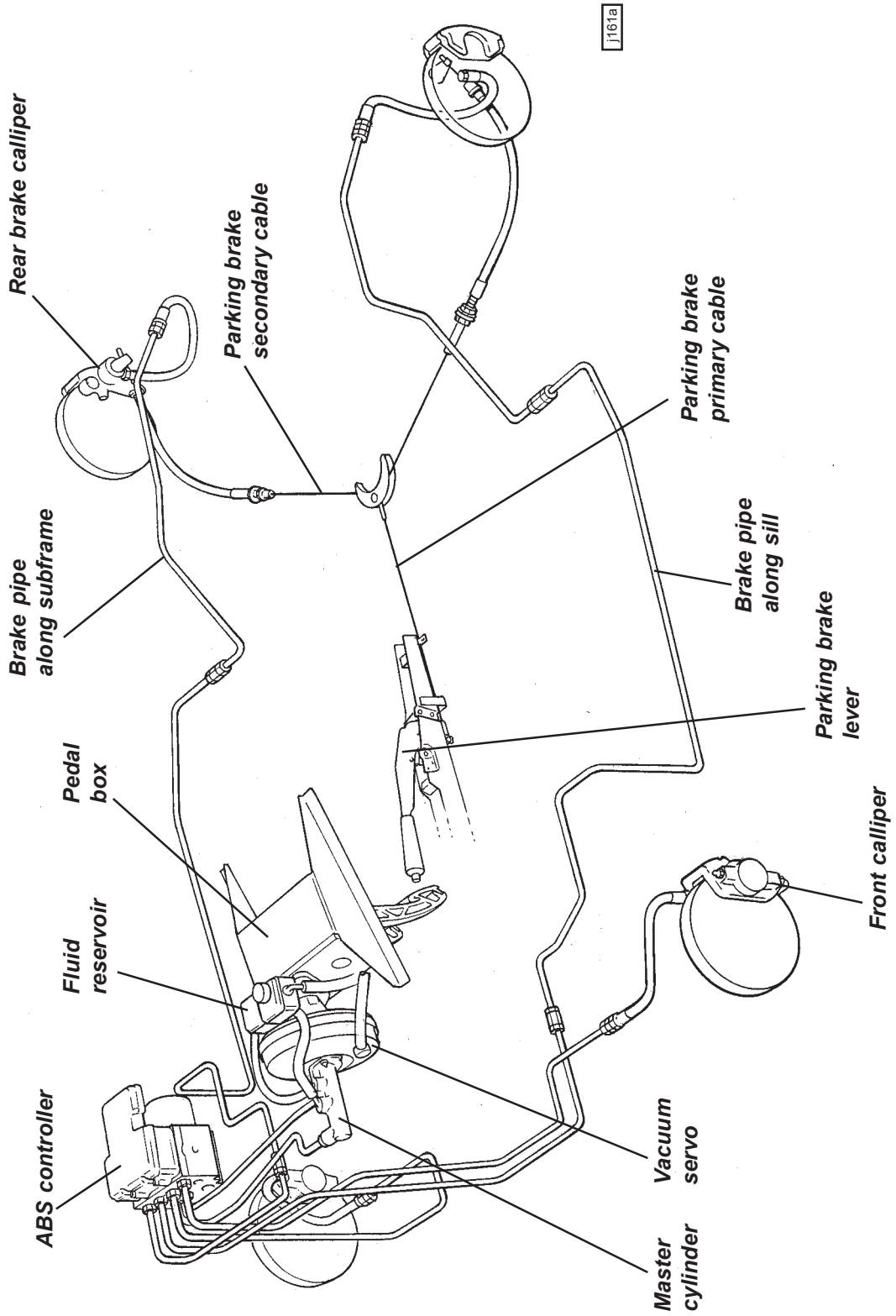


**BRAKING SYSTEM****SECTION JJ**

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GENERAL LAYOUT





JJ.1 - GENERAL DESCRIPTION

The Lotus Elise, when fitted with anti-lock brakes, comprises ventilated discs all round with AP Racing 2-piston fixed callipers on the front and Brembo single piston sliding callipers on the rear. A tandem master cylinder, with vacuum servo assistance, operates the callipers via a front/rear split hydraulic circuit with anti-lock control by a Kelsey-Hayes microprocessor based system. The centrally mounted parking brake lever, operates the rear calliper pistons by control cables.

