

LAND ROVER FUEL INJECTION SYSTEM

DESIGN AND FABRICATION

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Introduction

The land rover came with a standard induction system consisting of twin 1.75" SU carburettors fitted to a 3.5 litre 9.35:1 compression ratio rover V8 using electronic ignition. The vehicle employed a stainless steel exhaust system coupled with log style exhaust manifolds. However, even after rolling road jetting of the carburettors and with good and tight linkages for both throttle and choke, they were the usual SU horror to drive with. The mixture was generally fairly good on cruise and part throttle – but cold starting was erratic to say the least, and carburettor icing occurred regularly unless the weather was warm. It was quite typical to experience boggy stumbling running when having the audacity to approach traffic lights if the engine was anything other than fully warm and even when fully warm, the engine idle speed was impossible to set with any degree of precision.

Many will disagree, and some off roaders have very good reason to prefer carburetion over fuel injection – but speaking personally, while I admire the elegance of the constant vacuum carburettor, I have had first hand experience of both Stromberg and SU carburettors on three vehicles in my life, and have equally loathed them all.

This paper describes the conversion of the existing carburetion system to a fuel injection system in full and is designed as a maintenance aid.

The conversion project started in February 2010 with an extended period of research. By the end of May the basic injection system was running. Fine tuning was then undertaken over a period of months.

As stated, the primary intention when drafting this document was to have a maintenance aid. However, anyone thinking about attempting the same carburettor to EFi conversion on a Rover engine may find these notes useful even if just for background research – and so I took the decision to make these notes available on the web. If this is your aim - have fun with the conversion. I can say that once it works, it is a vast improvement on even an ideally setup carburetion system.

Overview

When it comes to injection systems there are a number of systems capable of fueling a Rover 216CID small block engine.

A company in the US called FAST have created a system known as EZ-EFi which is a self learning fuel injection system consisting of a large four barrel plenum fitted to a custom manifold. The kit comes with an ECU capable of learning the fuel requirements of broadly any size engine – but the system is costly and very much aimed at larger displacement engines (the CFM capability of the four barrel body is well over 1000CFM). By the time all aspects of system design were considered, the cost became prohibitive as did the injection air flow rates – suggesting poor low speed performance for what would be a low revving four wheel drive vehicle.

Another off the shelf DIY system is known as megasquirt. This consists of an ECU designed along the lines of open-source with enough instructions / help to build a fully working injection system using additional off the shelf sensors, injectors etc. Megasquirt has a significant data logging capability which when coupled with a laptop provides a tremendous degree of flexibility. It is also very popular and clearly is a viable option for this engine. However, it works by referring inputs to a fixed map of fuel requirements. That means that any change to the engine necessitates the rebuilding of fuel maps in order to achieve proper fueling – an aspect that appears only to be a useful asset when selling the product. To the end user it is a potential liability.

There are advantages and disadvantages to these systems – but it is worth factoring into the decision land rover research leading to a flexible, self adaptive system known as the C family and which culminated in the 14CUX. This system has two major advantages. Firstly it is self adaptive because it measures air flow into the engine using a mass air flow sensor – using that to determine the required amount of fuel. The air flow sensor employs a hot wire anemometer to sense air intake – and is consequently known as a hot wire system. Within certain limits, engine changes including displacement changes from 3.9 to 3.5 litre do not significantly alter the 14CUX's ability to correctly fuel the engine. Even aggressive profile cams are well within the range available to a 14CUX – except when the overlap becomes greater than about 12 degrees. The second advantage is that it is a readily available given it was used extensively from 1990 to 1995 on range rovers – many of which are now being retired and broken.

Bosch began the line of development for this system with the 4CU flapper system in 1990 – so called because air flow into the engine was monitored by a moving flap in the air flow. From 1985 to 1989 the 13CU hot wire system was built which used a hot wire system, cooled by incoming air, to detect the precise air flow into the engine. From then on, the hot wire system was the primary line of development leading, in 1990 to 1995, to the 14CU system which culminated in the 14CUX system. The 14CUX included a small degree of diagnostics and was capable of fueling the stricter emission controlled engine requirements of a vehicle running catalytic convertors running in different geographical markets.

Injection systems following on from the 14CUX (including the GEMS land rover system) incorporated fuel injection and per cylinder ignition and so are far more difficult to transfer between vehicles.

The 14CUX system was the one selected for the job of injecting the target engine.

It is important to understand one key feature of the 14CUX system – namely that there is no programming capability and little or no data logging built into the system. Effectively the 14CUX is a closed box. In reality, it is a straightforward microprocessor based system using an EPROM (27128) to hold the program code along with a number of fixed fuel maps for open loop operation. The system is also capable of using lambda sensors in closed loop mode at low speed.

Selected Donor Vehicle

Type: Range Rover 3.9Efi

Registration: KXXX XXX (VIN confirms the year of manufacture is 1993)

VIN: SALLHAMM3KAXXXXXX

VIN decoded:

- S=Europe region
- A=UK origin
- L=Land rover manufacturer
- LH=Range rover model type
- A=Wheelbase which includes
 - Series III 88"
 - Defender 90" extra heavy duty
 - Range rover classic 100"
 - Range rover (38A) 108"
 - Freelander
- M=Body style which includes
 - Defender 5 door station wagon
 - Range rover classic 5 door
 - Range rover (38A) 5 door
 - Discovery 5 door
- M=Engine 3.9 & 4.0L V8 EFi petrol
- 3=Gearbox – Chrysler 747 3 speed auto RHD
- K=Year of manufacture 1993

- A=Built at: Solihull, UK
- XXXXXX is serial number off the line

Donor vehicle parts supplied

The donor vehicle supplied the following parts.

1. Full wiring loom including main and fuel relays and a socket for the air conditioning control relay
2. ECU – stamped 14CUX
3. Intake manifold
4. Air horns
5. Plenum
6. Throttle blade and linkage control
7. Throttle potentiometer
8. Air bypass valve stepper motor
9. Under plenum heater
10. Pipe work linking to mass air flow sensor
11. Mass air flow sensor
12. Air filter housing
13. Air fliter
14. All 8 injectors
15. Fuel rail
16. Fuel rail regulator

Missing parts

Key parts not included (could not be sourced from the donor vehicle)

1. Inertia cut off switch
2. Road speed transducer and twin speedometer cables one leading from gearbox and one leading to the speedometer.
3. Oxygen (lambda) sensors

Project duration

The procurement of parts and research for the project began in February 2010, with the start of the hardware phase commencing on the 12th April 2010 (the day the major bulk of the components arrived). The project technically ended on 30th May 2010 with the resolution of the last bug and the successful firing of the engine – a total of 49 days, but fine tuning and design improvements were then carried out on the system over the following six months in order to improve the reliability and operational stability of the design.

The project was split into two parts – refurbishment and fabrication/design

Refurbishment process

Refurbishment involved stripping the received donor parts into individual components while analysing the condition and operation of each to understand function. There were a number of missing components – for example all the fuel system components up to and from the injection rail were missing, as were all the vacuum plumbing components. The throttle cable and all the water plumbing parts were missing – and what made matters slightly more interesting was that the water plumbing was quite different for the new intake manifold compared to the old.



Figure 1 – 1992 3.9EFI donor vehicle parts as shipped

The general condition of the donor parts was good and it was clear that the seller had done a good job of carefully removing the components in order to minimise damage.



Figure 2 – Plenum side view

The idle control system was intact, as was the throttle linkages and the fuel regulator (at the back of the fuel rail). The throttle linkages did however appear to be in a bad state of repair.

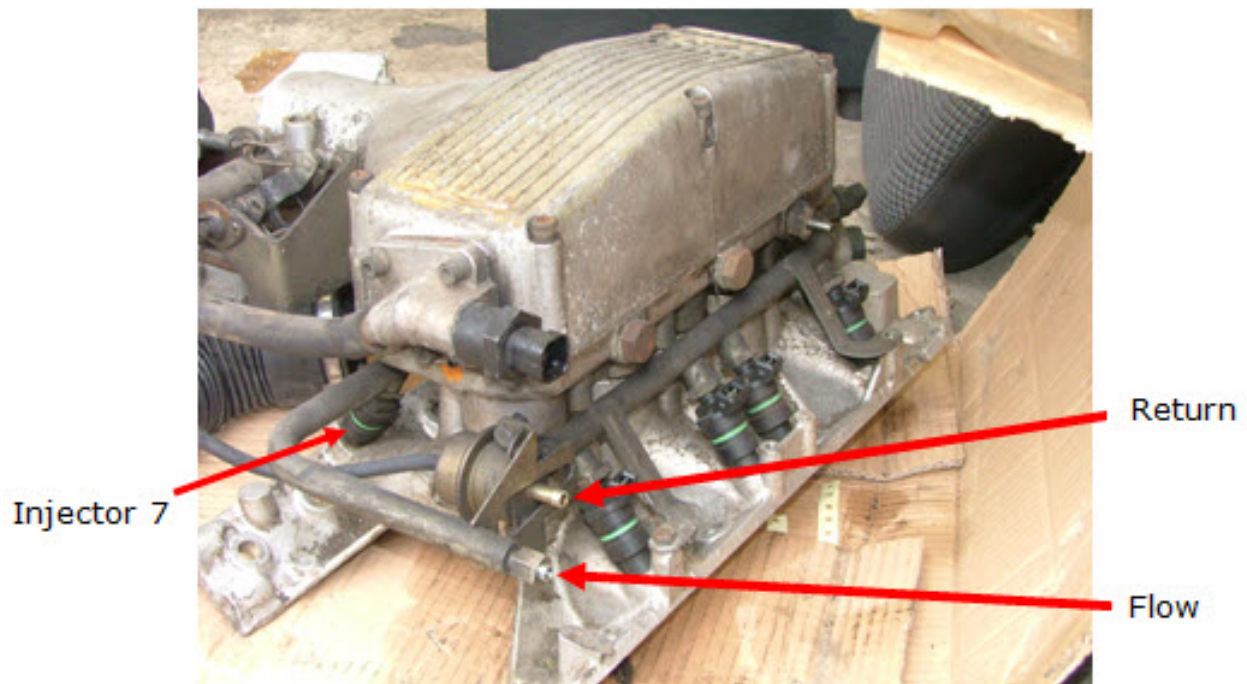


Figure 3 – Plenum rear quarter view – fuel flow and return

In the above photograph, you can see the flow and return feed pipes to the fuel rail, connected to the even bank of injectors (with the injector for cylinder 7 visible at the back left). Note the fuel rail connections – using a standard hose jubilee pipe on the low pressure side of the fuel regulator, but a machined fitment on the input high pressure side. This machined connection was tackled by removing the olive and the free rotating nut and using a standard jubilee clip connection on the rail after soldering a lip onto the pipe.



Figure 4 – View of stripped intake manifold

The above photograph details the front of the intake manifold when both the upper plenum and the inner runner manifold have been removed (shown just in shot on the left). Looking at the intake reveals all 8 injectors (the even set of four on the left of the photo, the odd set on the right) connected between the fuel rail and the intake manifold. Note the four bolts (one was missing) fastening the intake to the manifold. You can see the fuel temperature sensor screwed into the front of the fuel rail – and observe that this is not exposed to fuel. The sensor housing is actually brazed to a closed fuel pipe. On the thermostat housing another sensor exists (to drive radiator

fans – but which was not employed in my design) and just underneath that is a coolant temp sensor used to drive the dash board gauge. On the front right hand of the manifold you can see the coolant temperature sensor used by the fuel injection system screwed into the manifold. Just above that is a water coolant pipe that feeds hot engine water to the under plenum preheating plate.

At the back of the manifold fuel rail you can see the fuel inlet right at the back coming into the fuel rail, which sweeps round to all 8 injectors exiting into the fuel regulator – with its vacuum hose connected (this hose routes to the vacuum port directly under the idle by pass air valve stepper motor).



Figure 5 – View of Intake runners

The above photo shows the intake runners which bolt to the intake manifold via 6 bolts, and which the upper plenum (shown below) screws to via 6 hex head screws. An important point to note here is that the intake runner platform is actually reversible – and can be mounted either way on the intake manifold – a design advantage that was used to simplify the vacuum pipe routing.



Figure 6 – Underside of plenum.

The underside of the plenum in the figure above and below shows the plenum pre-heater plate with two water hoses and the idle bypass air valve stepper motor as well as the throttle linkages. Note also the cable and plug for the throttle potentiometer sensor.



Figure 7 – Close up of plenum chamber pre-heater

The above figure shows the plenum upside down. The primary metered air entry point is the large round point, and the pre-heater plate is shown above with the two heater hoses.

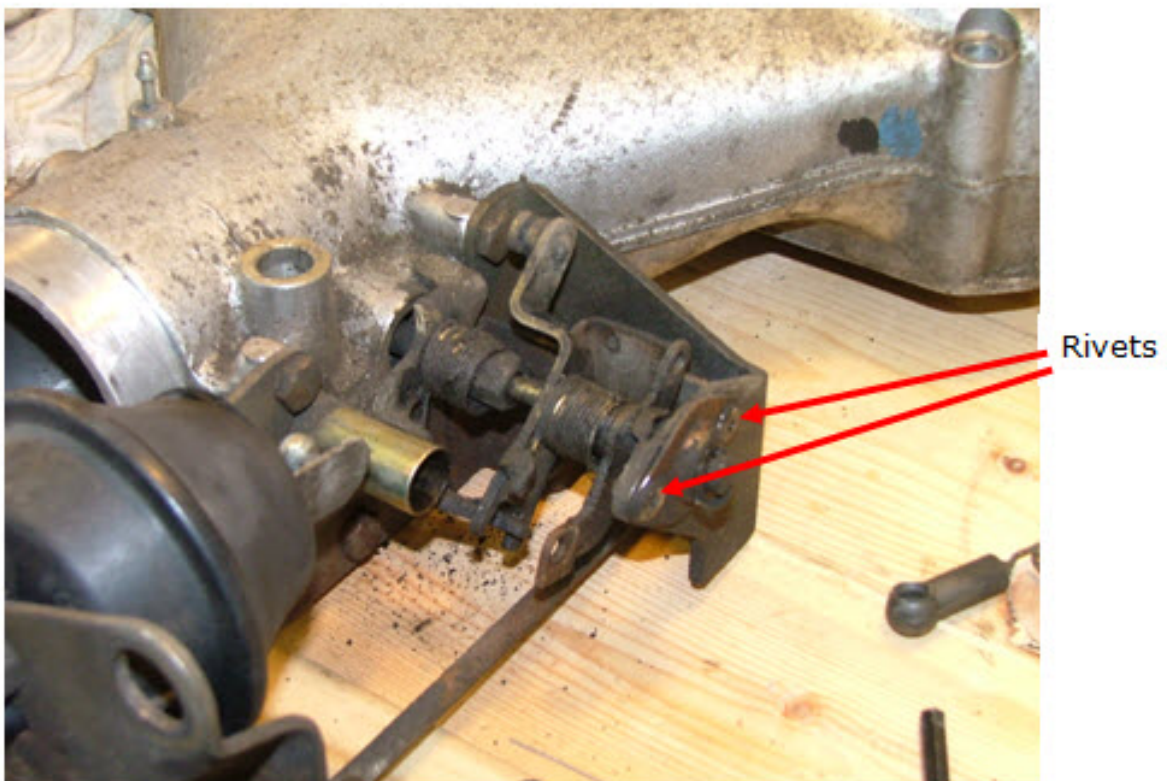


Figure 8 – Close up showing the throttle linkage

The throttle linkage looked in a very bad state during the initial inspection – however after cleaning and refurbishment it quickly became clear that the linkage was in exceptionally good condition with very little wear. Stripping the linkage involved drilling the rivets (shown on the RHS bearing) and

replacing.

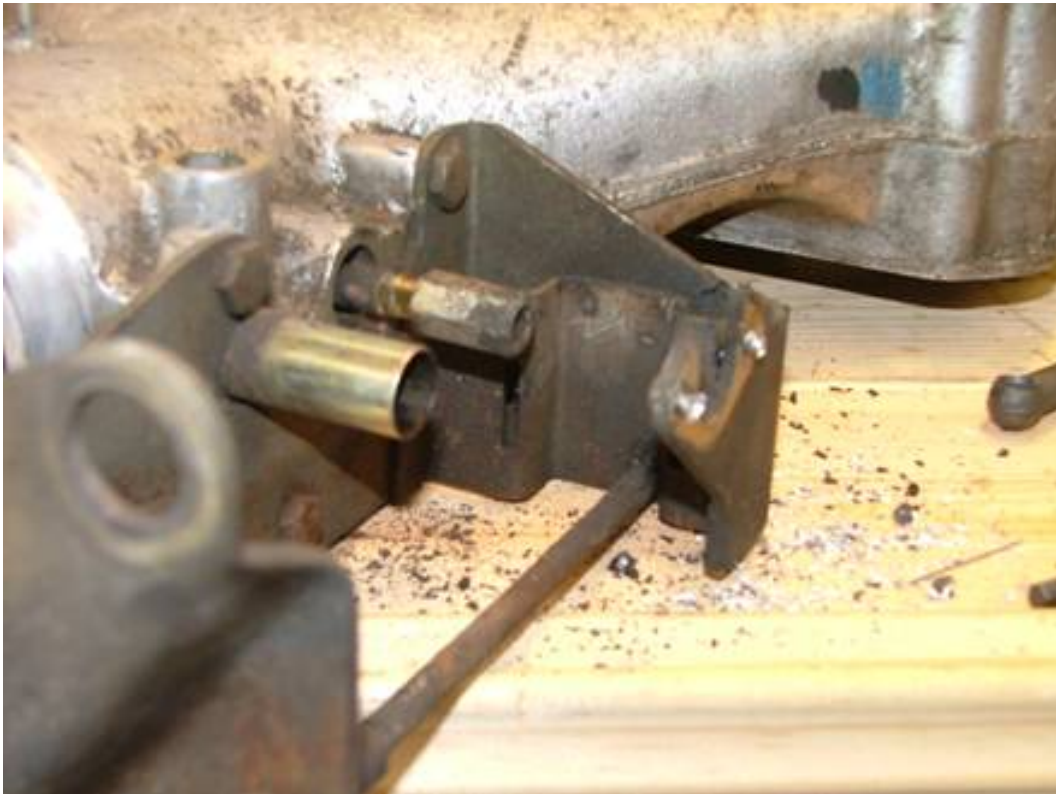


Figure 9 – Drilled throttle assembly rivets

With the degreasing and refurbishment complete, a new coat of paint was required. Matt black was used for everything other than the fuel rail (which was sprayed a bright red colour from Rover).



Figure 10 – Painted plenum - minus all ancillary components



Figure 11 – Sprayed idle bypass air valve housing and plenum pre-heater



Figure 12 – Sprayed plenum complete with rebuilt throttle linkages

Meanwhile – all the work required to clear the old carburetion system on the land rover had commenced to the point of leaving the valley clear



Figure 13 – Rover V8 cleared down to the valley

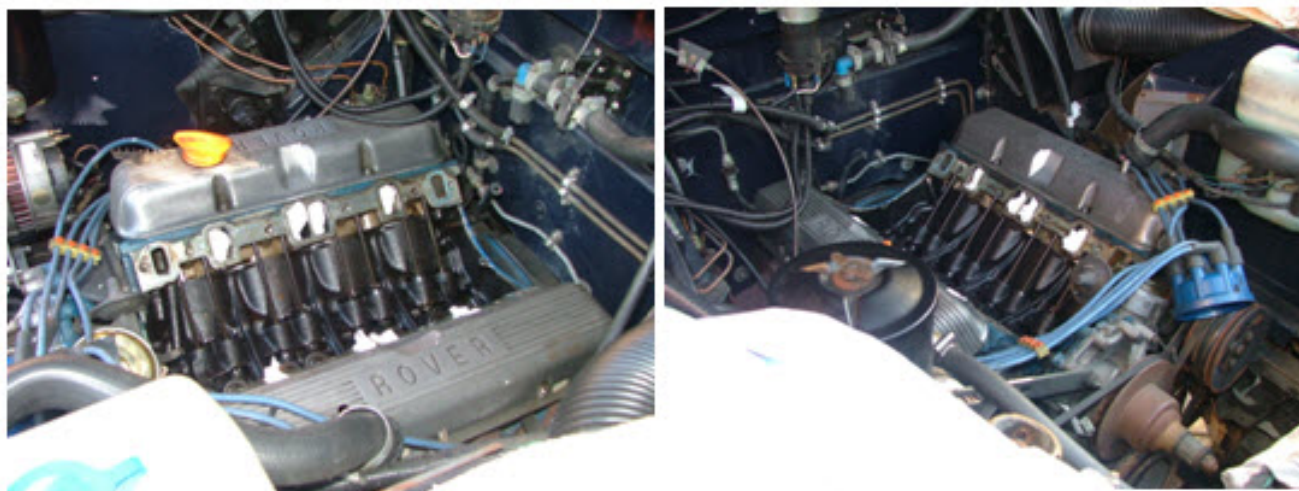


Figure 14 – Left and right views of the V8

A good deal of time was spent carefully cleaning the matting surfaces of the two heads, and also thread chasing all the intake mounting bolts using a stainless steel head bolt cut with a slot (obtained from Real Steel).



Figure 15 – Underside of original carburettor manifold (showing the plumbing)

With the original intake manifold the top and bottom radiator hoses followed a conventional route – although the top hose was interrupted (close to the radiator) by a metal unit holding two temperature switches designed to operate the two electric radiator fans. Closer to the manifold, the water pump had two ports which connected to hoses – one which was about 4" long and which connected to a corresponding metal pipe in the intake manifold front body (shown above as the bottom right hand most pipe). The second connected to a full length metal pipe screwed to the underside of the manifold. At the back of the manifold the screwed pipe and a second metal pipe in the intake manifold rear body acted as the flow and return feeds for the heater matrix.



Figure 16 – Underside of injection manifold

The new injection manifold had no full length pipe screwed to the underside and only one port at the front. There was no port at the rear. An additional complication was the fact that the water pump and manifold had 19mm (3/4" fittings) but the heater matrix had 16mm (5/8" fittings). The photo above illustrates one aspect of the plumbing solution adopted.

The existing steel port on the front of the injection manifold was connected to a 19-19mm U bend in silicon, and routed under the intake using a steel metal pipe. Underneath the manifold (towards the rear) the steel pipe connected to a 19mm to 16mm silicon hose reducer (still under the manifold) and the 16mm outlet was then connected via domestic half inch copper to an upright which connected to a 16-16mm right angle in silicon, connecting to the heater control valve (a sluice valve from an early VW Sirocco mounted on the firewall and shown as "V" in the figure below). On the other side of the sluice valve, a short length of 16mm rubber hose connects to the flow side of the heater matrix.

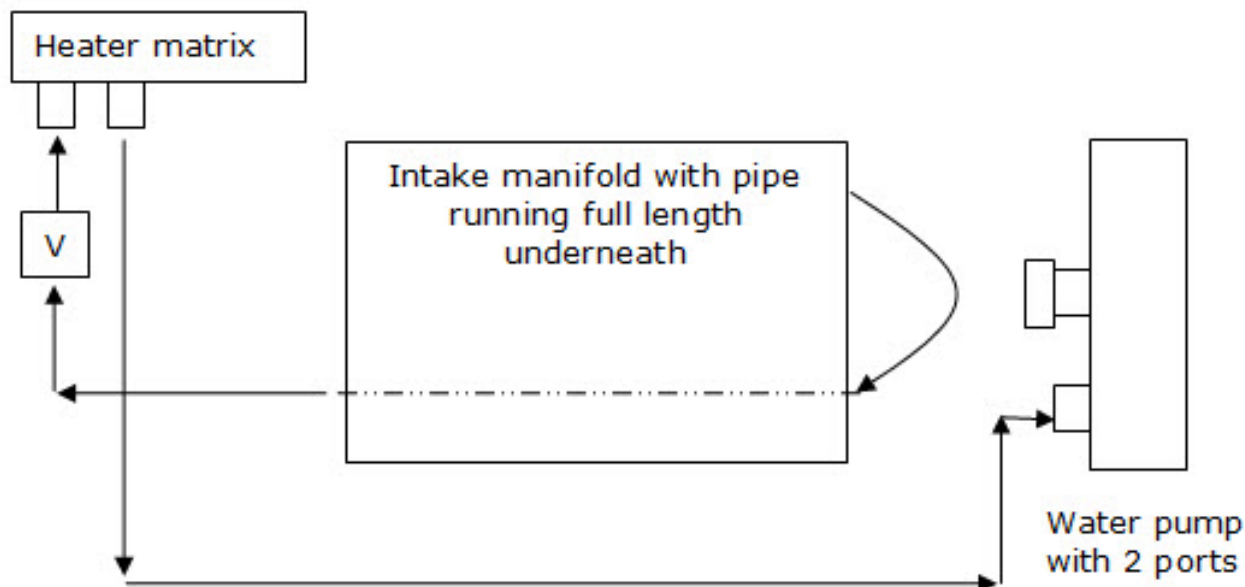


Figure 17 – Cooling plumbing for the heater matrix

The matrix return routed via a long sweeping 16mm hose, clamped just above the throttle linkage and routed from there to a straight 16-19mm reducer in plastic, and from that to the water pump port via a 19-19mm right angle in plastic. The innermost unused water pump port is blocked off.

Each of the water pump ports were odd, in the sense that they had no lips – which meant that when under pressure, even well clamped hoses could theoretically push off. (The author has experienced precisely this occurrence at speed in a vehicle with a small block Chrysler 360CID engine – with the instantaneous loss of all coolant). With that in mind, the pipe work has been fitted in such a way to physically lock each pipe into place on the water pump ports before being clamped with strong jubilee clips.

The metal pipe under the manifold was constructed using new steel pipe, with soldered lips at both ends, cleaned and painted matt black. It is not fixed.

There was one other complication with the cooling system involving the thermostat housing. The injection manifold came its own thermostat housing (which included a temp switch sensor). However, offering up the new intake manifold to the engine revealed a fouling problem between the thermostat housing and the distributor advance/retard vacuum actuator. A good deal of time was spent reviewing this problem – including an attempt to swap the original carburettor manifold thermostat housing onto the injection manifold (which failed because the top hose then fouled other components).

The solution involved fitting the housing as close to the manifold as possible by removing the gasket and using silicon to seal, followed by grinding additional clearance into the body of the housing. As it stands, the clearance permits slightly more than 12 degrees BTDC of advance before fouling. It is also relatively easy to remove the housing, albeit tricky to refit while keeping the thermostat locked in an upright position in its recess.

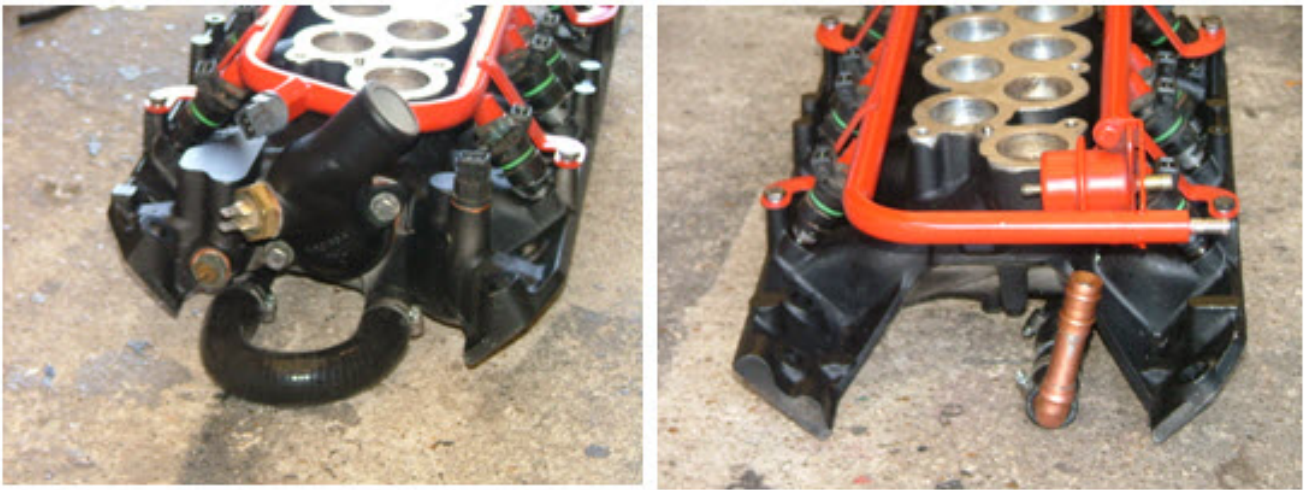


Figure 18 – Intake front and rear view

As part of the refurbishment, all eight injectors were sent to a specialist cleaning company (who also supplied the oxygen lambda sensors). Their injector cleaning service included replacing the pintle heads, all O rings (2 per injector) followed by ultrasonic cleaning and then a testing phase to assess the coil electrically, and to check the flow rating for each injector at 3 bar pressure along with measured leak down loss and spray pattern.

INJECTOR CLEANING									
Date: <u>20/11/10</u>									
Pre Clean									
Injector	Resistance	Leak Test	Spray Pattern Static	Spray Pattern Dynamic	Flow (cc's)				
1	OK	OK	Bad	Fair	Good	Bad	Fair	Good	60
2	OK	OK	Bad	Fair	Good	Bad	Fair	Good	61
3	OK	OK	Bad	Fair	Good	Bad	Fair	Good	61
4	OK	OK	Bad	Fair	Good	Bad	Fair	Good	54
5	OK	OK	Bad	Fair	Good	Bad	Fair	Good	57
6	OK	OK	Bad	Fair	Good	Bad	Fair	Good	61
7	OK	OK	Bad	Fair	Good	Bad	Fair	Good	60
8	OK	OK	Bad	Fair	Good	Bad	Fair	Good	58
9	OK	OK	Bad	Fair	Good	Bad	Fair	Good	
10	OK	OK	Bad	Fair	Good	Bad	Fair	Good	
11	OK	OK	Bad	Fair	Good	Bad	Fair	Good	
12	OK	OK	Bad	Fair	Good	Bad	Fair	Good	
Post Clean									
Injector	Leak Test	Spray Pattern Static	Spray Pattern Dynamic	Flow (cc's)					
1	OK	Bad	Fair	Good	Bad	Fair	Good	61	
2	OK	Bad	Fair	Good	Bad	Fair	Good	61	
3	OK	Bad	Fair	Good	Bad	Fair	Good	61	
4	OK	Bad	Fair	Good	Bad	Fair	Good	61	
5	OK	Bad	Fair	Good	Bad	Fair	Good	61	
6	OK	Bad	Fair	Good	Bad	Fair	Good	61	
7	OK	Bad	Fair	Good	Bad	Fair	Good	61	
8	OK	Bad	Fair	Good	Bad	Fair	Good	61	
9	OK	Bad	Fair	Good	Bad	Fair	Good		
10	OK	Bad	Fair	Good	Bad	Fair	Good		
11	OK	Bad	Fair	Good	Bad	Fair	Good		
12	OK	Bad	Fair	Good	Bad	Fair	Good		
Parts Replaced									
Filter Baskets	✓								
Top Hoses	✓								
Top Seals	✓								
Bottom Seals	✓								
Pintle Caps	✓								
Cleaning Time	150	Minutes							
Pressure	3	Bar							
Flow tested for 30 seconds at 50% duty cycle (3m/sec open – 3m/sec closed)									
Comments									

Figure 19 – Injector testing results

New fuel flow connection – redesigned for hose and jubilee clip



Figure 20 – Finalised injection intake base

The figure above shows the fully built injection manifold complete with refurbished injectors and fuel rail – note the converted fuel pipe connection on the rear of the fuel rail - now converted to use a standard hose connection

The injector and fuel rail refit involved the following steps.

1. Oil the manifold injector bores
2. Lightly oil the O-rings on the bases of the injectors
3. Carefully push fit all eight injectors into the bores without damaging the new O-rings and with the electrical connections in the upright position.
4. Lightly oil the injector upper O-rings
5. Place one side of the rail onto the even set of four injectors
6. Using a clamp with rubber jaws, press fit the rail onto all four injectors observing the mount positions to prevent push fitting the rail too far down.
7. Place the odd injector side of the rail onto the remaining four injectors
8. Using a clamp with rubber jaws, press fit the rail onto all four injectors observing the mount positions to prevent push fitting the rail too far down.
9. Move across the rail to ensure it is evenly pressed onto the 8 injectors.

10. Fit all four fuel rail mounting screws and tighten to 10ft/lbs

Fabrication / Design process

Following the refurbishment of the injection hardware, the engine fitting process began.

Broadly this involved the following steps

1. Fitting the intake manifold with new valley gasket and front and rear valley seals.
2. Deciding on the orientation for both the intake runners and the plenum
3. Fabricating and fitting the throttle linkage
4. Fabricating the air intake filter and mass air flow sensor mount
5. Designing the PCV system
6. The fuel system
7. Designing the vacuum plumbing
8. Fitting the electrical wiring loom for the ECU
9. Removing the two down pipes of the exhaust system – and fitting the mount points for both lambda sensors
10. Designing the road speed transducer system
11. Designing the mount for the ECU and main + fuel relays
12. Fitting the ECU
13. Wiring the loom into the ECU
14. Fitting the 14CUX diagnostic reader.

This was the time consuming part of the project and proceeded as follows

Fitting the injection Intake manifold

Fitting the intake manifold was the one area of ambiguity given it was from a different displacement engine. As it happens, the intake fit was fine – although it is worth saying that all mount bolts were extremely tight to get threaded. A full set of new multipoint head stainless steel bolts were available, but the decision was taken not to employ them as the original bolts were in good condition after careful cleaning. With that in mind, one stainless bolt was sacrificed as a thread cleaner and chaser – which given the state of the existing heads was a step well worth taking.

Use caution on the front two intake bolts. They are notorious for rusting and then sheering on removal.

The intake valley gasket was a fabric type (not pressed steel). Silicon sealant was employed on the four water openings (front and back, left and right), on the front and rear valleys and on all four outer valley corners where the head butts into the intake. Silicon was not used around the inlets.

Selection of orientation of plenum and trumpets

The selection of orientation for the trumpets was easy – given it is a reversible section of the intake. The external vacuum ports on the trumpet housing were the deciding factor given the need for the brake servo on one side, and on the other a PCV feed at idle, and the vac gauge. (*Note that the distributor advance/retard is fed from the port on the upper surface of the plenum, and the fuel regulator is fed by the port under the idle bypass air valve stepper motor*).



Figure 21 – Underside of plenum intake trumpet housing (note vacuum ports)

The plenum orientation again was an easy choice given it is also reversible. Fitted correctly (ie: with the 3.9 emblem visible at the front) the air intake fouled the land rover wing. Flipping the plenum with the air intake onto the drivers side of the vehicle not only resolved the fouling problem but also meant it was possible to reuse the existing carburettor throttle cable.

The one downside with this arrangement was that the route from the air intake to the logical place for fitting the mass air flow sensor required a tight C shape.



Figure 22 – Final position of the plenum

Throttle linkage

The arrangement of placing the plenum chamber with its air intake towards the drivers side meant that it was possible to reuse the existing throttle cable.



Figure 23 – Throttle fabrication

However, the existing throttle assembly steel frame fouled the intake metal air pipe running from the plenum to the mass air flow sensor assembly and so had to be discarded. The throttle assembly was cut back, and welded strengtheners were added to the existing frame. A bracket was then constructed (see below) and welded to the assembly to accommodate the throttle cable (the mounting bolts were then removed and the holes filed with weld).

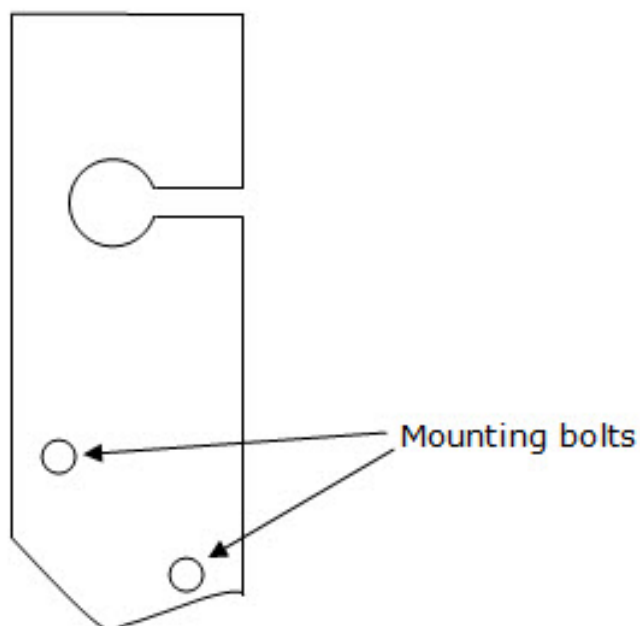


Figure 24 – Throttle cable mount bracket

The arrangement permits ingress of the fine throttle cable through the slot, at which point the whole throttle cable assembly can be moved forward to permit the mount screw thread to enter the main hole shown above. Once in position, the slot does not permit the throttle mount screw to exit.

The throttle linkages on the plenum are sprung at wide open throttle when the back stop is reached. In other words when the throttle blade is wide open, the throttle actuator can be opened slightly wider (by about 5 degrees of rotation). The cable was adjusted so that that springing state is only just engaged – which means that WOT is possible and accommodated accurately by the linkage system.

Mass air flow sensor and air filter

The mass air flow sensor is the electronic unit used to measure the precise amount of air entering the engine. It does this by using two wires in a balanced bridge circuit. One wire is exposed to the air flow entering the engine, and the other is encased and hidden. As air flow passes over the exposed wire, it is cooled, and its resistance alters. The bridge circuit measures the difference between the two wires to determine relative air flow.

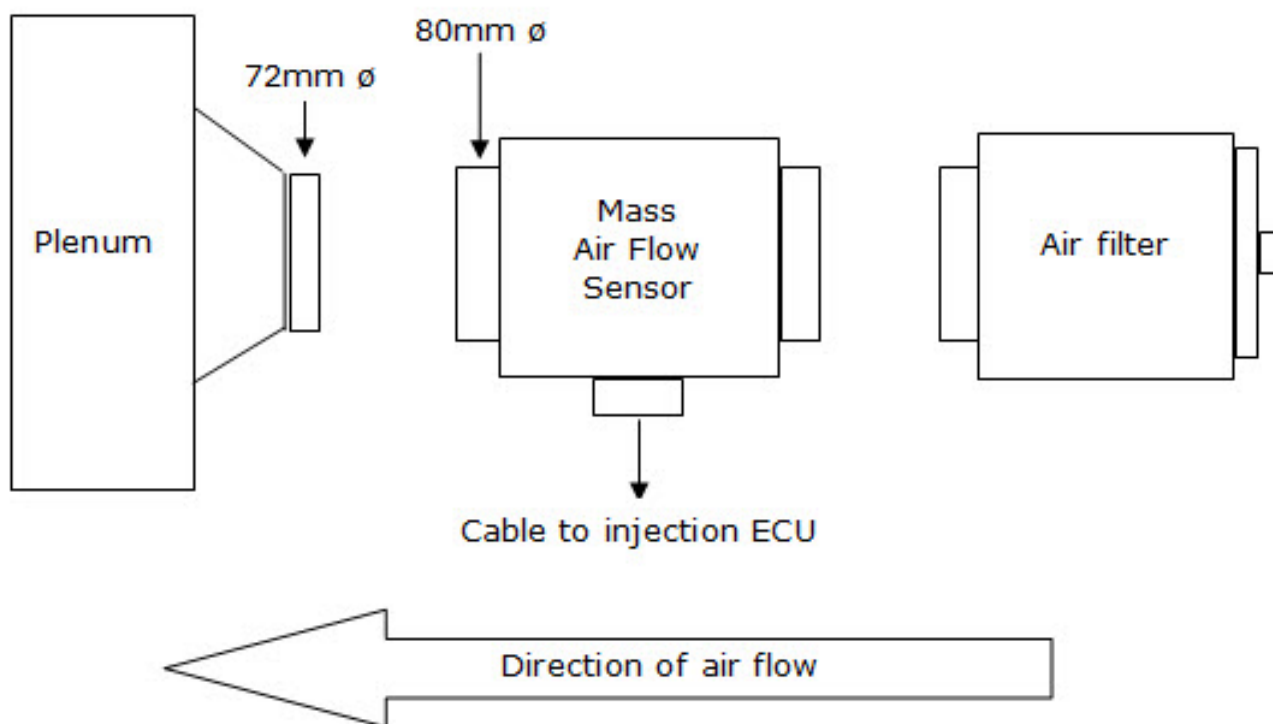


Figure 25 – Mass air flow sensor schematic

Filtered air enters the MAFS unit which is cabled into the injection loom via a four wire connector. A hose connects the outflow side of the MAFS unit directly to the plenum intake.

There is one interesting oddity about the design – which is that the diameter of the MAFS outflow is different to that of the plenum inflow. The MAFS unit is 80mm OD, whereas the plenum is 72mm OD – consequently the standard land rover plenum flexible hose used to make the connection has two different sized ends. 80mm diameter pipe is fairly easy to source, but 72mm is difficult to obtain and so this aspect of the design, coupled with the rather tight almost-but-not-quite C shape and long length has been the most problematic to resolve – all the more so given that it is vital that the hose connection linking the MAFS to the plenum is air tight in order to ensure that all air entering the engine is metered by the MAFS unit.

The solution (which passed through three different unsatisfactory designs) consisted of the following. First, a 20mm deep stainless steel sleeve was manufactured with a 72.1mm inside

diameter, and 80mm outside diameter. The sleeve was designed to be an interference fit on the 72mm collar of the plenum chamber. Silicon sealant was then applied to the inside of the sleeve and it was then driven carefully onto the plenum – and left to set for 24 hours.

Two brushed aluminium pipes with 80mm outside diameters were then purchased, one a right angle, and one a 45 degree. Both had been bent using a mandrill press resulting in a smooth inner radius. These two pipes were then cut, dressed and smoothed, and joined to the plenum, at the centre and to the MAFS in three places using silicon 80mm ID soft pipe and large jubilee clips.

One complication to this solution was that the 90 degree radius pipe when fitted fouled the throttle assembly frame. In order to resolve this, the entire throttle had to be disassembled, cut and welded to permit adequate clearance while ensuring it was strong enough not to flex.



Figure 26 – MAFS air path

With the main air intake pipe routing fitted and with clearance ensured all round the intake pipe (especially near the power steering reservoir canister – allowing for engine torque motion) the mount for the MAFS box and air filter was then created.



Figure 27 – MAFS mounting bracket

There are four bolt holes in the MAFS mounting bracket. Two bolts mount the bracket firmly on to the adjustment swing arm used to hold the alternator. An additional two bolts are used to mount the MAFS air filter case to the bracket. It is important to realise that there are two levels of adjustment deliberately built into this bracket. The mount holes for the MAFS air filter case are

slotted – permitting the entire MAFS assembly to move. In addition, the left hand curved mount bolt hole (see above – closest bolt to alternator) is also slotted, whereas the right hand lower bolt hole is fixed. That means that the entire assembly can rotate around the right hand lower bolt. The combination of the two adjustments allows the MAFS position to meet the intake pipe, while coping with minor adjustment changes to the alternator position.

During the fabrication phase, some time was spent reviewing adequate air filtration for the MAFS unit with an investigation of K&N filters and other third party units. However, the manufacturers filter case has the significant advantage of being equipped with a strong MAFS coupling which any third party filter would not. In addition the land rover air filters are very much cheaper than after market dress up models, and supply more air flow.

The donor vehicle air filter unit was a large metal canister using a solid clip coupling to the MAFS and a lid with nozzle for the raw air intake. There was interestingly no air preheating feature. The outer canister steel was badly rusted on the donor parts even though the base was in good condition. An elegant solution involved grinding off the outer canister welds leaving a base with proper clip couplings to the MAFS and an elongated bolt fixing mechanism for the air filter (a standard range rover filter).



Figure 28 – Mounted air filter (outer canister removed) clipped to MAFS

Positive crank case ventilation (PCV)

The standard PCV system is designed to draw un-burnt hydrocarbons resulting from blow-by past the piston rings, into the combustion process. This process removes hydrocarbons from the engine where they would otherwise reduce lubrication efficiency increasing wear (and emissions from the engine) while also creating a mild depression inside the engine to assist the gasket sealing process.

The original carburettor PCV system employed a filter (actually a plastic fuel filter) free standing and connected via a hose to a metal pipe on the rear of the engine valley. Additional hoses connected half inch ports on both rocker covers separately to a pair of flame traps and from there to vacuum ports on each carburettor. This design applied engine vacuum to both rocker covers – while drawing fresh air into the crankcase via the small plastic filter.

The design may have been adequate for a 1970's vehicle, but it is all but unusable for a fuel injected engine. PCV acts as a secondary source of air entering the system, and so considerable

care is required to meter the precise amount of air it passes, while ensuring that it functions as a self contained system of crankcase ventilation.

The standard PCV system designed by Rover for a fuel injected engine requires the use of different rocker covers (a new set had to be sourced from eBay). The key features of the new rocker covers are a built in PCV breather metered orifice (see (c) below), a screw thread capable of accommodating the oil separator (see (D) below), and a separate screw thread fixed in a raised tower for oil entry. A schematic of the final PCV plumbing is shown below.

Note that the oil entry screw thread on the passenger side rocker cover isn't shown and that the original pipe on the back of the valley is blocked off and sealed.

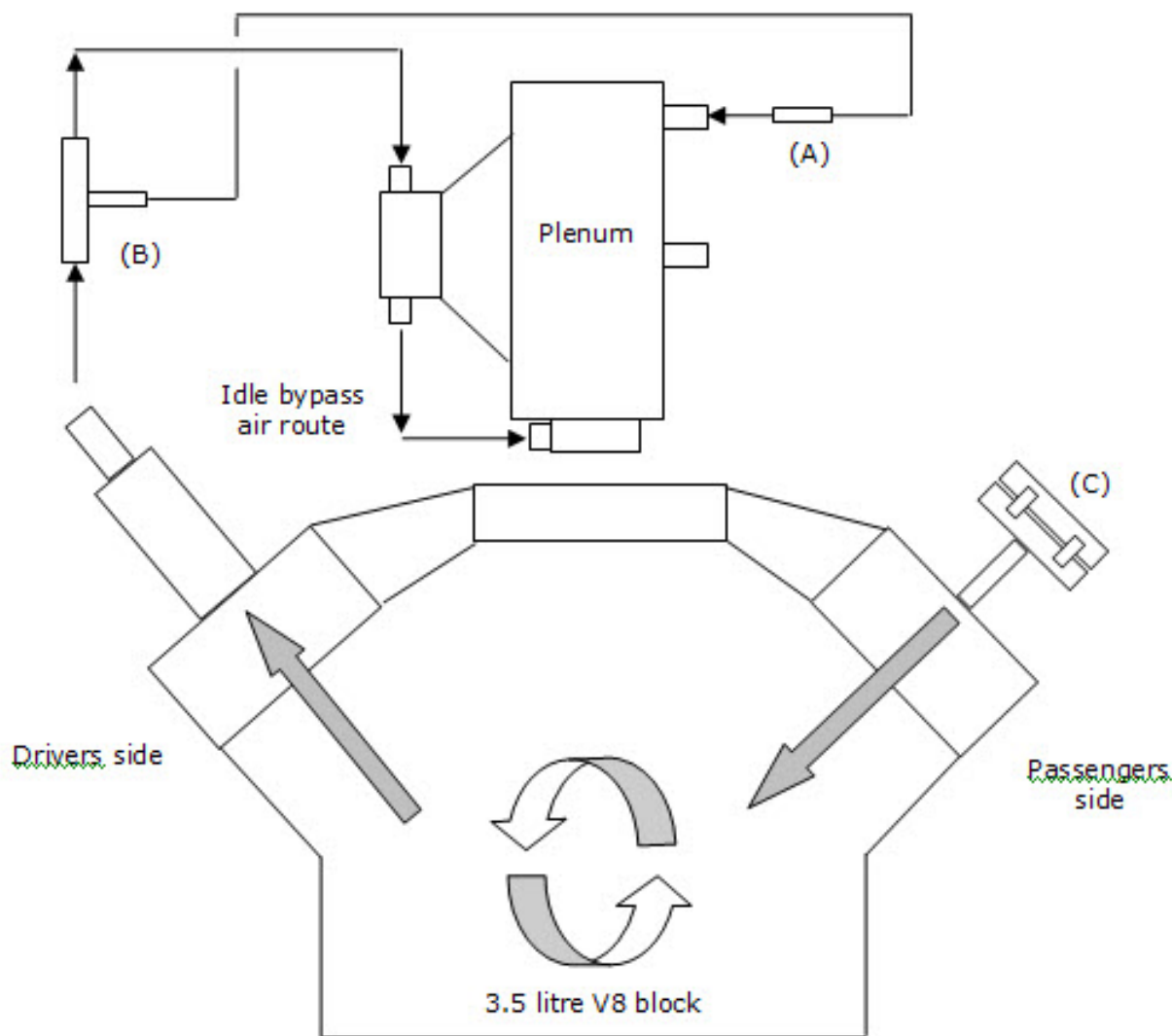


Figure 29 – PCV schematic

The passenger side rocker cover is fitted with a fixed small round metal T piece raised above the cover by perhaps 1cm (see (C) above). The stem of this T is drilled with a small 0.5mm hole passing into the inside of the rocker cover. A plastic shroud encases a gauze filter which clips onto the top of the metal T piece. Metered airflow draws into the engine via this filtered path and from there passes through the head into the main crankcase where it combines with oil and any hydrocarbons. It is then drawn out of the driver side rocker cover via a screw-in oil separator (see (D) above) which as the name suggests allows oil in the air flow to drain back into the engine while also acting as a flame trap in case of backfire. Airflow from the oil separator is drawn into the plenum via a T shaped plastic connector (supplied by Rover) and hose pipes.

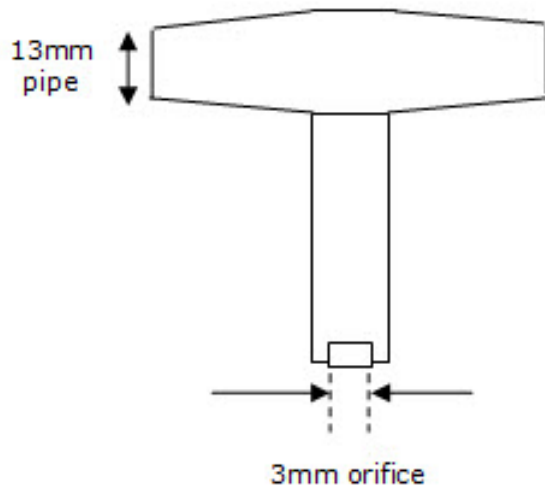


Figure 30 – Rover PCV coupling "T" piece

A large diameter hose (13mm ID) connects the oil separator directly to the large 13mm side of the plastic T piece. A second 13mm hose connects the other 13mm side of the T piece to a port on the plenum on the atmospheric side of the throttle housing. This path will only apply engine vacuum to the oil separator when the throttle is off idle – with the amount of airflow largest at wide open throttle.

