaust emission sampling at the tailpipe (referred to as 'downstream' measurement), that the the air/fuel ratio ahead of the catalyst (upstream) might not be correct. The catalyst may well be doing its job efficiently by reducing potentially rich mixtures during the reaction process and disguising the problem.

As no 'upstream' measurement is possible, Frank suggests that careful observation of oxygen sensor switching will confirm whether or not the fuelling is satisfactory.

*My thanks to Frank Massey, FKI Crypton and Sykes-Pickavant for their help with this feature. Frank is running diagnostic courses – DIY to dealership technician – call 01772 201597 for details.*

**NEXT MONTH**
Montego/Maestro 2-litre.