The AP Racing front callipers, have lightweight alloy bodies housing two opposed pistons, and are mounted via two bolts directly to the rear of the forged steel hub carriers. The rear brakes use Brembo cast iron, single piston callipers, sliding on pins mounted directly to the forged steel hub carriers. A ventilated cast iron brake disc with curved internal vanes and cross drilling is common to all four wheels, and is sandwiched between the road wheels and hubs, retained for convenience by a single countersunk screw.

The tandem master cylinder is made by FTE, and incorporates a front section to supply both front brakes, and a rear section to supply the rear brakes. A translucent fluid reservoir is mounted on a bracket above the master cylinder, and has separate compartments connected to the front and rear cylinder sections by flexible hose. A third hose connects the rear reservoir compartment with the clutch master cylinder to supply that system's needs. A fluid level sensor in the filler cap will light a fascia tell tale lamp if the level becomes dangerously low.

The parking brake ratchet lever is mounted between the seats and uses a short primary cable and balancing yoke to actuate a single control cable linked to each rear calliper. Adjustment of the calliper mechanism to compensate for brake pad wear is automatic. The parking brake should be applied by pulling up the lever with high effort, and engaging the highest ratchet setting attainable. When parking the car on a slope, the additional precaution should be taken of leaving the transmission in first or reverse gear and steering the wheels towards the kerb. If the parking brake is applied when the brakes are hot (e.g. after prolonged or vigorous braking), special care should be taken to ensure that the parking brake is securely engaged in order to allow for any potential affect on brake performance as the discs cool.

The braking system is designed to enhance brake performance during high speed driving, with good fade and pad wear characteristics, and have a higher friction level when heated to normal working temperature than when cold. Required pedal effort will reduce as cold brakes become heated to normal working temperature, and the braking efficiency will increase significantly as new discs or pads become 'bedded in'. After fitting new brake components, maximum braking efficiency will be achieved if, for the first few hundred miles, needless heavy braking is avoided, and the brake pads are allowed to 'bed in' fully before being used to their full potential.

A Kelsey-Hayes Antilock Brake System (ABS) is used to optimise brake performance in extreme conditions and reduce the tendency of any wheel to lock up. Under most conditions, the maximum braking force is provided by a wheel which is rotating at about 90% of road speed. Apart from the likelihood of increasing the stopping distance, a locked wheel provides no steering force, such that with both front wheels locked, movement of the steering wheel has no effect on vehicle direction. With the antilock system, even panic braking results in controlled deceleration and the retention of steering response and is especially advantageous when braking on slippery road surfaces and in bad driving conditions. The ABS control system is self monitoring and has the capability of switching itself off if a fault is detected, allowing the base brake system to operate without anti-lock control.

Under normal circumstances, the hydraulic power brake system of the vehicle operates without input from the ABS, with brake pressures governed by the force applied to the brake pedal. The ABS microprocessor receives signals from wheel speed sensors at each of the four wheel hubs, and interprets this data to determine if any wheel is tending to lock up. If imminent lock up is determined, the microprocessor commands solenoid valves in an electro-hydraulic unit to reduce the pressure in that particular brake circuit in order to restore wheel speed to that providing the maximum braking force consistent with continued wheel rotation.

When the ABS is operating, indication to the driver is provided by a 'pulsing' sensation felt at the brake pedal as fluid is pumped between the master cylinder and hydraulic control unit, and also by audible clicking of the relays and switches. These signals indicate to the driver that maximum retardation is being approached, and that driving style should be modified to suit the conditions. The minimum stopping distance is achieved by applying the brakes firmly and steadily, and allowing the ABS to modulate hydraulic pressure. The driver should not attempt to emulate this process by 'pumping' the brake pedal, as modulation at the pedal will treat all four wheels similarly, rather than the individual wheel control allowed by the electronics.

During ABS operation, the wheels may appear to lock momentarily as the wheel speed changes rapidly, and some tyre noise (intermittent screeching) may be heard. This noise is normal and will vary with road and



tyre conditions. However, a wheel that completely locks and stays locked for more than one or two seconds is not normal, and indicates that the vehicle should be serviced as soon as possible. The ABS cannot operate properly if the base brake system is faulty, and will also be affected by dragging brakes, faulty wheel bearings or other related faults.