The plastic T piece has a third metered orifice (a 3mm hole) which is connected to an engine vacuum port on the plenum, via hose pipe. This path is designed to provide a metered amount of vacuum to the PCV system when the engine is idling, with the throttle shut. It is worth noting that the amount of air flow is substantial, even with this metering orifice – a fact which has a bearing on the engine idle speed as the PCV system behaves as an alternate source of air flow into the engine at idle. The implementation includes an additional copper pipe in the path (see (A) in the PCV schematic figure) which further reduces the air flow via a 2mm drilled solder restriction.

The image below shows the PCV hose run from the oil separator to one side of the plastic T piece.



The close up below shows the routing from the rear of the T piece to the plenum port (via a 15mm copper U bend painted red). The third vacuum pipe leaving the plastic T piece is just visible heading down under the plenum chamber.



Figure 31 – View of the PCV system pipe routing

The fuel system

Fuel injection relies on high pressure fuel being delivered to the injector rail under all conditions. When the injectors open, the high pressure fuel instantly atomises into a fine spray and this effect greatly eases the traditional problem of vaporising fuel prior to combustion.

The 14CUX system requires the following fuel circuit

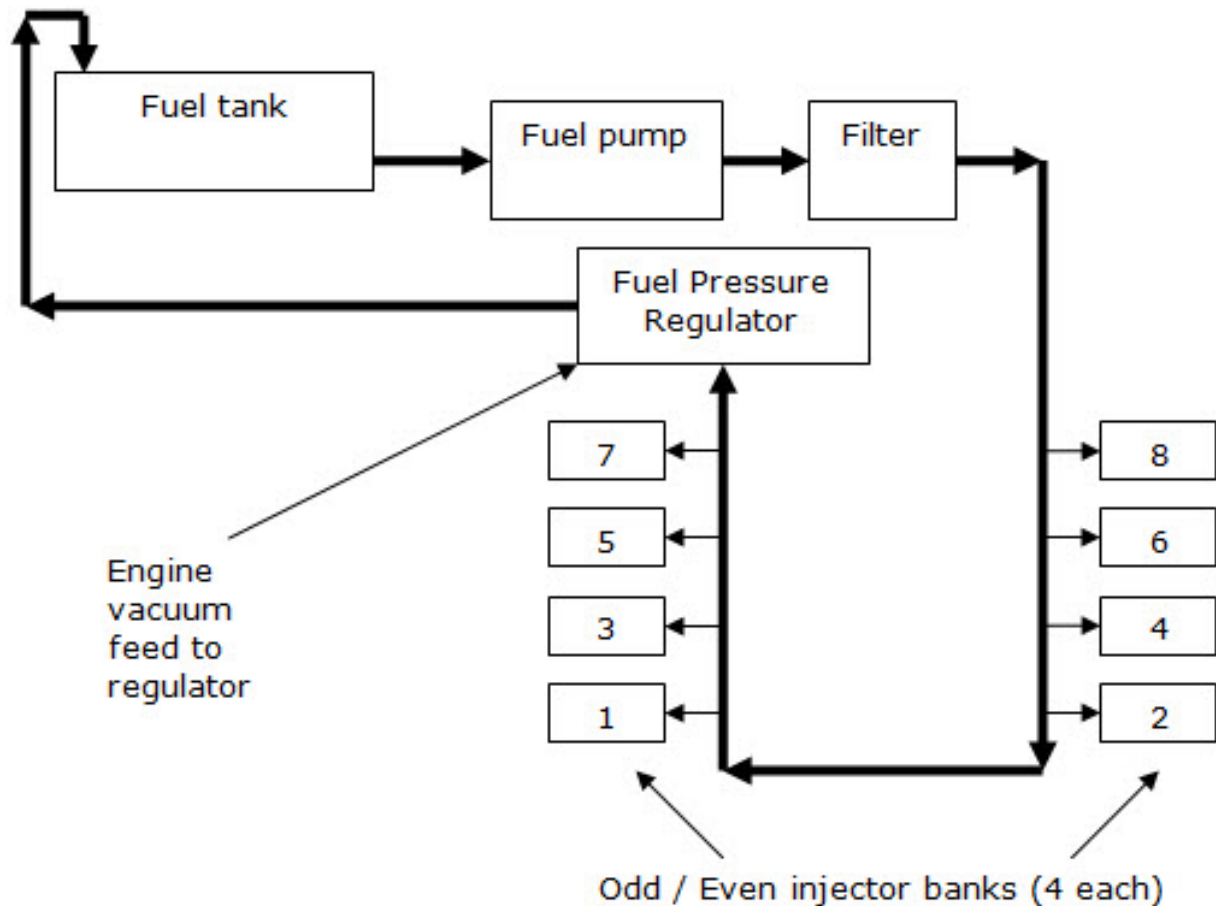
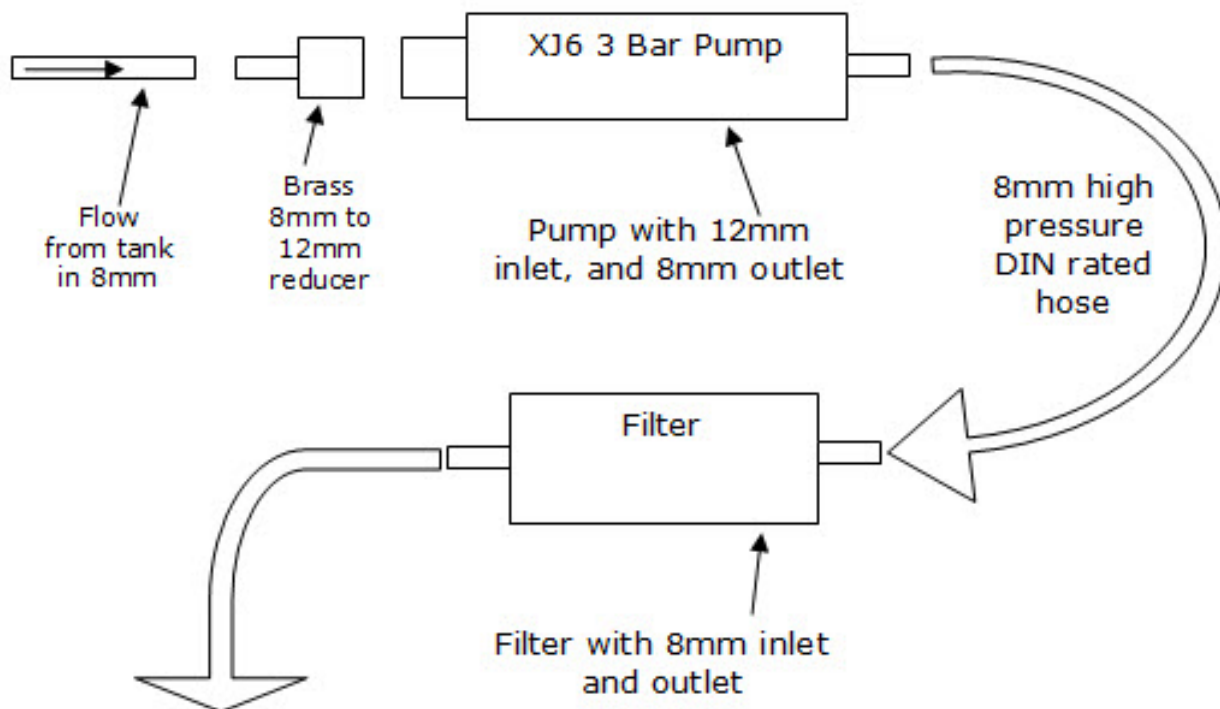


Figure 32 – Fuel system schematic

14CUX production implementations generally employed wet fuel pumps mounted inside the fuel tank along with non-serviceable gauze intake filters. The pump pressurises fuel to about 3 bar and delivers it to an inline replaceable filter and onto the fuel rail – connecting to all 8 injectors. At the distant end of the fuel rail, the pipe connects to the inlet of a fuel pressure regulator designed to regulate the pressure between 24 and 36 psi, relative to engine vacuum (the higher pressure obtained when vacuum is lowest). The outlet of that fuel regulator then feeds to a pipe designed to return excess fuel to the tank at relatively low pressure.

The land rover solution adopted is essentially identical – except that a dry inline Jaguar XJ6 fuel pump rated at 3 bar is mounted on the mid horizontal chassis rail along with a high pressure fuel filter (taken from a Katterham Seven vehicle).

The plumbing around the pump is worthy of note due to the odd mix of pipe sizes.



Flow feed to injection rail and back to the tank - all via 8mm high pressure DIN rated hose (even on the return).

Note that there is an aluminium tap off point located on the driver side rocker cover to permit the fitting of a non-permanent pressure gauge.

Figure 33 – Fuel pump and plumbing schematic

The fuel circuit was plumbed using predominantly 8mm fuel hose (rated to DIN standards for fuel injection). A small amount of 12mm hose was used to couple the inlet of the fuel pump.

Where the fuel line runs up the firewall to the rear of the engine, it connects to an aluminium block threaded with three holes – two designed to accept 8mm hose ends, and a third tapped to suit a 1/8th NPT non-permanent fuel gauge. After testing this gel filled gauge was removed and replaced with a threaded block plug.



Figure 34 – Fuel pressure tap off point

The fuel tank

During the early part of August 2010, the relatively new fuel pump failed as a result of an electrical fault (not linked to any plumbing problem). The pump was replaced (and a second spare pump purchased at the same time).

Later that month, a series of odd running problems hit at more or less the same time – but which were clearly linked to the recent rework of the induction intake routing. There had been a noticeable smell of fuel in the cab – which couldn't be traced and which lasted about a week. At the tail end of that week a series of intermittent misfiring problems occurred on part throttle cruising during a long drive into town – a condition which would appear and just as quickly vanish. During low speed parking manoeuvres the engine exhibited surging and stumbling with revs dipping below 500rpm. The 14CUX reported error code 48.

Based on the smell of fuel, and the surging (and code 48) it seemed reasonable to assess the fuel system for problems.

The one area of the system which hadn't been closely assessed was the fuel connections to the tank itself – so the panel under the driver seat was removed to gain access. It was immediately obvious that at least some degree of fuel was leaking from the tank seals – probably when the tank was filled to absolute capacity.

There are five pipe connections to the tank. A large fuel filler pipe coupled with a smaller breather/vent hose connect to the tank just behind the driver chair back. Closer to the front of the vehicle there are three brass units screwed to the tank and sealed with rubber gaskets. The first is the fuel level sender unit. The second is the return fuel line brass housing, and the third is the flow fuel line brass housing.

All three units were removed and cleaned – as was the surface of the tank. The return brass fuel pipe housing, and the electrical sender were immediately refitted using silicon gasket sealant on both sides of the rubber gasket surface to ensure correct sealing.

The brass flow fuel line housing unit was altogether more interesting. Two things were obvious after it was removed. The first was that it was coupled to a hard style plastic fuel hose pipe via a screw thread affair – which resulted in the 8mm pipe being reduced (easily) to less than 5mm diameter – a reduction constituting a very unwelcome restriction in what is the low pressure (suck) side of the fuel system. In addition, at the other end of the pipe (which would be inserted down into the fuel) there was a soldered sintered mesh filter screen fitted over the pick up end of the pipe with a rather unfortunate 5mm square hole in it. An attempt had been made to repair that hole by filling it with silicon – which had come loose and was flapping around in such a way to intermittently block the pick up.

Two steps were taken to alleviate these problems. Firstly, the upper fuel housing screw thread was discarded and drilled out to accommodate an 8mm interference fit copper pipe. A short length of pipe was then soldered into that hole. Secondly the sintered mesh was removed from the pick up end of the pipe and the broken end was cut off. A second area of the mesh filter was then cut off, flattened and hand soldered to close the pick up end of the filter. The pick up pipe was dressed to remove its sharp edges, and then the completed filter was refitted and soldered into place. It has to be said that the end result was not at all pretty, but it would form a capable filter which was vastly better than it had been before. The pick up was refitted and sealed, again using silicon. Time will tell if there is any leakage when the tank is filled to capacity.

An addition check was made of all the fuel line couplings at the back of the engine to try and find the elusive petrol smell. With the engine cold, the injection system was primed four times, at the end of which fuel could be found leaking from the flow side of the pipe work. All the jubilee clips for both the flow and return hoses were tightened and the leak was resolved. The fact that the engine was cold made that problem vastly easier to locate.

Vacuum plumbing design

Connections to the engine intake are used by a number of key engine components. There are five vacuum ports on the engine...

1. Primary vacuum feed for the brake servo
2. Advance / retard vacuum feed for the distributor
3. Vacuum feed for the fuel pressure regulator
4. Vacuum feed for the PCV (crankcase ventilation system) from two sources.
5. Vacuum feed for a dash board gauge.

The brake servo connects directly to a driver side port screwed into the plenum intake runner manifold using silicon hose. It is exposed to engine manifold pressure with no restrictions.

The passenger side of the plenum intake runner manifold has three ports screwed into the side, two of which have piped ports (one of which is fabricated in copper). All these ports are exposed to engine manifold vacuum without restriction.

The port nearest the firewall connects to a 10mm copper U bend to a hose. The hose connects to a small 10mm copper pipe blocked and drilled with a 2mm metering orifice the other side of which connects to the white plastic PCV "T" piece. This is designed to provide metered engine vacuum to the PCV system when the throttle is closed.

The second intake runner port (located in the middle of the manifold) connects to the dash vacuum gauge via a reducer.

The vacuum feed to the fuel pressure regulator is taken from the plenum upper chamber port located directly under the bypass air stepper motor valve and which is exposed to engine manifold vacuum without restriction. This feed uses red silicon hose.

The advance / retard feed for the distributor is taken from a metered port directly on the top of the plenum throttle body. This feed also uses red silicon hose.

Engine cooling

The plumbing used for engine cooling has been covered in the intake manifold section of these notes. There are three related issues worthy of note.

The first is that a standard 88 degree thermostat must not be used on this vehicle as it will cause overheating. Instead a 74 degree thermostat, with no joggle hole, must be fitted.

The second is that the original carburetted engine had the engine fan removed and replaced by twin electric fans switched by sensors in the top coolant hose. However, in warm conditions the arrangement is prone to overheating especially following a stop after long soak conditions. In an effort to reduce the problem a fabricated bracket has been added to the water pump shaft and a solid coupling MGB 14" plastic fan has been fitted. It will provide limited air flow over the radiator when the vehicle comes to a stop – and if it works well, a viscous coupling may be employed. In fact, that fan has now been removed – as it was wholly ineffective at resolving the marginal cooling problems.

The third is that the cooling system includes a warm water feed to a chamber directly under the injection plenum. This assists engine operation by increasing the temperature of the plenum during cold conditions – which increases the ability to vaporise fuel. The water supply is taken from the engine intake manifold (front, passenger side close to injector 1) and the return feed is connected via a hose directly to a port on the radiator.

Idle control system

The notorious weakness of the 14CUX system is its idle control. The system is intended to operate as follows:

1. Assume the engine is running and then switched off, at the instant of switch off - the 14CUX withdraws the idle air valve stepper motor fully, which opens the port on the plenum chamber leading to a port on the atmospheric side of the throttle (B) via a half inch hose. In effect, the full amount of air flow can then pass by this route the next time the engine is started and as the air flow is metered (remember it is being drawn from the atmospheric side of the throttle and is therefore being metered by the mass air flow sensor) the 14CUX will provide an appropriate air/fuel mixture. The temperature sensors are involved in the precise metering of fuel – as when starting a cold engine the injectors are actively opened for a longer duration in order to provide a rich enough mixture. Once the engine catches, the injection system runs through a purge fast idle cycle which holds the engine at about 1800RPM for a few seconds in order to smooth out the engines running (by gaining maximum air flow through the intake, and thereby purging any excess fuel which may have wetted the intake runners).
2. With the cold engine now running, the coolant temperature sensor showing a slow rise in temperature the 14CUX will test the rev speed of the engine and if too high will close the stepper motor by a predetermined amount. It will then pause for a short while and retests the engine speed to repeat the process. The objective is to slowly reduce the engine idle speed to about 720RPM in line with cold operation – a process known as hunt idling.

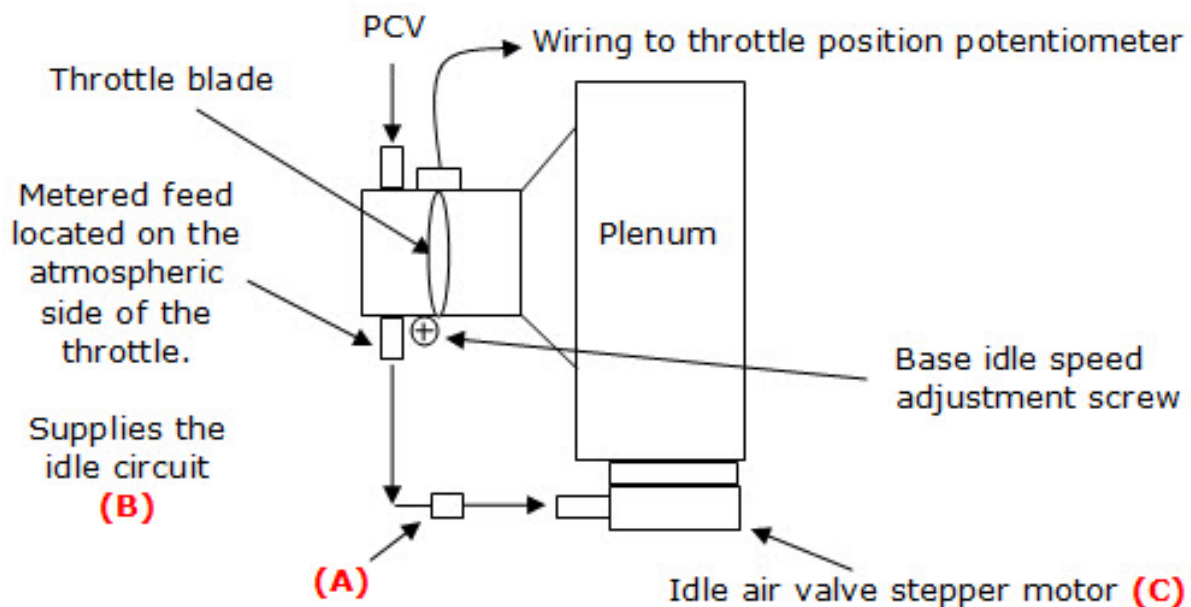


Figure 35 – Idle control system

There were multiple problems with the idle speed system on this vehicle – resulting in no hunt to idle, or a too fast idle speed when warm. An additional complication was that the normal method of connecting the plenum port to the idle air valve stepper motor housing (ie: (B) to (C)) involved using a soft L shaped rubber hose. However, after adding the new rocker covers (with PCV oil separator at the front of the driver side rocker) and with the plenum orientated as shown, the idle

air rubber hose fouled the PCV oil separator.

The first problem was that the unadjusted base idle speed for the injection system was much too high. The base idle is the speed the engine will run at when the throttle is closed and the fuel injection idle circuit is disabled. It is specified by Land Rover as 520RPM (+/-25RPM).

It is absolutely vital that the base idle speed is checked on a new installation.

In order to set the base idle, the engine is first run up to full working temperature. The engine is then stopped and the hose connecting (B) to (C) is removed. The two exposed ends (at end (B) and end (C)) are then blocked and made air tight. The engine is then restarted – but this time with the throttle initially opened by hand. The throttle is then slowly allowed to close in order to allow the engine speed to slowly reduce to its base speed. With the throttle closed, the resulting idle speed is adjusted to 520RPM by turning the base idle speed adjustment screw (via an Allen key) in the plenum. This allen key can be protected by a tamper proof plug – which must be removed if fitted. Once the base idle speed is set, hose (A) can be refitted.

As the plenum was delivered, base idle was in the order of 1100RPM – which is reasonable given it was being used on a larger displacement engine.

The second problem was that both the throttle potentiometer and idle stepper motor were faulty. The throttle potentiometer fault meant that the system always thought it was off idle (it was stuck set to about 80% open throttle) – which rather nicely demonstrates the value of an air flow metering system given that even with this fault, the system was safe and driveable. The idle valve fault was caused by a stuck stepper shaft – which is an extremely common fault with this design (given that the stepper motor shaft is exposed to engine blowby gasses and oil).

The third problem (as stated above) was that the standard Land Rover hose linking (B) to (C) fouled the new position of the PCV oil separator. The hose was therefore discarded, and replaced with two short rubber hose joiners, and a neatly bent 10mm copper pipe with soldered 10mm to 15mm reducers on both ends (all painted red). These reducers were a snug fit in the rubber hose pipe.



Figure 36 – Idle air supply pipe (red) – no longer used

While this solution did resolve the problem of the original hose fouling the PCV oil separator, it came with the disadvantage that the amount of air entering the idle circuit was proportionally reduced due to the smaller diameter of the copper pipe. Testing revealed a low idle speed – typically 200RPM lower than expected by the 14CUX, and so the ECU routinely reported fault code 17.

The idle air flow pipe was therefore reconstructed using half inch copper painted red (but with no restrictions) as shown below. The rubber hose ends coupling to the plenum and the idle air valve body were, again, ends cut from the standard hose.



Figure 37 – Idle air supply pipe (red) – finalised

The figure above shows the two rubber joining hoses coupling a red 15mm copper pipe formed to avoid fouling the PCV separator.

There are two more general observations that follow

1. The first is that the engine management switch to hunt mode is directly linked to the output from the transmission road speed transducer. The 14CUX repeatedly waits until the vehicle comes to a stop (with a slight pause) before implementing the relatively slow hunt to idle. This means that the switch to the lower idle speed is relatively slow – and arguably slower than it should be.
2. The second is that the ability of the injection system to properly control idle speed is directly linked to the cleanliness of the idle air bypass stepper motor shaft. It is possible to clean this part (as shown in Ginetta notes at http://www.g33.co.uk/fuel_injection.htm) and it is suggested that this step be taken on a fairly regular basis.

Exhaust and Lambda sensors

The 14CUX engine management system used in 1992 range rover vehicles has a tune resistor option fitted to the wiring loom permitting the selection of different modes of operation based on the emission legislative requirements of the geographical location of the vehicle when sold. The

loom simply contains a half watt resistor in a plastic case. The value of the resistor defines the mode of operation – with the following options ...

- 180 ohms – Australia rest of world
- 470 ohms – UK and Europe non catalyst
- 910 ohms – Saudi non catalyst
- 3900 ohms – USA and Europe catalyst

Non catalytic operation is much simpler in the sense that no extra exhaust sensors are required – but this mode of operation has the significant disadvantage that the system is unable to self compensate for any changes in air flow. In effect, the 14CUX will operate using a static fueling map, and any engine changes that tend to fall outside of the assumptions built into that map will result in substandard performance.

By contrast, catalytic operation requires the use of two oxygen sensors (lambda probes) one fitted into each exhaust down pipe, but this mode of operation does provide the 14CUX with a mechanism to monitor the combustion effectiveness of the engine by assessing its exhaust oxygen content levels. In effect, catalytic mode of operation allows the 14CUX to operate as a closed loop feedback system.

The vehicle employs catalytic operation requiring lambda probes in the exhaust system and therefore uses a 3.9K tune resistor.

The lambda probes were purchased online – complete with plugs for the range rover donor vehicle (it is possible to purchase cheaper variants of the probes without connectors – and this needs to be checked at the time of ordering). Price was roughly £70 each. The threads of the standard lambda probes are M12 with a 1.25mm pitch thread. The two down pipes were marked up for suitable lambda sensor positions and then fully removed from the engine, separating them from the back pipe at the split point under the gearbox. It was fortunate indeed that the exhaust system was relatively new and constructed from stainless steel. Penetrating oil and some sharp blows from a hammer at the joint was all that was required to separate the unions. Once on the bench the construction work for each down pipe began as follows

1. The down pipe was cleaned and punch marked at the hole location
2. A 13mm hole was drilled into the exhaust pipe at the punched location. The hole was dressed and cleaned and then roughened in preparation for welding.
3. An M12-1.25mm thread stainless steel nut was ground down to lose roughly a quarter of its height. The grind was curved to match the curve of the stainless steel exhaust pipe.
4. A MIG welder was fitted with 0.8mm stainless steel welding wire, and set to a high carbon argon gas feed in preparation for 1mm welding.
5. The nut was G clamped to the stainless steel exhaust pipe, and then tack welded into position.
6. Final checks were made that the position was correct and that the lambda sensor could thread and appear in the exhaust stream correctly.
7. The nut was then seam welded round the lower edge directly sitting on the pipe. The weld was allowed to cool and then the area above the weld (leading up to the high point of the nut) was welded.
8. The excess weld was ground down, smoothed and dressed to provide a gas tight seal.
9. Copper grease was used in the nut thread and the lambda sensors were checked for clearance.

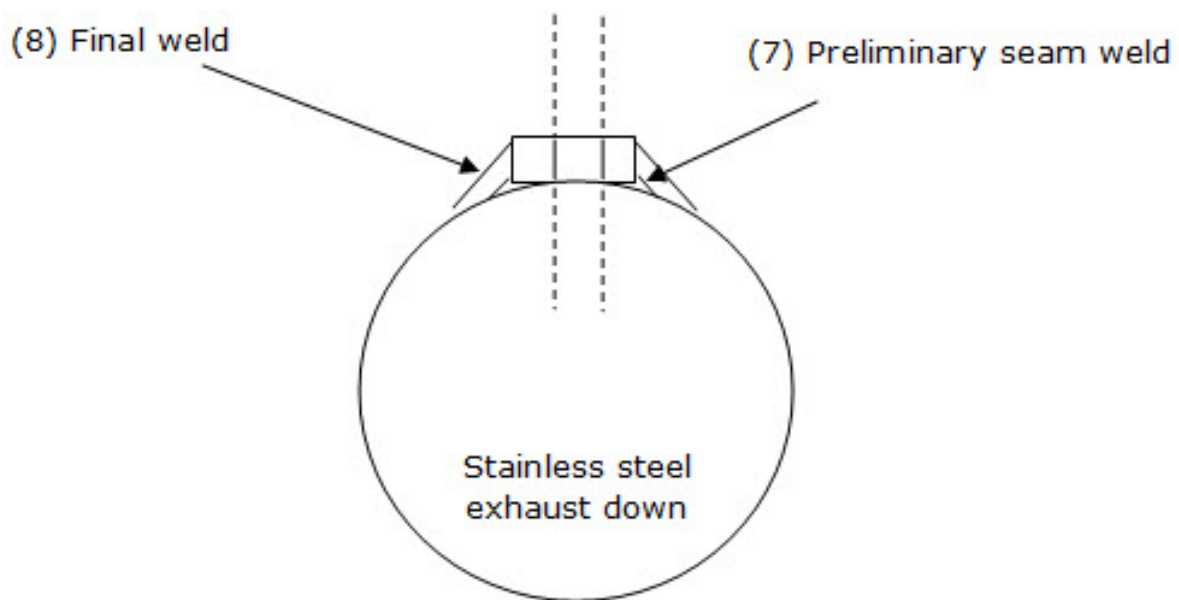


Figure 38 – Welding lambda sensor threads into the exhaust downpipes

Bench testing the electrical wiring loom for the ECU

The wiring loom taken from the donor vehicle was in generally good condition. Nonetheless, a number of wires close to the 14CUX harness plug had been cut, and some signal lines were broken perhaps due to the flexing incurred in removing the loom as one complete piece. Both main and fuel relays had been included in the loom along with the primary connector used to link the injection system to the vehicle (normally located behind the dash).

Before any of the loom was fitted to the vehicle it was assessed on the bench primarily to electrically test the loom for continuity and to repair any damage. Two other reasons made this step essential. Firstly it was necessary to understand precisely how each connector was wired (so that faults could be diagnosed when fitted in the vehicle). Secondly it was necessary to re-route some of the loomed cabling due to the reversal of plenum orientation (certain plugs had to be moved from the passenger side engine bank to the drivers side and from the rear of the engine to the front).

During bench checking a full set of hand drawings were used to record the wiring connections and layout. These are copied in the following set of figures.

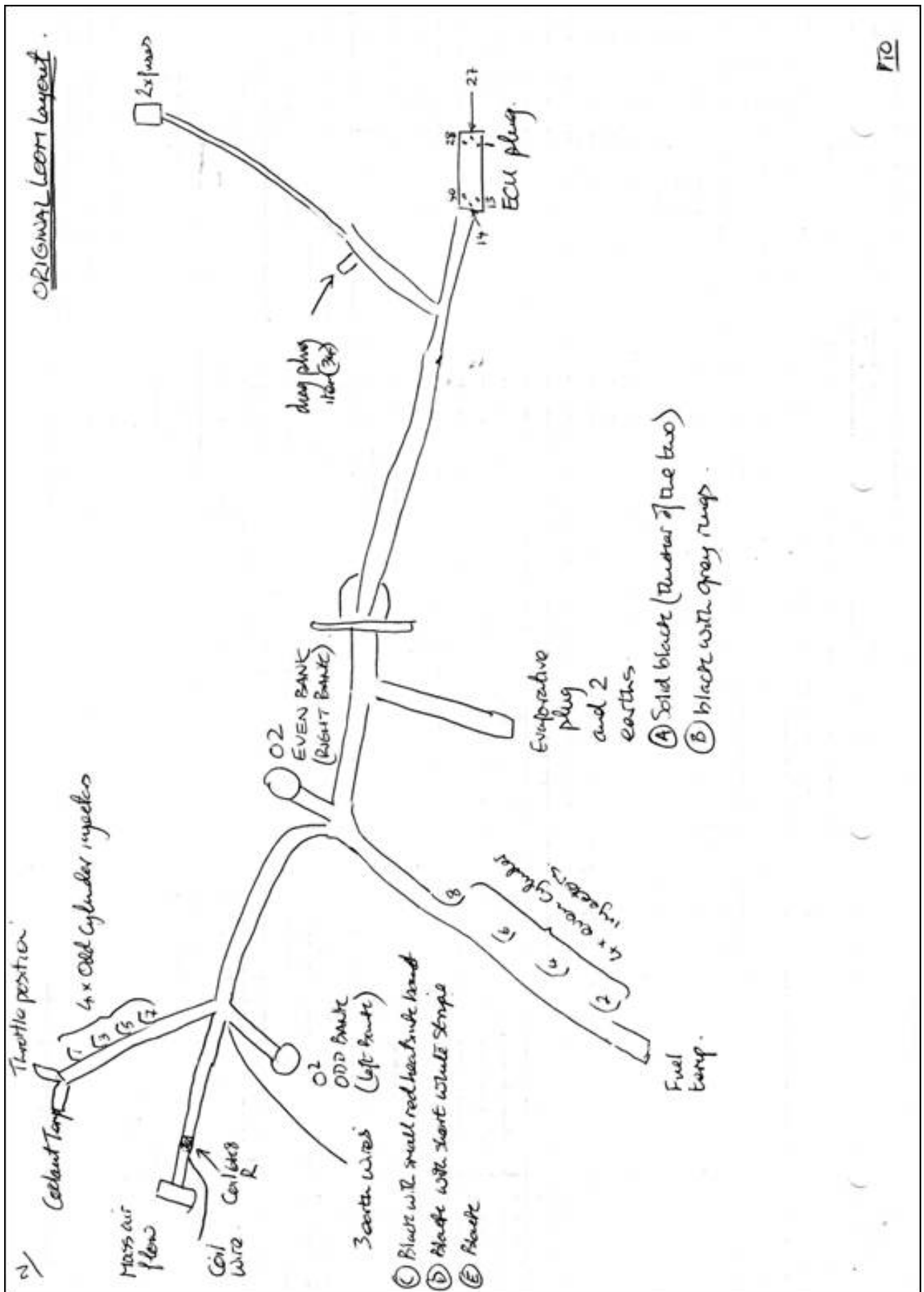


Figure 39 – Original loom connector layout in donor vehicle

The original layout reflected the needs of the donor vehicle. Due to the changes in orientation of the plenum, these changed when fitted to the target vehicle.

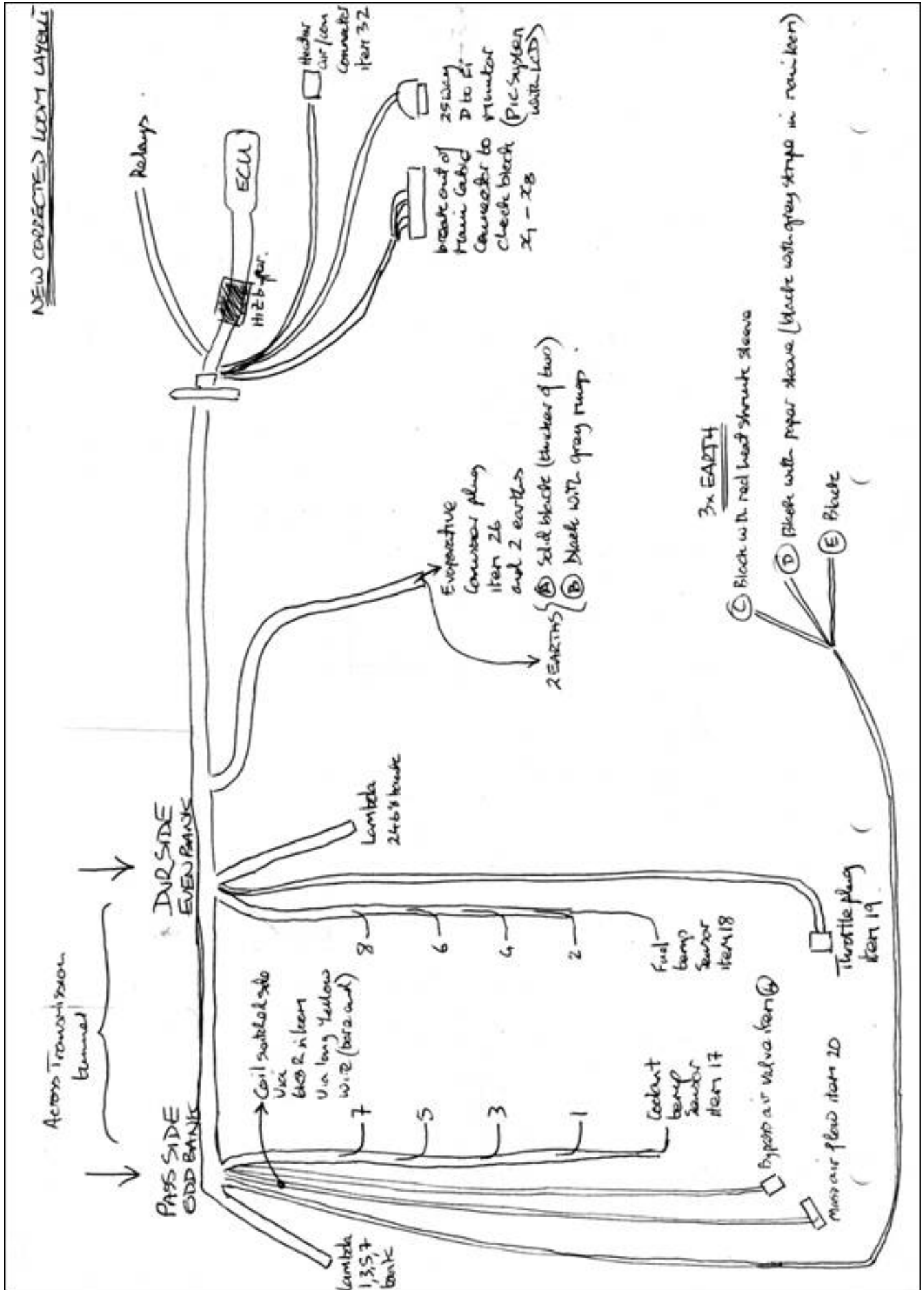


Figure 40 – New loom layout suited to the target engine bay

The new layout was ideally suited to the target vehicle. Exposed loom sections were rewrapped using self amalgamated tape.

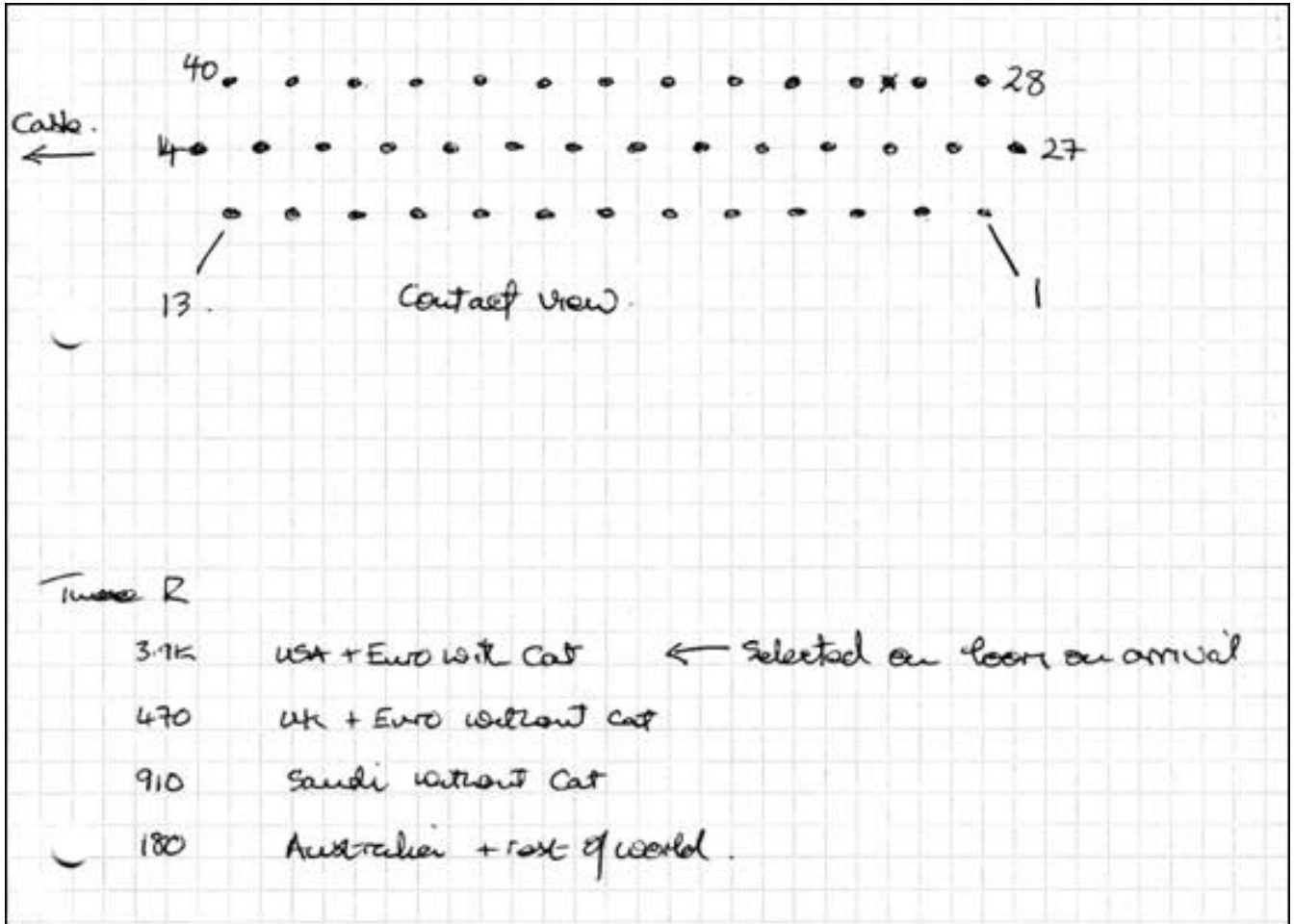


Figure 41 – ECU Connector layout and numbering (and tune R)

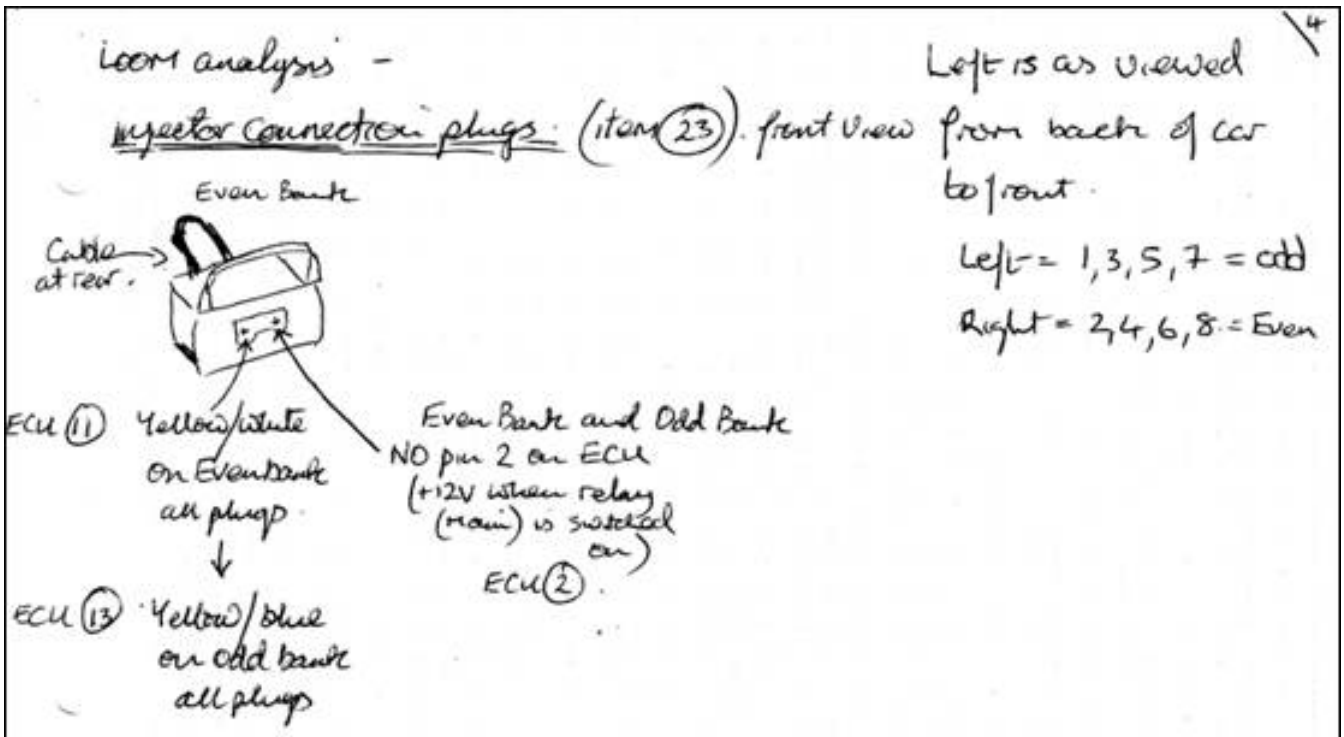


Figure 42 – Injector electrical connectors

Injector wiring is banked as two banks of four (one bank on the passenger side of the engine, and one on the driver side).

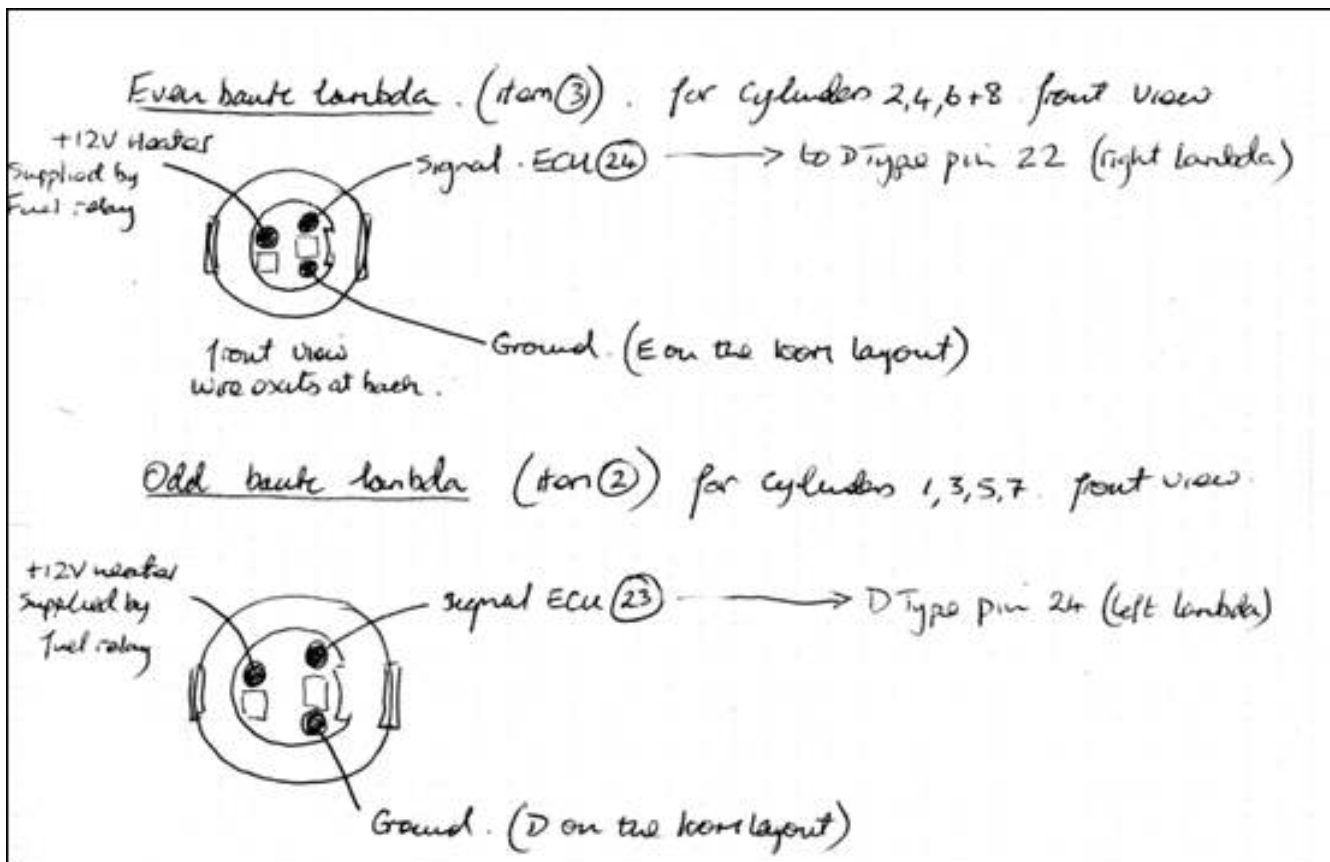


Figure 43 – Exhaust Lambda electrical connectors

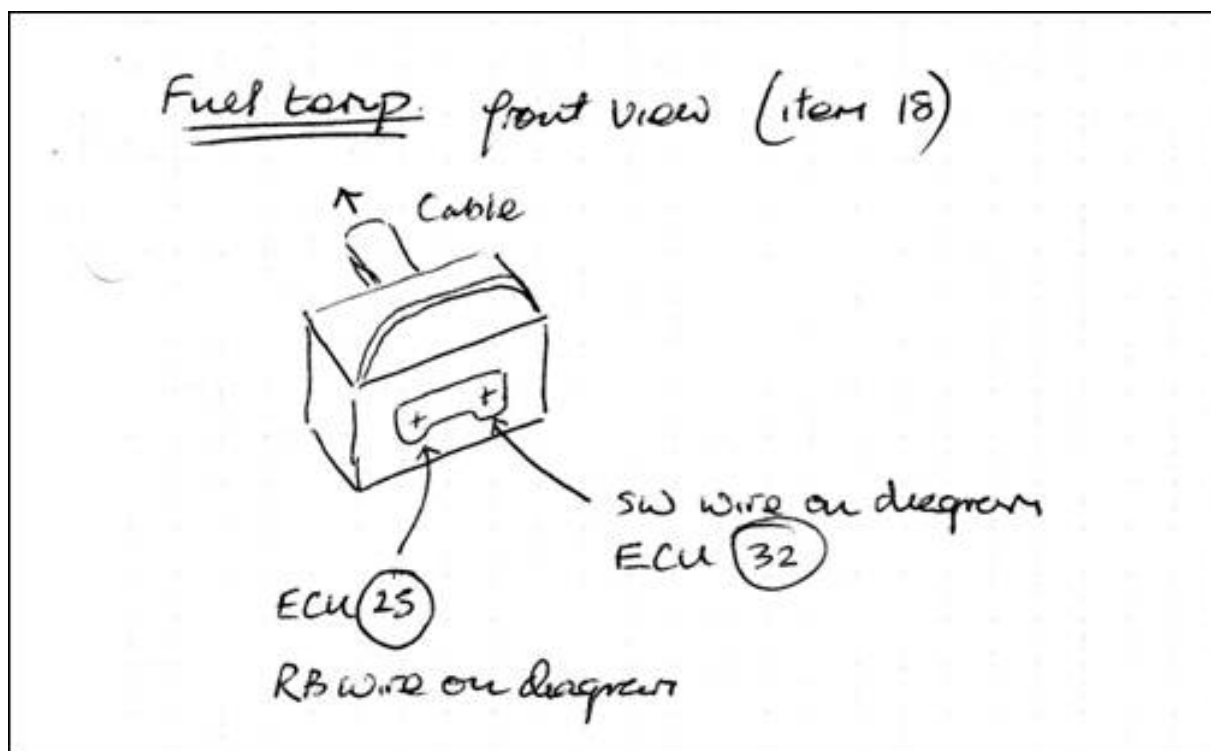


Figure 44 – Fuel temperature sender electrical connector

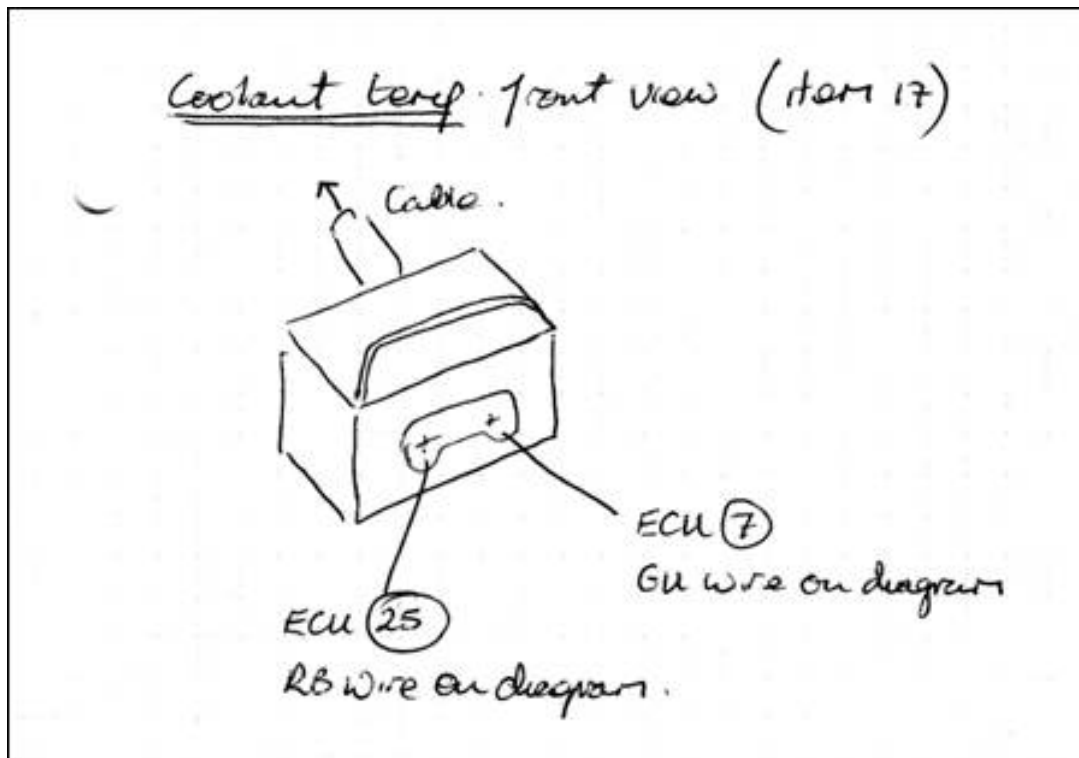


Figure 45 – Coolant temperature sender electrical connector

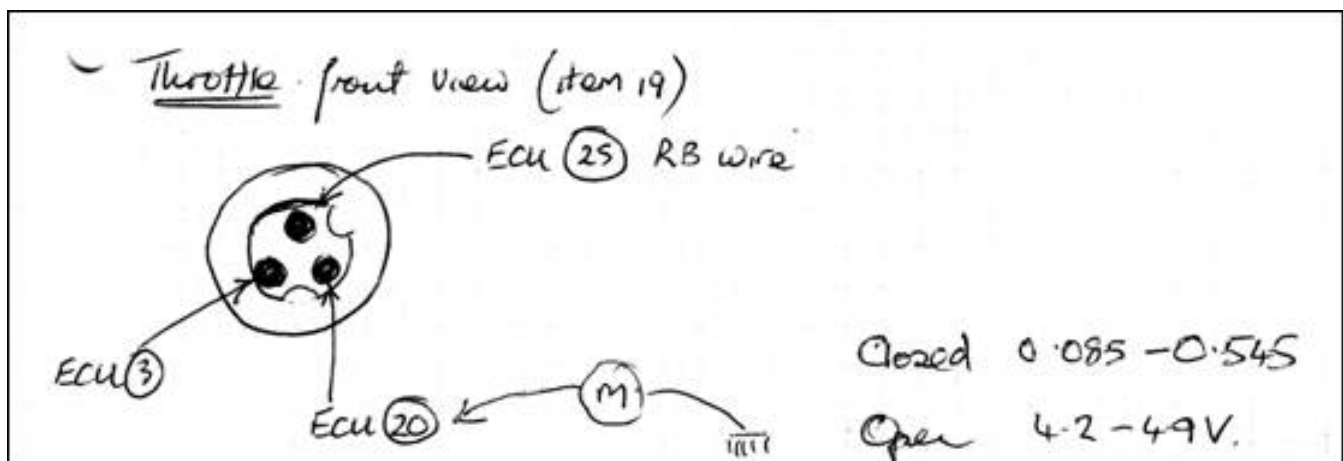


Figure 46 – Throttle position sensor (potentiometer) electrical connector

Note it was found to be difficult to electrically connect to the ECU(20) wire on the back of the throttle plug – therefore a short external wire has been added to the loom extending the red ECU (20) wire to an exposed (but insulated) spade connector just behind the throttle plug. Testing the throttle voltage is then a matter of measuring the voltage between the spade terminal and ground. The test results (after replacing the throttle potentiometer) were 0.45v with the throttle closed, and 4.8v when open – ie: within spec. Note that a code 17 fault will be reported if this test is carried out – requiring an ECU power down to clear.