The ABS controller constantly monitors the anti-lock system for faults, and lights a fascia tell tale if a problem is detected. Information stored in the computer's memory may be accessed via a hand held electronic scanner, in order to facilitate diagnosis of system faults (see later).

JJ.2 - TELL TALE LAMPS

Two tell tale lamps are provided in the instrument cluster to warn of problems in the brake system.

Brakes Tell Tale

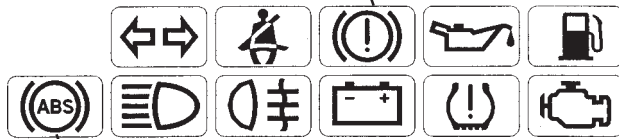
As a bulb check function, this tell tale will glow red for about six seconds after ignition switch on, and then go out unless one of the following conditions applies:

- i) The parking brake is applied.
- ii) The brake fluid level in the master cylinder reservoir is low.

Under normal circumstances, the tell tale should light when the ignition is switched on, and go out when the parking brake is released. If the lamp stays on, or comes on whilst driving, the car should be stopped immediately, as this may be an indication of low brake fluid level caused by a hydraulic leak. A button on the reservoir cap allows the tell tale circuit to be tested.

Euro spec.

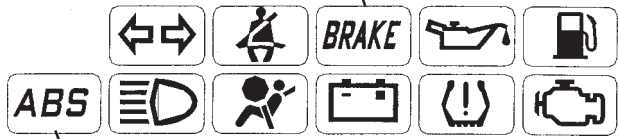
'Brakes' tell tale



'ABS' tell tale

USA spec.

'Brakes' tell tale



'ABS' tell tale

m252

ABS Tell Tale

The ABS tell tale warns the driver of problems in the anti-lock system. The lamp should light for about 6 seconds following ignition switch on, and then go out. If the lamp remains lit, or comes on whilst driving, a fault in the ABS is indicated. The base brake system will continue to operate normally, but without ABS regulation. The car can be driven but should be checked and repaired at the earliest opportunity.

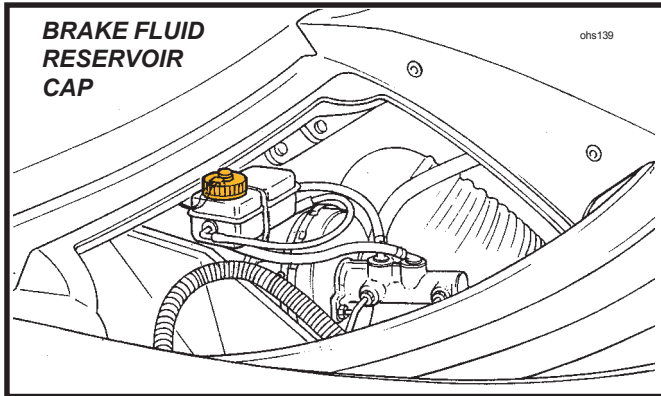
JJ.3 - BRAKE FLUID CHECK & CHANGE

Before checking the brake fluid level, ensure that the car is parked on a level surface, and remove the driver's side front body access panel. The level of fluid in the reservoir may be inspected without disturbing the filler cap, and should be level with the top of the 'MAX' mark moulded on the translucent reservoir body. The level will fall progressively as the brake pads wear in service, and should be checked at each service interval. A sensor incorporated into the filler cap will light a tell tale lamp in the instrument cluster if the level drops significantly. As a bulb check, the tell tale should light for about six seconds when the ignition is first turned on, but may also be tested by pressing the button on the filler cap, which action should light the tell tale with the ignition switched on.

The reservoir is mounted on a bracket over the master cylinder to which it is connected by flexible hoses. An internal baffle divides the reservoir into two compartments, with one section supplying the front brake circuit, and a second section supplying the rear brakes in addition to, via another flexible hose, the clutch master cylinder. Service wear of the clutch friction plate will cause fluid to be displaced from the self adjusting clutch slave cylinder, back to the reservoir, and will counteract to some extent the dropping of the level due to brake pad wear.



If the reservoir needs topping up, first clean around the cap to reduce the possibility of contamination before unscrewing the cap; it is not necessary to disconnect the level sensor cables. Take suitable precautions to guard against damage to paintwork caused by brake fluid dripping from the level sensor. Use only a fresh supply of DOT 4 **non-mineral** type fluid, identified by a yellow and black symbol.



**Non-mineral type
brake fluid symbol
(Yellow & Black)**



Do NOT use DOT 5 silicone fluid, or any fluid which has been exposed to the atmosphere for more than a brief period, or any fluid suspected of being wet, dirty or contaminated. Do not overfill. Replace the filler cap securely.

Some service operations, such as replacing brake pads, will result in the displacement of fluid from the hydraulic circuit back into the reservoir. In order to prevent fluid overflowing from the reservoir, it may be necessary to remove some fluid using a syringe.

Renewal of Brake Fluid

Brake fluid absorbs water from the atmosphere over a period of time (hygroscopical), resulting in a lowering of the boiling point of the fluid, and corrosion of the hydraulic system. For optimum safety and brake performance, the brake fluid should be renewed every twelve months (including clutch release system).

Brake Bleeding Procedure

If the brake fluid is to be renewed, or an hydraulic component replaced, the system should be bled of air using the following procedure:

1. Using conventional manual techniques, or low air pressure applied to the reservoir, bleed the system from each calliper bleed nipple in turn until no air bubbles can be seen.
2. Connect the Lotus Scan tool and select ABS and follow the brake bleeding instructions. Whilst this automatic process is taking place (with all 4 calliper nipples open), gently cycle the brake pedal up and down whilst keeping the reservoir topped up, to move any air bubbles displaced from the ABS unit down the hydraulic lines. Finish by closing each nipple with the pedal down.
3. Repeat step (1) to purge each calliper feed line in turn.

JJ.4 - FRONT BRAKE PAD REPLACEMENT

Pad thickness may be checked with the wheel removed without disturbing the calliper.

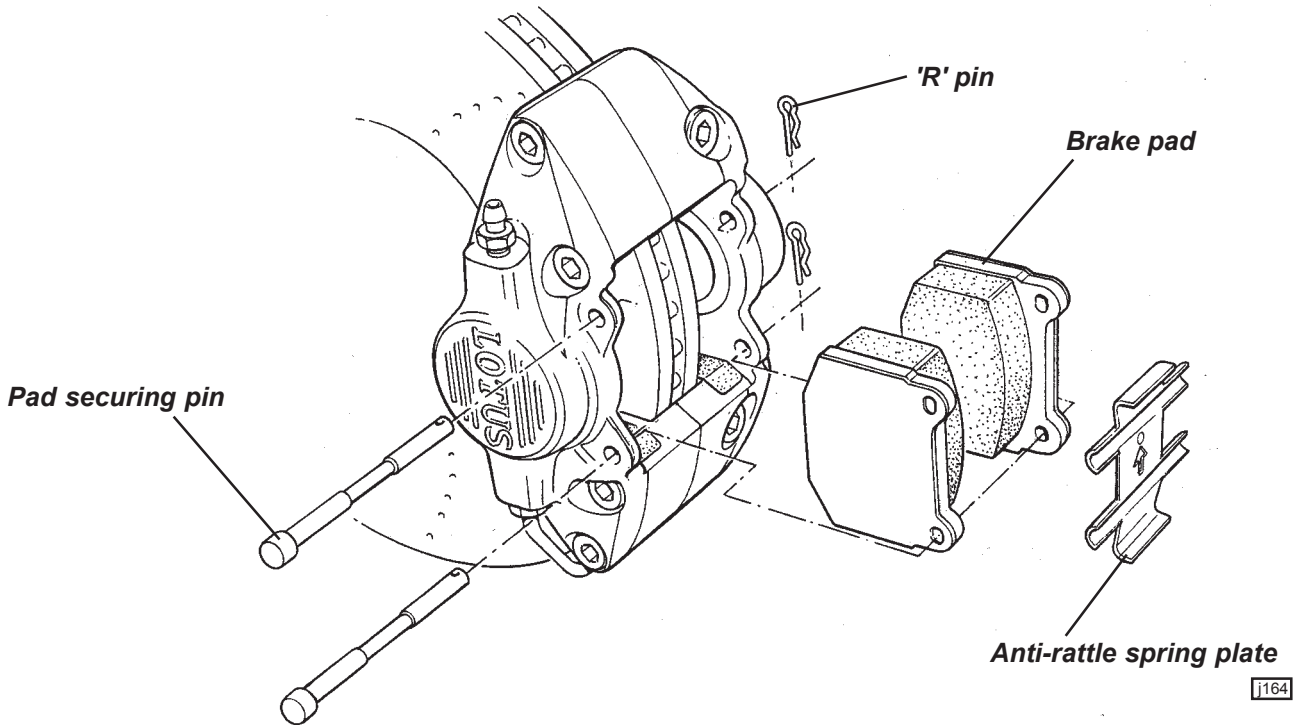
Standard pad thickness (excluding backplate);	9.0 mm
Minimum pad thickness (excluding backplate);	2.5 mm