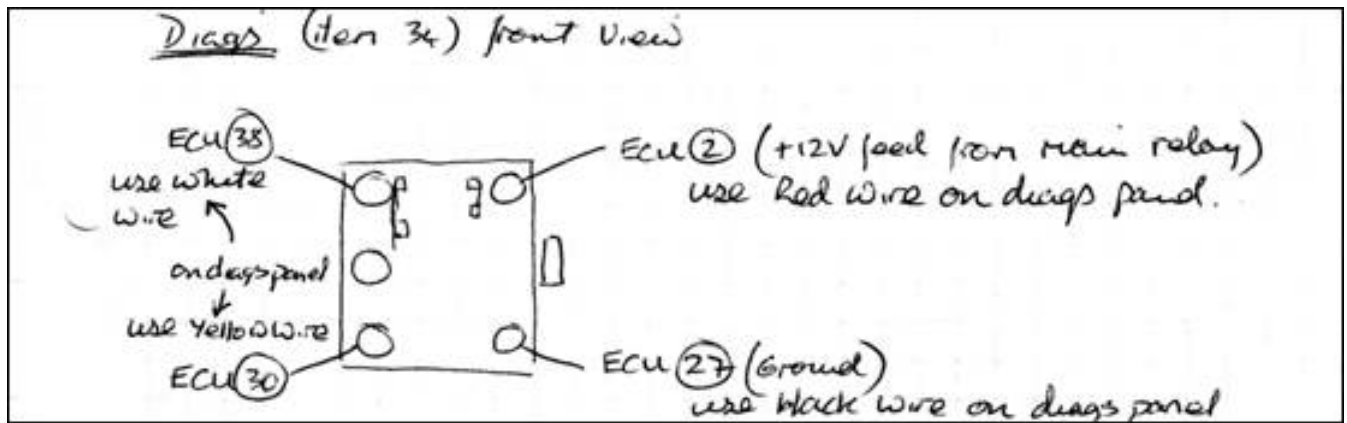


Figure 47 – Diagnostics plug (item 34 in workshop manual) electrical connector

The diagnostic display (located inside the cab) is coupled to this plug.

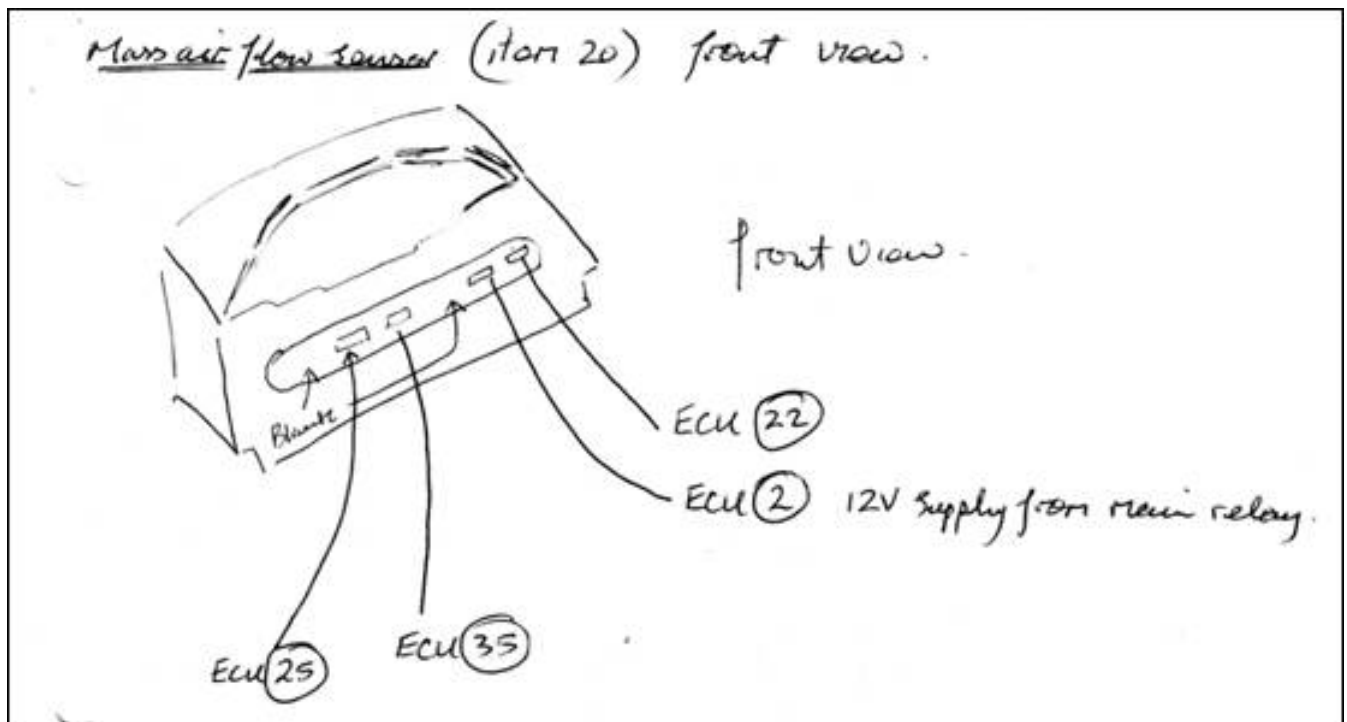


Figure 48 – Mass air flow sensor electrical connector

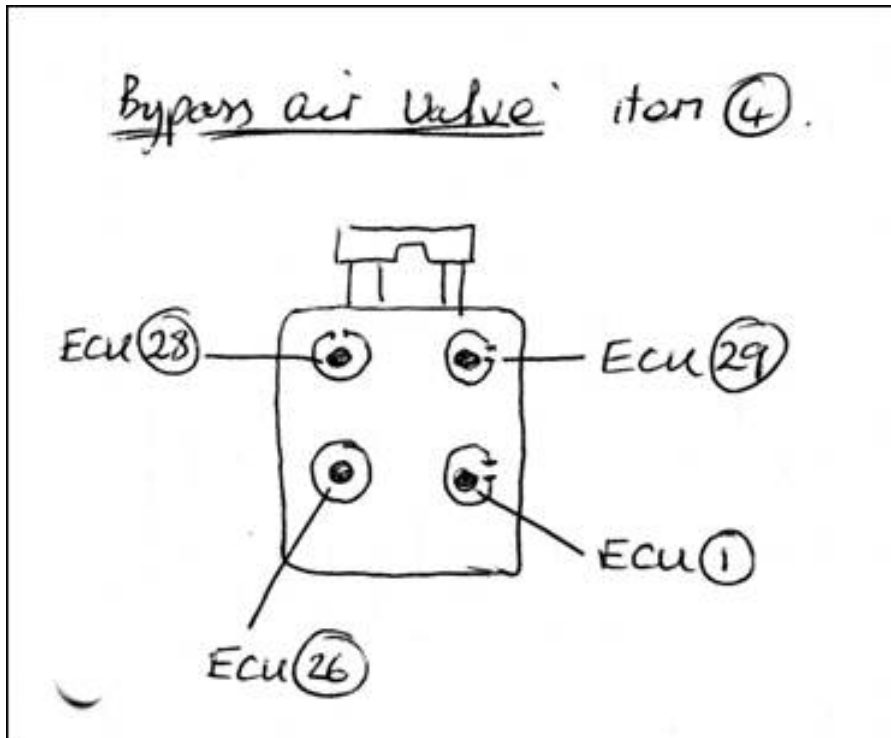


Figure 49 – Bypass air valve electrical connector

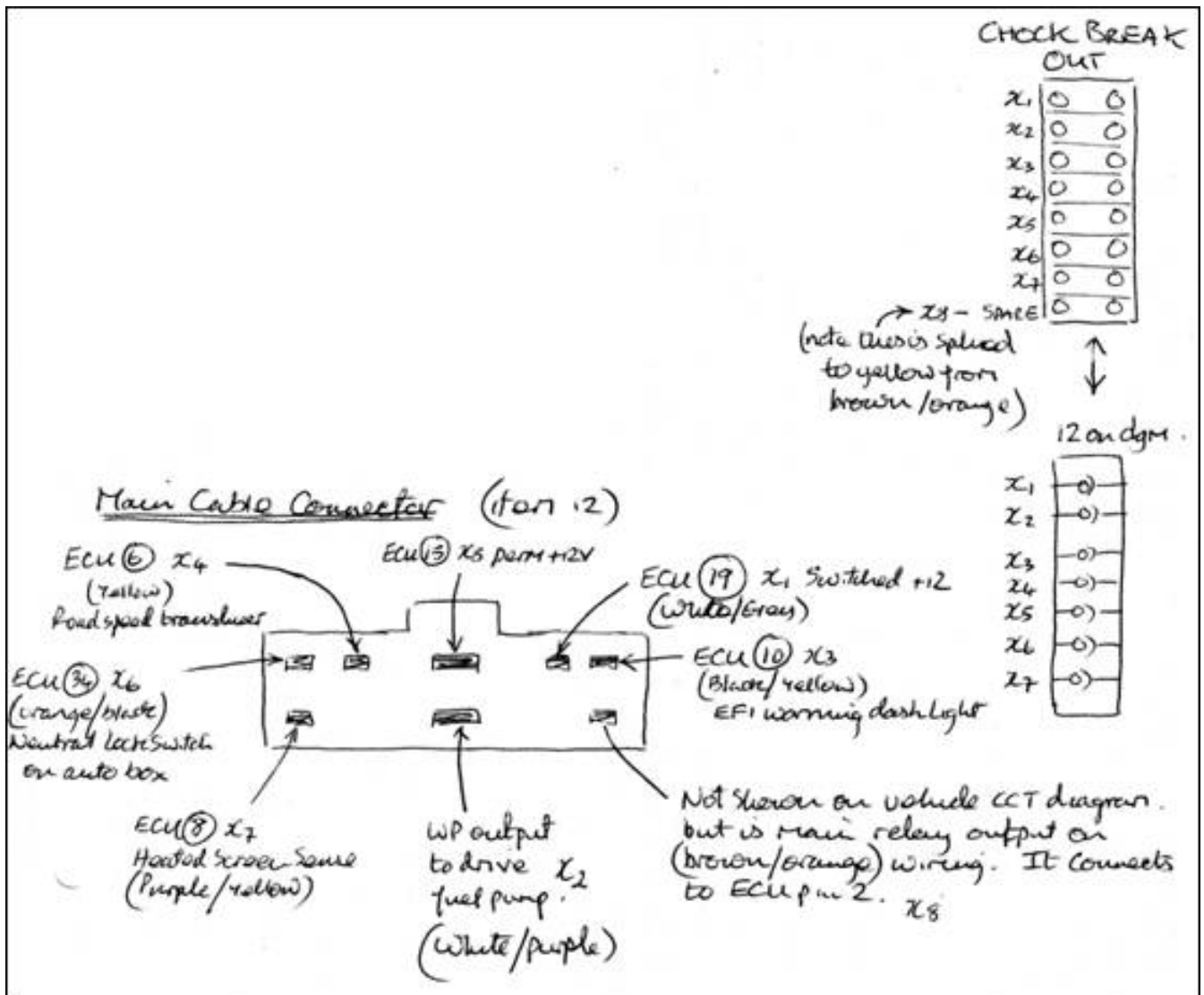
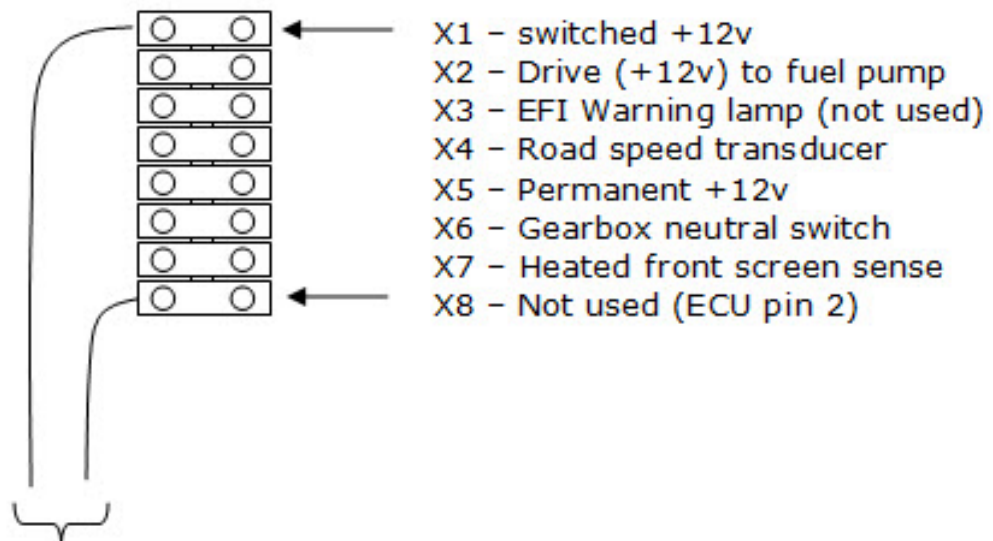


Figure 50 – Main cable connector linking loom to vehicle

The main cable connector was the primary method used to connect the injection loom to the vehicle electrical system. This plug was cut, and the wires fitted to a standard screw terminal chock block as shown below.



8 wires leading to injection wiring loom

Figure 51 – Main interface wiring chock block electrical connector

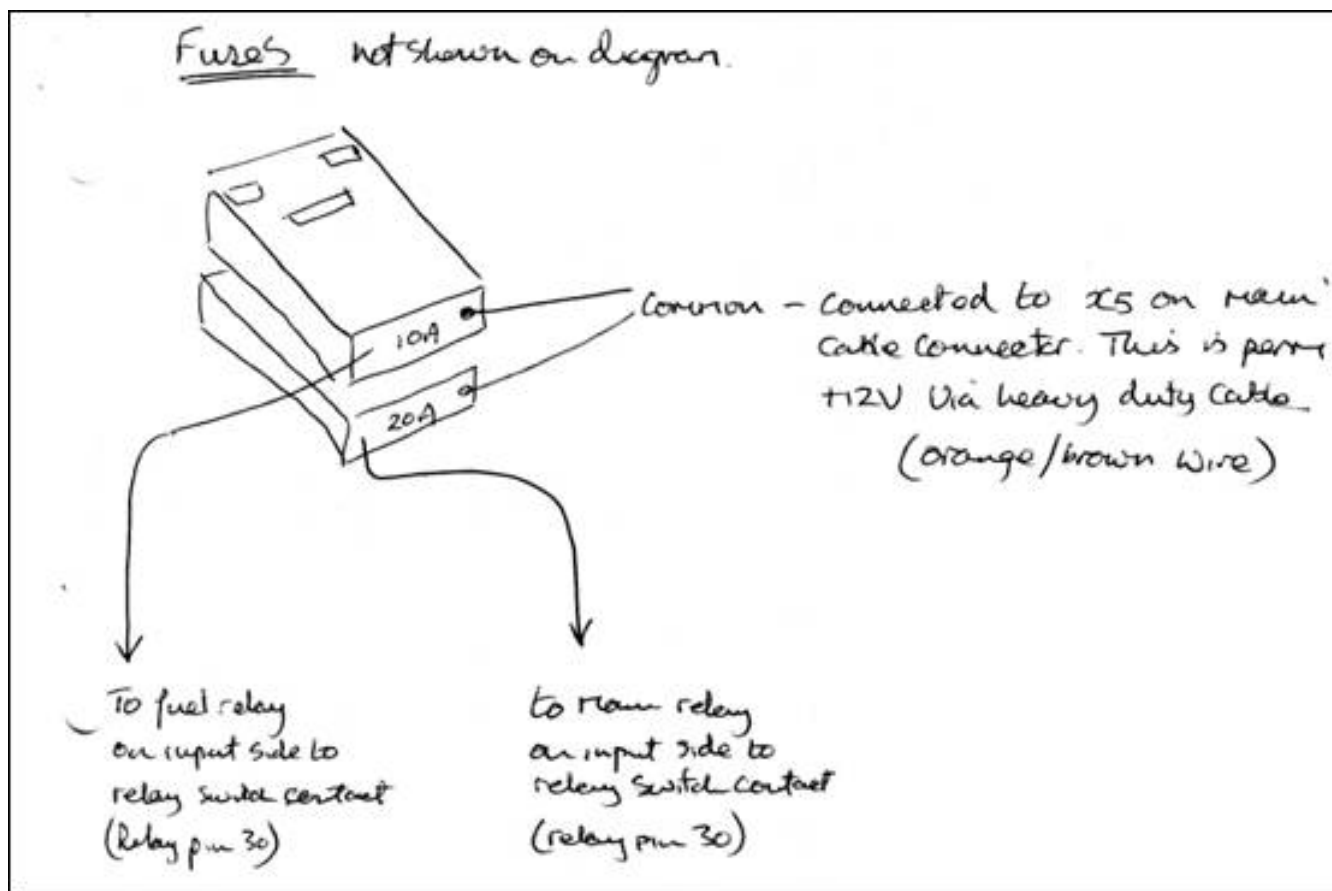


Figure 52 – Original loom fuse arrangement

The original donor vehicle injection loom fuses were heavily oxidised and were replaced using new water proof connectors. Both old and new employed spade style fuses. All connections were soldered.

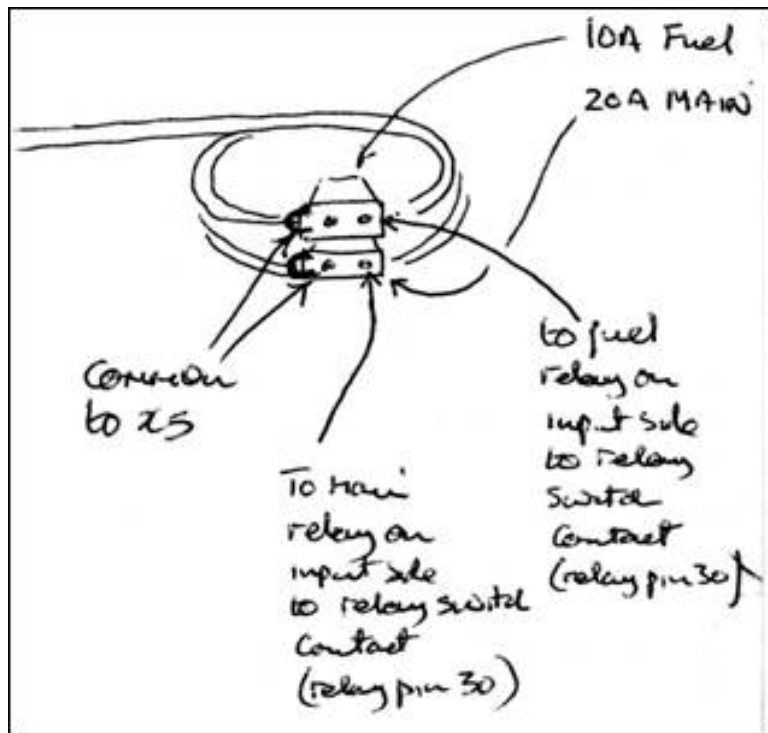


Figure 53 – New loom fuse arrangement

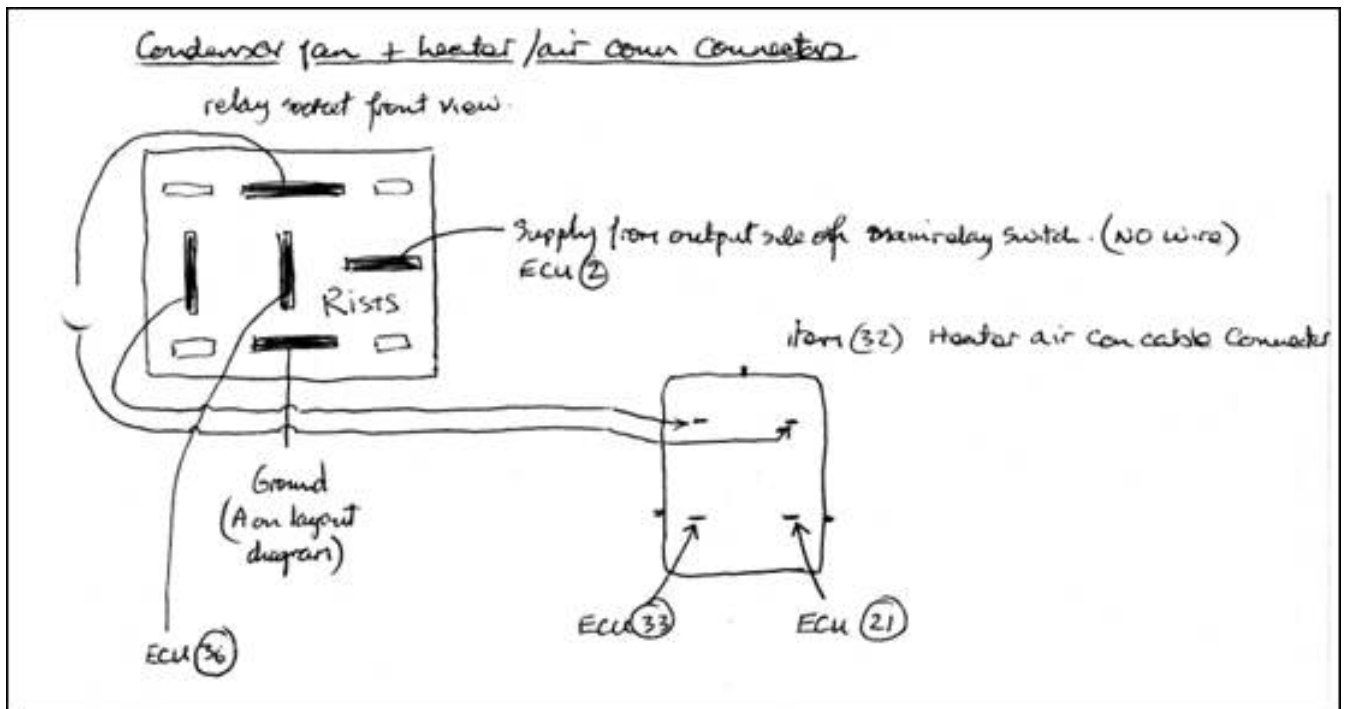


Figure 54 – Condenser fan and heater/air conn electrical connectors

The original wiring loom included a relay and connector to drive and interface to the air conditioning system. The primary motive for linking the two systems is to enable an increase in engine speed when the extra running load of the air conditioning compressor is enabled. As the target vehicle does not employ air conditioning – this circuit is entirely unused. Nevertheless the connections are shown above.

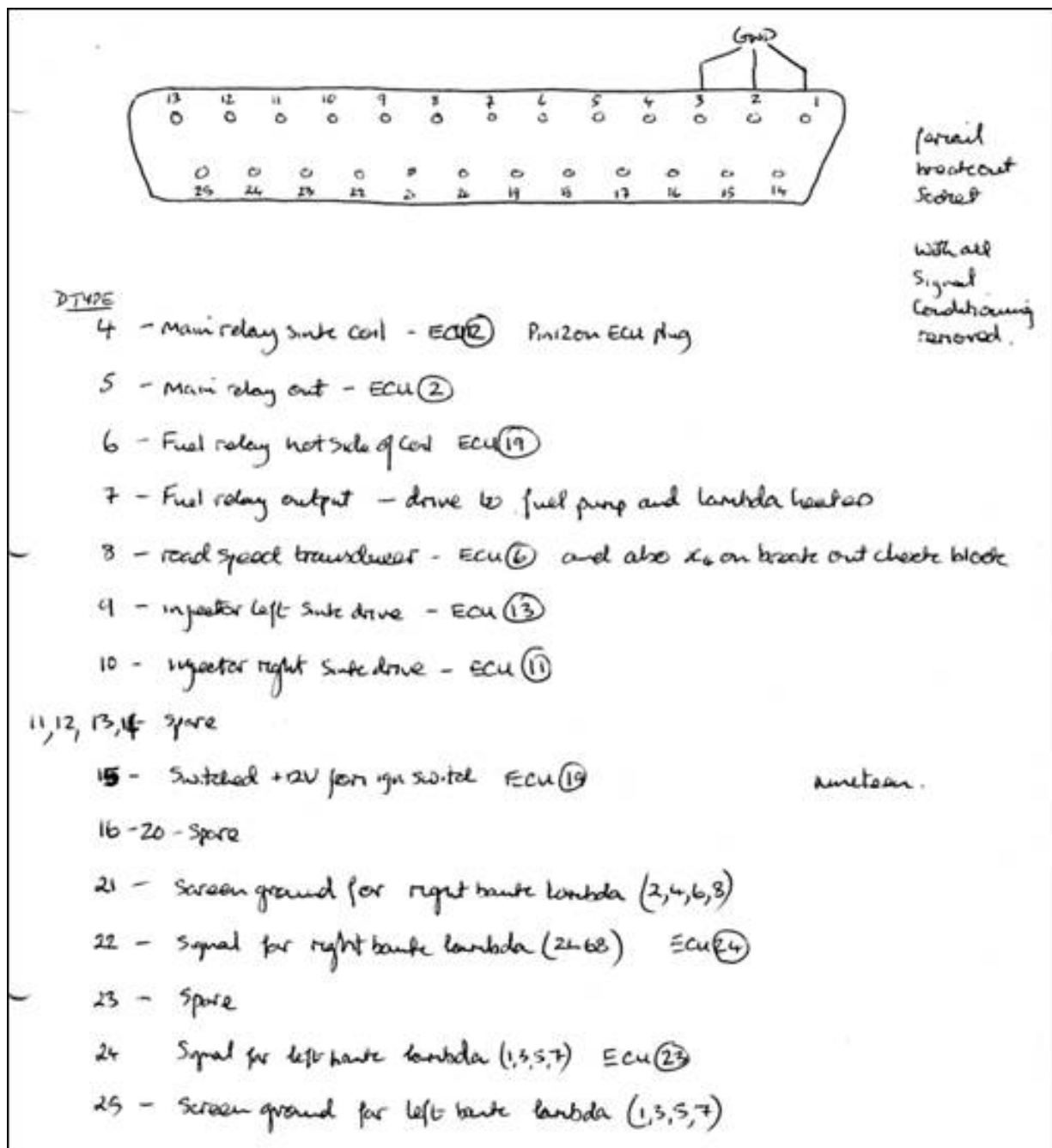


Figure 55 – Break out cable (close to ECU) wiring of 25 way female D

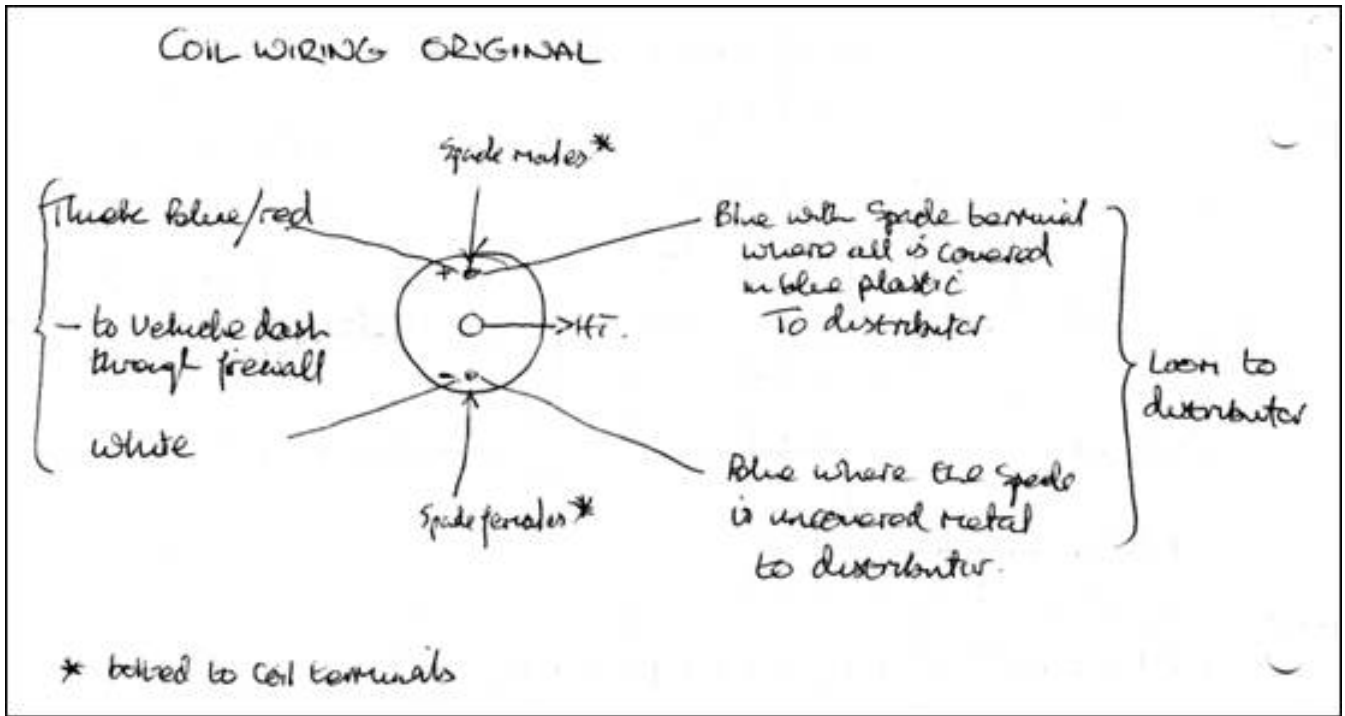


Figure 56 - Original coil wiring (when mounted on firewall)

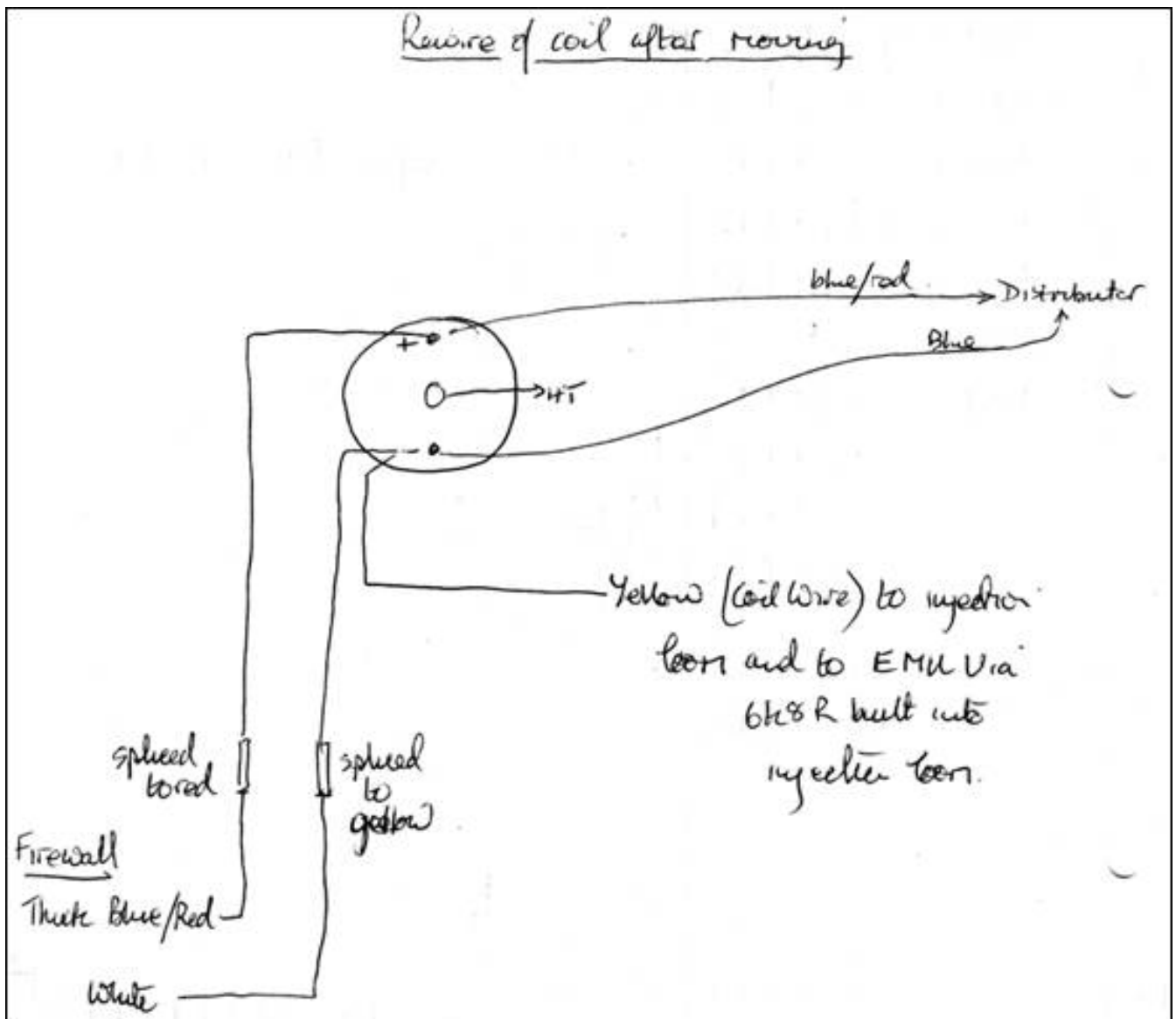


Figure 57 – New coil wiring (when mounted on passenger side fender)

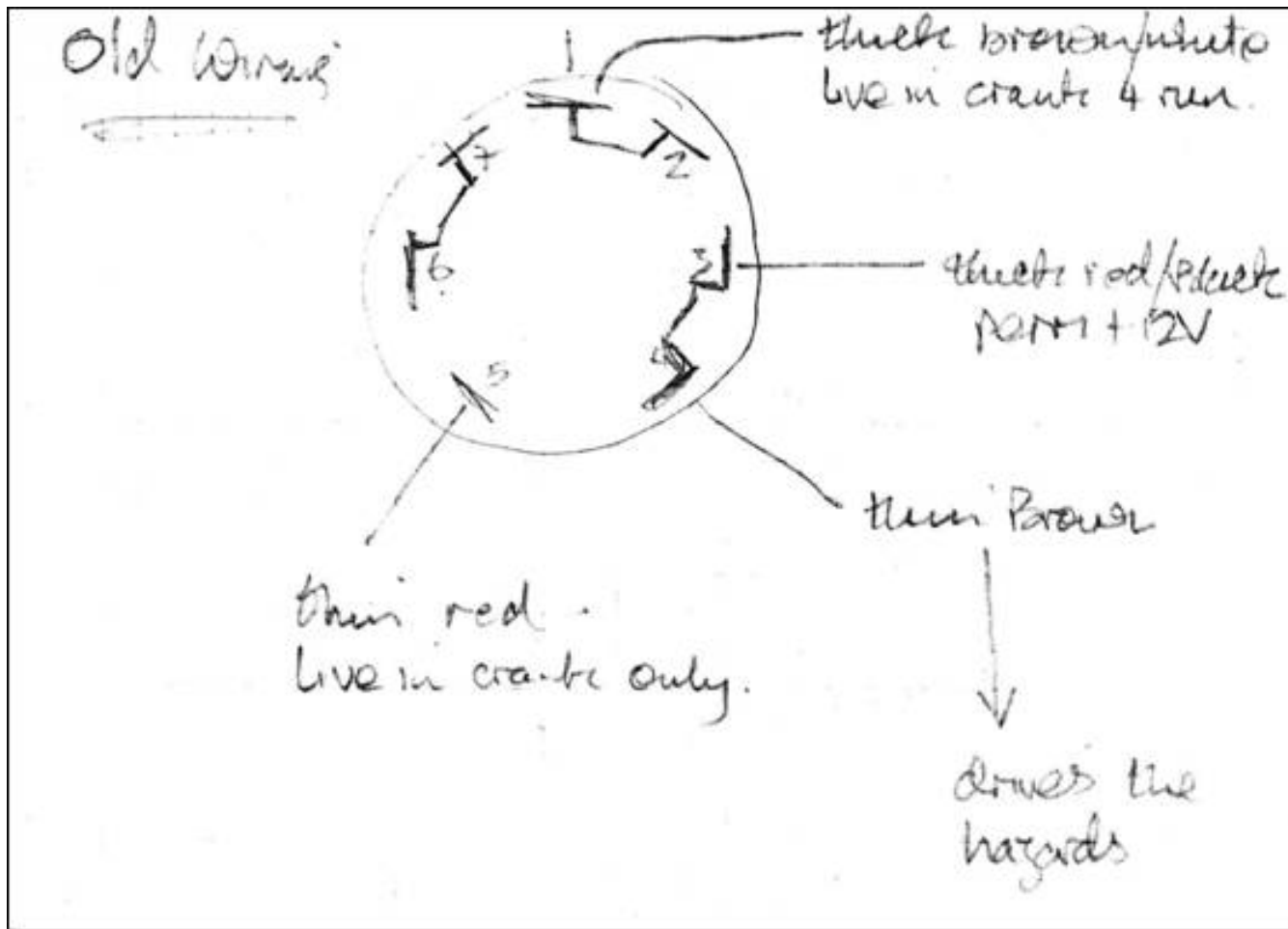


Figure 58 – Original ignition switch wiring

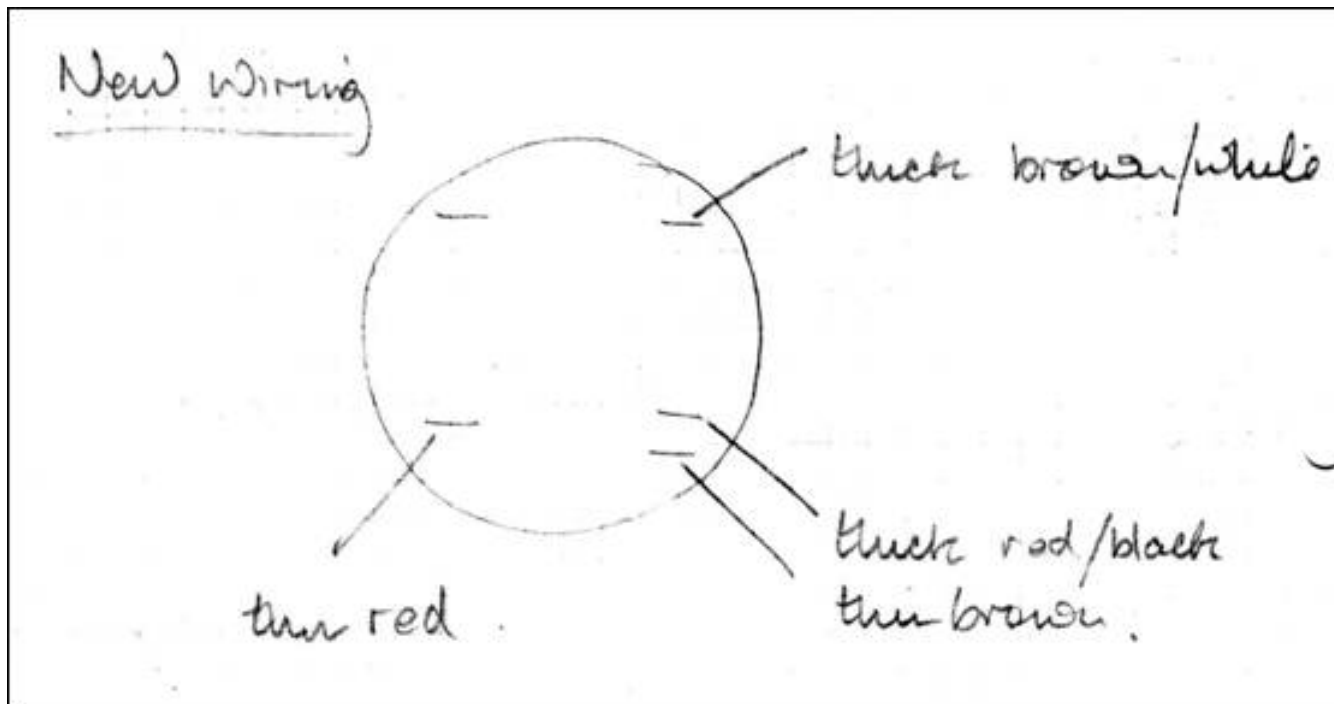


Figure 59 – New ignition switch wiring

Loom analysis results

The bench testing revealed only a small number of problems. The lambda sensor wiring was open

circuit (both sides). Also the two active feed wires (not the common feeds) to the injectors had been deliberately cut close to the ECU. It was assumed that the injector wiring had been spliced in the donor vehicle with an immobiliser.

The lambda fault was traced to a splice that had been made in the original loom again close to the cut injector wiring. All four faults were repaired with fresh wiring, and heat shrink. At the same spot, there were a total of six additional wires which had at some time in the past been cut and extended. However, some of the wire joints pulled apart because the soldering was poor quality, and some of the insulation was frayed and damaged. All of this wiring was rejoined using fresh soldered wiring and heat shrink insulation.

After testing had confirmed end to end continuity, the loom plastic outer sheath was removed in order to permit the movement of sensor positions to cope with the new plenum orientation. The main parts of the loom remained intact, but the following items were moved.

1. Throttle position connector was moved from odd to the even bank wiring
2. Coil wiring (with the built in 6k8 R in the loom) was extended
3. Mass air flow connector wiring was extended to the front of the engine

After which the loom was re-taped using self amalgamated tape and small link sections of sticky PYV insulation tape. At the end of that process, continuity was again tested end to end.

Road speed transducer system

The 14CUX uses a road speed transducer module to determine if the vehicle is moving – and if so at what speed. There are two reasons why this module appears to be required. The first is so that the system can determine if the vehicle is stationary (at which point the lowest idle speed is used). The second is to allow the injection system to limit the top speed of the vehicle.

The 1992 application used a simple chopper disc transducer in a metal module connected into the speedometer cabling running from the gearbox to the vehicle dash speedometer gauge. The unit has two wires, which are open circuit, but for every one revolution of the speedometer cable, the wires go low resistance 8 times (400ohms). When correctly calibrated the speedometer cable should rotate approximately 6 times for every single rotation of the road wheel.

The transducer itself is readily available – and there are a number of third party companies capable of manufacturing speedometer cables to particular customer requirements. As part of the fabrication, the road speed transducer was posted to Speedy Cables Ltd along with the existing single speedometer cable and an explanation of the pair of new cables required. Within 2 weeks the parts arrived.

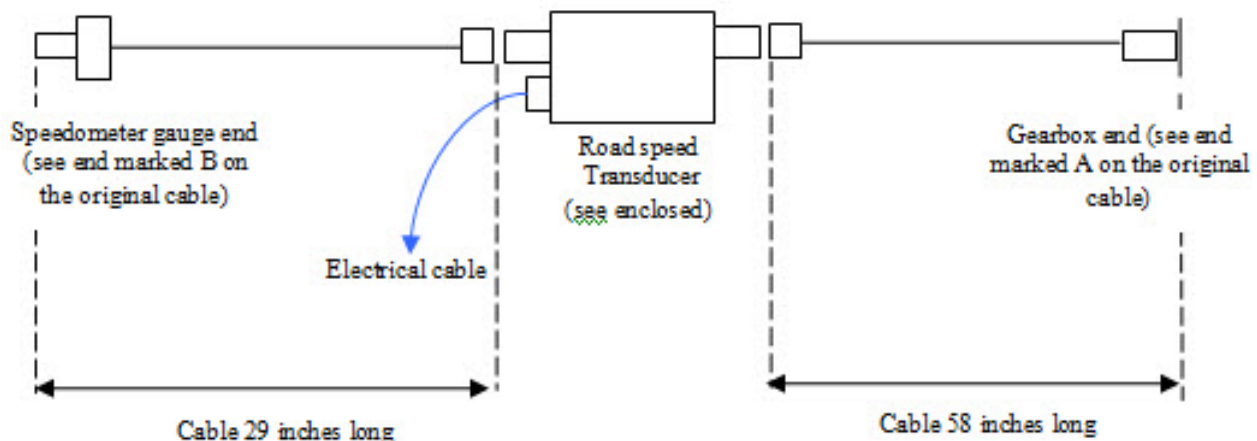


Figure 60 – Road speed transducer speedometer cable layout

Fitting was straightforward with the road speed transducer cable tied to the wiring loom running about 10 inches up the firewall on the drivers side.

Mounting ECU and main + fuel relays

A metal structure was constructed from sections of narrow gauge steel and angle iron to form a base in which the injection control box could tightly sit. This was screwed to mounting positions in the battery box under the passenger seat. The 14CUX frame clears the positive terminal of the battery by roughly 2 inches. Both main and fuel relays are mounted to the box frame using thin strip aluminium.

Fitting the wiring loom

The fitting process took just under a day to complete. The wiring required some clamps and supports to be fabricated, and copper ties were used in the exposed areas under the chassis. With the 14CUX mounted under the passenger seat, the loom wiring exits the battery box via a grommet lined large diameter hole. It then passes over the top of the gear box and on to the driver side of the vehicle where it turns sharp left to head towards the engine. As it passes under the chassis before the firewall it is clamped via two copper ties until it reaches the firewall. At that point it heads directly upwards while being tied tightly to the wall (in order to avoid the exhaust components). At the top of the firewall at roughly the same height as the rear of the drivers side engine rocker cover, the loom splits into three sub parts. The first is the wiring used to drive the even bank of injectors and which runs straight down the plenum side. The second is the even bank lambda sensor connector which hangs at that point with roughly 10 inches of cable slack, and the third is the wiring used to pass over the transmission tunnel.

That third section of the wiring extends for about 12" as one solid loom as it passes over the transmission tunnel before itself splitting into two further sub parts. The first is the odd bank lambda sensor connector which again hangs at that point with roughly 10 inches of cable slack, and the second is the section of wiring used to drive the odd bank of injectors.

The arrangement of the cabling round the injectors and various sensors is cable tied where appropriate.

Fitting the 14CUX diagnostic reader

The 14CUX does have a limited diagnostic capability. It is capable of driving a two digit display in order to announce fault codes. If the display is empty – the system is running correctly.

The 14CUX system on the donor vehicle did not include a fault display and unfortunately, Land Rover no longer manufacture these units. However, a company called Steve Heath Engineering Ltd does manufacture very good quality readers which saved the time required to analyse and interface to the serial communications link from the 14CUX control unit.

The Heath Engineering display is shipped with a cable employing an inline connector which breaks out to four push fit pins designed to insert directly into the standard 14CUX diagnostics plug as follows: -

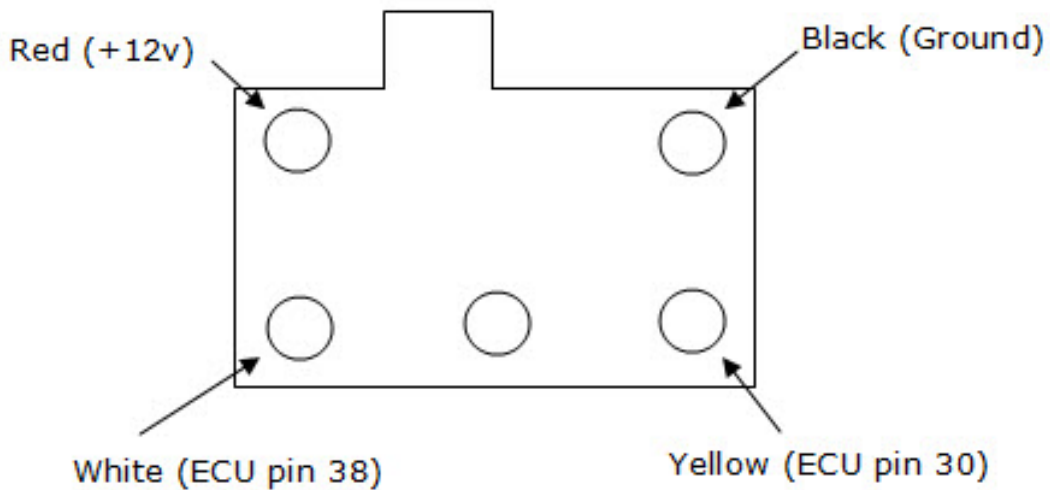


Figure 61 – Wiring the diagnostic display into the loom plug

Using the diagnostic reader

First the reader must be used in “connect” mode by pushing the switch away from you. Turn on the ignition, at which point the status LED (the DP on the seven segment display) will illuminate. If any error code is stored by the 14CUX it will be displayed now.