If the thickness of any pad is below the specified minimum, the axle set of pads should be renewed. Note that the pad backplates are factory fitted with anti-squeal overlays, and are identified with T 4139 on the backplate.

For cars used on track, where sustained hard use and extreme brake temperatures are likely to occur, 'Motorsport' pads made by Pagid may be fitted in complete vehicle sets under part number A111J0150S (front) and A111J0151S (rear).

1. To remove the brake pads; Remove the 'R' clip from the lower of the two pad retaining pins, and withdraw the lower of the pin taking care to restrain the anti-rattle spring. Remove the second retaining pin together with the anti-rattle spring plate. Withdraw the pads from the calliper. Measure the lining thickness and renew the axle set of pads if any lining is below 2.5 mm.

2. Before replacing the pads, inspect the calliper for any signs of fluid leakage from a piston seal or joint, and replace the calliper if any such signs are evident. Clean the pad recess in the calliper taking suitable precautions to protect from dust inhalation.
3. If refitting the existing brake pads, refit each pad in the same position as originally fitted.



4. If fitting new pads, the pistons must be pushed back into the calliper to provide the necessary clearance. This action will return fluid to the master cylinder such that some fluid may need to be removed in order to prevent overflowing. Take care to avoid damaging the brake disc surface, or distorting the disc.
5. Position the pads in the calliper, and insert the upper pad retaining pin from the outboard side. Secure with the split pin.
6. Fit the anti-rattle spring into position with the side tangs pressing against the top end of the pad backplates, and the centre tang beneath the retaining pin. Insert the second pad retaining pin into the calliper, passing over the lower central anti-rattle spring tongue.
7. Before driving the car, press the brake pedal several times to bring the pads to their correct running position. Top up the master cylinder reservoir if necessary to bring the level to the top of the 'MAX' mark.
8. Ensure the customer is made aware that maximum braking efficiency will be achieved if, for the first few hundred miles, needless heavy braking is avoided, and the brake pads are allowed to 'bed in' fully before being used to their full potential.

JJ.5 - REAR BRAKE PAD REPLACEMENT

Pad thickness may be checked after removing the road wheel, without disturbing the calliper.

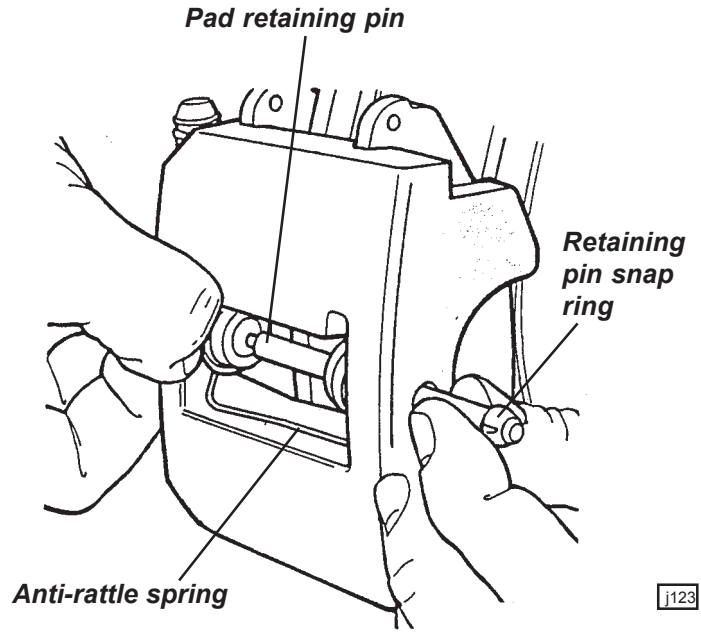
Standard pad thickness (excluding backplate);	6.5 mm
Minimum pad thickness (excluding backplate);	2.5 mm

If the thickness of any pad is below the specified minimum, the axle set of pads should be renewed. Note that the pad backplates are marked T 4139 and are factory fitted with anti-squeal overlays.