You can easily simulate a code 15 error by disconnecting the fuel temperature sensor.

Clearing error codes can be done in two ways. The ECU can be powered off by disconnecting the main harness connector. This will reset the ECU and clear all fault information. A second method will clear the current fault and then display the next one (when there are multiple faults). The procedure is repeated until no more codes are displayed. The procedure is as follows: -

1. Disable the immobiliser
2. Switch the ignition on
3. Disconnect the fault code reader by throwing the switch on the box. The status LED and any code will go out. Wait 5 seconds, and then reconnect the box by throwing the switch into the connect position.
4. Switch the ignition off and wait for the main relay to drop out (a good 5-10 seconds).
5. Disable the immobiliser
6. Switch the ignition on
7. The display will either display the next fault code, OR will be blank (when all fault codes have been shown). Repeat steps 3 to 6 until all codes have been seen.

If a fault causing a code isn't rectified, then the code will continue to be seen. On first sight it may seem that the code isn't being cleared – whereas it actually is being cleared but the 14CUX is continuing to see and report the same fault code.

It is also worth understanding that some codes can't be cleared by anything other than a full power down (removal of the main harness plug).

Fuel cut off – inertia switch

The injection system relies on a constant fuel pressure feed rated at approximately 3 bar. In terms of open flow rate, that equates to 135 litres of fuel flowing per hour, or 2.25 litres per minute. The risk of an accident rupturing the fuel lines but leaving the fuel pump powered represents an obvious threat. As a result Range Rovers were fitted with inertia switches mounted inside the vehicle, on a solid part of the frame. In the event of an accident exhibiting sufficient levels of

stopping G force, the inertia switch activated and disconnected the fuel pump.

If the inertia switch false triggers, it is a simple matter to push in the activation button in order to reset it. This switch is wired directly in line with the fuel pump.

The target vehicle employs the same precaution using an inertia switch specified for the donor vehicle.

A range rover inertia switch has been bolted to the B pillar directly behind the front passenger seat back rest. It is mounted button up with its back surface parallel to the side of the vehicle. It is wired in line with the supply feed to the fuel pump and interrupts that connection if a sufficiently violent impact occurs.

Appendix A – 14CUX Fault Codes

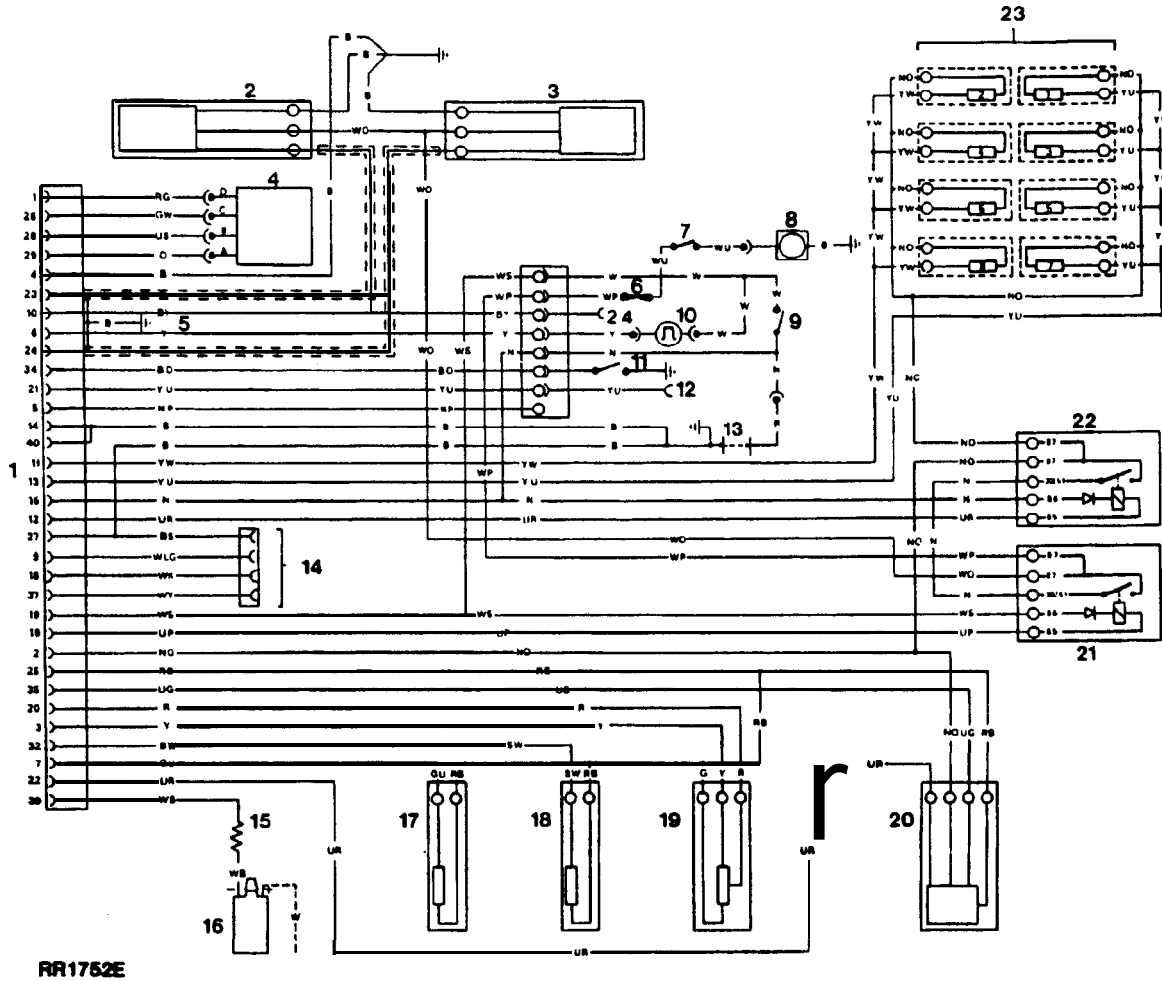
Code	Meaning	Comments
02	Live +12v supply to ECU has been disconnected	Normal code that appears whenever the ECU is first reconnected. Code 02 will clear when ignition is switched off, the main relay is allowed to release and the ignition is switched on again.
03	Stored data corrupted since last trip	No useful information available. Test drive and try again
13	Air flow meter out of range	Possible air leak or wiring fault
14	Coolant thermistor out of range	Faulty sensor or wiring
15	Fuel thermistor out of range	Faulty sensor or wiring
17	Throttle sensor out of range	Sensor needs adjustment, is faulty, or has wiring fault. This can cause low speed misfires and can also prevent the system setting low idle speed.
18	Throttle sensor output too high when air flow low	Large air leak between throttle butterfly and A/F meter or faulty throttle sensor or A/F meter
19	Throttle sensor output too low when air flow high	Faulty A/F meter or throttle sensor
21	Tune resistor out of range	Check tune resistor and wiring
23	Low fuel pressure	Blocked fuel filter or faulty pump or pressure regulator. Valid for cat cars only
25	Misfire at full load	Faulty plugs, leads, electronic ignition unit, distributor or coil, low fuel pressure or valve or head gasket leak. Valid for cat cars only. The lambda sensors have detected an emission fault which could be caused by almost anything in the ignition and injection system. If this is code 40 or 50 it will indicate which side of the engine the fault is (but be aware this can be misleading if the lambda sensors are faulty).

26	Very lean mixture	Lean or misfire condition. Probable causes are a faulty low or out of range lambda sensor or an ignition fault causing a misfire. This code is generally only used on the jaguar implementation of the 14CUX and is generally not listed under the Range Rover fault codes.
28	Air leak	Check for air leaks in the following areas <ul style="list-style-type: none"> • Hose, air flow meter to plenum • PCV • Brake servo hose • Distributor advance/retard pipe • Injector seals • Any other joints and seals
29	Checksum error	ECU has failed its internal self test. If detected, any other codes are unreliable. Try powering the ECU off. If the fault continues, then the ECU must be replaced.
34	Fueling fault in nearside injector bank	Injector or lambda sensor wiring fault, faulty injectors, air leak at injector seals or intake manifold, blocked injectors. Valid for cat cars only on cylinders 1,3,5 and 7
36	Fueling fault in offside injector bank	Injector or lambda sensor wiring fault, faulty injectors, air leak at injector seals or intake manifold, blocked injectors. Valid for cat cars only for cylinders 2,4,6 and 8
40	Misfire on nearside bank	Misfire has occurred on cylinders 1,3,5 and 7. Valid for cat cars only (see code 25 for more details and suggestions)
44	Nearside lambda sensor out of range	Faulty or lead-poisoned lambda sensor. Valid for cat cars only. If codes 45 and 45 appear then the likely cause is the heater wiring for both lambda sensors.
45	Offside lambda sensor out of range	Faulty or lead-poisoned lambda sensor. Valid for cat cars only. If codes 45 and 45 appear then the likely cause is the heater wiring for both lambda sensors.
48	Stepper motor (bypass air valve) fully open below 500RPM or fully closed above 750 RPM	Sticking stepper motor valve, incorrect base idle speed adjustment, air leak on non cat cars, incorrect stepper motor adjustment, incorrect throttle butterfly adjustment, rough running (due to fuel, ignition or mechanical faults) and finally a faulty road speed transducer can cause this problem. Note that low fuel pressure can cause this problem especially if it causes the engine to stumble at idle or very low speed.
50	Misfire on offside bank	Misfire has occurred on cylinders 2,4,6 and 8. Valid for cat cars only (see code 25 for more details and suggestions)
58	ECU unable to distinguish between faults 23 and 28	Fault occurred for an insufficient time for ECU to correctly diagnose.
59	Fuel thermistor our of range	Fuel thermistor fault – but be aware that in some documentation code 59 is described as code 58.

68	Road speed sensor output too low at medium RPM and high air flow	Possible sensor or wiring fault. Valid for cat cars only
88	Power up check	Two interpretations for this. For non cat cars, the code is shown on power up but isn't a code. For cat cars it is used to show that there is a purge valve fault with the evaporative emissions carbon canister system.

Appendix B – Final notes, comments and links

- Engine thermostat must be a 74 degrees C part with no joggle hole
- Engine air filter is standard range rover 1992 part number RTC 4683
- Bypass air valve is standard 1992 range rover part
- Throttle potentiometer is standard 1992 range rover ETC 8495 part
- As described above the PCV system connects to the plenum vacuum source via a 2mm drilled orifice. This is additional to the plastic PCV T piece supplied by land rover which has a 3mm restriction orifice.
- 14CUX workshop manual link: www.conehead.org/landrover/14cux_fuel_injection.pdf



FUEL INJECTION - Circuit Diagram

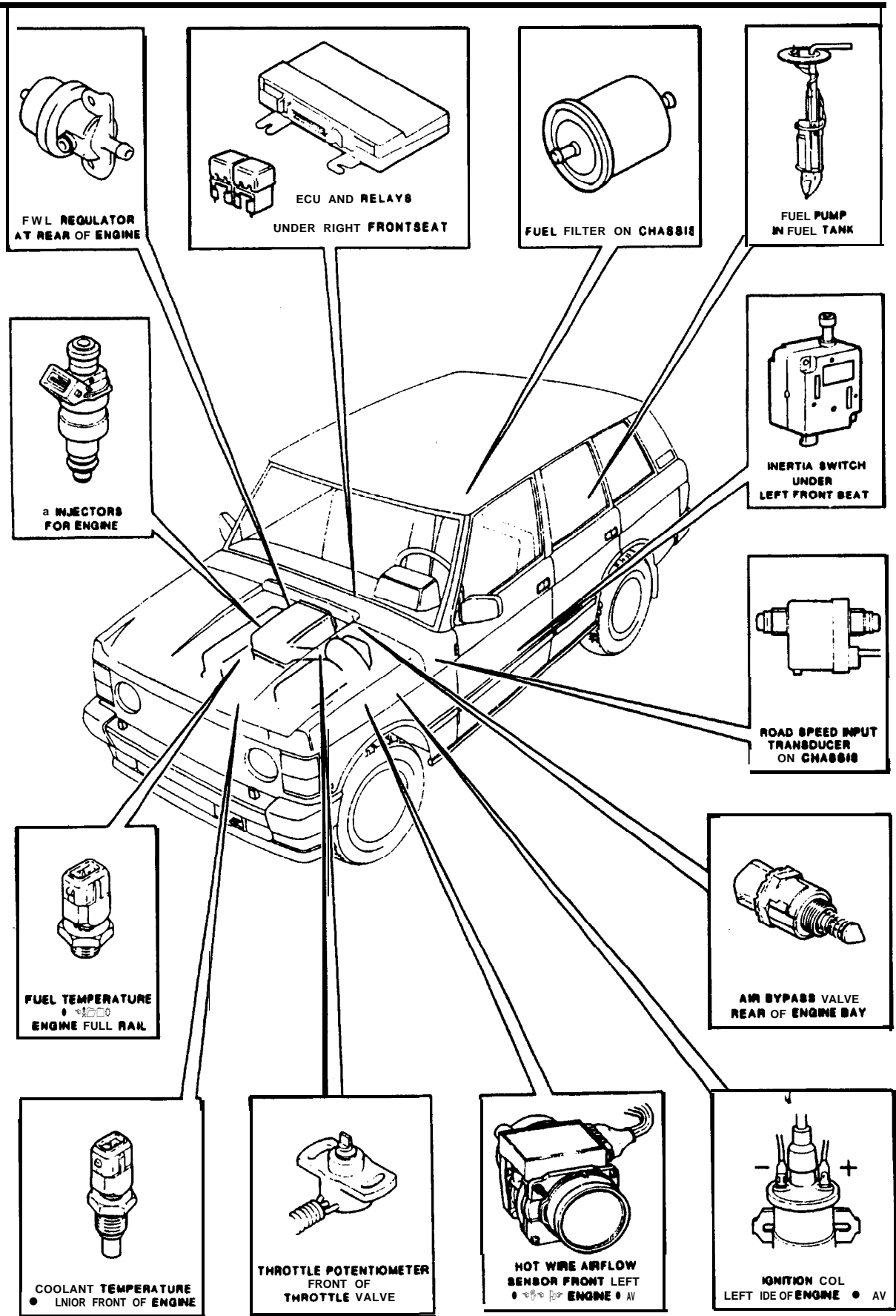
- | | |
|--|--|
| 1. 40 way connector to Electronic Control Unit (ECU). | 13. Battery. |
| 2. Lambda sensor (left side - bank A). | 14. Diagnostic plug. |
| 3. Lambda sensor (right side - bank B). | 15. In-line resistor. |
| 4. By-pass air valve (stepper motor) (fast idle). | 16. Coil/-ve (engine RPM input). |
| 5. Lambda sensor screened ground. | 17. Coolant temperature thermistor (sensor) (input). |
| 6. Fuse 18 - main fuse panel. | 18. Fuel temperature thermistor (sensor) (input). |
| 7. Inertia switch. | 19. Throttle potentiometer. |
| 8. Fuel pump. | 20. Air flow sensor. |
| 9. Ignition switch. | 21. Fuel pump relay. |
| 10. Speed transducer (road speed input). | 22. Main relay. |
| 11. Neutral switch (automatic gearbox) (load input). | 23. Injectors-I to 8. |
| 12. Pick-up point-air conditioning circuit (load input). | 24. Pick-up point E.F.I. warning symbol (instrument binnacle). |
- = = = Denotes screened ground.

NOTE: Reference to left and right side is made when viewing vehicle from rear.

Cable colour code

B	Black	C	Green	R	Red	S	Crey
U	Blue	O	Orange	W	White	K	Pink
N	Brown	P	Purple	Y	Yellow	LG	Light green

The last letter of a colour code denotes the tracer.



RR2178E

INTRODUCTION

The Electronic Fuel injection system provides a reliable and efficient microprocessor controlled fuel management system.

The function of the system is to supply the exact amount of fuel directly into the inlet manifold according to the prevailing engine operating conditions.

To monitor these conditions, various sensors are fitted to the engine to measure engine parameters. Data from the sensors is received by the Electronic Control Unit (E.C.U.), the E.C.U. will then determine the exact amount of fuel required at any condition.

The E.C.U. having received data from the sensors produces pulses, the length of which will determine the simultaneous open time of each bank of injectors in turn, which will govern the amount of fuel injected.

DESCRIPTION

ELECTRONIC CONTROL UNIT-ECU

The Electronic Fuel Injection system is controlled by the E.C.U. which is located under the front right hand seat. The control unit is a microprocessor with integrated circuits and components mounted on printed circuit boards. The E.C.U. is connected to the main harness by a 40 pin plug.

INJECTORS

The eight fuel injectors are fitted between the pressurized fuel rail and inlet manifold. Each injector comprises a solenoid operated needle valve with a movable plunger rigidly attached to the nozzle valve. When the solenoid is energized the plunger is attracted off its seat and allows pressurized fuel into the intake manifold.

ENGINE COOLANT TEMPERATURE THERMISTOR (SENSOR)

The coolant thermistor (sensor) is located by the front left hand branch of the intake manifold. The thermistor provides engine coolant information to the E.C.U. The E.C.U. on receiving the signal from the thermistor will lengthen slightly the time that the injectors are open, and reducing this time as the engine reaches normal operating temperature.

FUEL TEMPERATURE THERMISTOR (SENSOR)

The fuel temperature thermistor (sensor) is located in the fuel rail forward of the ram housing. The thermistor sends fuel temperature data to the E.C.U, the E.C.U on receiving the data will adjust the injector open time accordingly to produce good hot starting in high ambient temperatures.

BYPASS AIR VALVE (STEPPER MOTOR)

The bypass valve is screwed into a housing attached to the rear of the plenum chamber, between the plenum chamber and bulkhead. The bypass valve has two windings which enable the motor to be energised in both directions thus opening or closing the air valve as required by the E.C.U.

The bypass valve will open and allow extra air into the plenum chamber to maintain engine idle speed when the engine is under increased (Electrical and Mechanical) loads.

The bypass valve will control engine idle speed when the vehicle is stationary.

LAMBDA SENSORS (O₂ SENSORS)

The two Lambda sensors are located forward of the catalysts mounted in the exhaust downpipes.

The sensors monitor the oxygen content of the exhaust gases and provide feedback information of the air/fuel ratio to the E.C.U. Each sensor is heated by an electrical element to improve its response time when the ignition is switched on.

Continued

FUEL PRESSURE REGULATOR

The fuel pressure regulator is mounted in the fuel rail at the rear of the plenum chamber. The regulator is a mechanical device controlled by plenum chamber vacuum, it ensures that fuel rail pressure is maintained at a constant pressure difference of 2.5 bar above that of the manifold.

When pressure exceeds the regulator setting excess fuel is returned to the fuel tank.

FUEL PUMP

The electric fuel pump is located in the fuel tank, and is a self priming 'wet' pump, the motor is immersed in the fuel within the tank.

AIR FLOW SENSOR

The hot-wire air flow sensor is mounted on a bracket attached to the left hand valance, rigidly connected to the air cleaner and by hose to the plenum chamber inlet neck.

The air flow sensor consists of a cast alloy body through which air flows. A proportion of this air flows through a bypass in which two wire elements are situated: one is a sensing wire and the other is a compensating wire. Under the control of an electronic module which is mounted on the air flow sensor body, a small current is passed through the sensing wire to produce a heating effect. The compensating wire is also connected to the module but is not heated, but reacts to the temperature of the air taken in, as engine intake air passes over the wires a cooling effect takes place.

The electronic module monitors the reaction of the wires in proportion to the air stream and provides output signals in proportion to the air mass flow rate which are compatible with the requirements of the E.C.U.

THROTTLE POTENTIOMETER

The throttle potentiometer is mounted on the side of the plenum chamber inlet neck and is directly coupled to the throttle valve shaft.

The potentiometer is a resistive device supplied with a voltage from the E.C.U. Movement of the throttle pedal causes the throttle valve to open, thus rotating the wiper arm within the potentiometer which in turn varies the resistance in proportion to the valve position. The E.C.U. lengthens the injector open time when it detects a change in output voltage (rising) from the potentiometer.

In addition the E.C.U. will weaken the mixture when it detects the potentiometer output voltage is decreasing under deceleration and will shorten the length of time the injectors are open.

When the throttle is fully open, the E.C.U. will detect the corresponding throttle potentiometer voltage and will apply full load enrichment. This is a fixed percentage and is independent of temperature. Full load enrichment is also achieved by adjusting the length of the injector open time.

When the throttle is closed, overrun fuel cut off or idle speed control may be facilitated dependant on other inputs to the E.C.U.

ROAD SPEED TRANSDUCER

The road speed transducer is fitted between the upper and lower speedometer cables. It is mounted on a bracket located on the left hand chassis side member adjacent to the rear engine mounting. The transducer provides road speed data to the ECU. The ECU in turn detects vehicle movement from the road speed input and ensures that idle speed control mode is disengaged. Should the speed transducer fail in service the ECU idle speed control would become erratic.

INERTIA SWITCH

The inertia switch is a mechanically operated switch located under the left hand front seat attached to the seat base rear cross-member.

The switch is normally closed and is in the ignition feed (fuse to fuel pump). In the event of a sudden impact the switch opens, and disconnects the electrical feed to the fuel pump. The switch is reset by pressing down the button.

RELAYS

The two electronic fuel injection relays are located under the front right hand seat mounted forward of the E.C.U. The main relay is energized via the E.C.U when the ignition is switched on and supplies current to the fuel injection system. The fuel pump relay is energized by the E.C.U. which in turn operates the fuel pump to pressurize the fuel system.

E.F.I. WARNING SYMBOL (Instrument binnacle)

An E.F.I. warning symbol incorporated into the instrument binnacle will illuminate when the E.C.U. detects that it cannot maintain correct air/fuel ratio due to a fault in one of the following fuel injection system components.

Air flow sensor.

Lambda sensor.

Water temperature thermistor. (sensor)

Throttle potentiometer.

The symbol will illuminate on initial turn of the ignition key as part of the bulb check feature, and will go out after a few seconds.

If the symbol illuminates when the engine is idling or the vehicle is being driven it indicates a failure of one of the four functions, the vehicle should be driven with care, and the cause rectified, refer to test procedure for the particular functions. Should one of the functions fail, the vehicle can still be driven due to a limp home feature incorporated into the fuel injection system.

FUEL INJECTION SYSTEM

CAUTION: The fuel system incorporates fine metering components that would be affected by any dirt in the system; therefore it is essential that working conditions are scrupulously clean. If it is necessary to disconnect any part of the fuel injection system, the system **MUST** be **depressurized**. All openings left open after the removal of any component from the fuel system, **MUST** be sealed off to prevent ingress of dirt.

ENGINE SETTING PROCEDURE

If a major overhaul has been undertaken on the fuel injection/engine system, the following check and adjustments must be carried out before attempting to start the engine.

- A. Throttle potentiometer setting - see 'Throttle potentiometer' setting procedure.
- B. Spark plug gaps - see 'Section 05 Engine tuning data'.
- C. Throttle levers - see 'Throttle lever setting procedure'.
- D. Ignition timing - static - see 'Section 86 Electrical'.

CAUTION: IF THE ENGINE IS MISFIRING, IT SHOULD BE IMMEDIATELY SHUT DOWN AND THE CAUSE RECTIFIED. FAILURE TO DO SO WILL RESULT IN IRREPARABLE DAMAGE TO THE CATALYSTS.

NOTE: If the previous checks and adjustments are satisfactory but the engine will not start the ignition and fuel injection electrical **circuitry** must be checked using the appropriate recommended equipment.

Recommended Equipment -

Lucas 'Electronic Ignition Analyser'
Lucas Part Number - YWB 119.

Lucas Diagnostic Equipment
Lucas Part Number - 60600965 (complete kit)

Individual part numbers for the above kit are as follows:

Hand held test unit - Model 2HHT
Lucas Part Number - 84772

Interface unit - Model 21U
Lucas Part Number - 84773

Serial link lead
Lucas Part Number - 54744753

Memory card
Lucas Part Number - 54744754

Operating manual
Lucas Part Number . XXB825

Plastic case
Lucas Part Number - 54744755

NOTE: The Lucas diagnostic equipment can be connected to the diagnostic plug located by the E.C.U.

Use in conjunction with the Lucas Operating Instruction Manuals.

If the above equipment is unavailable the tests can be carried out using a multi-meter, following the instructions given in the charts.

CAUTION: Ensure the multi-meter is correctly set to volts or ohms, dependent upon which test is being undertaken.

Carry out the following static checks before undertaking the continuity procedure:-

- A. Fuse 18 - in main fuse panel - is intact.
- B. Inertia switch - not tripped.
- C. Fuel - ample fuel in fuel tank.
- D. Battery Condition - state of charge.
- E. Air Leaks - no unmetered air entering engine system.
- F. Electrical Connections - dry, clean and secure.

CONTINUITY TEST PROCEDURE

The continuity procedure and instructions on the following pages must be followed precisely to prevent damage occurring to any of the fuel system components.

To enable the tests to be carried out when the 40 way multi-plug is connected to the E.C.U., it is necessary to remove the two screws securing the shroud to the plug to enable the multi-meter probes to be inserted into the back of the appropriate pin.

CAUTION: Tests that require the plug to be removed from the E.C.U., must also have the meter probes inserted into the back of the plug. If the probes are inserted into the plug sockets, damage will occur to the sockets resulting in poor connections when the plug is reconnected.

TESTING

1. Remove the E.C.U., and harness plug from beneath the front right hand seat, access is gained through the rear opening of the seat base.
2. Remove the plug shroud and maneuver it along the harness until there is enough clearance enabling meter probes to be inserted into the back of the plug.
3. There are 4 pin numbers, 1, 13, 28, 40 moulded onto the rear of the plug for pin position identification as shown in the illustration below, (for clarity the electrical leads have been omitted).

Pins 1 to 13 top row.

Pins 14 to 27 centre row (Pin 14 is below pin 13 but is not identified on the rear of the plug).

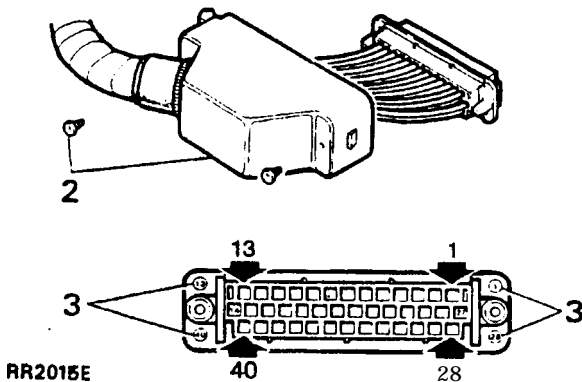
Pins 28 to 40 bottom row.

PIN NOS. CABLE COLOUR

1. Red/green
2. Brown/orange
3. Yellow
4. Black
5. Brown/purple
6. Yellow
7. Green/blue
8. Not used
9. White/light green
10. Black/Yellow
11. Yellow/white
12. Blue/red
13. Yellow/blue
14. Black
15. Brown
16. Blue/purple
17. Not used
18. White/pink
19. White/grey
20. Red
21. Yellow/blue
22. Blue/red
23. Blue
24. Blue
25. Red/black
26. Green/white
27. Black/grey
28. Blue/grey
29. Orange
30. Not used
31. Not used
32. Grey/white
33. Not used
34. Black/orange
35. Blue/green
36. Not used
37. White/yellow
38. Not used
39. White/black
40. Black

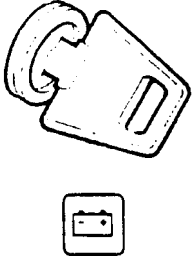
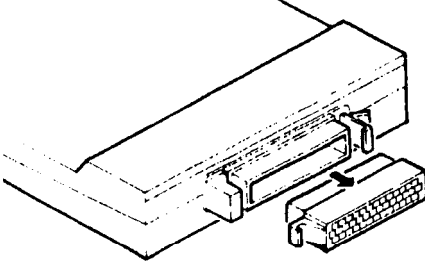



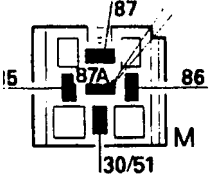
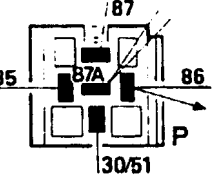
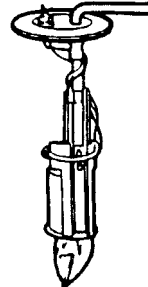
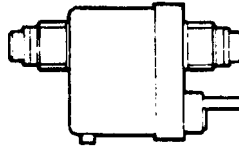
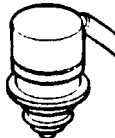
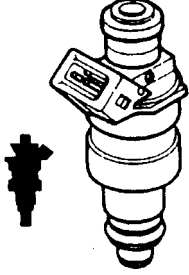
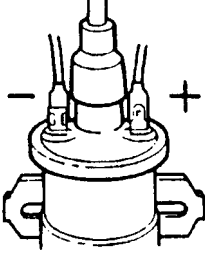
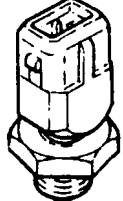
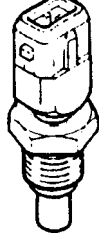
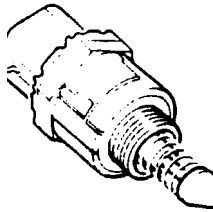
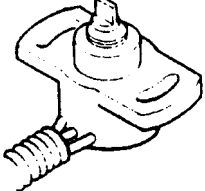
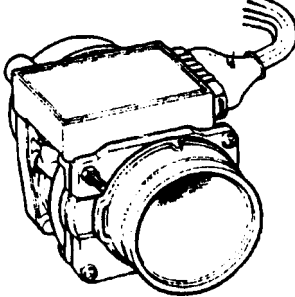
The last colour denotes the wire tracer colour.

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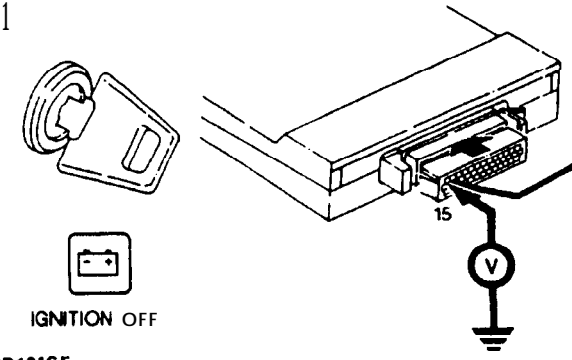
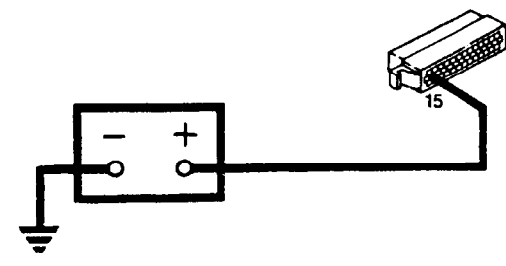
TESTS - Using a Multi-Meter

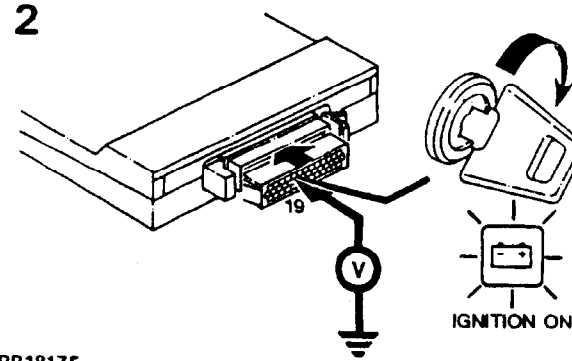
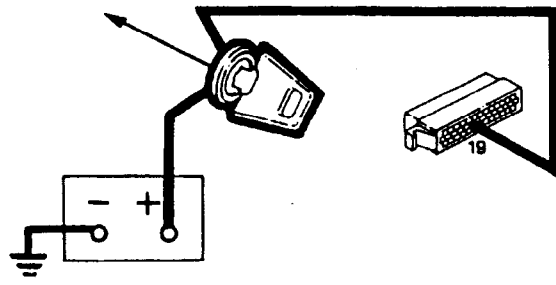
The following continuity tests are intended as a guide to identifying where a fault may be within a circuit; reference should be made to the fuel injection circuit diagram for full circuit information.

<p>KEY TO SYMBOLS</p>	 <p>IGNITION SWITCH</p>	 <p>ELECTRONIC CONTROL UNIT AND MULTIPLUG</p>		 <p>TEMPORARY CONNECTION</p>
 <p>OHMMETER CONNECTIONS</p>	 <p>VOLTMETER CONNECTIONS</p>	 <p>MAIN RELAY</p>	 <p>PUMP RELAY</p>	 <p>FUEL PUMP</p>
 <p>ROAD SPEED INPUT (SPEED TRANSDUCER)</p>	 <p>GEAR INPUT SWITCH (INHIBITOR) SWITCH</p>	 <p>INJECTOR</p>	 <p>IGNITION COIL</p>	 <p>FUEL TEMPERATURE SENSOR</p>
 <p>COOLANT TEMPERATURE SENSOR</p>	 <p>AIR BYPASS VALVE</p>	 <p>THROTTLE POTENTIOMETER</p>	 <p>HOT WIRE AIRFLOW SENSOR</p>	

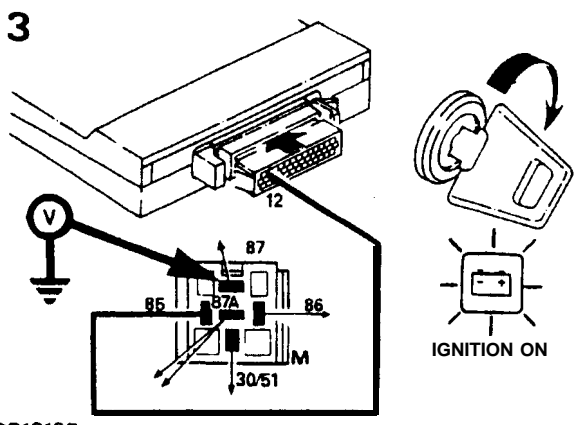
RR1782E

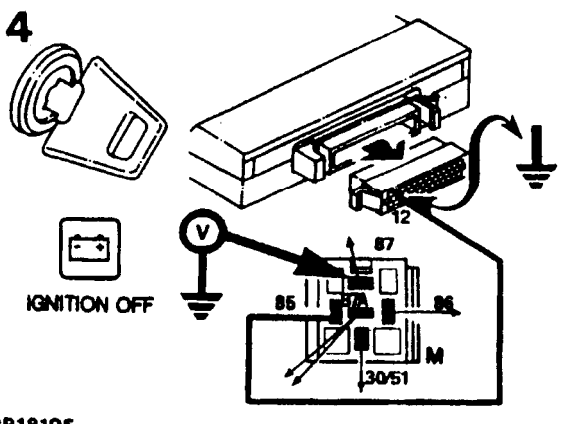
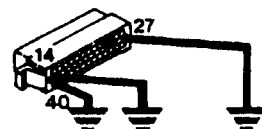
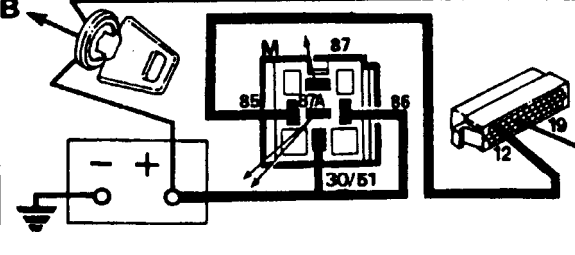
NOTE: All tests are carried out from the electronic control unit (ECU) harness multi-plug unless stated otherwise in the test procedure.

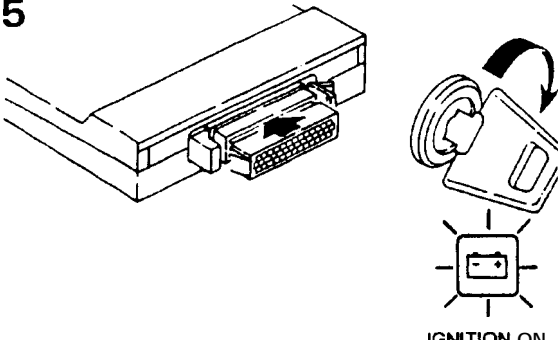
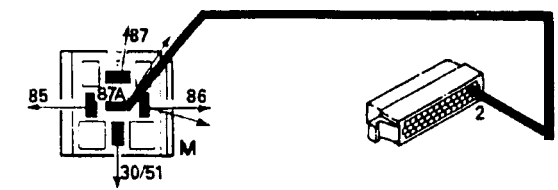
TEST PROCEDURE	RESULTS . Check cables and units shown in bold
<p>1. Check battery supply to ECU</p>	<p>Voltmeter reading of battery volts - (mimum battery voltage 10 volts) Proceed to Test 2 Voltmeter reading of zero volts Check:-</p>
<p>1</p>  <p>IGNITION OFF</p> <p>RR1816E</p>	

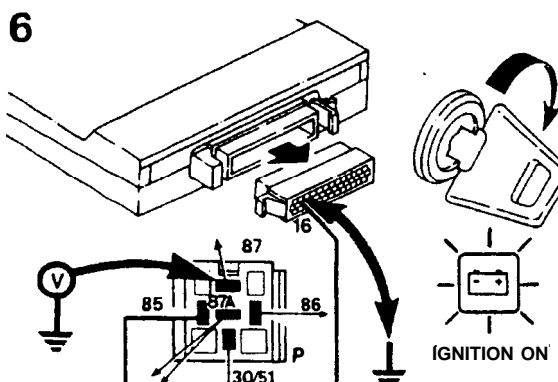
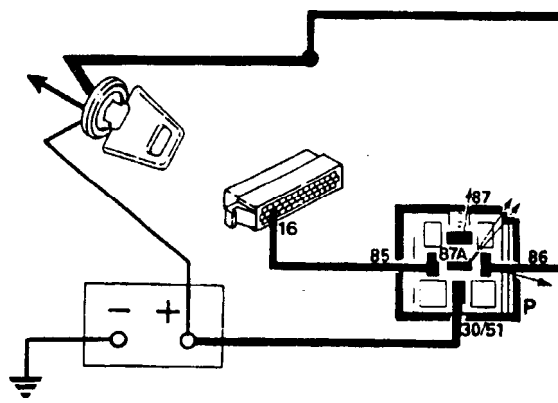
TEST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>2. Check ignition supply to ECU</p>	<p>Voltmeter reading of battery volts - (minimum battery voltage 10 volts) Proceed to Test 3 Incorrect reading check:-</p>
<p>2</p>  <p>IGNITION ON</p> <p>RR1817E</p>	

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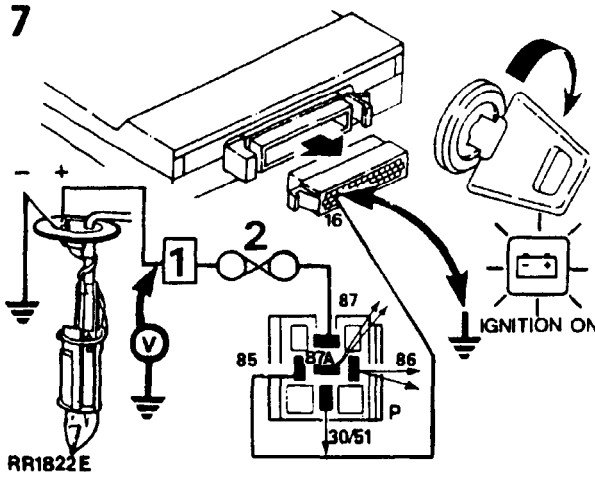
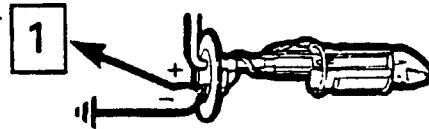
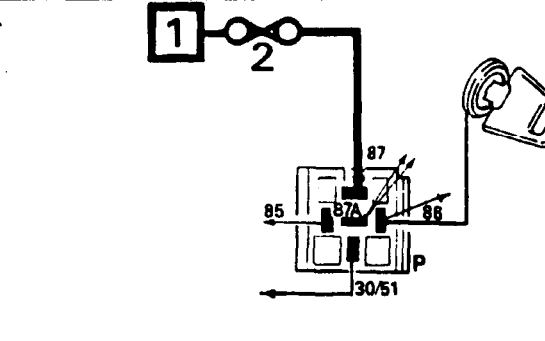
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>3. Check operation of Main relay</p>	<p>Voltmeter reading of battery volts - Proceed to Test 5</p> <p>Voltmeter reading of zero volts - Proceed to Test 4</p>
<p>3</p>  <p>RR1818E</p>	

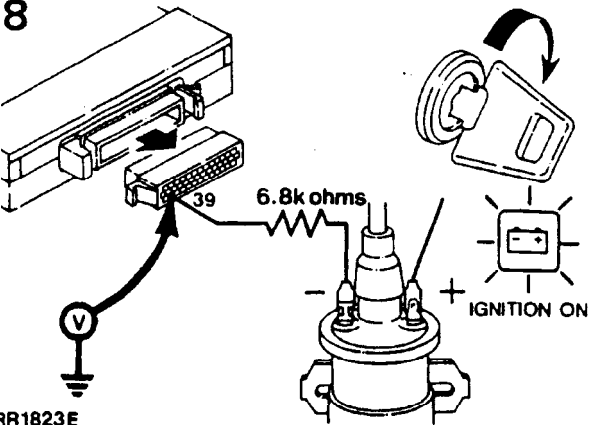
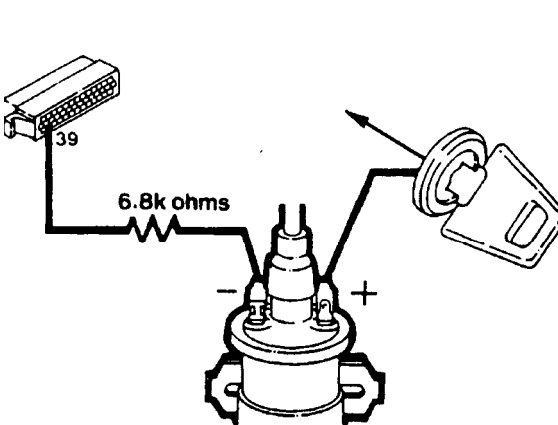
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>4. Fault Diagnosis Main relay circuits</p>	<p>A. Voltmeter reading of battery volts - Check:- If OK Suspect ECU</p> <p>B. Voltmeter reading of zero volts Check:-</p>
<p>4</p>  <p>RR1819E</p>	<p>A</p>  <p>B</p> 

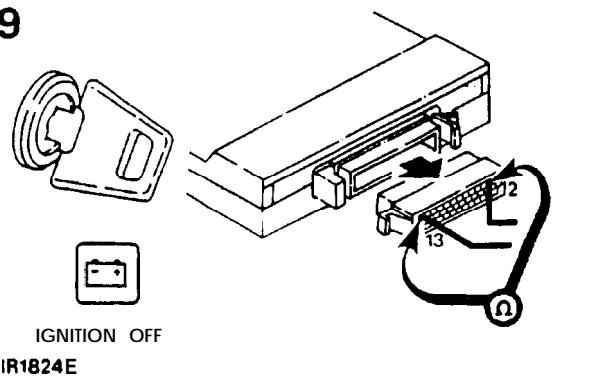
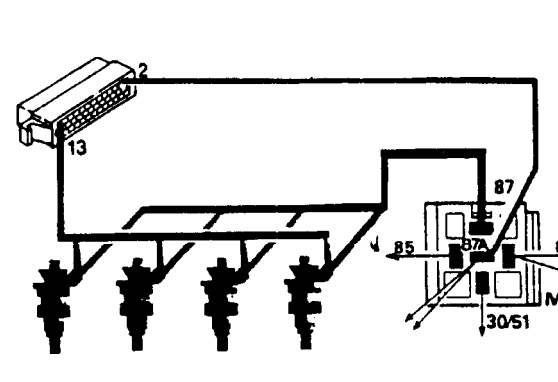
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>i. Check operation of pump relay</p>	<p>Listen for audible 'click' from pump relay. If O.K - Proceed to Test 7</p> <p>No audible 'click' from pump relay Check:- If OK proceed to Test 6.</p>
<p>5</p>  <p>RR1820E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>i. Fault diagnosis Pump relay circuits</p>	<p>Voltmeter reading of battery volts - Suspect ECU</p> <p>Voltmeter reading of zero volts Check:-</p>
<p>6</p>  <p>RR1821E</p>	

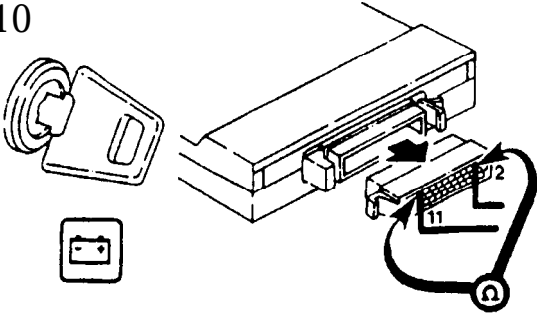
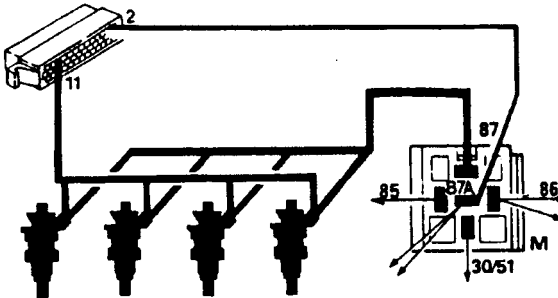
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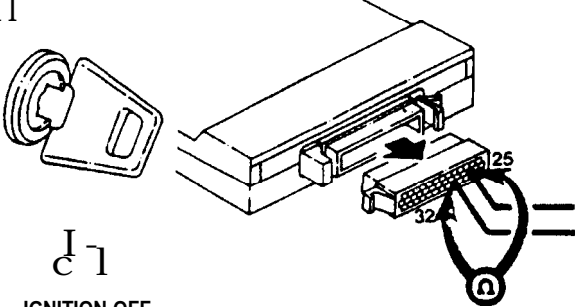
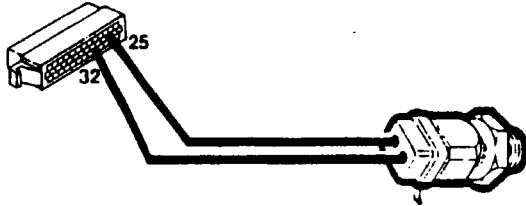
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>7. Check operation of Fuel pump</p> <p>NOTE: It is not possible to place the multi-meter probes directly onto the pump terminals. A link lead attached to the pump is accessible behind the rear left hand wheel located between the chassis and stowage area floor panel.</p> <p>KEY: 1. Inertia switch 2. Fuse 18</p>	<p>Voltmeter reading of battery volts - Pump operating - Proceed to Test 8</p> <p>(A) Voltmeter reading of battery volts - Pump not operating Check:-</p> <p>(B) Voltmeter reading of zero volts Check:-</p>
<p>7</p>  <p>RR1822E</p>	<p>A.</p>  <p>B.</p> 

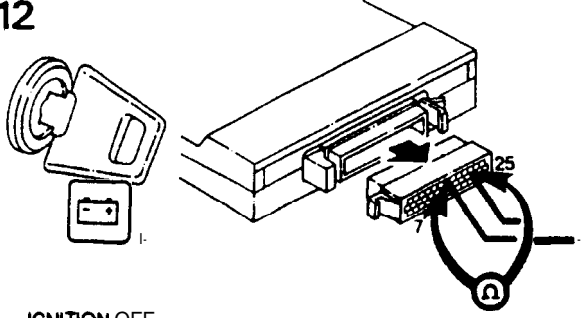
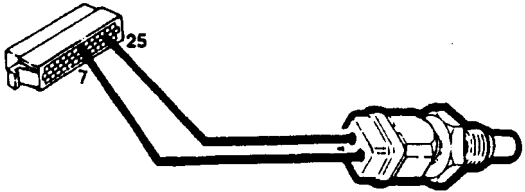
TESTPROCEDURE	RESULTS • Check cables and units shown in bold
<p>1. Check engine speed signal Cable and resistor</p>	<p>Voltmeter reading of battery volts - Proceed to Test 9</p> <p>Voltmeter reading of zero volts Check:-</p>
<p>8</p>  <p>IR1823E</p>	

TEST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>9. Check injectors, Injector circuit</p> <p>(Pin 13 left bank injectors 1,3,5,7).</p>	<p>Ohm-meter reading of 4-5 Ohms - Proceed to Test 10</p> <p>Ohm-meter reading of 5-6 Ohms • Suspect 1 injector Ohm-meter reading of 8-9 Ohms • Suspect 2 injectors Ohm-meter reading of 16-17 Ohms • Suspect 3 injectors Check for open circuit injector(s) or wiring faults.</p> <p>Ohm-meter reading of Infinity Check:</p>
<p>9</p>  <p>IR1824E</p>	

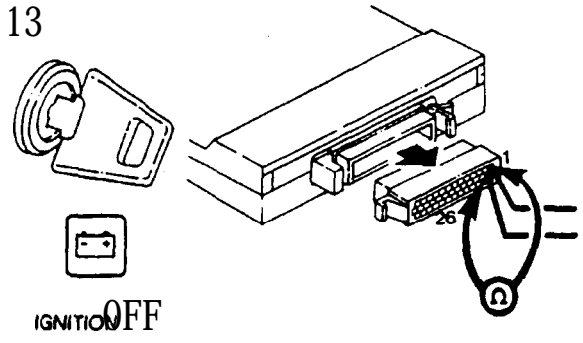
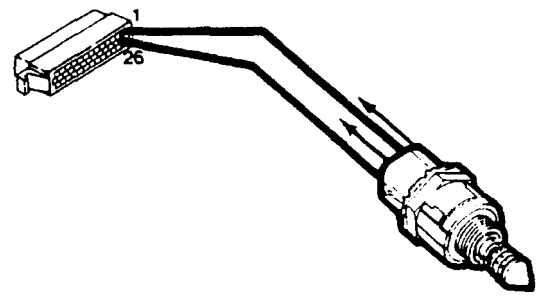
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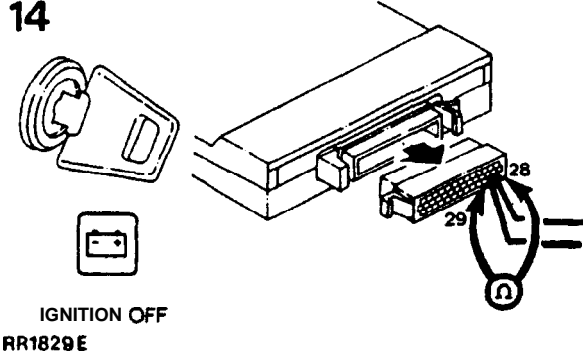
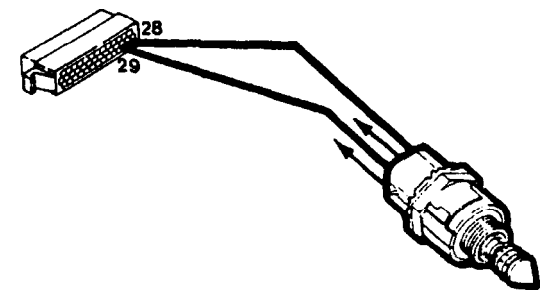
TESTPROCEDURE	RESULTS - Check cables and units shown in bold
<p>0. Check injectors Injector circuit</p> <p>pin 11 rightbank injectors 2,4,6,8)</p>	<p>Ohm-meter reading of 4-5 Ohms - Proceed to Test 11.</p> <p>Ohm-meter reading of 5-6 Ohms - Suspect 1 injector Ohm-meter reading of 8-9 Ohms - Suspect 2 injectors Ohm-meter reading of 16-17 Ohms - Suspect 3 injectors Check for open circuit injector(s) or wiring faults.</p> <p>Ohm-meter reading of Infinity Check:</p>
<p>10</p>  <p>IGNITION OFF RR1825E</p>	

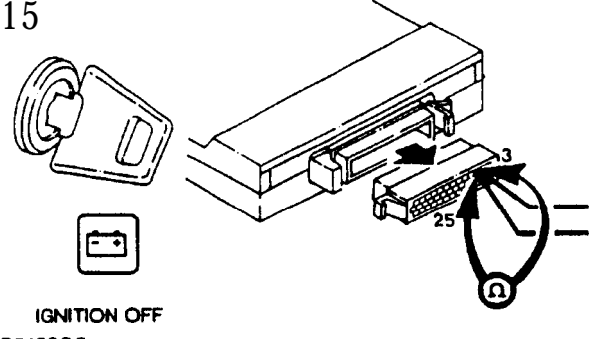
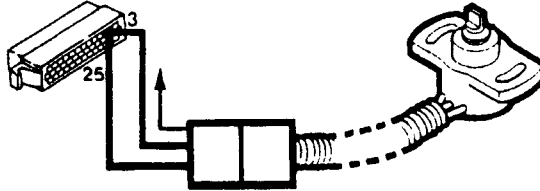
TESTPROCEDURE	RESULTS - Check cables and units shown in bold
<p>11. Check fuel temperature thermistor (sensor)</p>	<p>Correct reading-temperature to resistance - Proceed to Test 12 (Refer to Temperature Conversion Charts in Test 12)</p> <p>Incorrect Ohm-meter reading Check</p>
<p>11</p>  <p>IGNITION OFF RR1826E</p>	

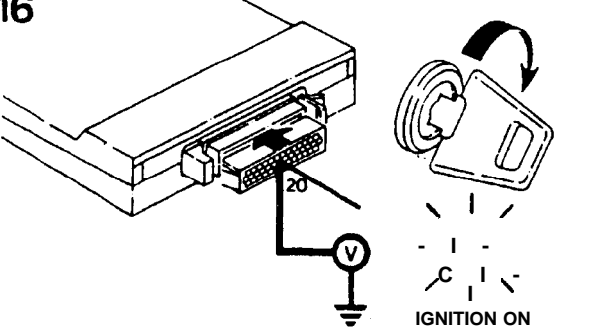
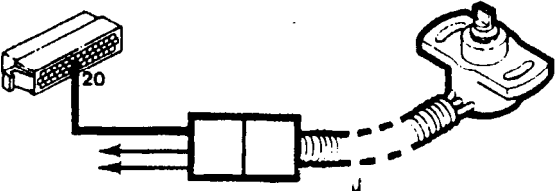
TESTPROCEDURE	RESULTS - Check cables and units shown in bold																											
<p>2. Check coolant temperature thermistor (sensor)</p>	<p>Correct reading-Temperature to resistance</p> <ul style="list-style-type: none"> • Proceed to Test 13 (Refer to Temperature Conversion Chart below. <table border="1" data-bbox="889 417 1417 697"> <thead> <tr> <th colspan="2">Fuel and Coolant Temperature</th> <th>Ohm-meter Reading Should be</th> </tr> <tr> <th>°C</th> <th>°F</th> <th>Ohms</th> </tr> </thead> <tbody> <tr> <td>-10°</td> <td>14°</td> <td>9100 - 9300</td> </tr> <tr> <td>0°</td> <td>32°</td> <td>5700 - 5900</td> </tr> <tr> <td>20°</td> <td>68°</td> <td>2400 - 2600</td> </tr> <tr> <td>40°</td> <td>104°</td> <td>1100 - 1300</td> </tr> <tr> <td>60°</td> <td>140°</td> <td>500 - 700</td> </tr> <tr> <td>80°</td> <td>176°</td> <td>300 - 400</td> </tr> <tr> <td>100°</td> <td>212°</td> <td>150 - 200</td> </tr> </tbody> </table> <p>Incorrect Ohm-meter reading Check:-</p>	Fuel and Coolant Temperature		Ohm-meter Reading Should be	°C	°F	Ohms	-10°	14°	9100 - 9300	0°	32°	5700 - 5900	20°	68°	2400 - 2600	40°	104°	1100 - 1300	60°	140°	500 - 700	80°	176°	300 - 400	100°	212°	150 - 200
Fuel and Coolant Temperature		Ohm-meter Reading Should be																										
°C	°F	Ohms																										
-10°	14°	9100 - 9300																										
0°	32°	5700 - 5900																										
20°	68°	2400 - 2600																										
40°	104°	1100 - 1300																										
60°	140°	500 - 700																										
80°	176°	300 - 400																										
100°	212°	150 - 200																										
<p>12</p>  <p>IGNITION OFF RR1827E</p>																												

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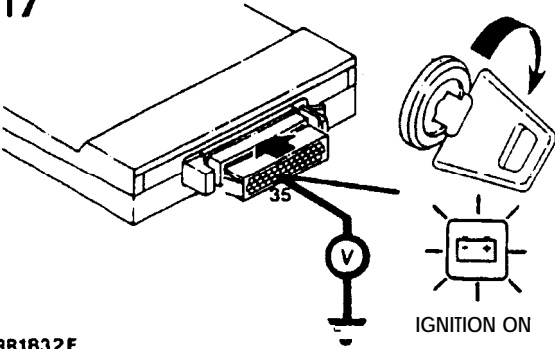
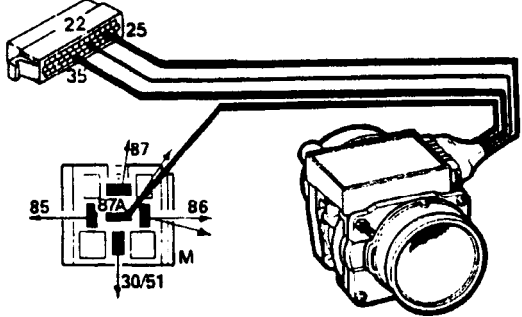
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>113. Check air bypass valve - Part 1</p>	<p>Ohm-meter reading of 48-58 Ohms - Proceed to Test 14</p> <p>Incorrect reading Check:-</p>
<p>13</p>  <p>IGNITION OFF RR1828E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>14. Check air bypass valve - Part 2</p>	<p>Ohm-meter reading of 48-58 Ohms - Proceed to Test 15</p> <p>Incorrect reading Check:-</p>
<p>14</p>  <p>IGNITION OFF RR1829E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
15. Check throttle potentiometer - Part 1	<p>Ohm-meter reading of 5000 Ohms - Proceed to Test 16</p> <p>Incorrect reading of Infinity Check:-</p>
<p>15</p>  <p>IGNITION OFF RR1830E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold															
16. Check throttle potentiometer - Part 2	<p>Correct voltmeter readings- Proceed to Test 17</p> <table border="0" style="width: 100%; text-align: center;"> <tr> <td style="width: 30%;">Throttle closed</td> <td style="width: 40%;"></td> <td style="width: 30%;">Throttle open</td> </tr> <tr> <td>0.29)</td> <td></td> <td>(4.6 Volts</td> </tr> <tr> <td>)</td> <td>smooth</td> <td>(</td> </tr> <tr> <td>)</td> <td>.....</td> <td>(</td> </tr> <tr> <td>0.36)</td> <td>swing</td> <td>(5.0 Volts</td> </tr> </table> <p>Incorrect voltmeter readings Check:-</p>	Throttle closed		Throttle open	0.29)		(4.6 Volts)	smooth	()	(0.36)	swing	(5.0 Volts
Throttle closed		Throttle open														
0.29)		(4.6 Volts														
)	smooth	(
)	(
0.36)	swing	(5.0 Volts														
<p>16</p>  <p>RR1831E</p>																

Continued

TEST PROCEDURE	RESULTS . Check cables and units shown in bold
<p>17. Check output of Airflow sensor</p>	<p>Voltmeter reading of 0.3-0.6 volts- Proceed to Test 18</p> <p>Incorrect voltmeter reading Check:-</p>
<p>17</p>  <p>RR1832E</p>	

PRECAUTION:

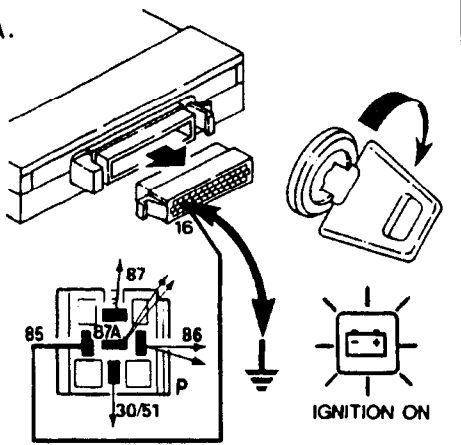
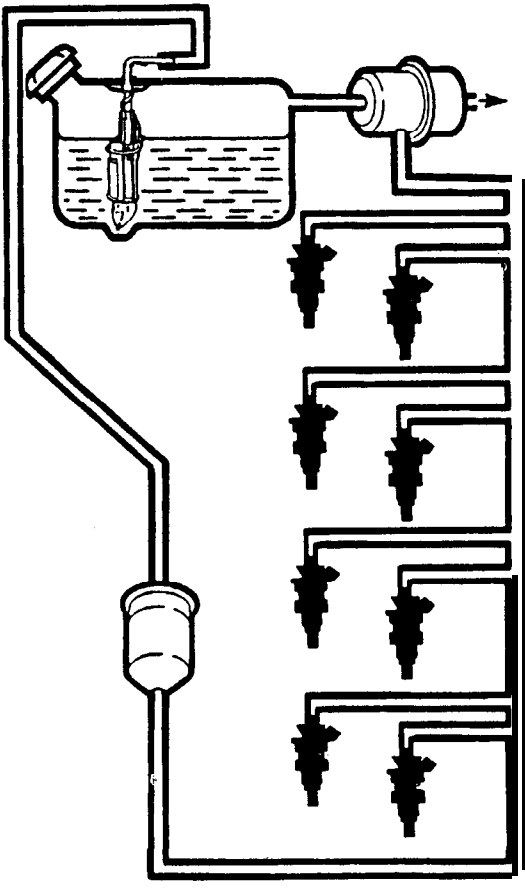
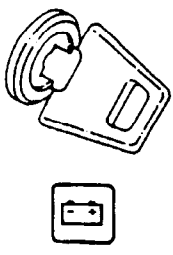
Depressurize the fuel system when fitting the fuel pressure gauge or disconnecting/replacing fuel system components.

CAUTION: Thoroughly clean the immediate area around the fuel filter and hose connections before disconnecting the fuel feed line from the filter. Failure to do so could cause foreign matter to be present in the fuel system which would be detrimental to the fuel system components.

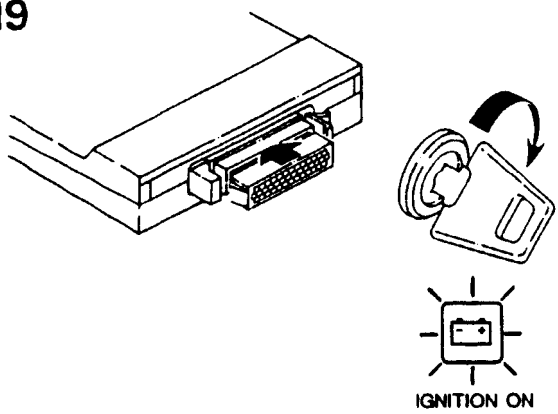
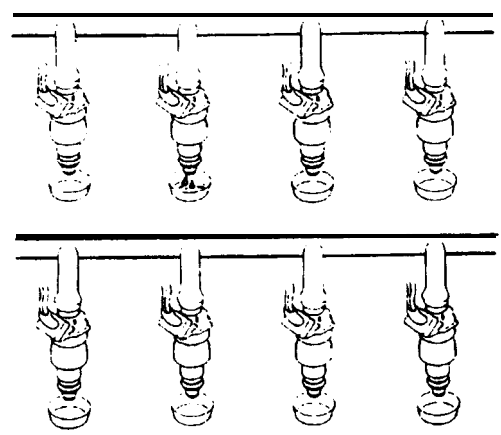
WARNING: The spillage of fuel from the fuel filter is unavoidable when disconnecting the fuel feed line, ensure that all necessary precautions are taken to prevent fire and explosion due to fuel vapour and fuel seepage.

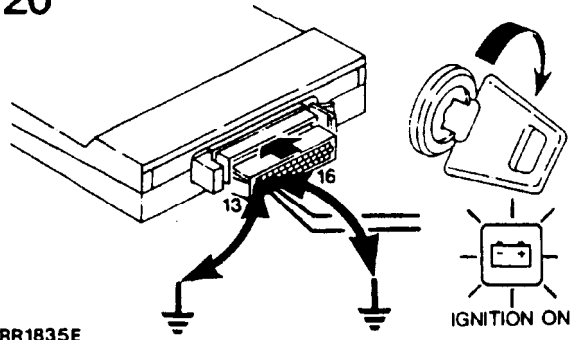
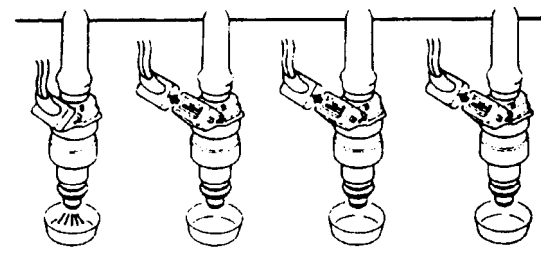
DEPRESSURIZING PROCEDURE

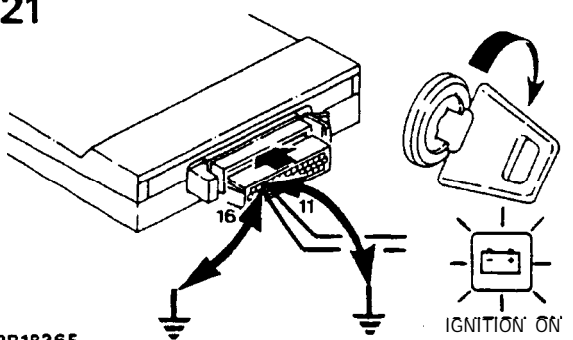
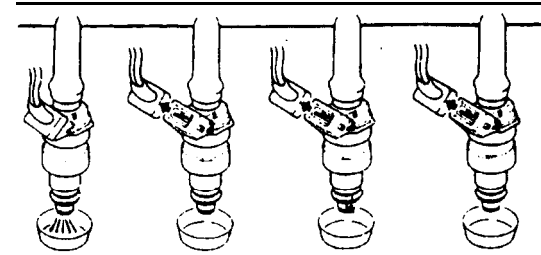
- a) Ignition off, pull pump relay off its terminal block.
- b) Crank engine for a few seconds - engine may fire and run until fuel pressure is reduced.
- c) Switch off the ignition.
- d) Connect fuel pressure gauge in the fuel supply line between the fuel rail and the fuel filter, adjacent to the filter (see Test 18).
- e) Reconnect the pump relay.

EST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>18. Check fuel system pressure Service tool 18G 1500</p> <p>NOTE: Insert the pressure gauge in the fuel feed line immediately after the fuel line filter. The filter is located beneath the right hand rear wheel arch attached to the chassis</p>	<p>(A) Expected reading 2,4-2,6 kg/cm² (34.0-37.0 p.s.i.)</p> <p>(B) Pressure drop-max 0.7 kg/cm² (10 p.s.i.) in one minute</p>
<p>18</p> <p>A.</p> 	
<p>B.</p>  <p>IGNITION OFF</p> <p>R1833E</p>	

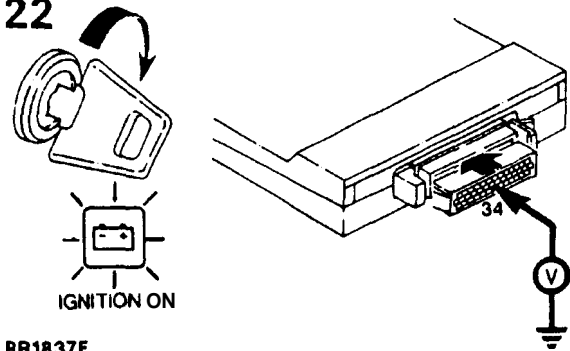
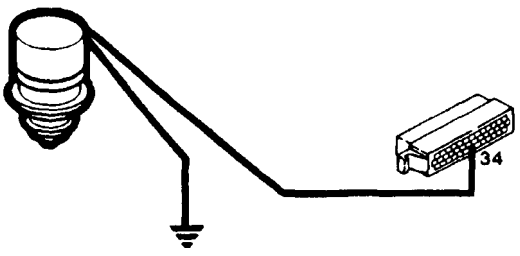
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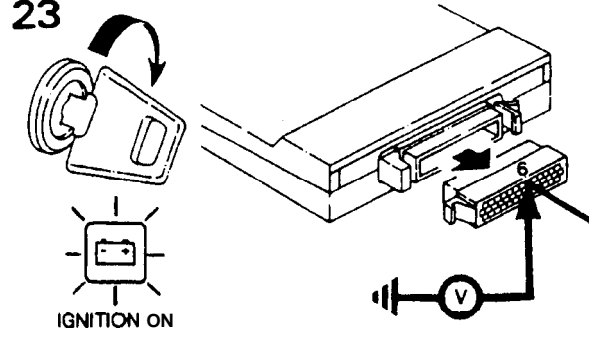
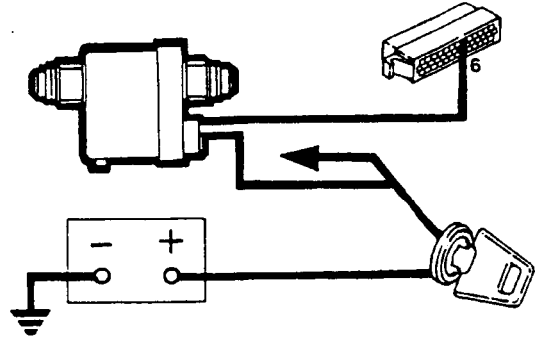
ESTPROCEDURE	RESULTS • Check cables and units shown in bold
<p>9. Check for leaking injector</p> <p>NOTE: Before removing any of the injectors, remove and examine the spark plugs. check for consistent colouration of plugs. A leaking injector will result in the appropriate spark plug being 'sooted up'.</p> <p>Remove all injectors from manifold but do not disconnect from fuel rail</p>	<p>WARNING: Ensure that all necessary precautions are taken to prevent fire and explosion.</p> <p>Replace any injector which leaks more than 2 drops of fuel per minute.</p>
<p>19</p>  <p>IR1834E</p>	

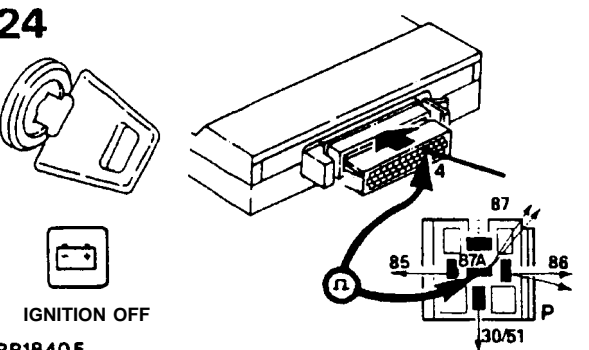
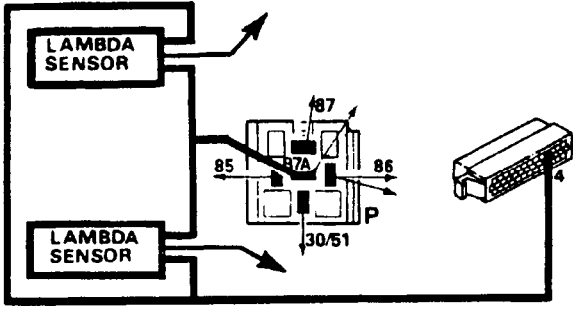
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>20. Check for injector operation Left bank injectors 1,3,5,7</p>	<p>WARNING: Ensure that all necessary precautions are taken to prevent fire and explosion.</p> <p>Repeat test for other injectors Replace any injector which does not operate.</p> <p>NOTE: Fuel flow is 167cc minimum per minute per injector</p>
<p>20</p>  <p>RR1835E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>21. Right bank injectors 2,4,6,8</p>	<p>WARNING: Ensure that all necessary precautions are taken to prevent fire and explosion.</p> <p>Repeat test for other injectors Replace any injector which does not operate.</p> <p>NOTE: Fuel flow is 167cc minimum per minute per injector</p>
<p>21</p>  <p>RR1836E</p>	

Continued

TESTPROCEDURE	RESULTS • Check cables and units shown in bold
<p>22. Check gear switch input</p>	<p>Voltmeter reading of zero volts- Neutral and park</p>
	<p>Voltmeter reading of 4.5-5.0 Volts -R.D.3.2.1- Proceed to Test 23</p>
<p>22</p>  <p>IGNITION ON</p> <p>RR1837E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>23. Check road speed input</p> <p>NOTE: Raise and rotate the left hand rear road wheel slowly</p>	<p>Voltmeter reading of 0 to 12V fluctuating 6 times per revolution - Proceed to Test 24</p> <p>Incorrect reading Check:</p>
<p>23</p>  <p>IGNITION ON</p> <p>RR1838E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>24. Check Lambda sensor heater coils</p> <p>NOTE: Remove pump relay from its connector</p>	<p>Ohm-meter reading of 2.65-3.35 Ohms</p> <p>Incorrect reading Check:</p> <p>NOTE: A reading of 5.3 to 6.7 Ohms indicates a faulty Lambda sensor</p>
<p>24</p>  <p>IGNITION OFF</p> <p>RR1840E</p>	

After completing the tests with either the 'Diagnostic' equipment or multi-meter, re-test the vehicle to ensure the faults have been rectified. If faults still persist, recheck using the Lucas diagnostic equipment.

ENGINE TUNING PROCEDURE

Before carrying out 'Engine Tuning' on fuel injection vehicles, it is important that all other engine related setting procedures are undertaken first; air flow sensor to air cleaner correctly fitted, ignition and throttle potentiometer correctly set; all hoses correctly fitted and secured.

These checks should be carried out with the engine coolant temperature between 80° to 95°C (176° to 203°F).

CHECK AND ADJUST IGNITION TIMING

1. Check that ignition timing is at $6^{\circ} \pm 1^{\circ}$ BTDC.
2. Timing to be checked when engine speed is less than 800 rev/min using a stroboscopic lamp.
3. If adjustment is necessary, loosen the distributor clamp nut and rotate clockwise to retard or counter-clockwise to advance. When the required setting has been attained, tighten the clamp nut and recheck the setting.

NOTE: Timing to be checked with vacuum hose connected.

IDLE SPEED is preset at the factory and should not normally require adjustment.

CAUTION:

- A. If engine fails to start within a maximum time of 12 seconds the cause must be rectified. Following rectification the engine must be run at 1500 rpm (no load) for 3 minutes to clear any accumulation of fuel in the catalyts.
- B. If the engine is misfiring, it should be immediately shut down and the cause rectified.

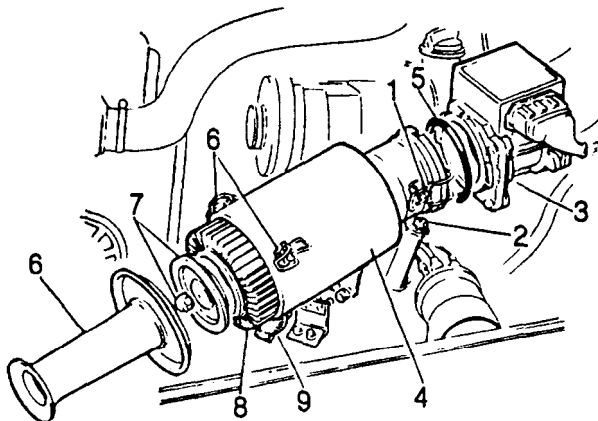
Failure to comply with A or B will result in irreparable damage to the catalyts.

AIR CLEANER

Remove and Refit

Removing

1. Release the two clamps securing the air cleaner to the airflow sensor.
2. Release the two nuts and bolts securing the air cleaner to the left hand valance mounting bracket.
3. Detach the airflow sensor from the air cleaner, and lay carefully to one side.
4. Detach the air cleaner from the centre mounting bracket and withdraw from the engine compartment.
5. Remove the large 'O' ring from the outlet tube of the air cleaner, inspect for condition, fit a new 'O' ring if in poor condition.
6. Unclip the three catches securing the inlet tube to the air cleaner canister and remove the inlet tube.
7. Remove the nut and end plate securing the air cleaner element in position.
8. Withdraw the air cleaner element and discard.
9. Inspect the dump valve for condition and that it is clear of obstructions.



RR1854E

Refitting

10. Fit a new element and secure in position.
11. Refit the inlet tube to the air cleaner canister.
12. Refit the air cleaner to the mounting bracket and tighten the two nuts and bolts.
13. Clip the air flow sensor to the air cleaner.

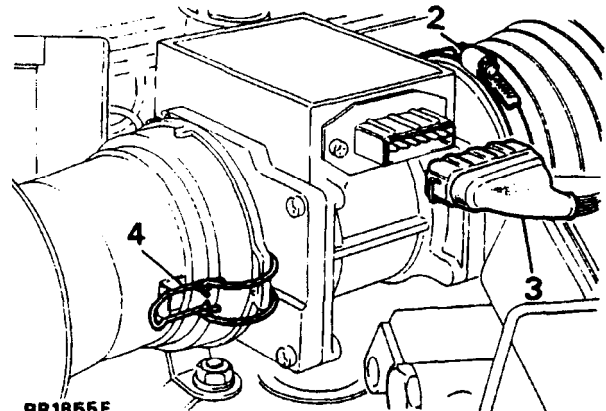
AIR FLOW SENSOR

Remove and refit

Removing

NOTE: The air flow sensor is not a serviceable item. In the event of failure or damage the complete unit is to be replaced.

1. Disconnect the battery negative terminal.
2. Release the large hose clamp at the rear of the air flow meter and disconnect the hose from the sensor.
3. Disconnect the multi-plug.
4. Release the two clips securing the air flow sensor to the air cleaner case detach the sensor from the case and withdraw it from the engine compartment.



RR1855E

Refitting

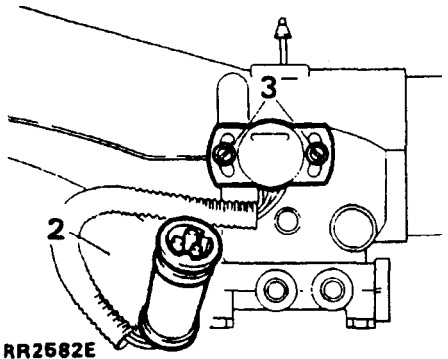
5. Reverse the removal procedure ensuring that the multi-plug is firmly reconnected to the air flow sensor and that the hose clamp at the rear of the sensor is securely tightened, to prevent un-metered air entering the engine.

THROTTLE POTENTIOMETER

Remove, refit and reset

Remove

1. Disconnect the battery negative terminal.
2. Disconnect the electrical three-pin plug.
3. Remove the two screws securing the switch to the plenum chamber and carefully pull the switch off the throttle valve shaft.



4. Remove the old gasket.

Refit

5. Fit a new gasket between the throttle switch and plenum chamber.
6. Align the switch and shaft flats; slide the switch *on* to the throttle shaft and secure the switch to the plenum chamber.
7. The throttle potentiometer must be reset using the following procedure.

CAUTION: The throttle mechanism must not be operated while the potentiometer is loosely fitted, otherwise damage may be caused to the potentiometer wiper track.

Setting the Potentiometer using a multi meter.

ENSURE THE MULTI METER USED TO CARRY OUT THIS CHECK IS SET TO VOLTS. A MULTI METER SETTING OTHER THAN VOLTS WILL RESULT IN DAMAGE TO THE POTENTIOMETER.

8. Loosen the potentiometer securing screws.
9. Reconnect the potentiometer three-pin plug and reconnect the battery. Switch on the ignition.
10. Connect the multi meter between the red and green leads at the potentiometer electrical plug.
11. Rotate the potentiometer clockwise or counter-clockwise, until the multi meter reads 325 ± 35 mV.
12. Tighten the potentiometer securing screws.
13. Re-check the multi-meter reading. Check also for a 'smooth swing' of the meter needle between minimum and maximum throttle opening between the voltage reading of 4.6 - 5.0 volts

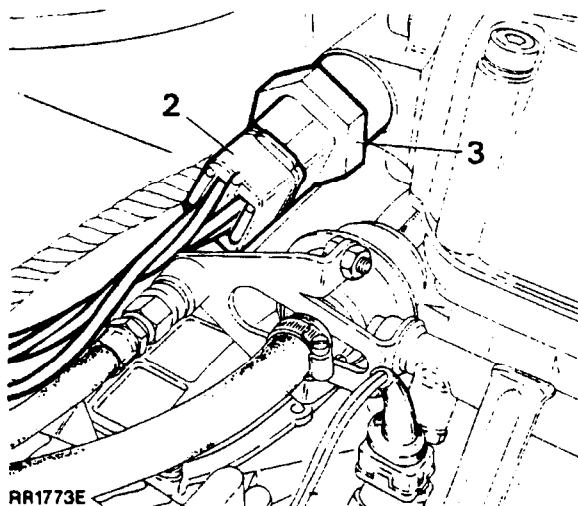
NOTE: After setting the potentiometer, lock and tamperproof each screw head by coating them with yellow paint.

**BY-PASS AIR VALVE
(STEPPER MOTOR)**

Remove and refit

Removing

1. Disconnect the battery negative terminal.
2. Remove the multi-plug from the unit.
3. Unscrew the valve from its location at the rear of the plenum chamber.
4. Remove the captive washer.



Refitting

5. Fit a NEW sealing washer.

NOTE: If the same by-pass valve is being refitted clean any previous sealing compounds from the threads. Apply Loctite 241 to threads of the valve before reassembly.

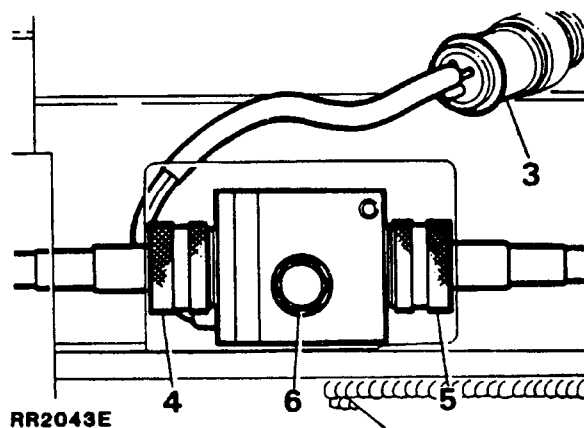
6. Tighten the valve to the specified torque (see Torque values-section 06).
7. Reverse the remaining removal instructions.

SPEED TRANSDUCER

Remove and refit

Removing

1. Place the vehicle on a hydraulic hoist and apply the parking brake.
2. Disconnect the battery negative terminal.
3. Raise the hoist and disconnect the speed transducer electrical plug.
4. Disconnect the speedometer cable from the transducer to the binnacle at the transducer.
5. Disconnect the speedometer cable from the transducer to the speedometer housing at the transducer.
6. Remove the single bolt securing the transducer to its mounting bracket and withdraw the unit from the vehicle.



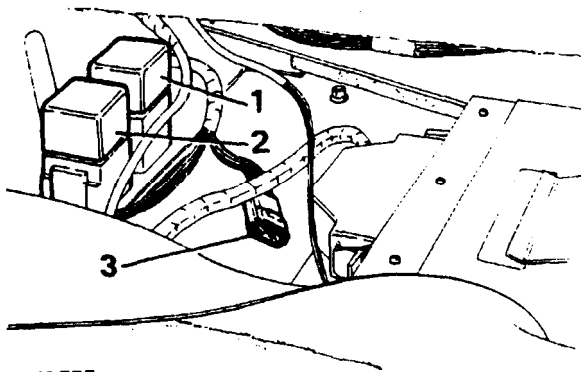
Refitting

7. Reverse the removal instructions.

ELECTRONIC FUEL INJECTION RELAYS

incorporated into the fuel injection electrical circuits are two relays. The relays are located beneath the front right-hand seat, adjacent to the E.C.U.

1. Fuel pump relay (mounted on a blue terminal block).
2. Main relay (mounted on a black terminal block).
3. Diagnostic plug.



RR1857E

Remove and refit

Removing

1. Disconnect the battery negative terminal.
2. Pull the relay(s) from the multi-plug(s).

Refitting

3. Reverse the removal procedure.

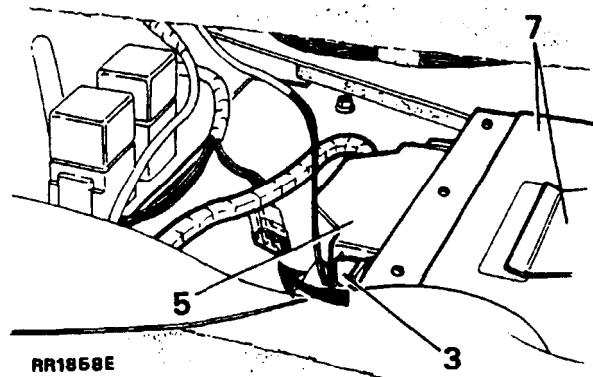
ELECTRONIC CONTROL UNIT-ECU

NOTE: The ECU is not itself a serviceable item, in the event of a unit failure, the ECU must be replaced.

Remove and refit

Removing

1. Disconnect the battery negative terminal.
2. The ECU is located under the front right hand seat and is accessible through the rear opening of the seat base when the seat is in its most forward position.
3. Release the E.C.U plug retaining clip.
4. Pull the rear of the multi-plug out of the ECU.
5. Maneuver the front of the plug (in the direction of the bold arrow) to release the hooked rear end of the plug from the retaining peg.
6. Release the screws securing the ECU to the mounting bracket.
7. Withdraw the ECU from the spring clip and remove it from the vehicle.



RR1858E

Refitting

8. Refit the E.C.U. securely in the spring clip and tighten the two screws.
9. Re-connect the E.C.U. harness plug, ensure the plug is firmly pushed into its location and that the retaining clip secures the plug in position.

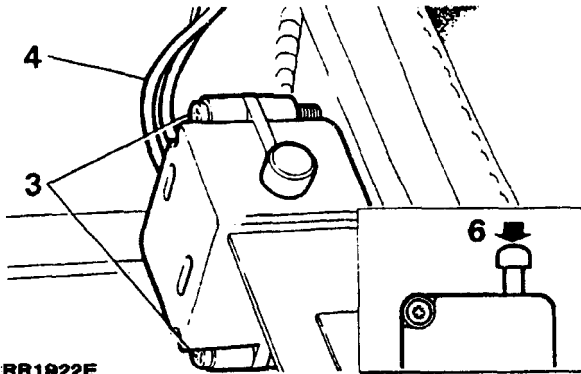
INERTIA SWITCH

The inertia switch is located under the left hand front seat attached to the inner face of the rear front seat base. Access to the switch is gained through the opening at the rear of the seat base.

Remove and refit

Removing

1. Ensure the seat is in its fully forward position.
2. Disconnect the battery negative terminal.
3. Remove the two screws securing the switch to the cross member.
4. Withdraw the switch and disconnect the electrical multi-plug.
5. Remove the switch from the vehicle.



RR1922E

Refitting

6. Reverse the removal procedure ensuring that the multi-plug clips firmly into position, and that the plunger is reset (plunger is in its lowest position).

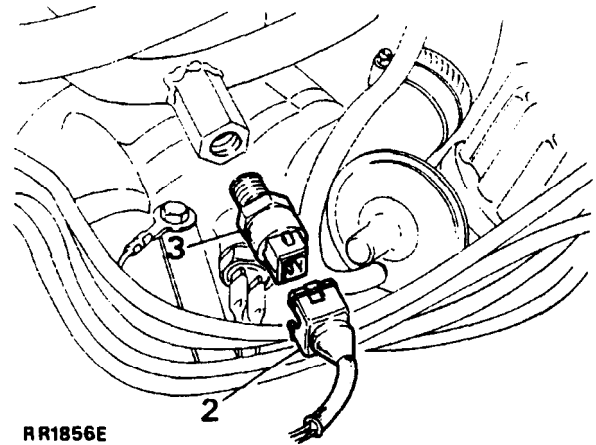
FUEL TEMPERATURE THERMISTOR (SENSOR)

Remove and refit

Removing

NOTE: No fuel leakage will occur when the thermistor is removed from the fuel rail therefore it is not necessary to depressurize the fuel system before removal.

1. Disconnect the battery negative terminal.
2. Remove the electrical multi - plug from the thermistor.
3. Release the thermistor from the fuel feed rail.



RR1856E

Refitting

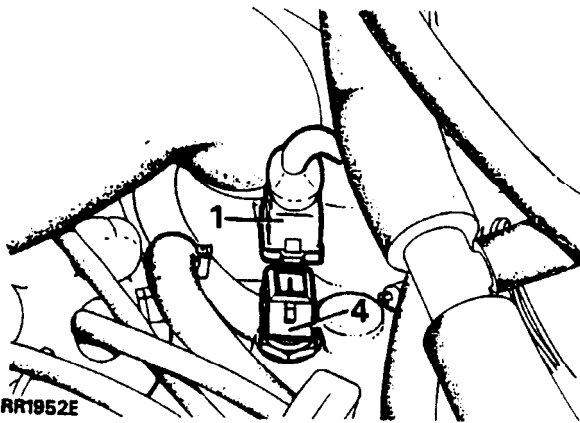
4. Reverse the removal procedure, ensuring that the thermistor is tightened securely in the fuel rail.

COOLANT TEMPERATURE THERMISTOR (SENSOR)

Remove and refit

Removing

1. Remove the multi-plug from the thermistor.
2. Release the radiator bottom hose and partially drain the cooling system.
3. Refit the hose and tighten the clamp securely.
4. Remove the thermistor from the left hand front branch of the intake manifold.
5. Remove the copper washer.



RR1952E

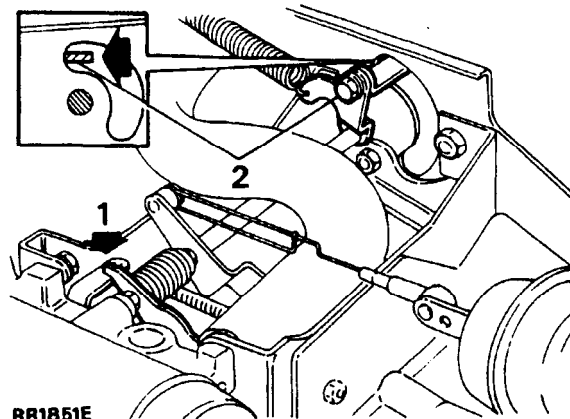
Refitting

6. Fit a NEW copper washer to the thermistor.
7. Fit the thermistor to the intake manifold and tighten securely.
8. Refill the cooling system.
9. Run the engine, check for water leaks around the coolant temperature thermistor.

RESETTING THROTTLE LEVERS

NOTE: The setting procedure outlined is applicable at minimum throttle condition only.

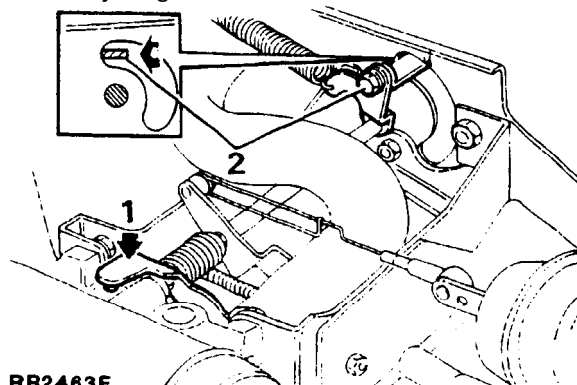
1. Ensure that the throttle valve is retained at its 90° vertical setting by holding down the stop lever and throttle/kick down lever denoted by the bold arrow while adjusting the throttle operating levers.
2. Release the throttle operating lever securing screw and adjust the lever until contact is made with the top end of the slot in the throttle lever mounting bracket; retaining the lever in this position retighten the screw.
3. Lightly grease all throttle lever bearing surfaces and torsion spring with Admax 13 grease or a suitable equivalent.



RR1851E

NOTE: Check the clearance between the cruise control actuator link and throttle lever (see Cruise Control Actuator Setting-Section 19, Page 47).

LATER MODELS:- have a redesigned stop lever that seats on a factory-set adjustment screw which is located in the plenum chamber casting. The screw should not normally require adjustment. If new throttle bracketry and linkages are fitted it is advisable to check that the throttle valve is vertical before adjusting the screw.



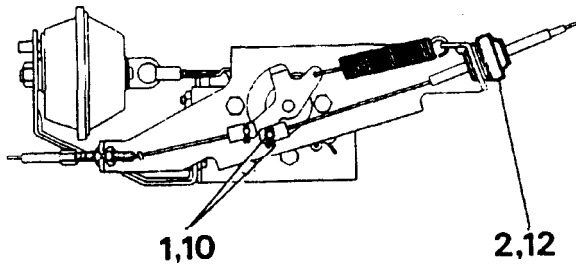
RR2463E

THROTTLE CABLE

Remove and refit

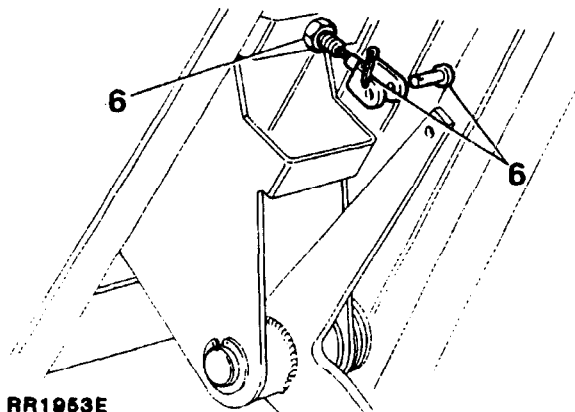
Removing

1. Remove the cotter pin and clevis pin securing the cable to the lever.
2. Carefully pry the throttle cable adjustment nut out of the linkage mounting bracket.
3. Withdraw the cable from the mounting bracket.



RR1964E

4. Release the outer cable from the retaining clips within the engine compartment.
5. Remove the lower dash panel from beneath the steering column.
6. Disconnect the cable from the throttle pedal and release the cable locknut.
7. Feed the cable through the bulkhead grommet and into the engine compartment.



RR1963E

FIT NEW THROTTLE CABLE

8. Feed the new cable from the engine compartment through the bulkhead grommet.
9. Connect the cable to the throttle pedal.

10. Connect the cable to the throttle linkage, fit a new cotter pin and secure in position.
11. Clip the outer cable adjustment nut into the mounting bracket.
12. Adjust the outer cable to give 1.57 mm (0.062 in) free play in the throttle cable and check the throttle operation.

THROTTLE PEDAL

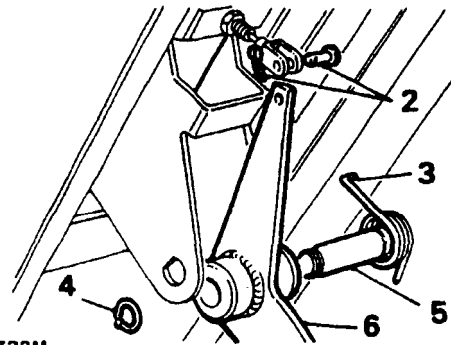
Remove and refit

Remove

1. Release the six screws securing the lower dash panel, lower the panel and disconnect the two electrical leads to the rheostat switch, detach the bulb check unit from the spring clip and remove the dash panel from the vehicle.
2. Remove the cotter pin and clevis pin securing the throttle cable to the throttle pedal.
3. Release the tension from the pedal return spring.
4. Remove the circlip from the pedal pivot pin.
5. Withdraw the pivot pin.

NOTE: It may be necessary to remove the steering column fixings enabling the column to be lowered to gain access to the pedal pivot pin circlip.

6. Withdraw the throttle pedal.



RR 732M

Refitting

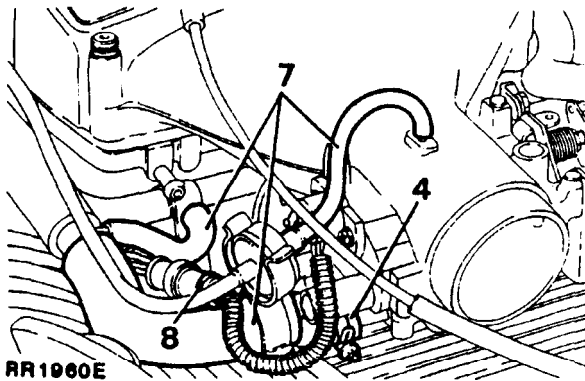
7. Lightly grease the pivot pin and clevis pin before re-assembly.
8. Fit a NEW cotter pin to the clevis pin.
9. Reverse the remaining removal instructions.

PLENUM CHAMBER

Remove and refit

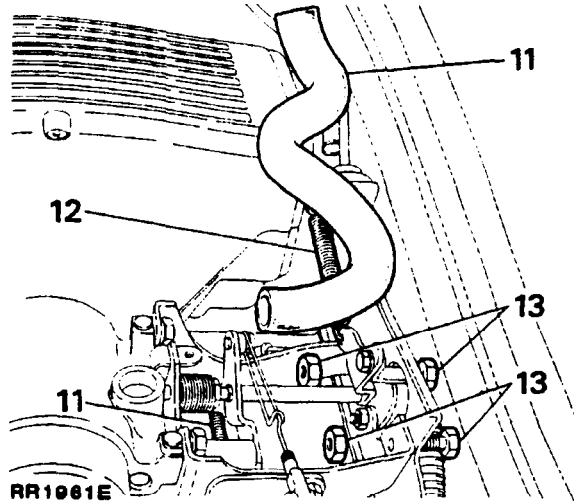
Removing

1. Disconnect the battery negative terminal.
2. Release the radiator bottom hose and partially drain the cooling system, reconnect the hose to the radiator.
3. Release the two large hose clamps from the neck of the plenum chamber and outlet bore of the airflow sensor and remove the hose from its location.
4. Release the clamps and remove the two coolant hoses from the bottom of the plenum chamber inlet neck. Identify each hose to aid re-assembly.
5. Remove the vacuum supply hose from the cruise control actuator.
6. Disconnect the actuating link at the cruise control actuator.
7. Remove the distributor vacuum hose, positive crankcase ventilation breather filter hose and servo hose.
8. Disconnect the throttle potentiometer multi-plug.



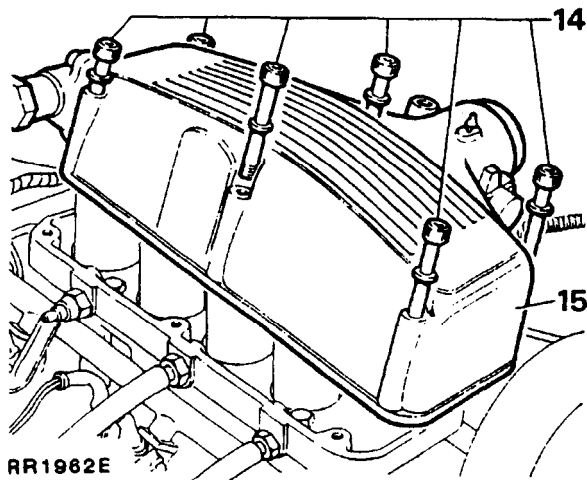
9. Disconnect the multi-plug from the air by-pass valve.
10. Disconnect the small vacuum hose at the rear of the plenum chamber, located below the air by-pass valve.
11. Remove the hose from the air by-pass valve to plenum chamber to enable the small return spring located below the throttle levers to be unhooked.

12. Release the two throttle return springs.
13. Remove the two bolts (with spring washers) securing the throttle cable and kick-down cable anchor bracket to the throttle lever support bracket, lay the assembly to one side.



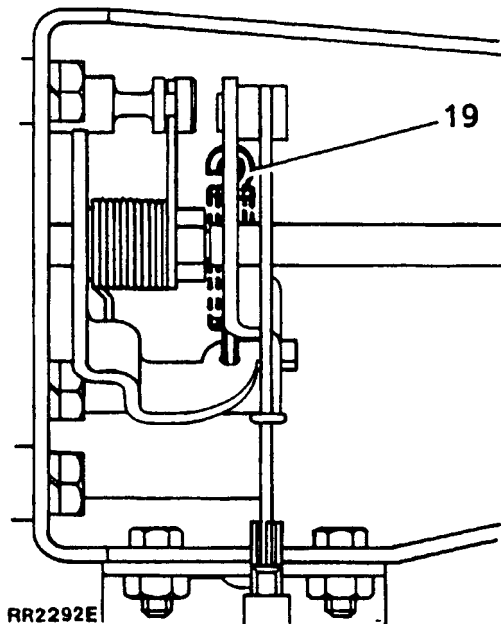
14. Remove the six socket head bolts (with plain washers) securing the plenum chamber to the ram housing.
15. Maneuver the plenum chamber and remove it from the ram housing.

NOTE: To prevent ingress of dirt into the ram tubes, place a protective cover over the ram tube openings.



Refitting

16. Ensure that all mating faces are free from any previous sealing compounds.
17. Coat the mating faces of the plenum chamber and ram housing with 'Hylomar' sealant.
18. Refit the plenum chamber and tighten the six bolts to the specified torque (see torque values-section 06).
19. When refitting the small return spring, item 11 in the removal procedure, it must be noted that the 'hooked' open end of the spring **MUST** face the plenum chamber as shown in illustration RR2292E below.



20. Reverse the remaining removal instructions.

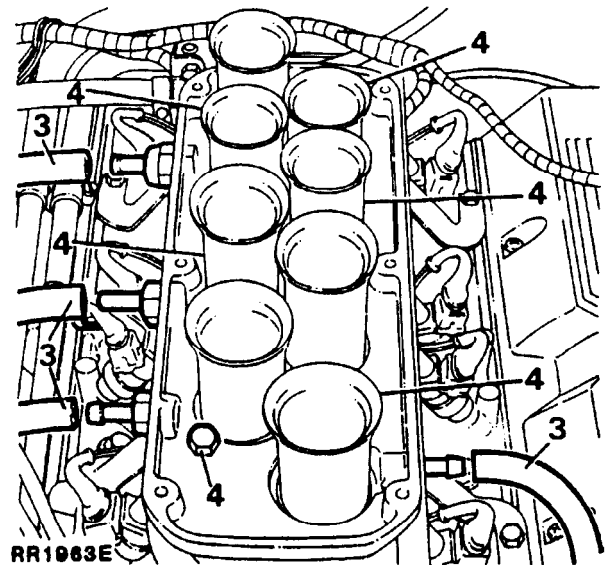
NOTE: Ensure that all hoses are connected securely to prevent un-metered air entering the engine.

RAM HOUSING

Remove and refit

Removing

1. Disconnect the battery negative terminal.
2. Remove the plenum chamber (see Plenum Chamber remove and refit).
3. Release the hoses from around the outer edges of the ram housing.
4. Remove the six through bolts (with plain washers) securing the ram housing to the intake manifold.



5. Lift the ram housing off the intake manifold and remove it from the engine compartment.
6. Place a protective cover over the top of the intake manifold inlet bores to prevent ingress of dirt.

Refitting

7. Ensure that all mating faces are clean and free from dirt and **any** previous sealing compounds.
8. Apply 'Hylomar' sealant to the intake manifold face before refitting the ram housing.
9. Fit the ram housing and retighten the bolts, working from the two centre bolts, **diagonally** towards the outer four bolts.
10. Tighten to the correct torque (See section 06-Torque values).

DEPRESSURIZING THE FUEL SYSTEM

WARNING: Under normal operating conditions the fuel injection system is pressurized by a high pressure fuel pump, operating at up to 2.3 to 2.5 bar (34 to 37 p.s.i.). When the engine is stationary this pressure is maintained within the system. To prevent pressurized fuel escaping and to avoid personal injury it is necessary to depressurize the fuel injection system before any service operations are carried out.

NOTE: If the vehicle has not been run there will still be a small amount of residual pressure in the fuel line. The depressurizing procedure must still be carried out before disconnecting the component within the fuel system.

WARNING: The spilling of fuel is unavoidable during this operation. Ensure that all necessary precautions are taken to prevent fire and explosion.

1. The fuel pump relay is located under the front right hand seat.
2. Pull the fuel pump relay off its multi-plug (see Electronic Fuel Injection Relays-Section 19, Page 28).
3. Start and run the engine.
4. When sufficient fuel has been used up causing the fuel line pressure to drop, the injectors will become inoperative, resulting in engine stall. Switch the ignition off.
5. Disconnect the battery negative terminal.

NOTE: Fuel at low pressure will remain in the system. To remove this low pressure fuel, place an absorbent cloth around the fuel feed hose at the fuel rail and release the fuel feed hose at the appropriate end.

6. Disconnect either:
 - a) The nut and ferrule at the fuel rail
 - OR
 - b) The hose at the inlet end of the fuel filter.

Refitting

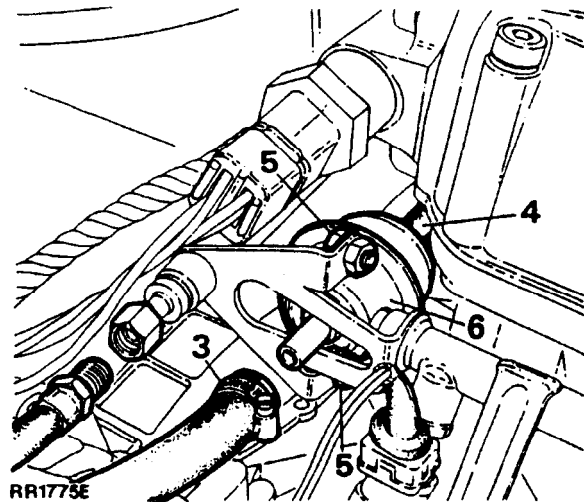
7. Refit the fuel feed hose.
8. Refit the fuel pump relay, reconnect the battery.
9. Crank the engine (engine will fire within approximately 6 to 8 seconds).

FUEL PRESSURE REGULATOR

Remove and refit

Removing

1. Depressurize the fuel system.
2. Disconnect the negative battery terminal.
3. Release the hose clamp securing the fuel return hose to the regulator and remove the hose.
4. Pull the vacuum hose from the rear of the regulator.
5. Remove the two nuts and bolts securing the regulator to the fuel rail, carefully ease the regulator fuel inlet pipe out of the fuel rail.
6. Withdraw the regulator from the engine compartment.



NOTE: If the original regulator is being refitted, fit a NEW 'O' ring to the fuel inlet pipe.

Refitting

7. Lightly coat the 'O' ring with silicon grease 300 before fitting the regulator to the fuel rail.
8. Reverse the removal procedure.
9. Reconnect the battery, and pressurize the fuel system and check that there are no fuel leaks around the regulator connections.

FUEL RAIL-INJECTORS R/H AND L/H

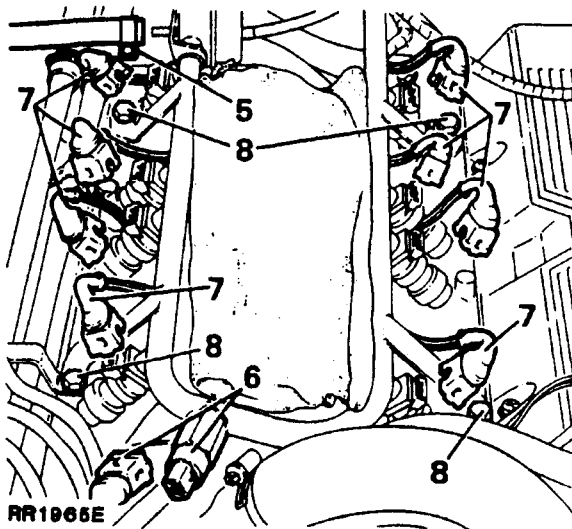
Remove and refit

Removing

1. Depressurize the fuel system.
2. Disconnect the negative battery terminal.
3. Remove the plenum chamber. (See Plenum Chamber, remove and refit).
4. Remove the ram housing. (See Ram Housing remove and refit).

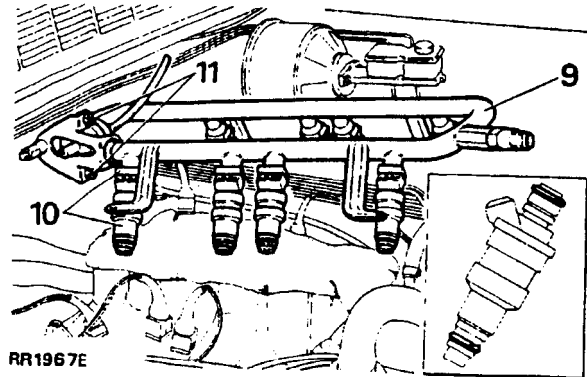
NOTE: Place a cloth over the ram tube openings to prevent ingress of dirt into the engine.

5. Release the hose clamp and remove the fuel return hose from the pressure regulator.
6. Disconnect the multi-plug from the fuel temperature thermistor (sensor).
7. Disconnect the multi-plugs from the eight injectors.
8. Remove the five bolts securing the fuel rail support and heater pipe brackets to the intake manifold. Lay the heater pipes to one side.



9. Remove the fuel rail, complete with injectors, from the intake manifold.
10. Remove the retaining clips securing the injectors to the fuel rail, ease the injectors from the rail.

11. If necessary, remove the two nuts and bolts securing the regulator to the fuel rail, and carefully pull the regulator away from the rail.



Refitting

12. Fit NEW 'O' rings, protective cap and supporting disc to the injectors, lightly coat the 'O' rings with silicon grease 300 and insert the injectors into the fuel rail, multi-plug connections facing outwards.
13. Refit the retaining clips.

CAUTION: Care must be taken when refitting the fuel rail and injectors to the intake manifold to prevent damage occurring to the 'O' rings.

14. Fit a NEW 'O' ring to the pressure regulator lightly coat the 'O' ring with silicon grease 300 and secure the regulator to the fuel rail.
15. Fit the fuel rail and heater pipe assemblies to the intake manifold, secure the rail and pipes in position with the five bolts.
16. Reverse the remaining removal instructions.
17. Pressurize the fuel system and check for fuel leaks around the injectors and pressure regulator.

INTAKE MANIFOLD

Remove and refit

Removing

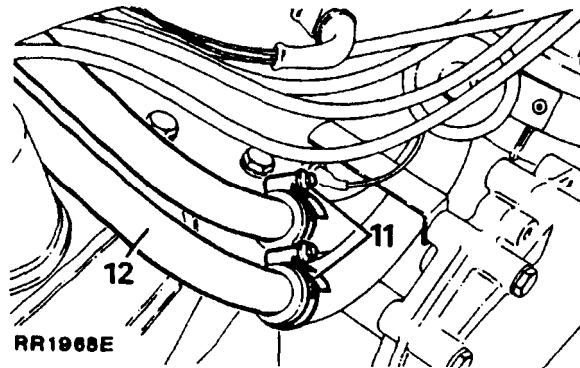
1. Depressurize the fuel system.
2. Disconnect the battery negative terminal.
3. Release the hose clamp and remove the radiator bottom hose to enable the cooling system to be partially drained, so that coolant level is below the thermostat housing, refit the hose and secure in position with the hose clamp.
4. Remove the plenum chamber (see Plenum Chamber, remove and refit).
5. Remove the ram housing (see ram housing remove and refit).

CAUTION: Place a protective cover over the intake manifold openings to prevent ingress of dirt.

6. Disconnect the electrical multi-plugs to the fuel temperature thermistor (sensor), coolant temperature thermistor (sensor) and injectors.
7. Remove the two nuts and bolts securing the pressure regulator to the fuel rail, ease the regulator out of the rail, seal the end of the fuel rail with suitable plastic plugs to prevent ingress of dirt.

NOTE: The intake manifold can be removed from the cylinder block without removing the fuel rail and injectors.

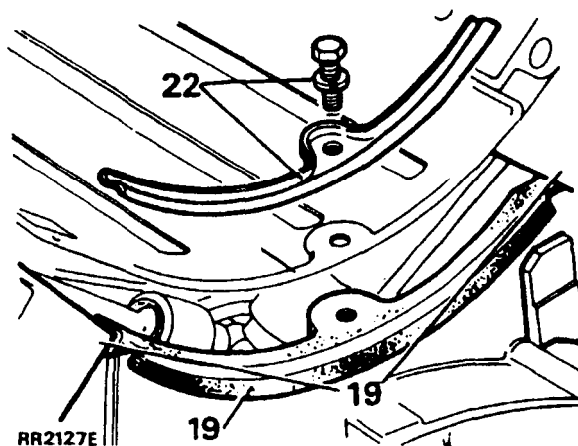
8. Disconnect the electrical leads from the air-conditioning engine coolant sensor located on the thermostat elbow.
9. Disconnect the electrical leads to the coolant temperature transmitter (sensor) located at the front of the intake manifold.
10. Remove the injector harnesses from behind the fuel rail and lay to one side.
11. Release the hose clamps securing the two heater hoses to the rigid heater pipes at the front of the right hand rocker cover.
12. Remove the two bolts securing the rigid heater pipes to the intake manifold and ease the pipes out of the hoses.



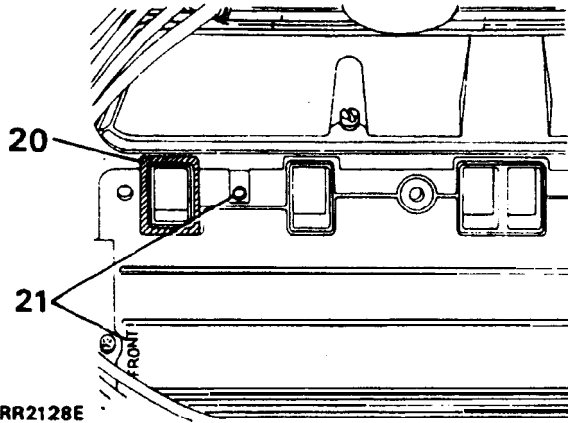
13. Lay the heater pipe assembly to one side.
14. Release the twelve bolts securing the intake manifold to the cylinder heads.
15. Lift the manifold off the cylinder heads and remove from the engine compartment.
16. Remove the two gasket clamps from the top of the cylinder block.
17. Lift off the gasket and remove the gasket seals.
18. Remove previous sealing compound from around the water passage openings of the cylinder heads.

Refitting

19. Locate the NEW seals in position with their ends engaged in the notches formed between the cylinder heads and block.



20. Lightly apply 'Hylomar' sealant around the outside of the water passage openings on the cylinder heads, manifold gasket and intake manifold.



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21. Fit the manifold gasket with the word 'FRONT' to the front and the open bolt hole to the front right hand side.
22. Fit the gasket clamps but **DO NOT** fully tighten the bolts at this stage.
23. Locate the intake manifold onto the cylinder heads, clean the threads of the manifold securing bolts.
24. Fit all manifold bolts and tighten them a little at a time, evenly, alternate sides working from the centre outwards.
25. Tighten to correct torque (see section 06 Torque values).
26. Tighten the gasket clamps to the correct torque (see section 06 Torque values).
27. Reverse remaining removal instructions.
28. Replenish the cooling system.
29. Start the engine, check for water and fuel leaks.

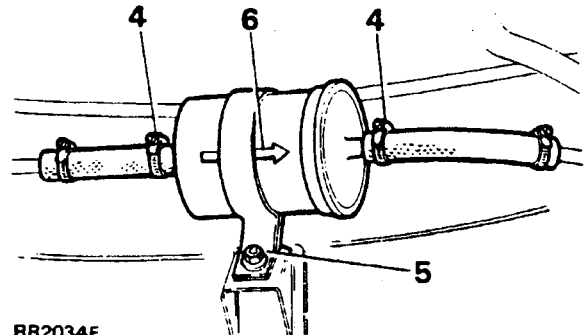
FUEL FILTER

Remove and refit

Refitting

WARNING: The spilling of fuel is unavoidable during this operation. Ensure that all necessary precautions are taken to prevent fire and explosion.

1. Depressurize the fuel system.
2. The fuel filter is located on the right hand chassis side member forward of the fuel tank filler neck. Access to the filter is gained through the right hand rear wheel arch.
3. Thoroughly clean the immediate area around the hose connections to prevent ingress of foreign matter into the fuel system.
4. Loosen the two hose clamps nearest the filter to enable the hoses to be removed from the filter canister. Plug the end of the hoses to prevent ingress of dirt.
5. Release the securing bolt and bracket and remove the filter from the chassis side member.



RR2034E

Refitting

6. Fit a new filter observing the direction of flow arrows stamped on the canister.
7. Start the engine and inspect for fuel leaks around the hose connections.

FUEL TANK

Remove and refit

Removing

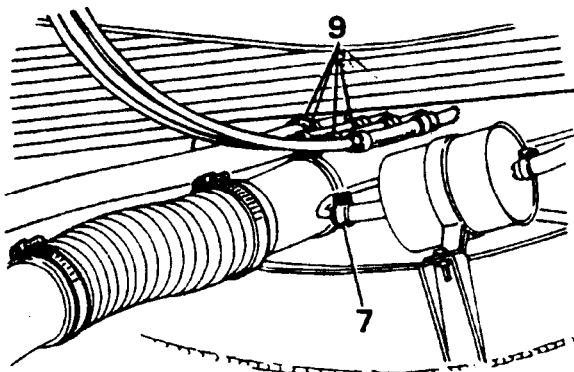
WARNING: Ensure that the Fuel Handling Precautions given in Section 01 - Introduction regarding fuel handling are strictly adhered to when carrying out the following instructions.

CAUTION: Before disconnecting any part of the fuel system it is imperative that all dust, dirt and debris is removed from around the components to prevent ingress of foreign matter into the fuel system.

1. Drive the vehicle onto a suitable hoist.
2. Depressurize the fuel system. (see depressurizing procedure-page 34)
3. Disconnect the battery negative terminal.
4. Disconnect the electrical leads to the fuel tank sender unit. Disconnect the fuel pump electrical multiplug, access to which is gained through the left hand rear wheel arch, the plug is located between the underside of the body and chassis side member.
5. Raise the hoist.
6. Remove the drain plug from the bottom of the fuel tank and drain the fuel into a suitable container that can be sealed afterwards.
ENSURE THAT THE TANK IS DRAINED COMPLETELY.
Refit the drain plug (refer to Warning concerning fuel handling at start of this procedure.

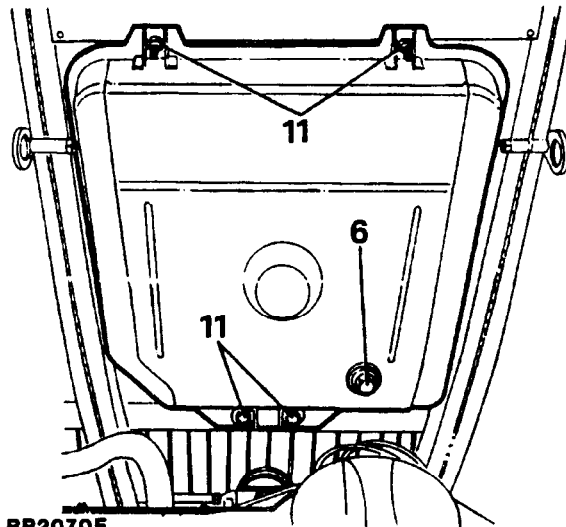
From underneath the vehicle

7. Disconnect the fuel hose from the inlet side of the fuel filter.
8. Disconnect the fuel return pipe to the fuel tank.
9. Remove the breather hose and three evaporative loss hoses from the fuel tank, seal all hose and pipe openings to prevent ingress of foreign matter.



RR2089E

- IO. Release the two large hose clamps, securing the inter-connecting hose to tank and filler tube, maneuver the hose up the outside of the filler tube to enable it to be withdrawn from the tank filler neck.
11. With assistance from a second person supporting the fuel tank, remove the four tank fixings.



RR2070E

12. Tilt the left hand side of the tank downwards and maneuver it out of the chassis frame. Care should be taken to ensure that the fuel feed pipe to filter is not damaged when lowering the tank.
13. Place the tank in a safe area and ensure that all necessary precautions are undertaken to make all personnel within the vicinity aware that the tank will give off residual fuel fumes.
14. If necessary remove the fuel pump from the tank. (See Fuel Pump remove and refit).

Refitting

15. Refit the fuel tank to the chassis, taking care to relocate the fuel feed pipe grommets between the fuel tank and chassis.
16. Reverse the removal procedure, ensuring that the sealing ring, fuel line and hose connections are secure.
17. Run the engine and re-check all connections to ensure no fuel leaks exist. Reverse the remaining removal procedure. Recode the radio.

FUEL PUMP

Remove and refit

Removing

WARNING: Ensure that the Fuel Handling Precautions given in Section 01 - Introduction regarding fuel handling are strictly adhered to when carrying out the following instructions.

1. Drive the vehicle onto a suitable hoist.
2. Depressurize the fuel pump system. (see depressurizing procedure-page 34)
3. Disconnect the battery negative terminal.
4. Remove the fuel tank from the chassis frame. (see fuel tank remove and refit-page 38)
5. Place the tank in a safe area.
6. Disconnect the fuel supply hose from the pump.
7. Remove any previous sealant from the top of the pump flange.
8. Remove the five screws and withdraw the pump from the tank.

Refitting

9. Clean the immediate area around the pump opening in the fuel tank.
10. Fit a **NEW** pump seal.
11. Secure the pump to the tank and tighten the screws securely.
12. Liberally coat the heads of the screws and flange of the fuel pump with Sikaflex 221 flexible adhesive sealant.
13. Reverse the removal procedure, ensuring that the sealing ring, fuel line and hose connections are secure. Recode the radio.
14. Run the engine and re-check all connections to ensure no fuel leaks exist. Reverse the remaining removal procedure.

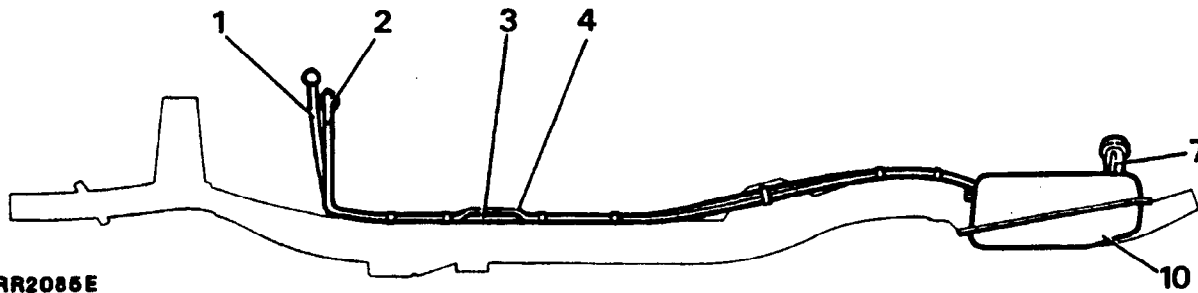
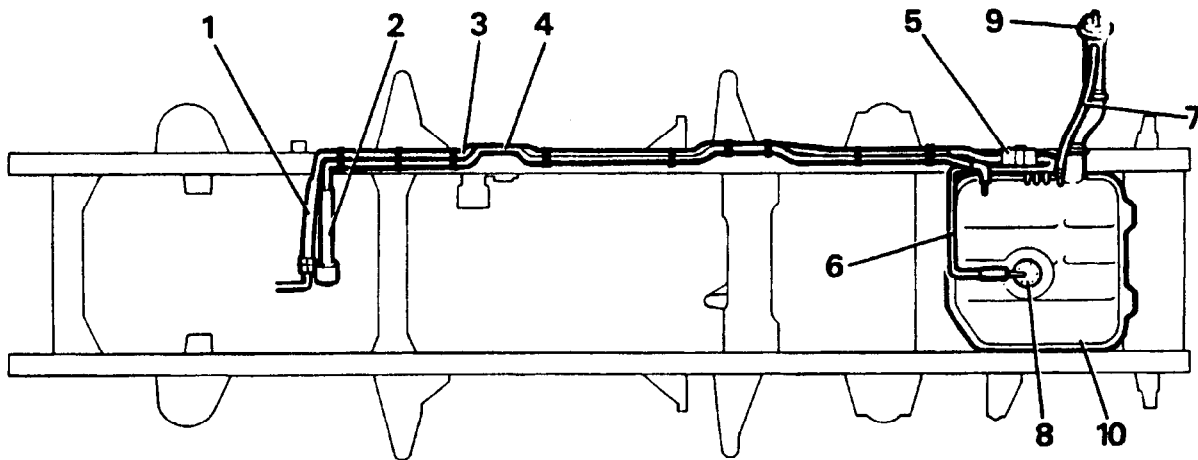
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FUEL PIPES

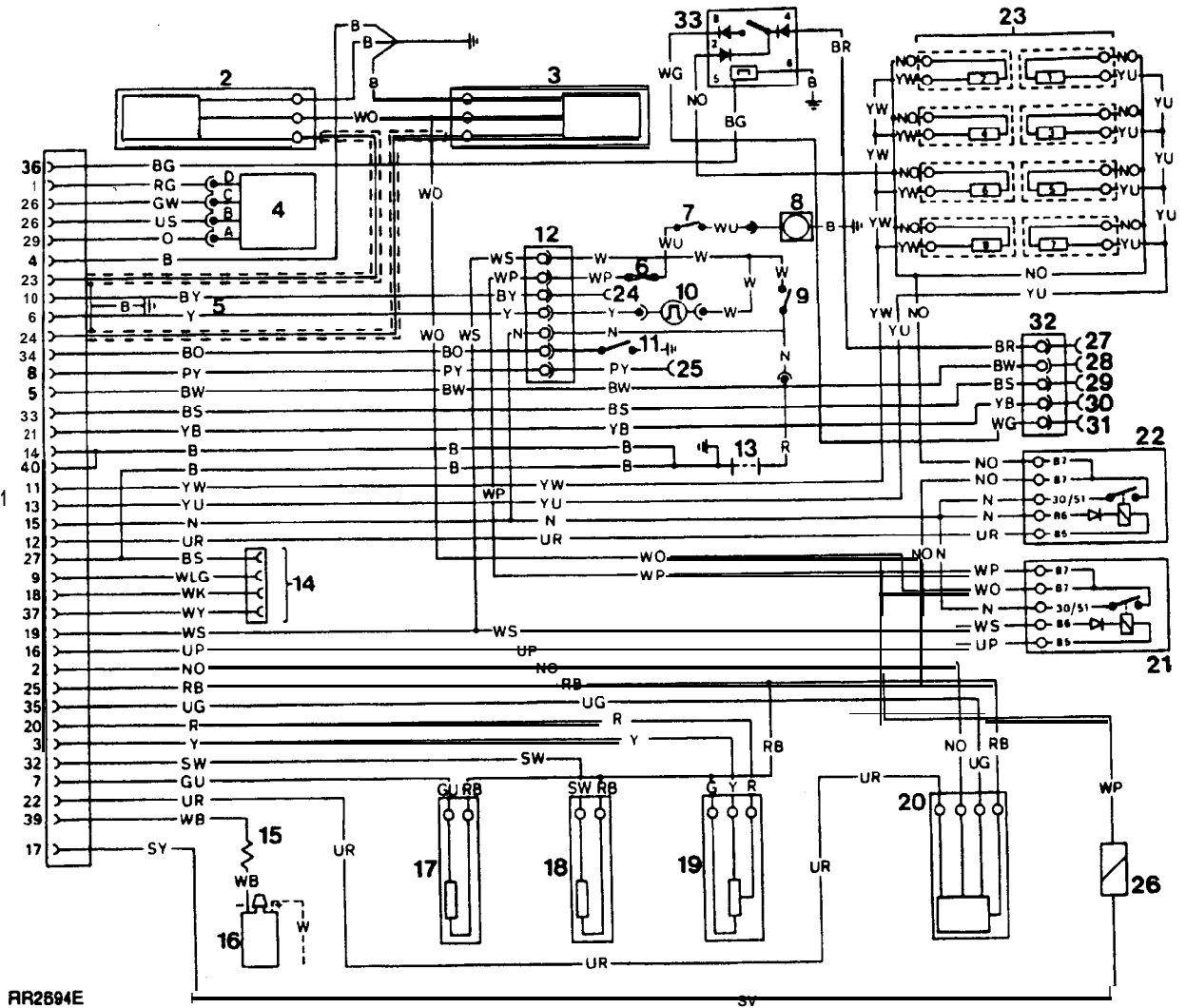
KEY

WARNING: Depressurize fuel system before disconnecting any of the fuel pipes and ensure that all necessary precautions are taken against fuel spillage.

1. Fuel feed hose to fuel rail.
2. Fuel return hose to fuel tank.
3. Rigid fuel feed pipe.
4. Rigid fuel return pipe.
5. Fuel filter.
6. Rigid fuel feed pipe to filter.
7. Breather hose.
8. in-tank fuel pump.
9. Fuel filler neck.
10. Fuel tank.



RR2086E



RR2694E
FUEL INJECTION - Circuit Diagram - 1989 Model Year

- | | |
|--|---|
| <ol style="list-style-type: none"> 1. 40 way connector to Electronic Control Unit (ECU). 2. Lambda sensor (left side - bank A). 3. Lambda sensor right side - bank B). 4. By-pass air valve (stepper motor) (fast idle). 5. Lambda sensor screened ground. 6. Fuse 18 - main fuse panel. 7. Inertia switch. 8. Fuel pump. 9. Ignition switch. 10. Speed transducer (road speed input). 11. Neutral switch (automatic gearbox) (load input). 12. Main cable connector. 13. Battery. 14. Diagnostic plug. 15. In-line resistor. 16. Coil/-ve (engine RPM input). 17. Coolant temperature thermistor (sensor) (input). | <ol style="list-style-type: none"> 18. Fuel temperature thermistor (sensor) (input). 19. Throttle potentiometer. 20. Air flow sensor. 21. Fuel pump relay. 22. Main relay. 23. Injectors-1 to 8. 24. Pick-up point E.F.I. warning symbol (instrument binnacle). 25. Heated front screen sense. 26. Purge control valve. 27. 12V from fan relay. 28. Air conditioning switch sense. 29. Air conditioning output control. 30. Air conditioning load input. 31. Fan relay feed. 32. Heater/air con. cable connector. 33. Condenser fan timer control. <p>== = Denotes screened ground.</p> |
|--|---|

NOTE: Reference to left and right side is made when viewing vehicle from rear.

FUELINJECTIONSYSTEM

For 1989 model year, the EFI system has a Lucas 14CU electronic control unit. This is a development of the 13CU used on 3.5 litre vehicles.

In most respects the 14CU works in the same way using the same engine components, it does however have additional capacity, enabling it to control fuel tank vapour purging and air conditioning.

Condenser fans

It should be noted that under high coolant temperatures, when the engine is switched off, the condenser fans will be activated and will run for approximately ten minutes.

Throttle potentiometer

A further improvement is the fitting of a 'self adaptive' throttle potentiometer. This means that adjustment of the throttle potentiometer is no longer possible. It also means that the potentiometer setting is not lost, for example, when throttle stop wear occurs.

Purge valve

The operation of the charcoal canister purge valve is checked during the fuel injection system test. See TESTS 9 and 10 Section 19, page 48.

Recommended equipment

The diagnostic equipment used for checking out the 14CU system is the same as that used for 13CU, with the addition of a new memory card for the Hand held test unit.

14CU Memory card

Lucas Part Number - 54746500

CONTINUITY TEST PROCEDURE

Test procedure using a multi-meter is carried out as for 13CU, with the addition of tests for the purge control valve, air conditioning, heated front screen and condenser fan inputs.

The use of a hand held vacuum pump, for example a 'Mityvac', is required to carry out Tests 9 and 10.

Note that the 40 way multi-plug to the ECU is wired as in the following table.

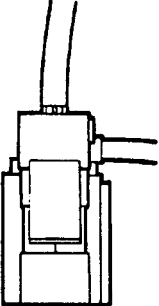
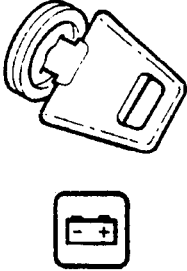
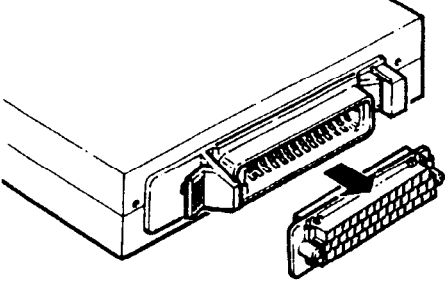



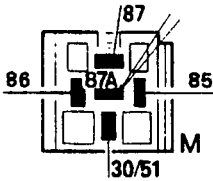
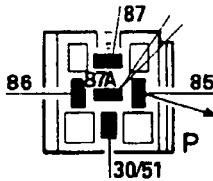
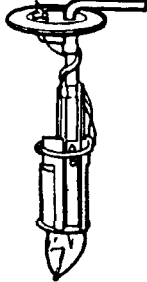
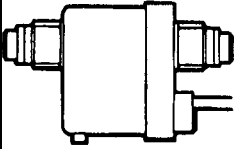
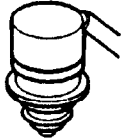
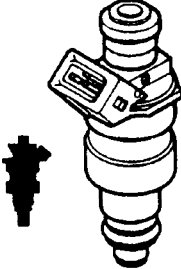
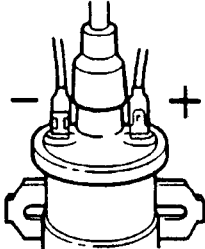
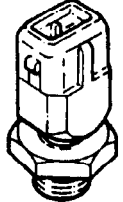
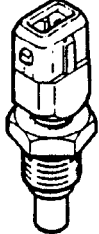
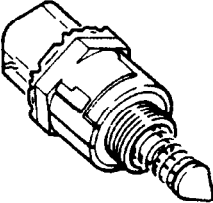
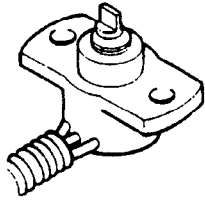
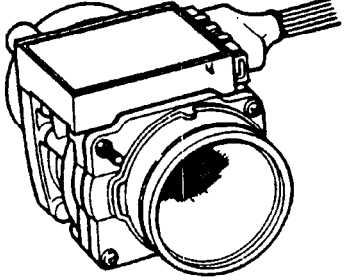
PIN NOS. CABLE COLOUR

1. Red/green
2. Brown/orange
3. Yellow
4. Black
5. Black/white
6. Yellow
7. Green/blue
8. Purple/yellow
9. White/light green
10. Black/Yellow
11. Yellow/white
12. Blue/red
13. Yellow/blue
14. Black
15. Brown
16. Blue/purple
17. Grey/yellow
18. White/pink
19. White/grey
20. Red
21. Yellow/black
22. Blue/red
23. Blue
24. Blue
25. Red/black
26. Green/white
27. Black/grey
28. Blue/grey
29. Orange
30. Not used
31. Not used
32. Grey/white
33. Black/grey
34. Black/orange
35. Blue/green
36. Black/green
37. White/yellow
38. Not used
39. White/black
40. Black

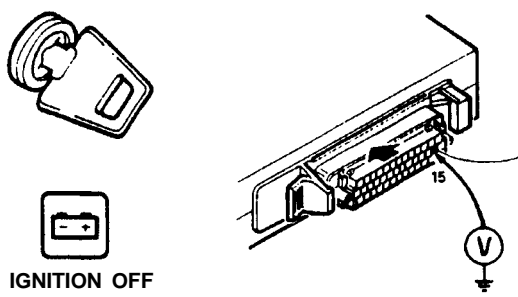
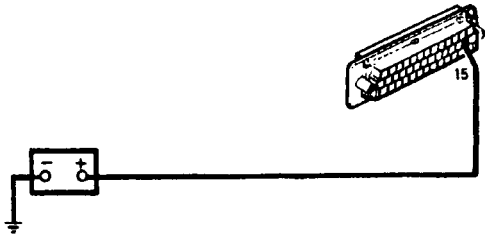
The last colour denotes the wire tracer colour.

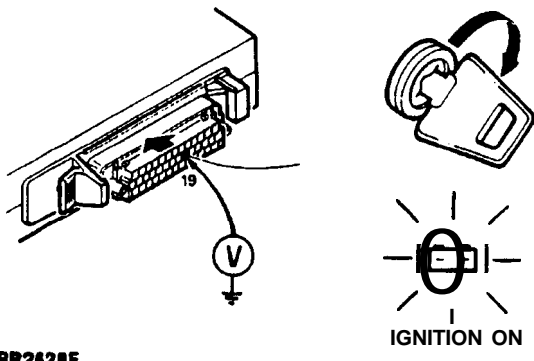
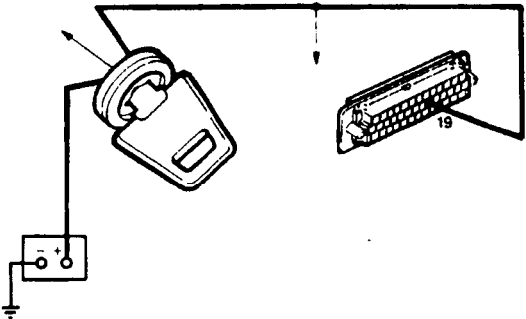
TESTS • Using a Multi-Meter • 14CU system • Key to Symbols

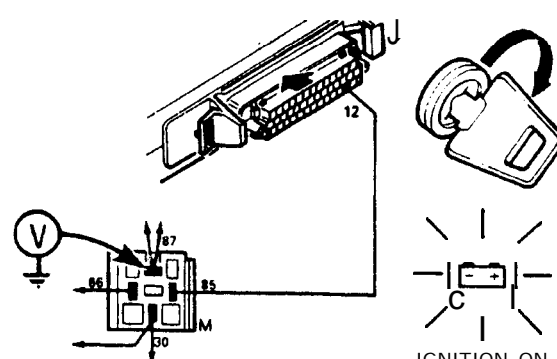
The following continuity tests are intended as a guide to identifying where a fault may be within a circuit; reference should be made to the fuel injection circuit diagram for full circuit information.

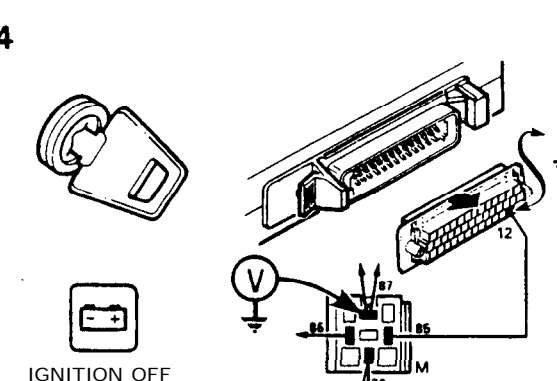
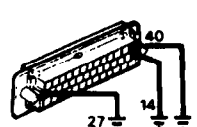
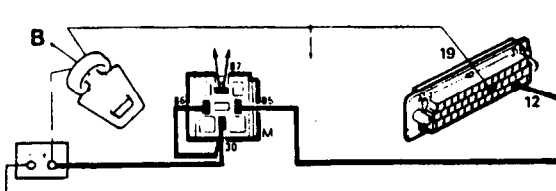
 <p>PURGE VALVE</p>	 <p>IGNITION SWITCH</p>	 <p>ELECTRONIC CONTROL UNIT AND MULTIPLUG</p>		 <p>TEMPORARY CONNECTION</p>
 <p>OHMMETER CONNECTIONS</p>	 <p>VOLTMETER CONNECTIONS</p>	 <p>MAIN RELAY</p>	 <p>PUMP RELAY</p>	 <p>FUEL PUMP</p>
 <p>ROAD SPEED INPUT (SPEED TRANSDUCER)</p>	 <p>GEAR INPUT SWITCH (INHIBITOR SWITCH)</p>	 <p>INJECTOR</p>	 <p>IGNITION COIL</p>	 <p>FUEL TEMPERATURE SENSOR</p>
 <p>COOLANT TEMPERATURE SENSOR</p> <p>RR2626E</p>	 <p>AIR BYPASS VALVE</p>	 <p>THROTTLE POTENTIOMETER</p>	 <p>HOT WIRE AIRFLOW METER</p>	

NOTE: All tests are carried out from the electronic control unit (ECU) harness multi-plug unless stated otherwise in the test procedure.

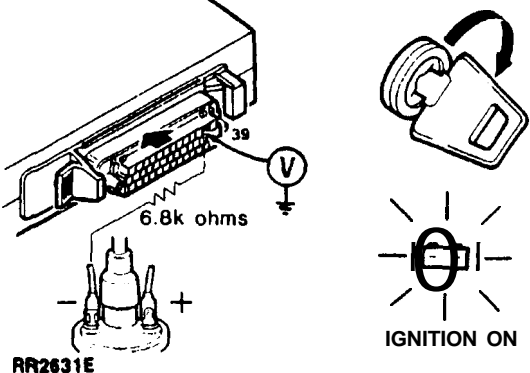
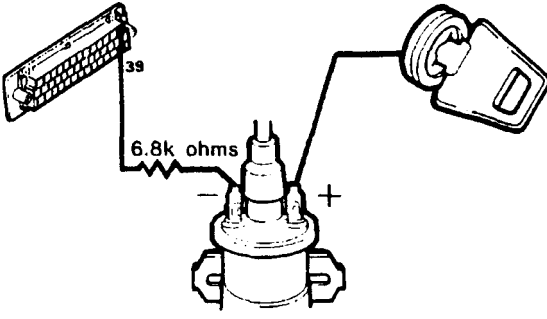
TEST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>1. Check battery supply to ECU</p>	<p>Voltmeter reading of battery/ volts - (minimum battery voltage 10 volts) Proceed to Test 2 Voltmeter reading of zero volts Check:-</p>
<p>1</p>  <p>RR2627E</p>	

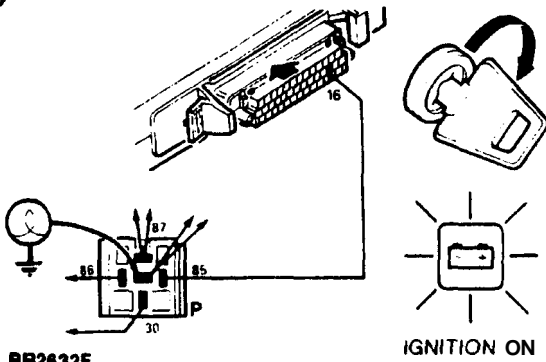
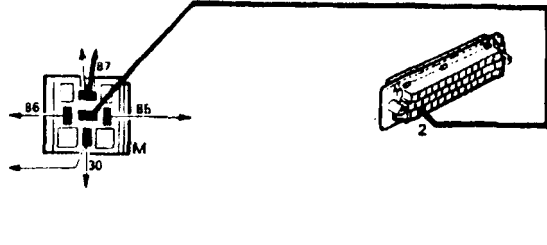
TEST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>2. Check ignition supply to ECU</p>	<p>Voltmeter reading of battery volts - (minimum battery voltage 10 volts) Proceed to Test 3 Incorrect reading check:-</p>
<p>2</p>  <p>RR2628E</p>	

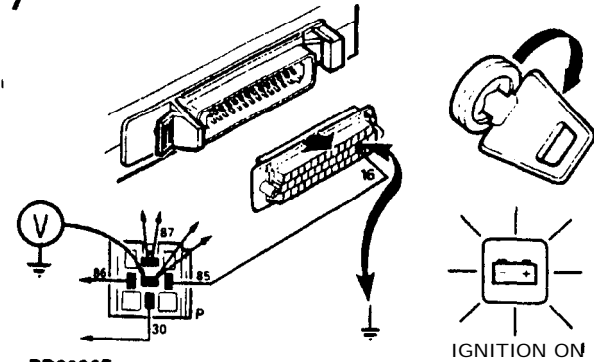
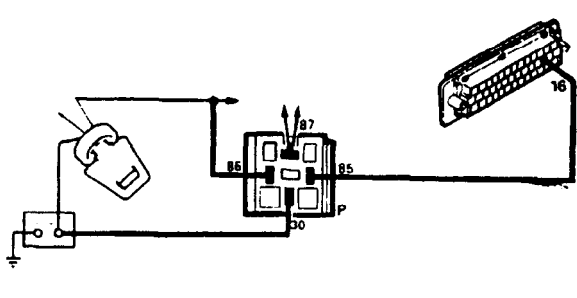
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>3. Check operation of Main relay</p>	<p>Voltmeter reading of battery volts - Proceed to Test 5</p>
<p>3</p>  <p>RR2629E</p>	<p>Voltmeter reading of zero volts - Proceed to Test 4</p>

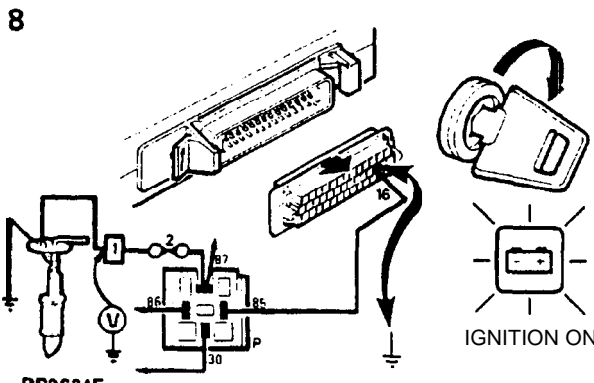
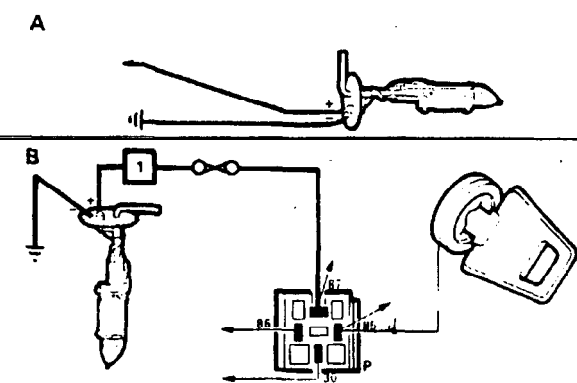
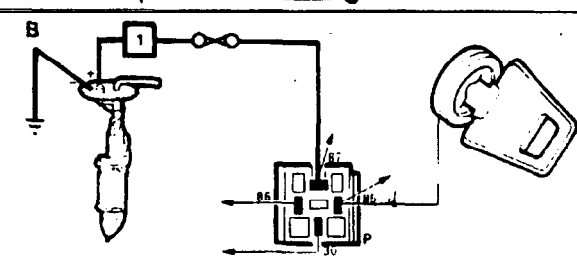
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>4. Fault Diagnosis Main relay circuits</p>	<p>A. Voltmeter reading of battery volts - Check:- If OK Suspect ECU</p>
<p>4</p>  <p>IGNITION OFF</p> <p>RR2630E</p>	<p>A</p>  <p>B</p> 

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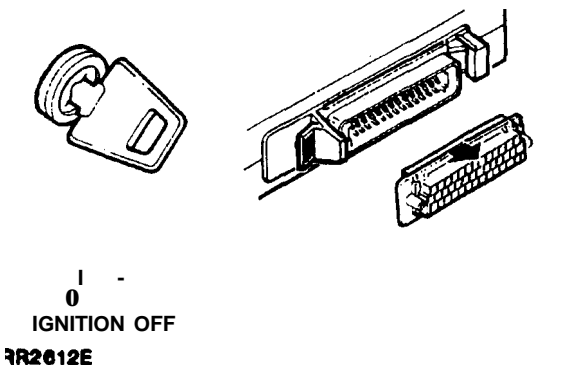
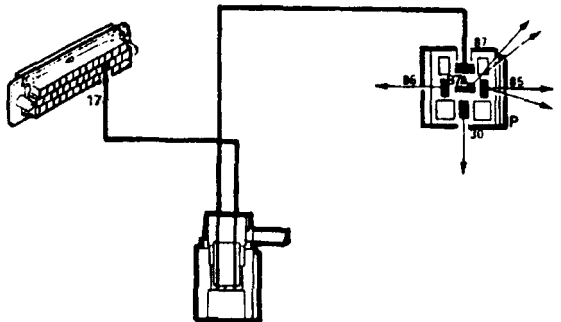
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>5. Check engine speed signal Cable and resistor</p>	<p>Voltmeter reading of 9.5 volts \pm 1 volt Proceed to Test 6</p> <p>Voltmeter reading of zero volts Check:-</p>
<p>5</p>  <p>RR2631E</p> <p>IGNITION ON</p>	

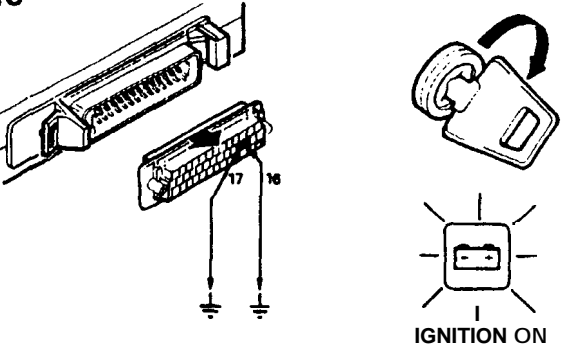
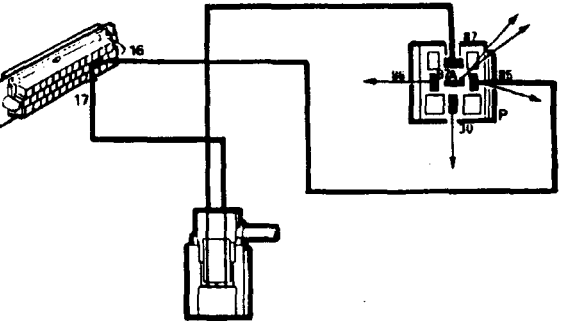
TESTPROCEDURE	RESULTS - Check cables and units shown in bold
<p>6. Check operation of pump relay</p>	<p>Test lamp will illuminate for approximately 1 second when ignition is switched on If O.K - Proceed to Test 8</p> <p>Lamp does not illuminate Check:- If OK proceed to Test 8</p>
<p>6</p>  <p>RR2632E</p> <p>IGNITION ON</p>	

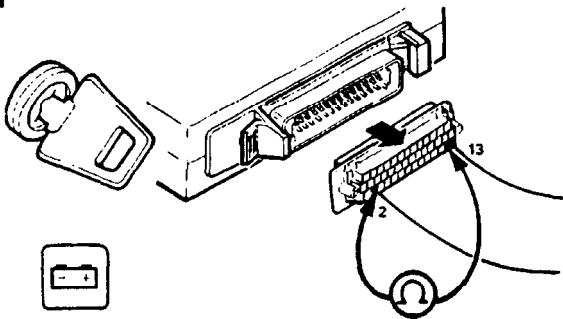
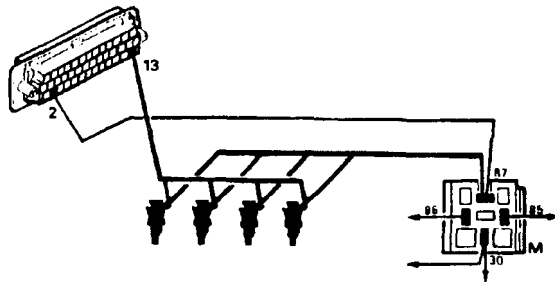
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>7. Fault diagnosis Pump relay circuits</p>	<p>Voltmeter reading of battery volts - Suspect ECU</p>
<p>7</p>  <p>RR2633E</p>	<p>Voltmeter reading of zero volts Check:-</p> 

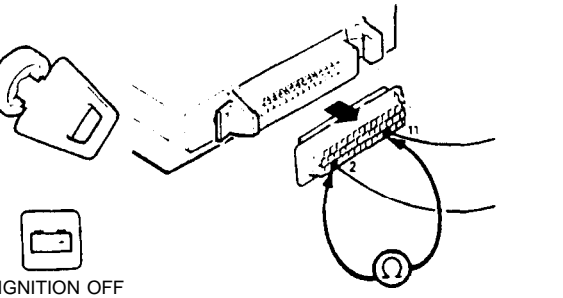
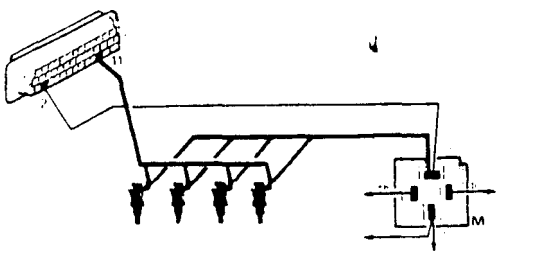
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>8. Check operation of Fuel pump</p> <p>NOTE: It is not possible to place the multi-meter probes directly onto the pump terminals. A link lead attached to the pump is accessible behind the rear left hand wheel located between the chassis and stowage area floor panel.</p> <p>KEY: 1. Inertia switch 2. Fuse 18</p>	<p>Voltmeter reading of battery volts - Pump operating - Proceed to Test 10</p> <p>(A) Voltmeter reading of battery volts - Pump not operating Check:-</p> <p>(B) Voltmeter reading of zero volts Check:-</p>
<p>8</p>  <p>RR2634E</p>	<p>A</p>  <p>B</p> 

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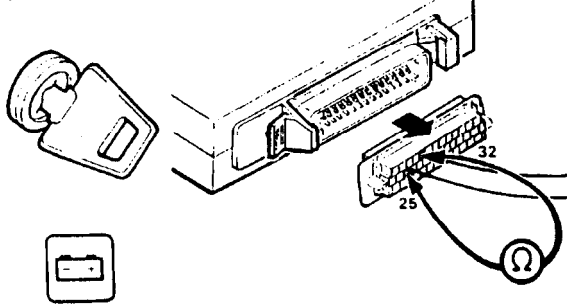
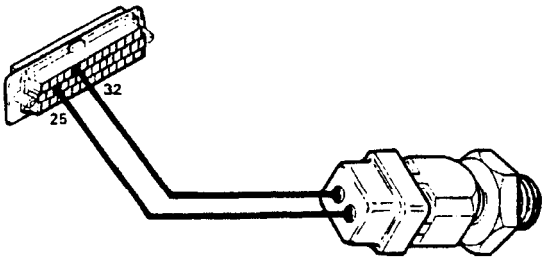
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>9. Check purge valve. Part 1 - seating</p> <ol style="list-style-type: none"> 1. Disconnect pipe from purge valve to plenum (at plenum) 2. Connect vacuum pump to pipe to purge valve 3. Apply vacuum of 2.5 in/Hg 	<p>Vacuum should hold for 2.5 minutes If vacuum correct proceed to test 10</p> <hr/> <p>If vacuum incorrect check:</p>
<p>3</p>  <p>IGNITION OFF RR2012E</p>	

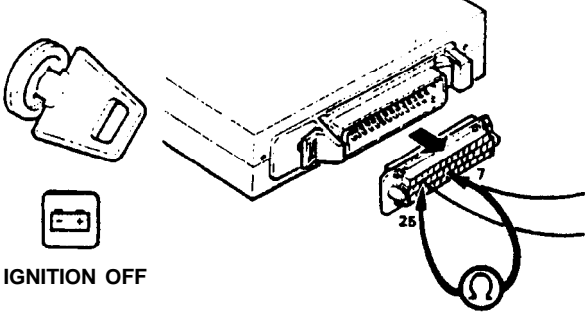
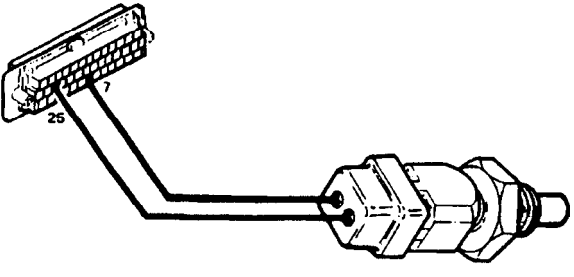
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>10. Check purge valve. Part 2 - operation</p> <ol style="list-style-type: none"> 1. Apply vacuum - 2.5 in/Hg, switch ignition on 2. Connect pins 16 and 17 to earth to energise pump relay. 	<p>Vacuum should be released If OK proceed to test 11</p> <hr/> <p>If vacuum not released check:</p>
<p>10</p>  <p>IGNITION ON RR2013E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>11. Check injectors, Injector circuit</p> <p>(Pin 13 left bank 'A' injectors 1,3,5,7).</p>	<p>Ohm-meter reading of 4-4.5 Ohms - Proceed to Test 12</p> <p>Ohm-meter reading of 5-6 Ohms - Suspect 1 injector</p> <p>Ohm-meter reading of 8-9 Ohms - Suspect 2 injectors</p> <p>Ohm-meter reading of 16-17 Ohms - Suspect 3 injectors</p> <p>Check for open circuit injector(s) or wiring faults.</p>
<p>11</p>  <p>IGNITION OFF</p> <p>RR2635E</p>	

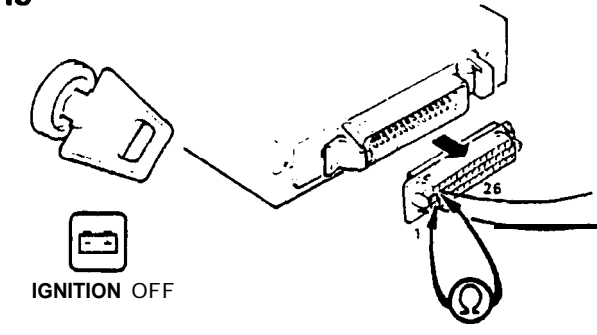
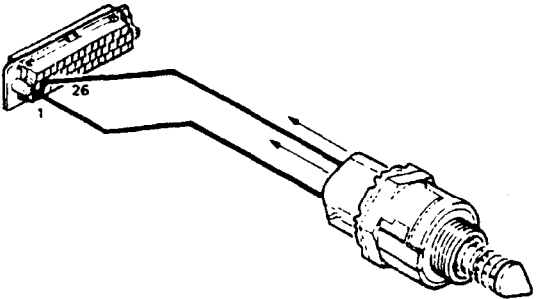
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>12. Check injectors, Injector circuit</p> <p>(Pin 11 rightbank 'B' injectors 2,4,6,8)</p>	<p>Ohm-meter reading of 4-4.5 Ohms - Proceed to Test 13</p> <p>Ohm-meter reading of 5-6 Ohms - Suspect 1 injector</p> <p>Ohm-meter reading of 8-9 Ohms - Suspect 2 injectors</p> <p>Ohm-meter reading of 16-17 Ohms - Suspect 3 injectors</p> <p>Check for open circuit injector(s) or wiring faults.</p>
<p>12</p>  <p>IGNITION OFF</p> <p>RR2636E</p>	

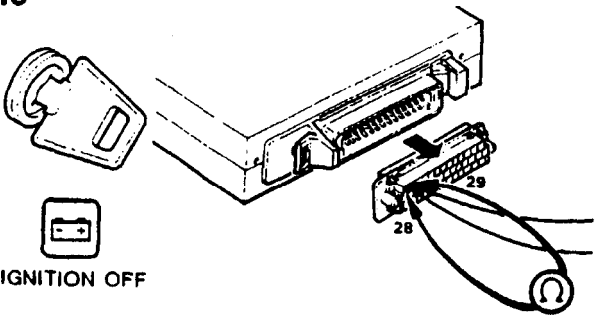
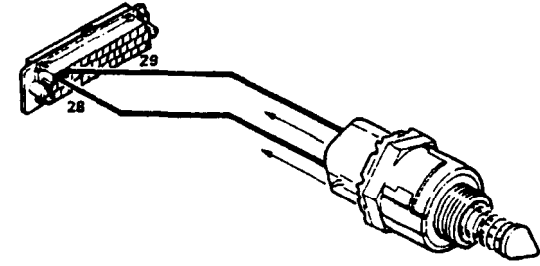
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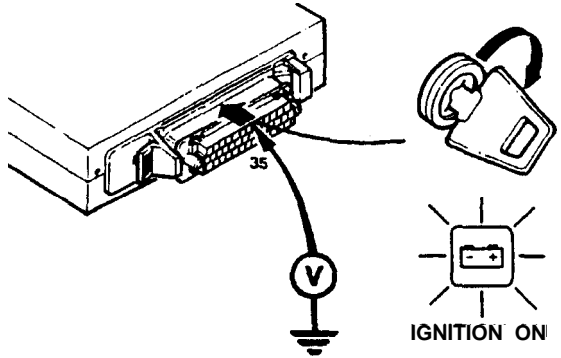
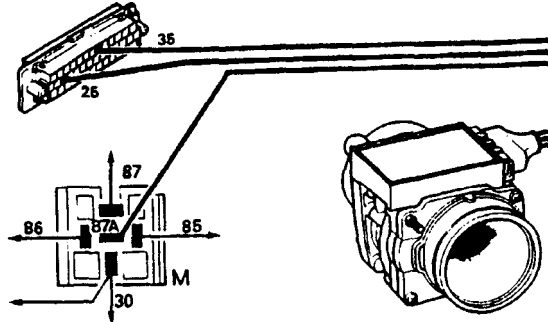
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>13. Check fuel temperature thermistor (sensor)</p>	<p>Correct reading-temperature to resistance - Proceed to Test 14 (Refer to Temperature Conversion Charts in Test 14)</p> <p>Incorrect Ohm-meter reading Check</p>
<p>13</p>  <p>IGNITION OFF</p> <p>RR2638E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold																											
<p>14. Check coolant temperature thermistor (sensor)</p>	<p>Correct reading-Temperature to resistance - Proceed to Test 15 (Refer to Temperature Conversion Chart below.</p> <table border="1" data-bbox="922 410 1409 697"> <thead> <tr> <th colspan="2">Fuel and Coolant Temperature</th> <th>Ohm-meter Reading Should be</th> </tr> <tr> <th>°C</th> <th>°F</th> <th>Ohms</th> </tr> </thead> <tbody> <tr> <td>-10°</td> <td>14°</td> <td>9100 - 9300</td> </tr> <tr> <td>0°</td> <td>32°</td> <td>5700 - 5900</td> </tr> <tr> <td>20°</td> <td>68°</td> <td>2400 - 2600</td> </tr> <tr> <td>40°</td> <td>104°</td> <td>1100 - 1300</td> </tr> <tr> <td>60°</td> <td>140°</td> <td>500 - 700</td> </tr> <tr> <td>80°</td> <td>176°</td> <td>300 - 400</td> </tr> <tr> <td>100°</td> <td>212°</td> <td>150 - 200</td> </tr> </tbody> </table> <p>Incorrect Ohm-meter reading Check:-</p>	Fuel and Coolant Temperature		Ohm-meter Reading Should be	°C	°F	Ohms	-10°	14°	9100 - 9300	0°	32°	5700 - 5900	20°	68°	2400 - 2600	40°	104°	1100 - 1300	60°	140°	500 - 700	80°	176°	300 - 400	100°	212°	150 - 200
Fuel and Coolant Temperature		Ohm-meter Reading Should be																										
°C	°F	Ohms																										
-10°	14°	9100 - 9300																										
0°	32°	5700 - 5900																										
20°	68°	2400 - 2600																										
40°	104°	1100 - 1300																										
60°	140°	500 - 700																										
80°	176°	300 - 400																										
100°	212°	150 - 200																										
<p>14</p>  <p>IGNITION OFF</p> <p>RR2637E</p>																												

Continued

MT PROCEDURE	RESULTS - Check cables and units shown in bold
<p>15. Check air bypass valve - Part 1</p>	<p>Ohm-meter reading of 40-60 Ohms - Proceed to Test 16</p> <p>Incorrect reading Check:-</p>
<p>15</p>  <p>RR2639E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>16. Check air bypass valve - Part 2</p>	<p>Ohm-meter reading of 40-60 Ohms - Proceed to Test 17</p> <p>Incorrect reading Check:-</p>
<p>16</p>  <p>IR2640E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>IS. Check output of Airflow sensor</p>	<p>Voltmeter reading of 0.2-0.7 volts- Proceed to Test 20</p> <p>Incorrect voltmeter reading Check:-</p>
 <p>IR2643E</p>	

PRECAUTION:

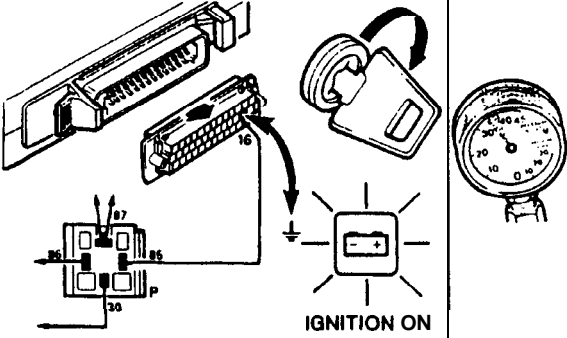
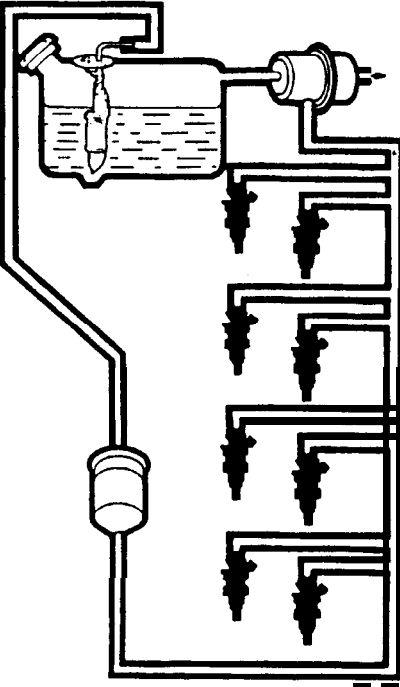
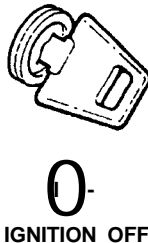
Depressurize the fuel system when fitting the fuel pressure gauge or disconnecting/replacing fuel system components.

CAUTION: Thoroughly clean the immediate area around the fuel filter and hose connections before disconnecting the fuel feed line from the filter. Failure to do so could cause foreign matter to be present in the fuel system which would be detrimental to the fuel system components.

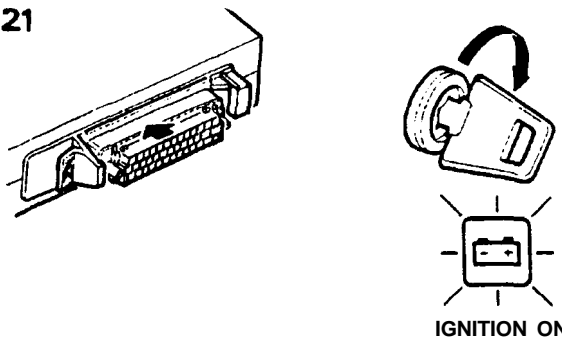
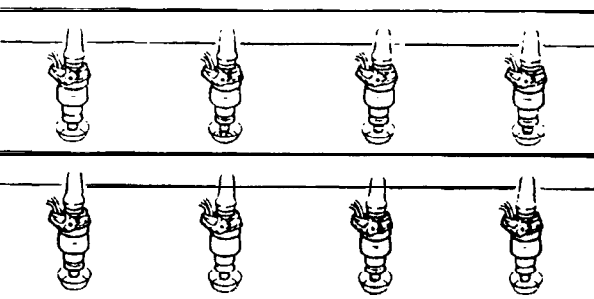
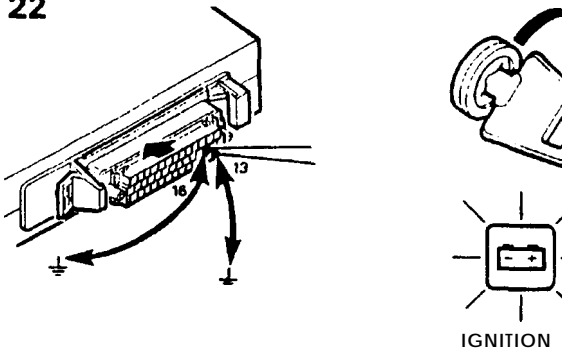
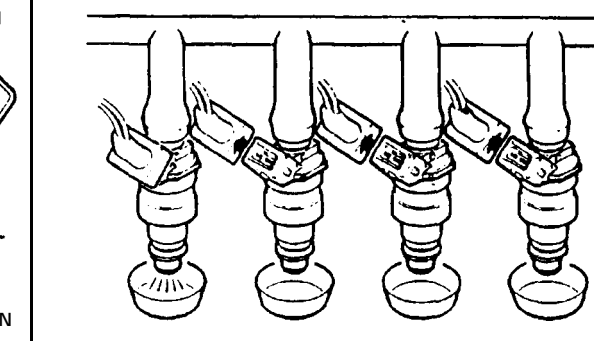
WARNING: The spillage of fuel from the fuel filter is unavoidable when disconnecting the fuel feed line, ensure that all necessary precautions are taken to prevent fire and explosion due to fuel vapour and fuel seepage,

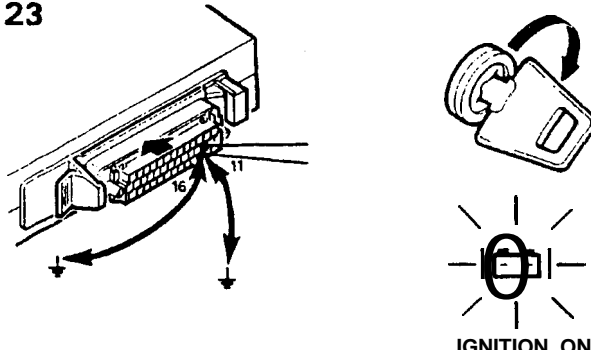
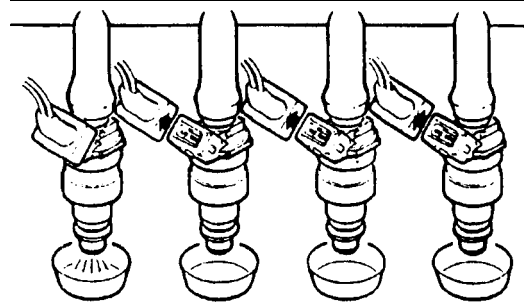
DEPRESSURIZING PROCEDURE

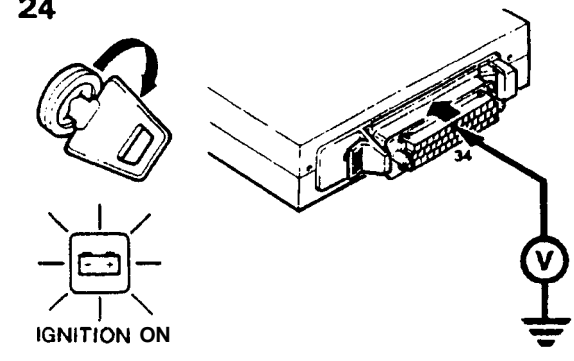
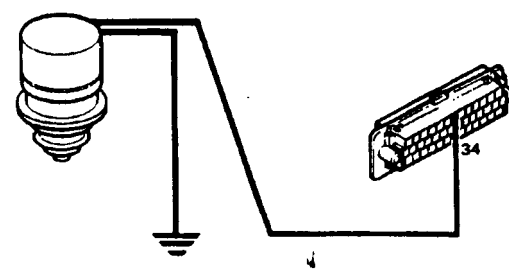
- a) Ignition off, pull pump relay off its terminal block.
- b) Crank engine for a few seconds - engine may fire and run until fuel pressure is reduced.
- c) Switch off the ignition.
- d) Connect fuel pressure gauge in the fuel supply line between the fuel rail and the fuel filter, adjacent to the filter (see Test 20).
- e) Reconnect the pump relay.

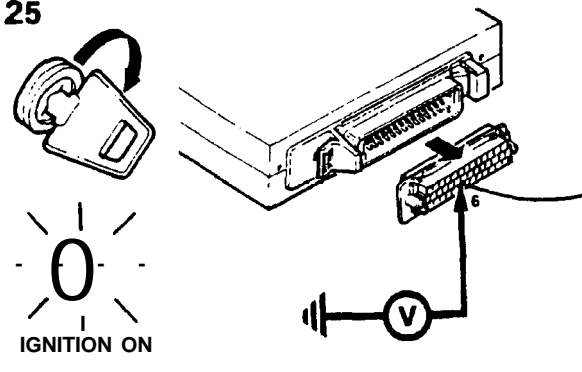
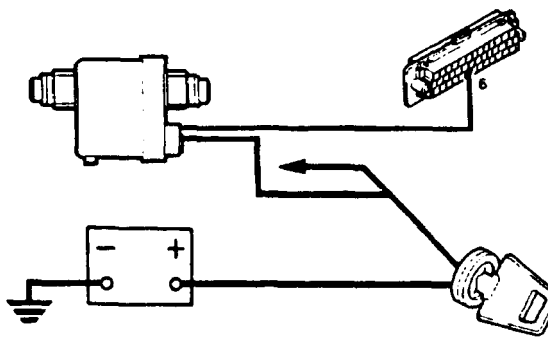
TEST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>20. Check fuel system pressure Service tool 18G 1500</p> <p>NOTE: Insert the pressure gauge in the fuel feed line immediately after the fuel line filter. The filter is located beneath the right hand rear wheel arch attached to the chassis</p>	<p>(A) Expected reading 2,39-2,672 kgf/cm² (34.0-38.0 p.s.i.)</p> <p>(B) Pressure drop-max 0.7 kgf/cm² (10 p.s.i.) in one minute</p> <p>Proceed to Test 21</p>
<p>20</p>  <p>IGNITION ON</p>	
 <p>IGNITION OFF</p> <p>RR2644E</p>	

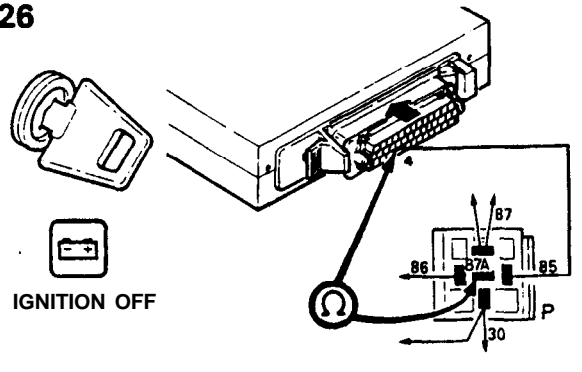
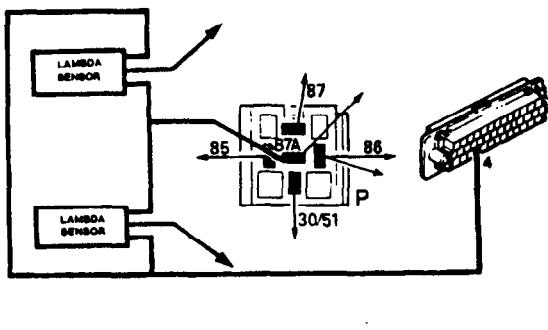
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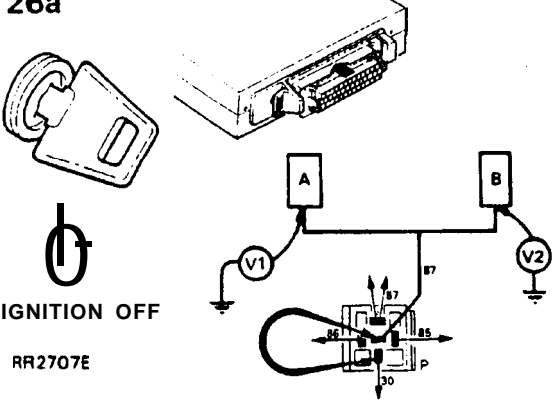
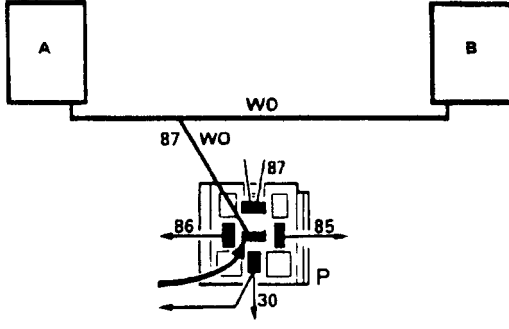
EST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>11. Check for leaking injector</p> <p>NOTE: Before removing any of the injectors, remove and examine the spark plugs, check for consistent colouration of plugs. A leaking injector will result in the appropriate spark plug being 'sooted up'.</p> <p>Remove all injectors from manifold but do not disconnect from fuel rail</p>	<p>WARNING: Ensure that all necessary precautions are taken to prevent fire and explosion.</p> <p>Replace any injector which leaks more than 2 drops of fuel per minute.</p>
<p>21</p>  <p>RR2645E</p>	
'EST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>12. Check for injector operation Left bank 'A' injectors 1,3,5,7</p>	<p>WARNING: Ensure that all necessary precautions are taken to prevent fire and explosion.</p> <p>Repeat test for other injectors Replace any injector which does not operate.</p> <p>NOTE: Fuel flow is 160-175 cc (using white spirit) or 180-195 cc fusing petrol) (minimum) per minute per injector, at 2.54 kgf/cm² (36.25 psi) system pressure at 20°C ± 2°C</p>
<p>22</p>  <p>RR2646E</p>	

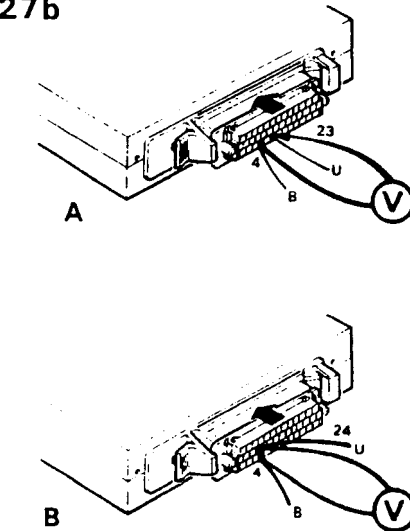
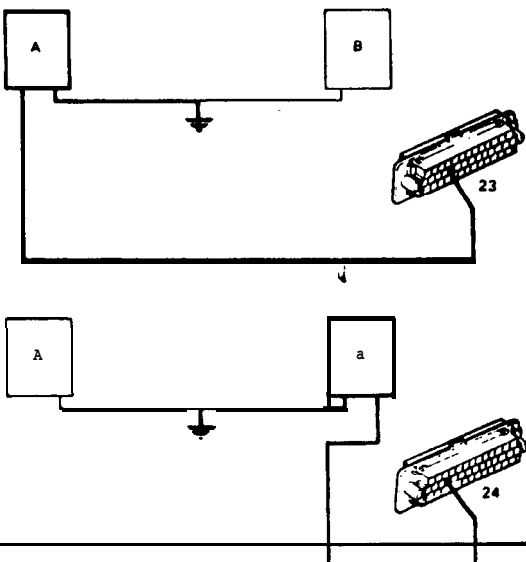
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>23. Right bank 'B' injectors 2,4,6,8</p>	<p>WARNING: Ensure that all necessary precautions are taken to prevent fire and explosion</p> <p>Repeat test for other injectors Replace any injector which does not operate</p> <p>NOTE: Fuel flow is 160-175 cc fusing mineral spirits) or 180-195 cc (using gasoline) (minimum) per minute per injector, at 2.54 kgf/cm² (36.25 psi) system pressure at 20°C ± 2°C</p>
<p>23</p>  <p>RR2647E</p>	

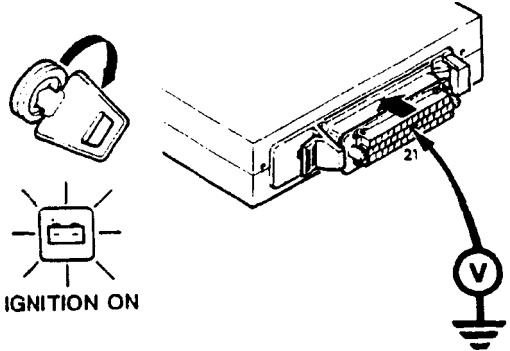
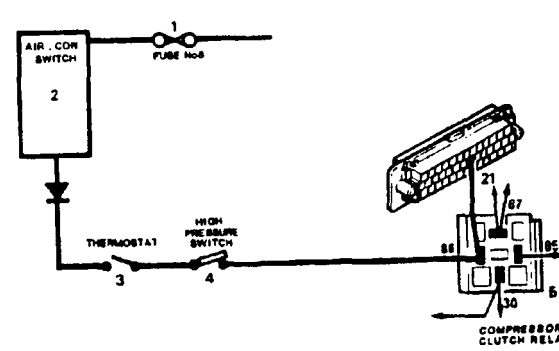
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>24. Check gear switch input</p>	<p>Voltmeter reading of zero volts- Neutral and park</p> <p>Voltmeter reading of 2.5-5.0 Volts -R.D.3.2.1- Proceed to Test 25</p> <p>Incorrect reading Check:</p>
<p>24</p>  <p>RR2648E</p>	

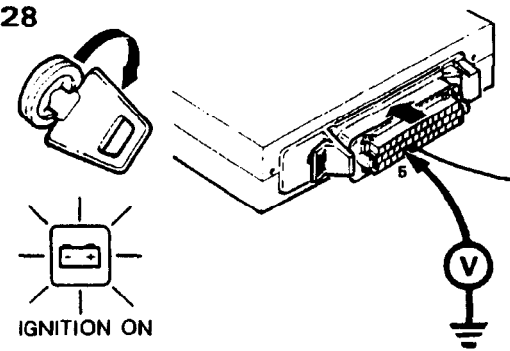
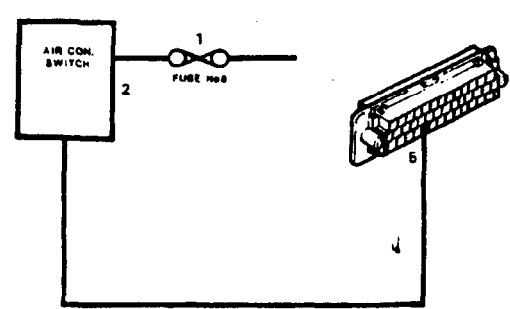
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>25. Check road speed input</p> <p>NOTE: Raise and rotate the left hand test road wheel slowly</p>	<p>Voltmeter reading of 0 to 12V fluctuating 6 times per revolution - Proceed to Test 26</p> <p>Incorrect reading Check:</p>
<p>25</p>  <p>IGNITION ON</p> <p>RR2649E</p>	 <p>RR2649E</p>

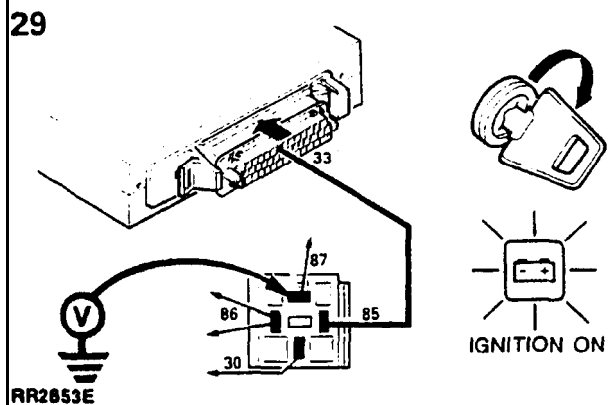
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>26. Check Lambda sensor heater coils</p> <p>NOTE: Remove pump relay from its connector</p>	<p>Ohm-meter reading of 2.5-6.0 Ohms</p> <p>Incorrect reading Check:</p>
<p>26</p>  <p>IGNITION OFF</p> <p>RR2650E</p>	 <p>RR2650E</p>

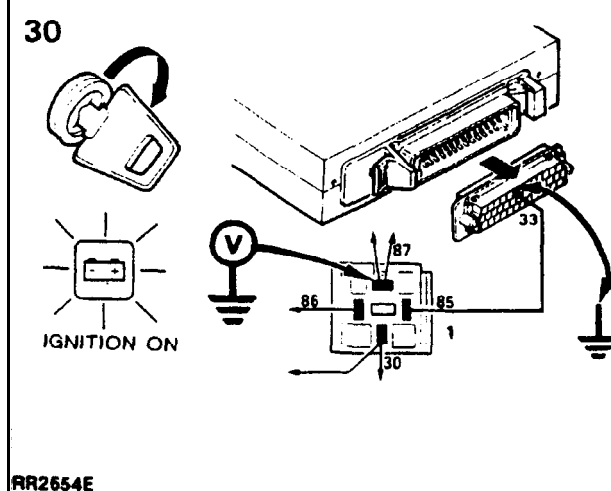
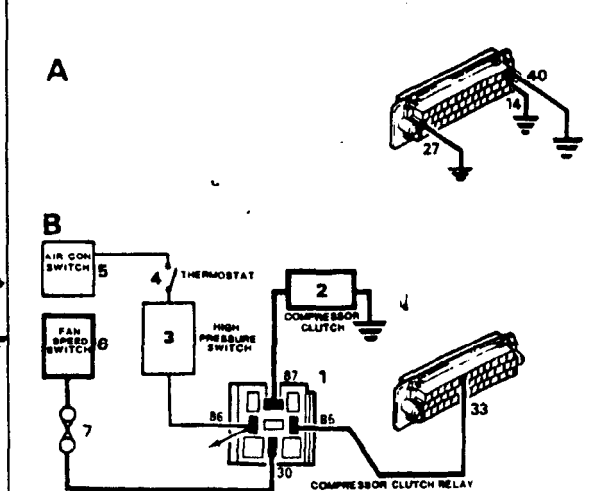
TEST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>26a. Check Lambda sensor supply</p> <p>A. LH Lambda sensor B. RH Lambda sensor</p>	<p>Correct V1 and V2 • 12 volts Proceed to Test 26b</p> <p>Incorrect reading Check:</p>
<p>26a</p>  <p>IGNITION OFF</p> <p>RR2707E</p>	

TEST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>26b. Check Lambda sensor operation</p> <p>Note: Select 'P' in main gearbox and run engine at 1000 rev/min, normal operating temperature</p> <p>A. LH Lambda sensor B. RH Lambda sensor</p>	<p>Correct 0.50V - 1.00V fluctuating</p> <p>Incorrect 0.050 V • Check: Air leaks, faulty or contaminated injectors, low fuel pressure • if OK fit new Lambda sensor</p> <p>Incorrect 1.00V • Check: High fuel pressure, leaking injectors, saturated carbon canister • if OK fit new Lambda sensor.</p>
<p>27b</p>  <p>RR2708E</p>	

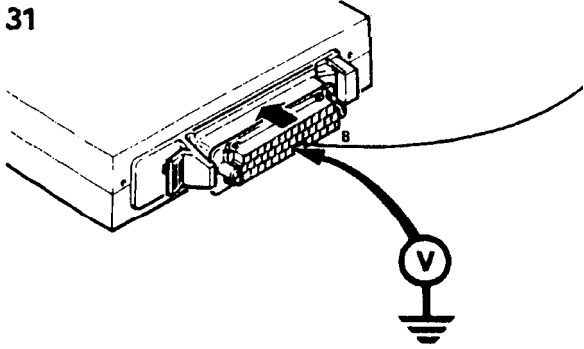
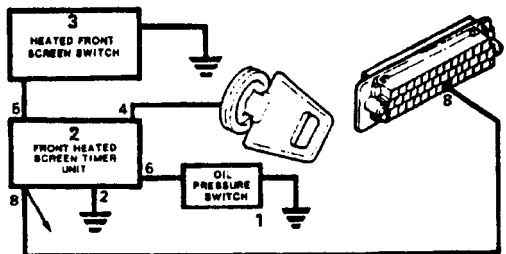
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>17. Check air conditioning thermostat input</p> <p>NOTE: Select air conditioning position and move thermostat switch to cold</p> <p>KEY: 1. Fuse 8 2. Air conditioning switch 3. Air conditioning thermostat 4. High pressure switch - air conditioning 5. Compressor clutch relay</p>	<p>Voltmeter reading of battery volts - Proceed to Test 28</p> <p>Incorrect reading Check:</p>
<p>27</p>  <p>IGNITION ON</p> <p>1R2651E</p>	 <p>AIR CON. SWITCH 2</p> <p>FUSE No. 8 1</p> <p>THERMOSTAT 3</p> <p>HIGH PRESSURE SWITCH 4</p> <p>21 87 86 30 85</p> <p>COMPRESSION CLUTCH RELAY 5</p>

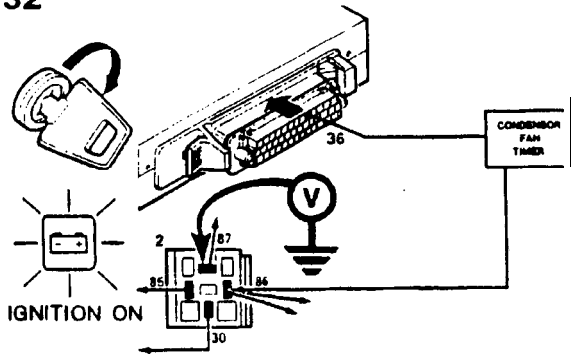
TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>18. Check air conditioning input</p> <p>NOTE: Select heater fan speed I, II or III</p> <p>KEY: 1. Fuse 6 2. Air conditioning switch</p>	<p>Voltmeter reading of battery volts - Proceed to Test 29</p> <p>Incorrect reading Check:</p>
<p>28</p>  <p>IGNITION ON</p> <p>RR2652E</p>	 <p>AIR CON. SWITCH 2</p> <p>FUSE No. 6 1</p> <p>6</p>

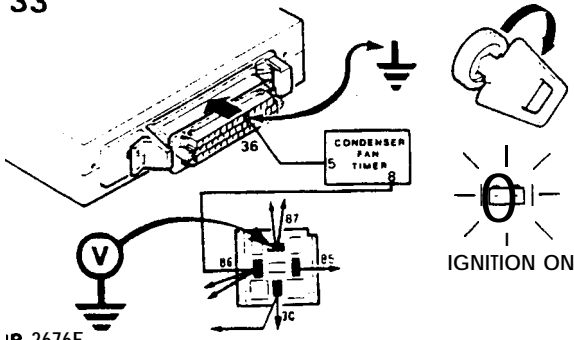
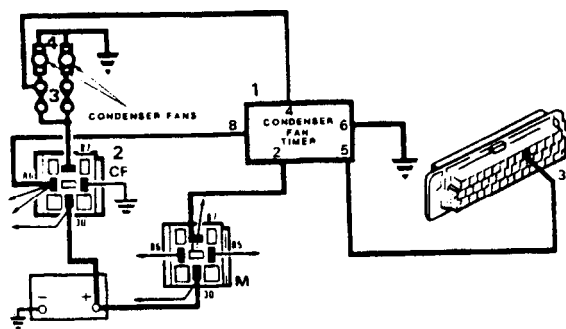
<p>TEST PROCEDURE</p>	<p>RESULTS • Check cables and units shown in bold</p>
<p>29. Check operation of compressor clutch relay</p> <p>NOTE: Select air conditioning position, thermostat cold, and fan speed I, II, or III</p>	<p>Voltmeter reading of 12 volts - Proceed to Test 31</p> <p>Incorrect reading of zero volts - Proceed to Test 30</p>
<p>29</p> 	

<p>TEST PROCEDURE</p>	<p>RESULTS • Check cables and units shown in bold</p>
<p>30. Fault diagnosis • compressor clutch relay</p> <p>NOTE: Select air conditioning position, thermostat cold, and fan speed I, II or III</p> <p>KEY:</p> <ol style="list-style-type: none"> 1. Compressor clutch relay 2. Compressor clutch 3. High pressure switch 4. Thermostat 5. Air conditioning switch 6. Fan speed switch 7. Fuse A3 	<p>Voltmeter reading of 12 volts - Check A</p> <p>Voltmeter reading of zero volts - Check B</p>
<p>30</p> 	

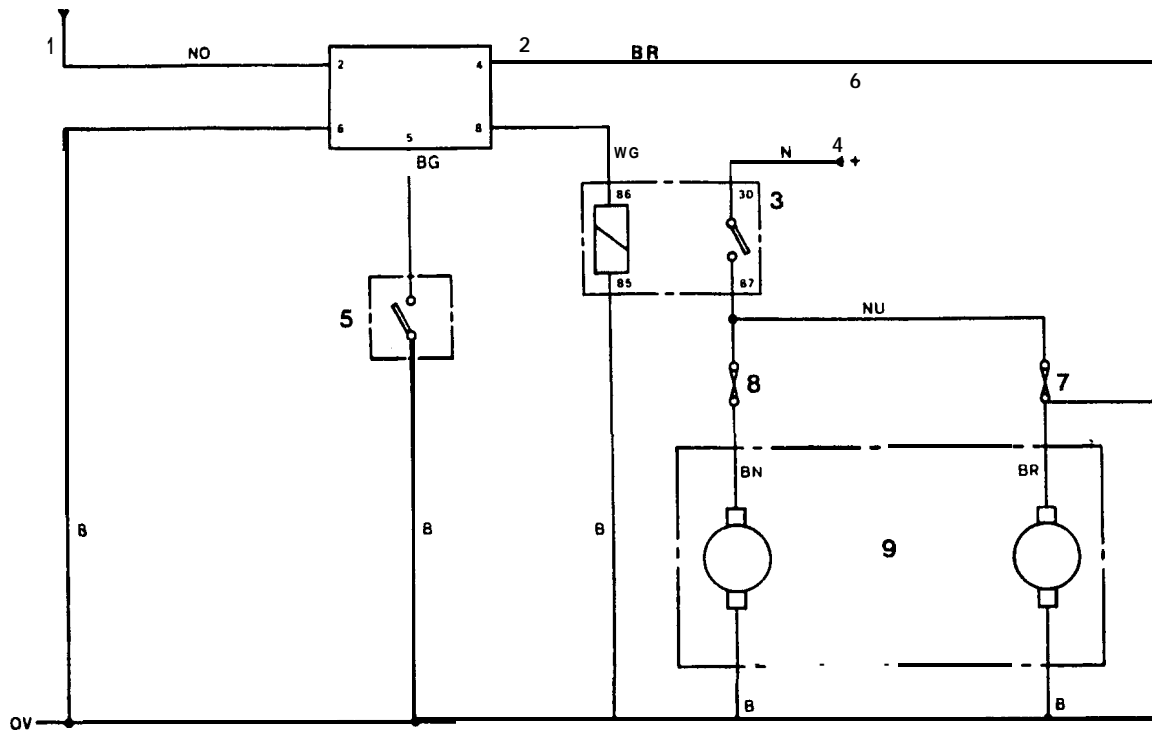
Continued

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>31. Check heated front screen input</p> <p>NOTE: Engine running, heated front screen switched 'ON'</p> <p>KEY: 1. Oil pressure switch 2. Front screen timer unit 3. Front screen switch</p>	<p>Voltmeter reading of 12 volts - Proceed to Test 32</p> <p>Incorrect reading of zero volts Check:</p>
<p>31</p>  <p>RR2655E</p>	

TEST PROCEDURE	RESULTS - Check cables and units shown in bold
<p>32. Check operation of condenser fan output</p> <p>Disconnect coolant temperature sensor and fuel temperature sensor and bridge plug connectors</p> <p>NOTE: Switch ignition 'ON' for 5 seconds, switch ignition 'OFF'</p> <p>The fan timer will operate the fans for approximately 10 minutes unless it is disconnected</p> <p>KEY: 1. Condenser fan timer 2. Condenser fan relay</p>	<p>Voltmeter reading of 12 volts - end of tests</p> <p>Voltmeter reading of zero volts Proceed to Test 33</p>
<p>32</p>  <p>RR2660E</p>	

'EST PROCEDURE	RESULTS • Check cables and units shown in bold
<p>13. Fault diagnosis • condenser fan output</p> <p>KEY:</p> <ol style="list-style-type: none"> 1. Condenser fan timer 2. Condenser fan relay 3. Fuses A1 and A2 4. Condenser fans 	<p>Voltmeter reading of 12 volts - Suspect ECU</p> <p>Incorrect reading Check:</p>
<p>33</p>  <p>IR 2676E</p>	

After completing the tests with either the 'Diagnostic' equipment or multi-meter, re-test the vehicle to **ensure** the faults have been rectified. If faults still persist, recheck using the Lucas diagnostic equipment.



RR2610E

Condenser fan circuit diagram RR2610E

1. 12V from EFI main relay.
2. Condenser fan timer unit.
3. Fan relay.
4. 12V battery feed.
5. Trigger, from ECU.
6. 12V from fan relay.
7. Fuse A1-20 amp.
8. Fuse A2-20 amp.
9. Fan motors

Condenser fans/Condenser fan timer

Check operation

1. Start engine.
2. Move air con/heater control to air conditioning position.
3. Check condenser fans, if working the condenser fan relay and wiring to the fans is functioning.
4. If not working check fuses A1 and A2, and the voltage between connections 86 on fan relay and earth. If 12 volts is not present, check wiring back to air con switch.
5. If 12 volts is present, but fans NOT working, short out connections 30 and 87 on fan relay. If fans work fit new relay. If fans NOT working, check supply to fan relay from main harness.
6. Apply a 12 volt supply for at least two seconds to connection 5 on fan timer within **SIX SECONDS** of switching engine off. The condenser fans should run for 9.5 minutes \pm 0.5 minutes, and switch off.
7. If the fans do not work after applying voltage to timer, short out connections 4 and 8 on fan timer, if fans work fit new fan timer. If fans do not work, check wiring.

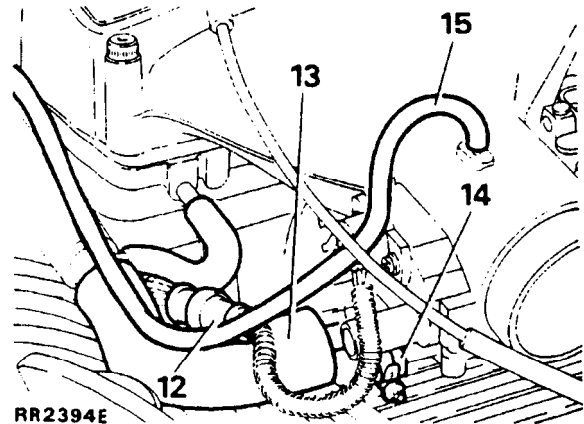
OVERHAUL THROTTLE LEVERS AND THROTTLE VALVE - 3.9 V8 Model

Preparation, remove, overhaul and refit

Preparation

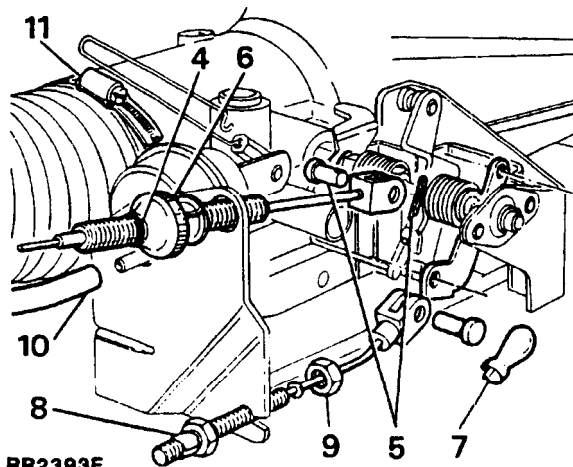
1. Disconnect the battery negative terminal.
2. Disconnect the electrical multi-plug from the bypass air valve (stepper motor).
3. Disconnect the small vacuum hose at the rear of the plenum chamber, located below the bypass air valve.
4. To assist re-assembly mark an identification line on the throttle cable outer covering directly behind the adjustment thumb wheel before disconnecting the throttle cable from the throttle lever.
5. Remove the cotter pin and clevis pin securing the throttle cable to the lever.
6. Carefully pry the adjustment thumb wheel from the throttle bracket. Lay the cable aside.
7. Release the retaining clip from the kick down cable and remove the clevis pin.
8. To assist re-assembly apply adhesive tape behind the rear adjustment nut on the kick down cable outer sleeve to prevent the nut moving out of position.
9. Release the front lock nut and remove it from the outer sleeve to enable the cable to be removed from the throttle bracket. Lay the cable aside.
10. Remove the vacuum hose from the cruise control actuator.

11. Remove the large hose from the neck of the plenum chamber.
12. Disconnect the multi-plug to the throttle potentiometer.
13. Remove the PCV breather hose.
14. Disconnect the two coolant hoses in turn and immediately plug the end of each hose to prevent excessive loss of coolant. Identify each hose for re-assembly.
15. Remove the distributor vacuum hose.

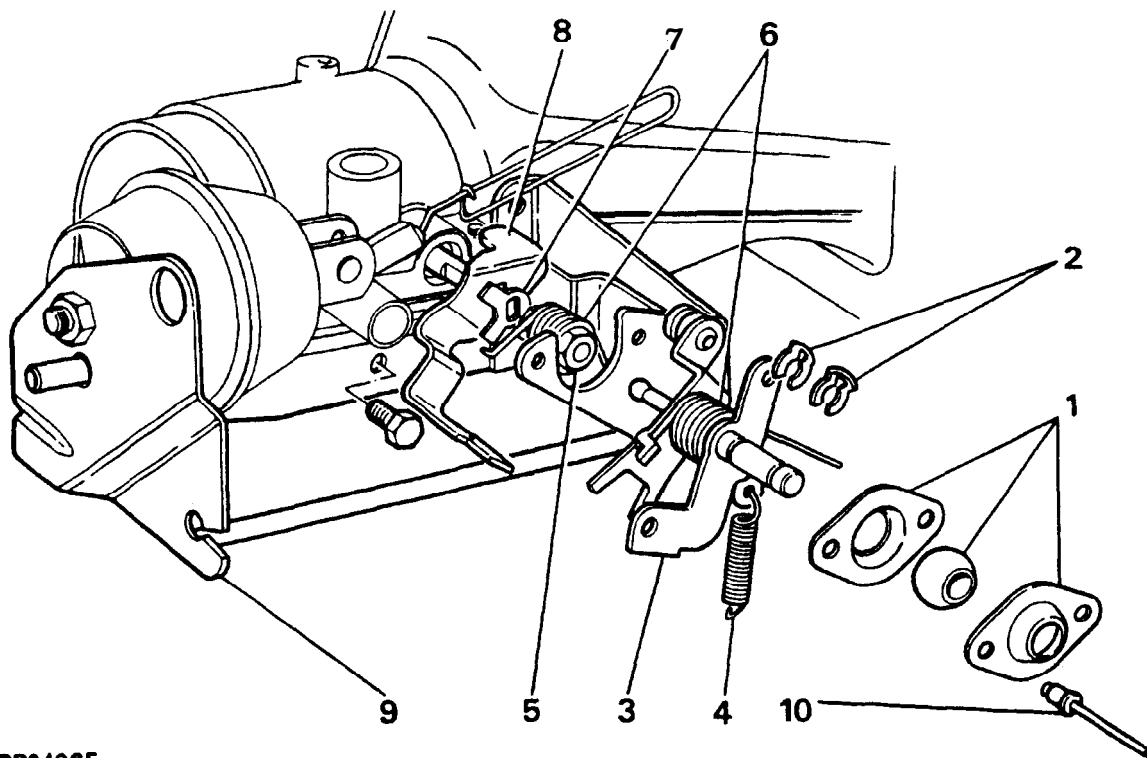


RR2394E

16. Release the two screws and remove the potentiometer.



RR2393E



RR2406E

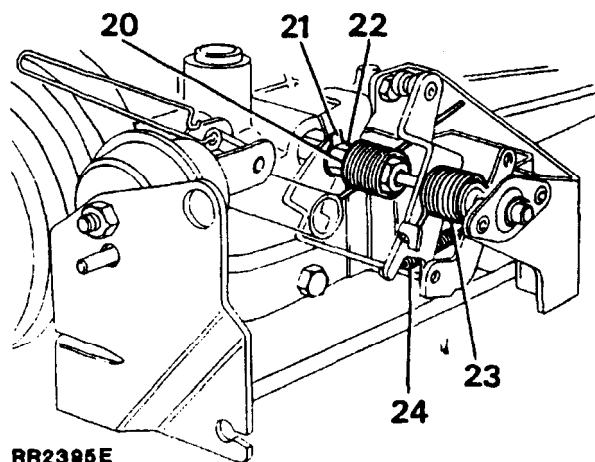
KEY

- 1. Spherical bearing
- 2. Retaining clips (2)
- 3. Countershaft assembly
- 4. Overtravel spring
- 5. Throttle spindle nut
- 6. Throttle return spring (2)
- 7. Tab washer
- 8. Throttle stop lever
- 9. Throttle bracket assembly
- 10. Pop rivets (2)

- 21. Bend back the the tabs of the lock washer.
- 22. While holding the throttle stop lever in the closed position, **release the nut** until it is free of the throttle valve shaft.
- 23. Release the tension on the outboard throttle return spring.
- 24. Unhook and remove the over-travel spring.

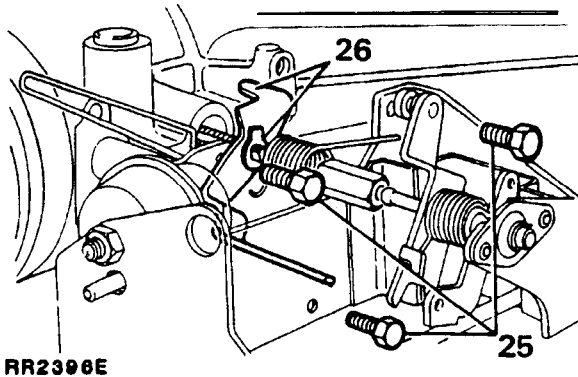
Remove throttle lever assembly

- 17. Remove the six screws securing the plenum chamber to the ram housing. Lift off the plenum chamber.
- 18. Remove the hose from the air bypass valve housing and plenum chamber air inlet pipe.
- 19. Unclip the cruise control actuator link. While holding the throttle valve fully open release the link from the countershaft assembly. Carefully return the lever assembly to the closed throttle position.
- 20. Release the tension on the inboard throttle return spring and slide the spring along the countershaft assembly to give access to the throttle shaft nut.



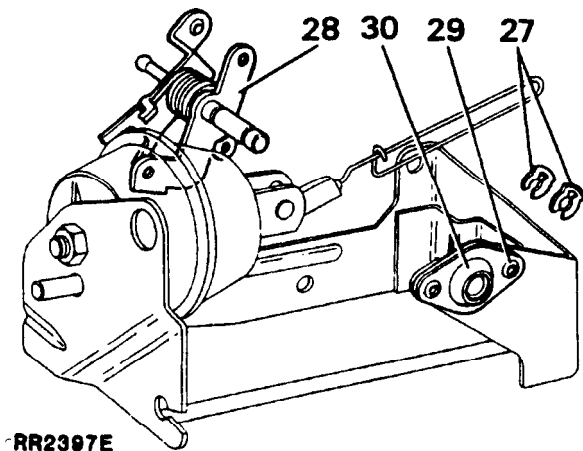
RR2395E

25. Remove the three bolts securing the throttle bracket to the plenum chamber and withdraw the bracket assembly.
26. Remove the tab washer and throttle stop lever from the throttle valve shaft.

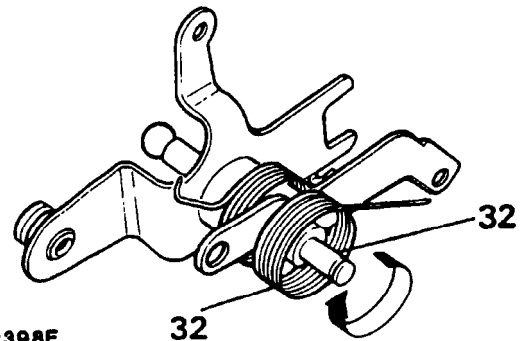


Inspect and overhaul throttle lever assembly

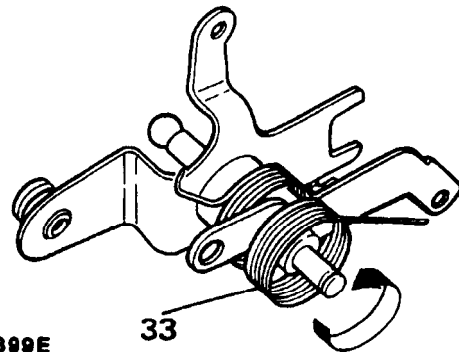
27. Remove the two retaining clips from either side of the spherical bearing.
28. Remove the countershaft assembly from the bearing.
29. If the spherical bush appears to be worn, dismantle as follows. Using a 4,7 mm (3/16 in) diameter drill, drill out the two pop rivets securing the spherical bearing to the throttle bracket assembly.
30. Split the bearing assembly and discard the bearing bush.



31. Pre-grease a new bush with Admax L3 or Energrease LS3 assemble the bush into the bearing retaining plates and pop-rivet the assembly to the throttle bracket with two 4.7 mm (3/16 in) diameter domed head rivets 9 mm (0.361 in) long.
32. Examine the bearing surface of the countershaft assembly. If worn fit a new assembly, otherwise wind the throttle return spring off the levers.



33. Wind a new spring onto the countershaft assembly noting that the small hooked end of the spring is wound on first.

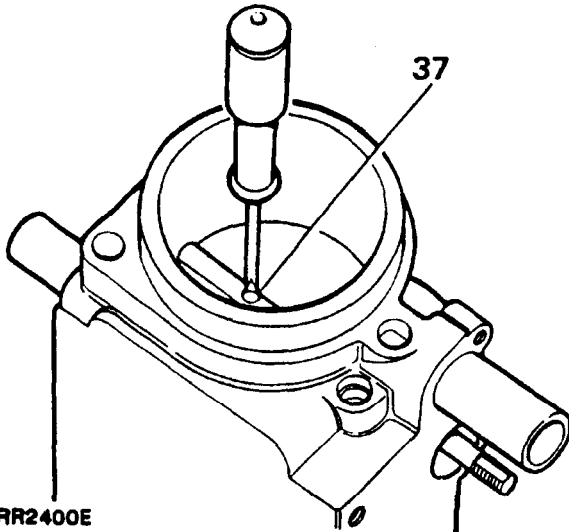


34. Pre-grease the shaft with Admax L3 or Energrease LS3 and fit the countershaft assembly to the spherical bearing and secure with the two clips.
35. Examine the throttle stop lever for wear, fit a new lever if necessary.

Continued

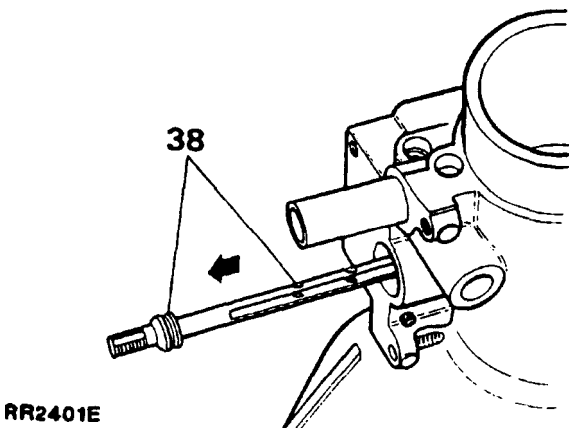
Inspect and overhaul throttle valve

36. Examine the throttle valve shaft for excessive wear between the bearing bushes in the plenum chamber and the shaft. A small amount of clearance is permissible. If excessive wear is evident fit new shaft and bushes as follows.
37. Remove the two split screws securing the throttle valve disc and withdraw the disc, taking care not to damage the shaft.



RR2400E

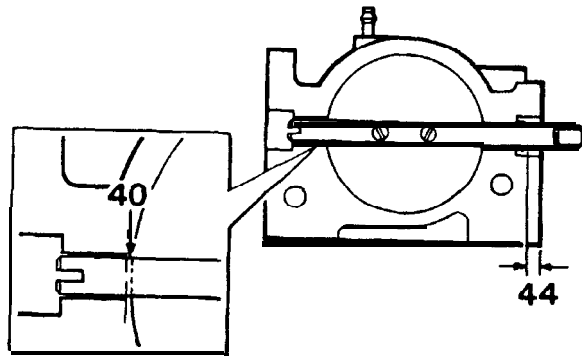
38. Remove the shaft and air seal from the plenum chamber.



RR2401E

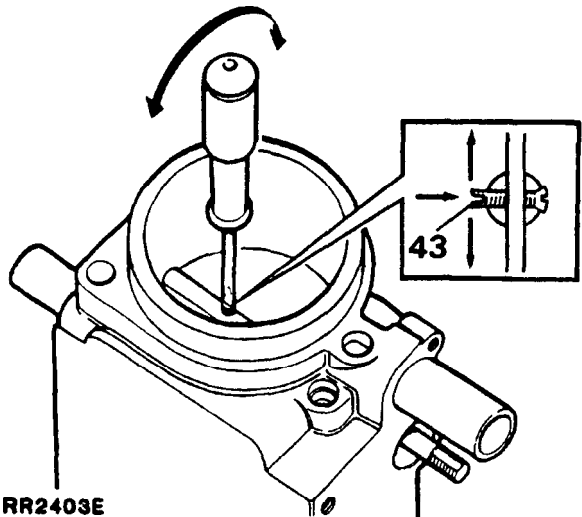
39. Using a suitable drift, drive out the bushes taking care not damage the bores in the plenum chamber.
40. Press in new bushes until they are flush with the throttle valve bore.

CAUTION: Ensure that the bushes do not protrude into the bore as they will interfere with the movement of the throttle valve disc.



RR2402E

41. Fit the throttle valve shaft and disc, secure in position with the two split screws. Do not fully tighten the screws at this stage.
42. Rotate the throttle shaft 360° once or twice to centralise the disc in the bore. Tighten the two screws.
43. Rotate the shaft until the split end of the screws are accessible. Using the blade of a screw driver spread the split to secure the screws in the shaft.

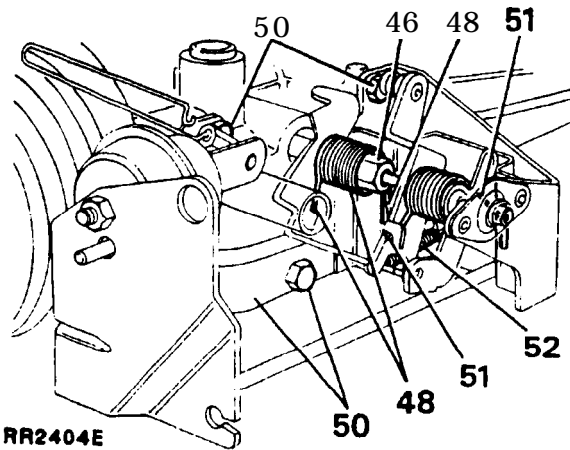


RR2403E

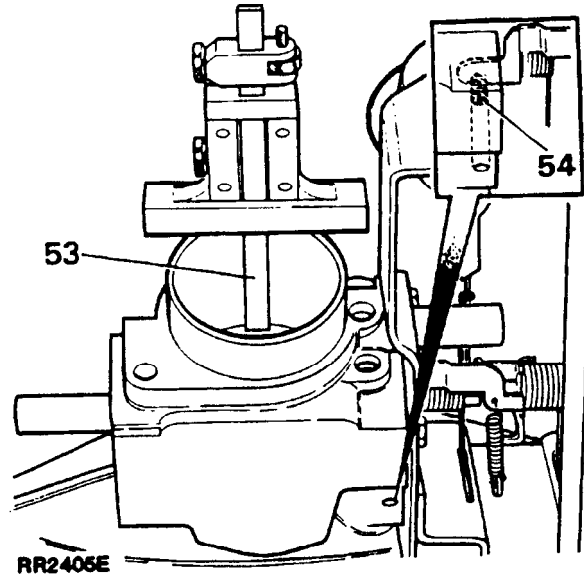
44. Pre-grease a new air seal with Admax L3 or Energrease LS3. Fit the seal pushing it down the shaft and into the counterbore until the seal is 6.0 mm (0.236 in) below the face of the plenum chamber.

Assemble throttle levers and bracket

45. Fit the stop lever to the throttle valve shaft followed by a new tab washer and secure with the interconnecting nut.
46. Holding the stop lever on its stop, tighten the interconnecting nut securely and bend over the tabs of the tab washer to lock the nut in position.
47. Fit the inboard throttle return spring noting that the small hooked end of the spring is nearest the plenum chamber.
48. Locate the hooked end of the inboard spring on the stop lever and wind up the straight end one full turn and anchor it in the appropriate slot.
49. Fit the countershaft to the interconnecting nut of the throttle valve shaft.
50. Fit the throttle bracket assembly and secure with the three retaining bolts.
51. Ensuring that the hooked end of the outboard spring is anchored by the lever, wind the spring up one full turn and locate the free end in its appropriate slot.
52. Fit the over-travel spring.
Lightly grease the throttle return and over-travel springs with Admax L3 or Energrease LS3.



53. Using a depth vernier or depth micrometer from the mouth of the bore check the top and bottom of the valve disc. The disc must be within 0.5 mm (0.019 in) total indicator reading across the full diameter of the disc.
54. If the throttle disc is out of limits adjust the small set screw below the stop lever. Access to the screw is gained from the bottom of the plenum chamber neck adjacent to the throttle levers support bracket.



Refitting

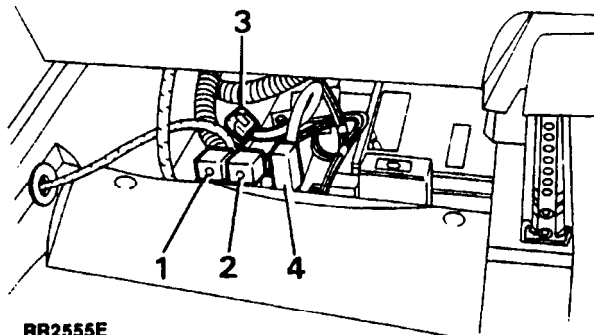
55. Reconnect and adjust the cruise control actuator link. (See cruise control-actuator link setting)
56. Clean any previous sealant from the joint face of the plenum chamber and ram housing. Apply 'Hylomar' sealant to the faces and refit the plenum chamber. Tighten the bolts to the correct torque value-see section 06.
57. Reverse the remaining preparation instructions.

NOTE: If new throttle levers have been fitted the minimum throttle setting of the disc must be checked to ensure that it is 50° to the bore.

ELECTRONIC FUEL INJECTION-RELAYS

Incorporated in the fuel injection electrical system are two relays which are located beneath the front right hand seat adjacent to the cruise control relay and emission maintenance reminder. Access to the relays is gained through the opening at the bottom of the seat when the seat is in its fully forward position on the seat slides.

1. Fuel pump relay (mounted on a blue terminal block).
2. Main relay (mounted on a black terminal block).
3. Diagnostic plug.
4. Condenser fan timer unit.



RR2555E

Remove and refit

Removing

1. Disconnect the battery negative terminal.
2. Pull the relay(s) from the terminal block(s).

Refitting

3. Reverse the removal procedure.

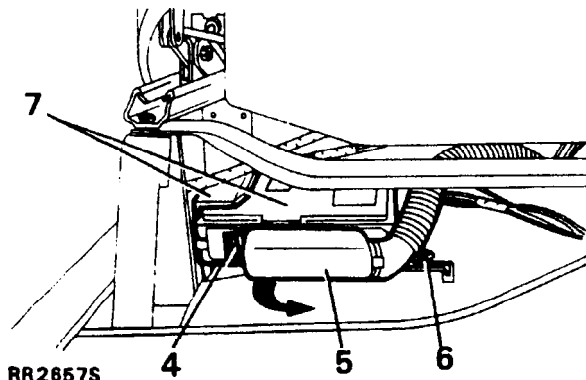
ELECTRONIC CONTROL UNIT (ECU)-14 CU

NOTE: The ECU is not a serviceable item. In the event of a unit failure the ECU must be replaced.

Remove and refit

Removing

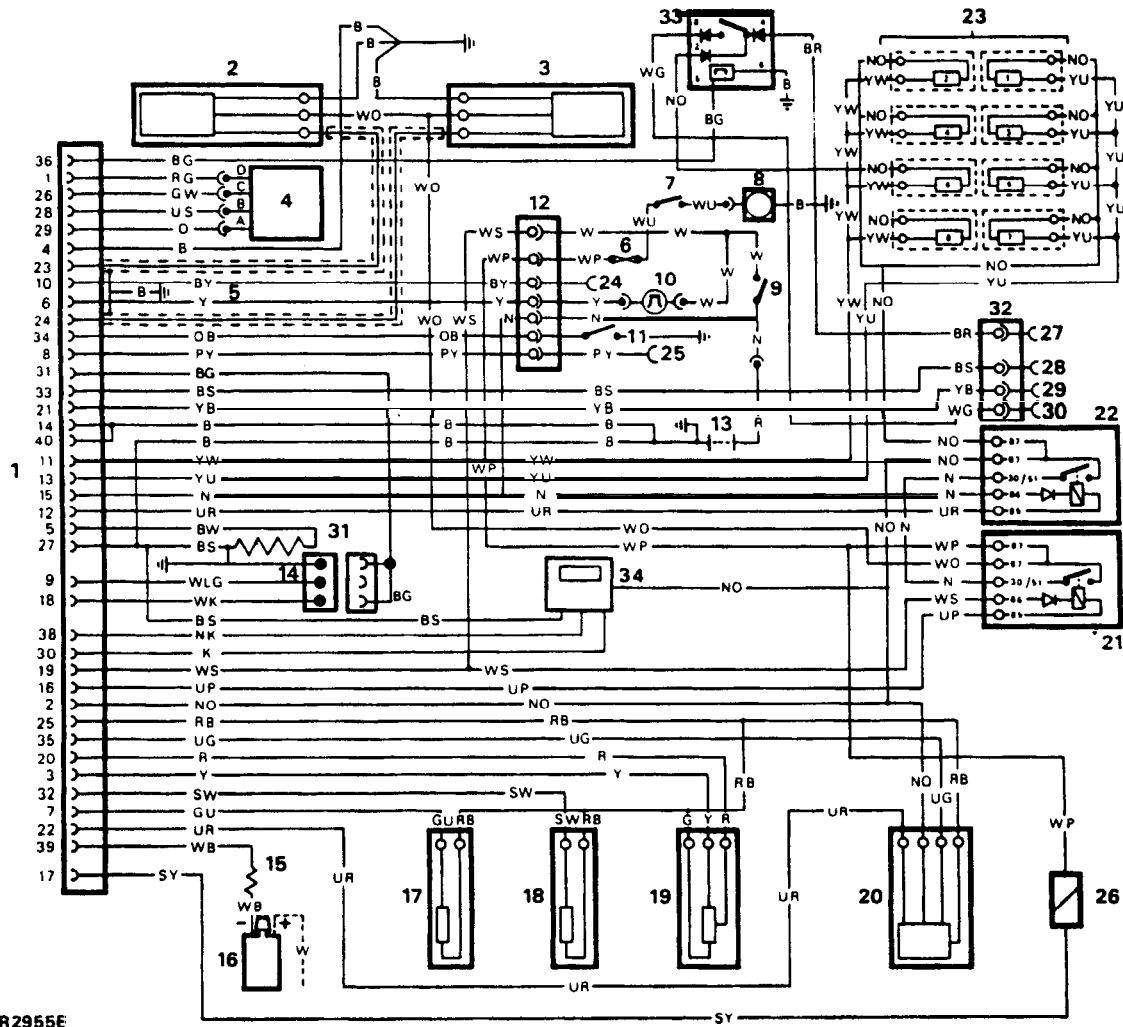
1. Remove the front and side seat base trim of the front right hand seat.
2. Adjust the seat to its most rearward position and raise the seat cushion height to allow access to the ECU fixings.
3. Disconnect the battery negative terminal.
4. Release the ECU plug retaining clip.
5. Maneuver the front of the plug (in the direction of the bold arrow) and detach the other end of the plug from the retaining peg.
6. Release the two screws securing the ECU to the mounting bracket.
7. Withdraw the ECU from the spring clip and remove it from the vehicle.



RR2657S

Refitting

8. Refit the ECU securely in the spring clip and fit and tighten the two screws.
9. Reconnect the ECU harness plug. Ensure that the plug is pushed firmly into its location and that the retaining clip secures the plug in position.
10. Remove remaining removal procedure.



RR2955E

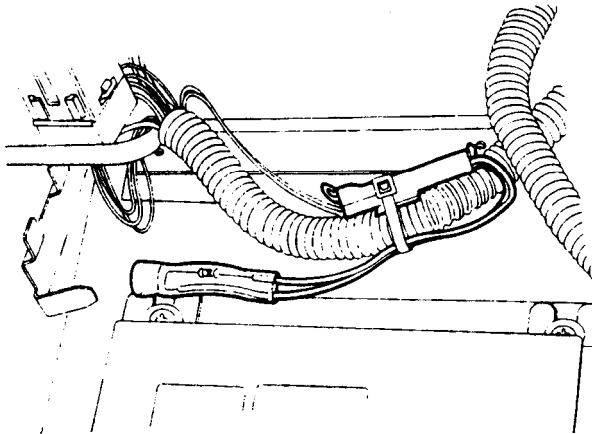
FUEL INJECTION - Circuit Diagram - 1990/91 model year

- | | |
|---|--|
| <ol style="list-style-type: none"> 1. 40 way connector to Electronic Control Unit (ECU). 2. Lambda sensor (left side - bank A). 3. Lambda sensor (right side - bank B). 4. By-pass air valve (stepper motor) (fast idle). 5. Lambda sensor screened ground. 6. Fuse C4 - main fuse panel. 7. Inertia switch. 8. Fuel pump. 9. Ignition switch. 10. Speed transducer (road speed input). 11. Neutral switch (automatic gearbox) (load input). 12. Main cable connector. 13. Battery. 14. Diagnostic plug. 15. In-line resistor. 16. Coil/-ve (engine RPM input). 17. Coolant temperature thermistor (sensor) (input). | <ol style="list-style-type: none"> 18. Fuel temperature thermistor (sensor) (input). 19. Throttle potentiometer. 20. Air flow sensor. 21. Fuel pump relay. 22. Main relay. 23. Injectors-1 to 8. 24. Pick-up point E.F.I. warning symbol (instrument binnacle). 25. Heated front screen sense. 26. Purge control valve. 27. 12V from fan relay. 28. Air conditioning output control. 29. Air conditioning load input. 30. Fan relay feed. 31. Tune resistor (early vehicles). 32. Heater/air con. cable connector. 33. Condenser fan timer control. 34. Fault display input. <p>== = Denotes screened ground.</p> |
|---|--|

NOTE: Reference to left and right side is made when viewing the vehicle from the rear.

**ELECTRONIC FUEL INJECTION
-LUCAS 14CUX SYSTEM**

1990 model year vehicles have an enhanced fuel injection system, using a Lucas 14CUX electronic control unit. The system is a development of the 14CU system introduced on 3.9 litre vehicles. The system works in the same way, new components being a tune select resistor and a fault code display unit.

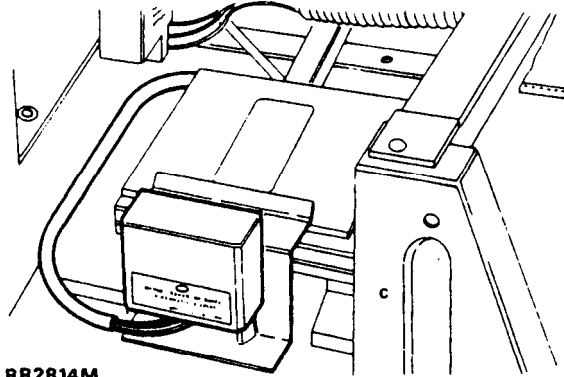
TUNE SELECT RESISTOR - RR281 1M**RR2811M**

The 14CUX system is used in various markets, but a common ECU is used. To suit individual market requirements a tune select resistor is connected across pins 5 and 27 of the ECU.

It is located adjacent to the ECU, and strapped to the EFI cable assembly. The value of the resistor is dependent on the market application.

NOTE: For USA market models the resistor value is 3900 Ohms, wire colour, white.

NOTE: Vehicles after VIN No 451518 are fitted with a new ECU, Part No. PRC 8747 to replace PRC 7081. This ECU no longer requires the tune select resistor, which is therefore deleted. Fault code 21 is no longer stored by the ECU.

17EM FAULT CODE DISPLAY UNIT - RR2814M**RR2814M**

1990 model year vehicles have a fault code display unit which is located underneath the right hand front seat, adjacent to the EFI ECU. The unit will display the relevant fault code, in addition to the EFI warning light being illuminated.

NOTE: Fault code 59 will NOT be indicated by the EFI warning light.

Recommended equipment

The diagnostic equipment for checking out the 14CUX system is the same as that used for 14CU, with the addition of two new memory cards for Hand Held Tester.

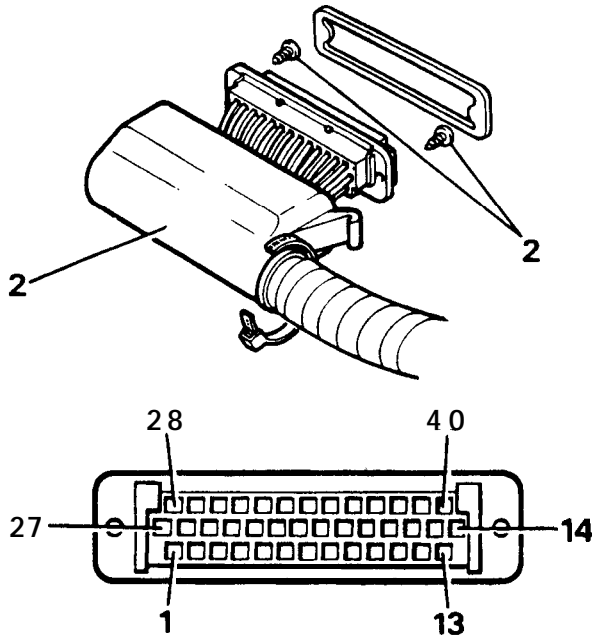
14CUX Memory cards, Lucas Part Number:
- 606 01 379.

CONTINUITY TEST PROCEDURE

NOTE: The continuity test procedure for 14CUX systems is similar to that for 14CU. Note the addition of the tune select resistor test and the deletion of Test 28, which does not apply to 14CUX systems.

TESTING

1. Release the ECU plug retaining clip and remove the plug from the ECU. Access is gained by removing the front seat base trim of the right hand front seat.
2. Remove the plug shroud and manoeuvre it along the harness until there is enough clearance to enable meter probes to be inserted into the back of the plug.
3. There are six pin numbers 1, 13, 14, 27, 28 and 40 moulded onto the rear of the plug as shown in the illustration below, for clarity the electrical leads have been omitted.



RR2800M

Pins 1 to 13 bottom row.
 Pins 14 to 27 centre row.
 Pins 28 to 40 top row.

CONNECTIONS TO 40 WAY CONNECTOR

PIN Nos. CABLE COLOUR

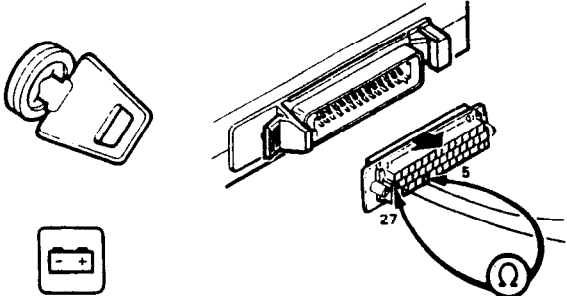
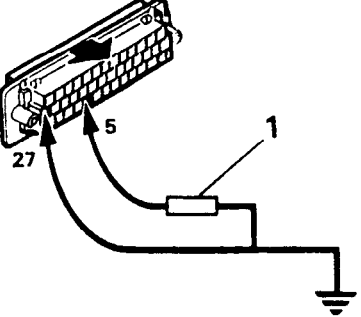
1. Red/green
2. Brown/orange
3. Yellow
4. Blak
5. Grey/Black
6. Yellow
7. Green/blue
8. Purple/yellow
9. White/light green
10. Black/yellow
11. Yellow/white
12. Blue/red
13. Yellow/blue
14. Black
15. Brown
16. Blue/purple
17. Grey/yellow
18. White/pink
19. White/grey
20. Red
21. Yellow/black
22. Blue/red
23. Blue
24. Blue
25. Red/black
26. Green/white
27. Black/grey
28. Blue/grey
29. Orange
30. Pink
31. Black/green
32. Grey/white
33. Black/grey
34. Orange/black
35. Blue/green
36. Black/green
37. Not used
38. Brown/pink
39. White/black
40. Black

The last colour denotes the wire tracer colour

Tune select resistor test

It is recommended that this test is carried out before Test 1. of Continuity Test Procedure, Section 19, page 44.

NOTE: This test is not required on vehicles after VIN No 451518, which are no longer fitted with a tune select resistor.

TEST PROCEDURE	RESULTS - check cables and units shown in bold
<p>TUNE SELECT RESISTOR TEST KEY 1) Tune select resistor</p>	<p>CORRECT READING: 3700-4100 OHMS Resistor wire colour: White INCORRECT OHMMETER READING CHECK:</p>
 <p>IGNITION OFF RR2812M</p>	 <p>RR2813M</p>

Description of fault codes

The fault codes are listed in order of priority. Where more than one fault exists, clearing the first fault code will permit the next code to be displayed.

NOTE: Fault code 02 will show if the ECU has just been reconnected. Switch on ignition to clear the display.

Clearing fault code display

It is necessary to clear the code displayed when the fault has been rectified, and to access any further fault codes that may exist. Clear the fault code displayed using the following procedure:

1. Switch On ignition.
2. Disconnect serial link mating plug, wait 5 seconds, reconnect.
3. Switch OFF ignition, wait for main relay to drop out.
4. Switch ON ignition. The display should now reset. If no other faults exist, and the original fault has been rectified, the display will be blank.
5. If multiple faults exist repeat Steps 1. to 4. as each fault is cleared the code will change, until all faults are cleared. The display will now be blank.

Code 29 - ECU MEMORY CHECK - If this fault is detected, all other faults are unreliable and must therefore be ignored.

Proceed as follows:

1. Leave battery connected
2. Switch ignition off
3. Wait for approximately 5 seconds
4. Disconnect ECU plug
5. Re-connect ECU plug
6. Switch ignition on and check display unit.

NOTE: If fault code 29 is detected again, substitute ECU and restart test sequence.

Code 44 - LAMBDA SENSOR A - left bank
 Code 45 - LAMBDA SENSOR B - right bank

If one of these fault codes is displayed check the wiring to that particular lambda sensor.

If both codes are displayed, the voltage supply to the heater coils of the sensors must be checked. Refer to Test 26, continuity test procedure.

Code 25 - IGNITION MISFIRE - This code indicates that an ignition system misfire has been detected. Codes 40 or 50 indicate on which bank the misfire has occurred.

Code 40 - MISFIRE BANK A - left bank
Code 50 - MISFIRE BANK B - right bank

If both fault codes are displayed check the following components common to both banks:

- Distributor cap
- Rotor arm
- Coil
- Electrical connections
- Pick-up (air gap)
- Amplifier
- Injectors - if code 34 or 36 displayed.

If either fault code 40 or 50 is displayed check components applicable to the particular bank that the misfire has occurred on:

- Spark plugs
- HT leads
- Distributor cap
- Injectors - if code 34 bank A or 36 bank B displayed.

Code 12 - AIRFLOW METER - Refer to Test 19, continuity test procedure.

Code 21 - FUEL TUNE SELECT - Identifies that the tune select resistor is open circuit - Refer to tune select resistor test.

Code 34 - INJECTOR BANK A - The display will indicate if the injector/s are causing the engine to run rich or lean.

If the bank is running rich, check for:-
 - faulty injector wiring and connectors
 - stuck open injectors

If the bank is running lean, check for:-
 - faulty injector wiring and connectors
 - blocked injectors

Code 36 - INJECTOR BANK B - As code 34 except relevant to bank A injectors.

Code 14 - COOLANT THERMISTOR - Refer to Test 14, continuity test procedure.

Code 17 - THROTTLE POTENTIOMETER - Refer to Test 17, continuity test procedure.

Code 18 - THROTTLE POTENTIOMETER input high/AIRFLOW METER - low. - Refer to Tests 17, 18 and 19 of the continuity test procedure

Code 19 - THROTTLE POTENTIOMETER input low/AIRFLOW METER - high. - Refer to Tests 17, 18 and 19 of the continuity test procedure

Code 88 - PURGE VALVE LEAK - Refer to Test 9 and 10 of the continuity test procedure.

Code 28 - AIR LEAK - Check for air leaks in the following areas.

- Hose, air flow meter to plenum
- Breather system hoses to plenum
- Brake servo hose
- Vacuum reservoir hose (fresh air solenoid)
- Distributor vacuum advance
- Hose, purge valve to plenum
- Injector seals
- Joint - By pass air valve to plenum
 - Plenum chamber to ram housing
 - Ram housing to inlet manifold
 - Inlet manifold to cylinder head
- By pass air valve hose

Code 23 - FUEL SUPPLY - Check fuel system pressure, Test 20 of the continuity test procedure.

Code 48 - STEPPER MOTOR - Check base idle speed - see setting procedure. - Refer to Tests 15 and 16 of the continuity test procedure. Check road speed sensor - Refer to Test 25 of the continuity test procedure.

Code 68 - ROAD SPEED SENSOR - Refer to Test 25 of the continuity test procedure.

Code 69 - GEARSWITCH - Refer to Test 24 of the continuity test procedure.

Code 59 - GROUP FAULTS 23/28 - This indicates that a fault has been registered that is caused by the fuel supply or an air leak but the exact fault cannot be identified. Check all items outlined under code 23 and 28.

Code 15 - FUEL THERMISTOR - Refer to Test 13 of the continuity test procedure.

BASE IDLE SPEED SETTING

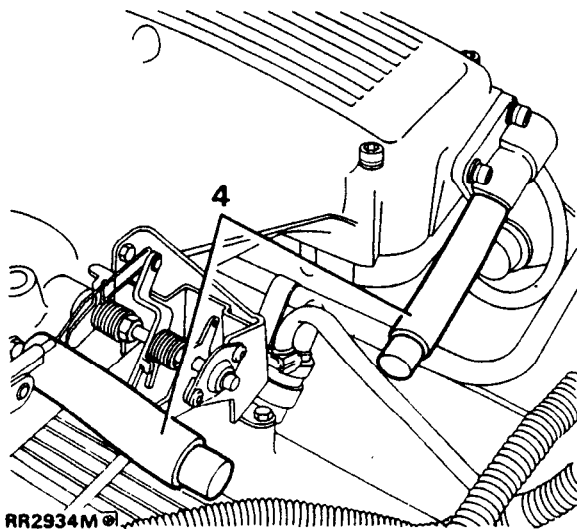
NOTE: the base idle speed is set at the factory. It should not require further adjustment unless the plenum chamber is changed. The adjustment screw is sealed with a plug to prevent unauthorised alteration. Check the ignition timing before attempting the following procedure, since this will affect the idle speed.

Equipment required

Two blanking hoses. It is recommended that these are manufactured using a new air by-pass valve hose - Part No.ETC7874. Cut two equal pieces 90mm (3 1/2 inches) long from the hose and seal one end of each, using 13mm (1/2 inch) diameter bar. A suitable clamp can be used to ensure an air tight seal

Checking procedure

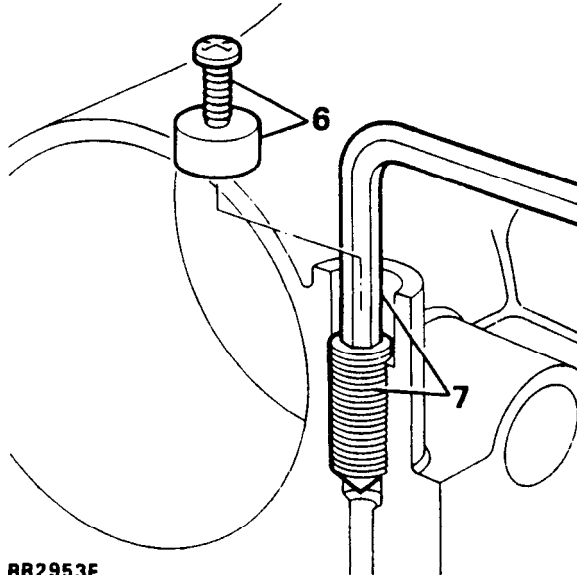
1. Drive the vehicle for at least two miles until the engine and transmission are hot. Switch off the engine.
2. Check that all electrical loads are off including air conditioning.
3. Remove the air by-pass valve hose.
4. Fit the blanking hoses to both the plenum chamber and the air by-pass valve. Ensure the hoses are securely fitted to prevent air leaks. Note that the throttle cable and cruise control actuator have been omitted from the illustration for clarity.



5. Start the engine and check that the idle speed is within the limits specified in Section 05 - Engine Tuning Data.

Adjusting base idle speed

6. Remove the tamper proof plug that protects the idle speed screw. Drill the plug and insert a self tapping screw to enable the plug to be extracted.



7. Start the engine, and using a suitable Allen key, adjust the idle screw clockwise to decrease or counter-clockwise to increase the idle speed.
8. Check fault code display, and clear the memory - see 'Clearing fault code display' - section 19, page 74.

FUEL SYSTEM 1991 MODEL YEAR

A revised fuel system is fitted to 1991 model year vehicles. The major change is the fitting of a plastic fuel tank with improved breather system. The remote expansion tank is now deleted.

A further improvement is the fitting of a combined fuel pump and sender unit. A panel in the floor of the vehicle permits access to the fuel pump/sender unit

FUEL PUMP/SENDER UNIT

WARNING: Ensure that the Fuel Handling Precautions given in Section 01 - Introduction regarding fuel handling are strictly adhered to when carrying out the following instructions.

CAUTION: Before disconnecting any part of the fuel system, it is imperative that all dust, dirt and debris is removed from around the components to prevent ingress of foreign matter into the fuel system.

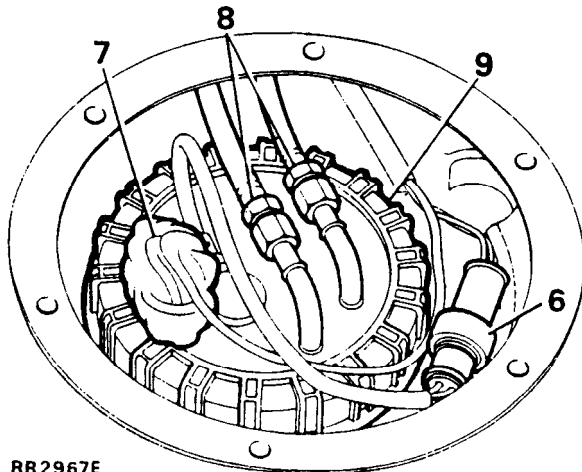
Special Tool - LST131, wrench - pump retaining ring

- LST 144 - 'Speedfit' disconnecter

Remove and refit

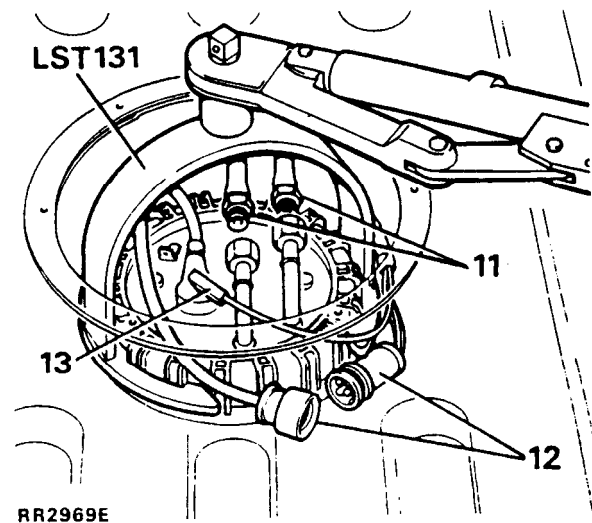
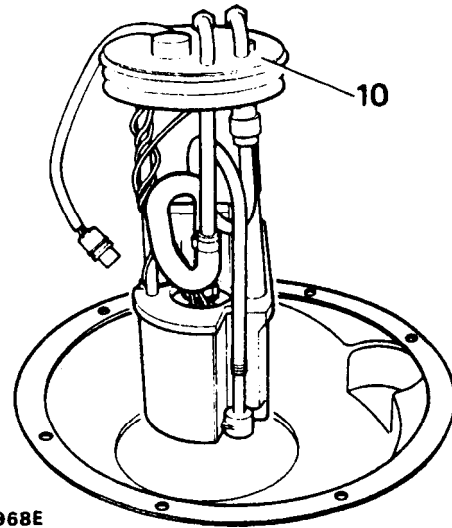
Removing

1. Depressurise the fuel system.
2. Disconnect battery negative lead.
3. Syphon at least 9 litres (2 gallons) of fuel from the fuel tank using a suitable container that can be sealed afterwards.
4. Remove carpet from loadspace floor and tailgate.
5. Fold back the sound insulation to reveal the access panel.



6. Remove the securing screws and detach the access panel from the floor.
7. Disconnect the electrical connections at the multi-plug.
8. Remove the insulation sealant from around the ground lead, and disconnect the ground lead.
9. Disconnect the two fuel line unions from the fuel pump.
10. Using Special Tool No. LST131, remove pump assembly retaining ring and withdraw the pump from the fuel tank.

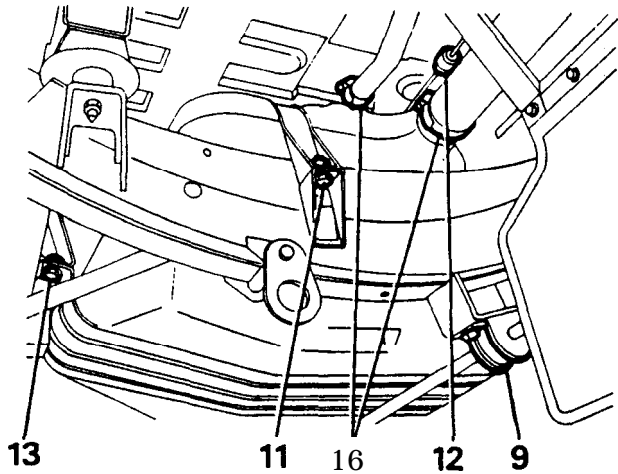
WARNING: A quantity of fuel will be retained in the body of the unit, care must be taken to prevent fuel spillage when the unit is removed.



Refitting

11. Insert the fuel pump into the tank. Fit the retaining ring and tighten to a torque of 45-50 Nm (34-37 lbf ft).
12. Connect the fuel lines to the pump.
13. Connect the electrical leads at the multi-plug.
14. Connect the ground lead to the pump and insulate with suitable sealant.
15. When the fuel system has been reassembled check all fuel pipes, sealing rings and hose connections are secure.
16. Run the engine to check for fuel leaks before final assembly.
17. Inspect the access panel seal, fit a new seal if necessary.
18. Fit the access panel and secure to the floor with the screws.
19. Reverse operations 4 - 5 to refit the sound insulation and carpet.

7. Remove the insulation sealant from around the ground lead, and disconnect the ground lead.
8. Disconnect the two fuel line unions from the fuel pump.
9. Working underneath the vehicle, remove the rear anti-rol bar straps, and allow the bar to swing down clear of the tank.



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FUEL TANK

WARNING: Ensure that the Fuel Handling Precautions given in Section 01 - Introduction regarding fuel handling are strictly adhered to when carrying out the following instructions.

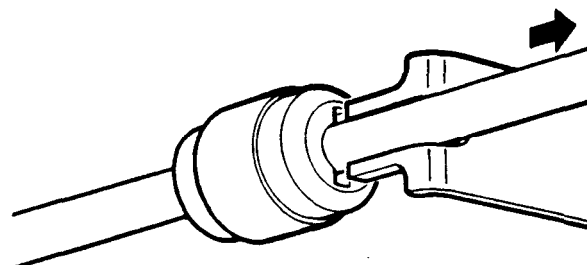
CAUTION: Before disconnecting any part of the fuel system, it is imperative that all dust, dirt and debris is removed from around the components to prevent ingress of foreign matter into the fuel system.

10. Remove the tank filler and vent hoses at the fuel tank.
11. Remove the nut and bolt securing the right hand side of the fuel tank strap.
12. Disconnect the evaporative control pipe at the green end of the 'speedfit' connector.

Remove and refit

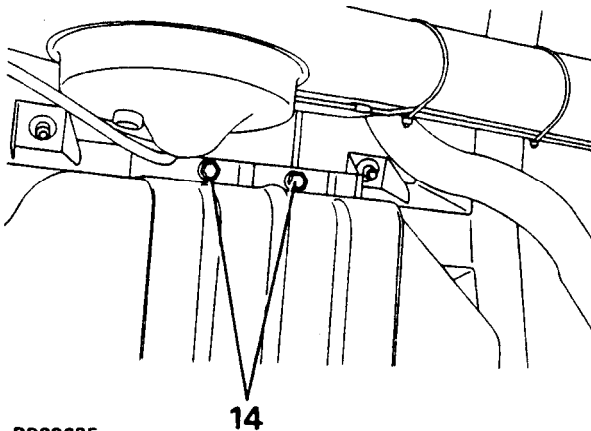
Removing

1. Depressurise fuel system. Disconnect battery negative lead.
2. Syphon the fuel tank into a suitable container that can be sealed afterwards. ENSURE THAT THE TANK IS DRAINED COMPLETELY. (refer to Warning concerning fuel vapor and spillage at start of this procedure).
3. Remove carpet from loadspace floor and tailgate.
4. Fold back the sound insulation to reveal the access panel.
5. Remove the securing screws and detach the access panel from the floor.
6. Disconnect the electrical connections at the multi-plug.



ST2877M

NOTE: To disconnect the 'speedfit' connector, forked end into the two slots of the connector as shown in the illustration above. Press down on the collet and simultaneously pull the pipe from the connector. Special tool LST 144 is available for this operation.



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13. Remove the back two bolts and nut plates securing the fuel tank cradle.
14. Remove the front nuts, bolts and washers, and remove the fuel tank cradle.
15. With the aid of an assistant, tilt the right hand side of the tank upwards and manouver the tank through the chassis to remove.

Refitting

16. Reverse the removal procedure, ensuring that the sealing ring, fuel pipe and hose connections are secure.
17. Run the engine and recheck all connections to ensure no fuel leaks exist. Reverse the remaining removal procedure.

FUEL FILTER

Remove and refit

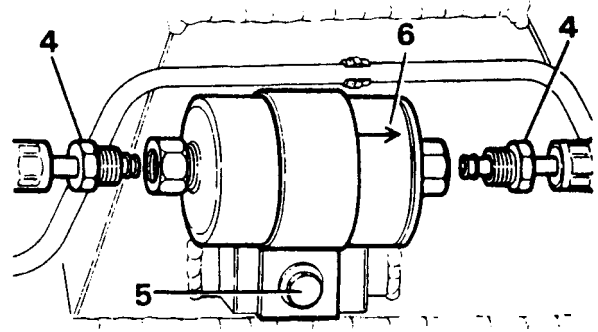
WARNING: ENSURE THAT THE FUEL HANDLING PRECAUTIONS GIVEN IN SECTION 01 - INTRODUCTION REGARDING FUEL HANDLING ARE STRICTLY ADHERED TO WHEN CARRYING OUT THE FOLLOWING INSTRUCTIONS.

WARNING: THE SPILLING OF FUEL IS UNAVOIDABLE DURING THIS OPERATION. ENSURE THAT ALL NECESSARY PRECAUTIONS ARE TAKEN TO PREVENT FIRE AND EXPLOSION.

Removing

1. Depressurise the fuel system.
2. The fuel filter is located on the right-hand chassis side member forward of the fuel tank filler neck. Access to the filter is gained through the right-hand rear wheel arch.

3. Clamp the inlet and outlet hoses to prevent the minimum of fuel spillage when disconnecting the hoses.
4. Loosen the two fuel line unions and remove the hoses from the filter canister.
5. Release the single nut and bolt securing the filter and clamp and remove the filter.



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Refitting

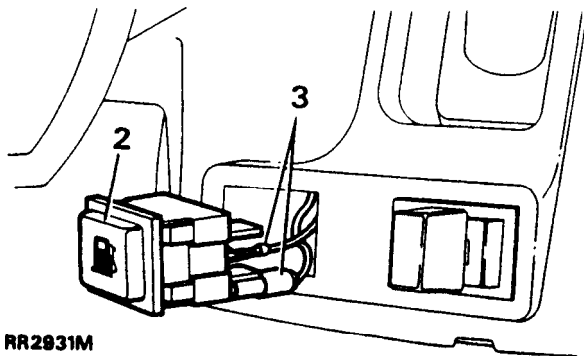
6. Fit a new filter observing the direction of flow arrow on the canister.
7. Tighten the single nut and bolt.
8. Fit the inlet and outlet hoses. Tighten the unions to a torque of 20-25 ft lb(27-34Nm).
9. Refit the fuel pump relay, reconnect the battery. Recode the radio.
10. Start the engine and inspect for fuel leaks around the hose connections.

FUEL FILLER FLAP RELEASE BUTTON

The fuel filler flap is no longer part of the central locking system on 1991 model year vehicles. The filler flap is permanently locked. To release the flap press the button situated on the steering column shroud. On closing, the filler flap will be locked automatically. Note that the release button will only work with ignition switched OFF.

Remove and refit**Removing**

1. Disconnect the battery negative lead.
2. Carefully pry the release button from the steering column shroud.



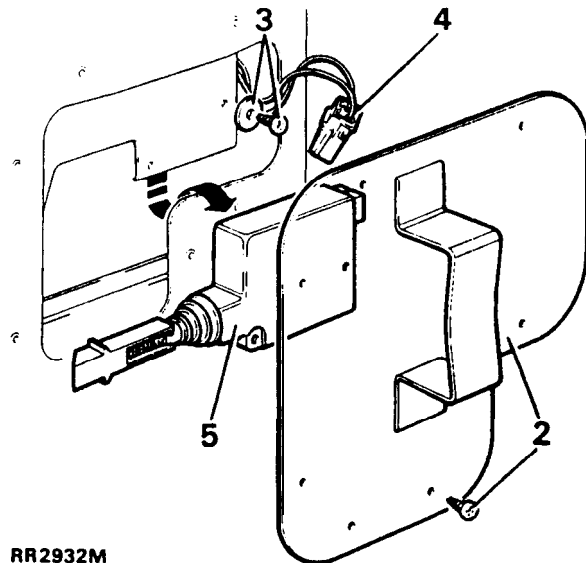
3. Remove the release button from the shroud and disconnect the two wiring connectors. Ensure that the wires protrude through the shroud to facilitate reassembly.

Refitting

4. Reverse the removal procedure. Recode the radio.

FUEL FILLER FLAP RELEASE ACTUATOR**Remove and refit****Removing**

1. Ensure that the fuel filler flap is released. Disconnect the battery negative lead.
2. Remove eight screws, and withdraw the closure panel, situated in the right hand side of the load space.
3. Release two screws and maneuver the actuator clear of its mounting.
4. Disconnect the wiring plug.
5. Withdraw the actuator.

**Refitting**

6. Reverse the removal procedure. Recode the radio.