Tools Required:

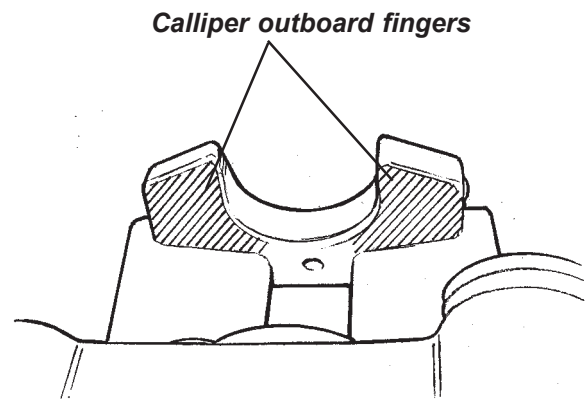
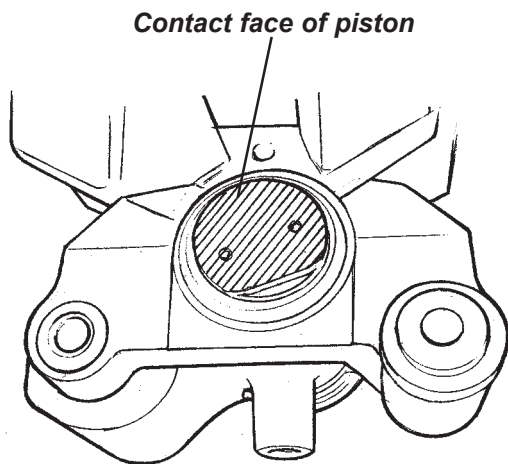
Piston Retraction Tool T000T1242

1. Remove the rear road wheels.
2. At each rear corner: using a suitable pin punch, knock the pad retaining pin out of the calliper towards the outside, taking precautions as necessary to restrain the anti-rattle spring from flying off as the pin is withdrawn.
3. Remove the anti-rattle spring, and withdraw both brake pads from the calliper. Measure the thickness of the lining material, and renew the axle set of pads if any are below 2.5 mm.



j123

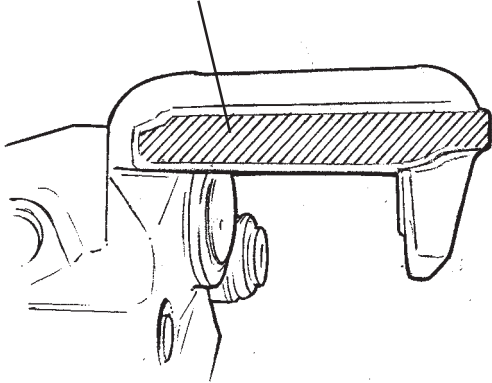
4. Before refitting the pads, inspect the piston boot for splits, cracks or other damage, and for any signs of fluid leakage or wetness. If any such signs are apparent, the complete calliper should be replaced as Brembo do not recommend that this calliper be dismantled.
5. If refitting the existing brake pads, refit each pad in the same position as originally fitted.
6. Before fitting new rear pads, the calliper piston must be screwed back into the calliper down the parking brake actuation mechanism. This operation requires the use of special tool T000T1242 and the removal of the brake disc:
 - Remove the single socket head screw retaining the brake disc, and remove the disc.
 - Fit special tool T000T1242 into the holes in the calliper piston, and screw the piston back down the parking brake mechanism screwthread until fully bottomed.
 - Refit the brake disc, and tighten the countersunk retaining screw to 12 Nm.
7. In order to minimise brake squeal from new pads during the bedding-in period, a copper based (PBC) paste (e.g Renolit) should be used on the pad contact surfaces of the rear callipers in the areas shown:



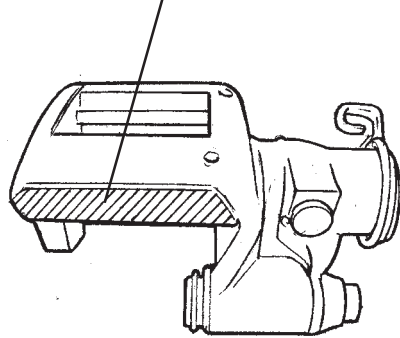
j188



Top surface of bridge including inner surface in contact with pad backplate

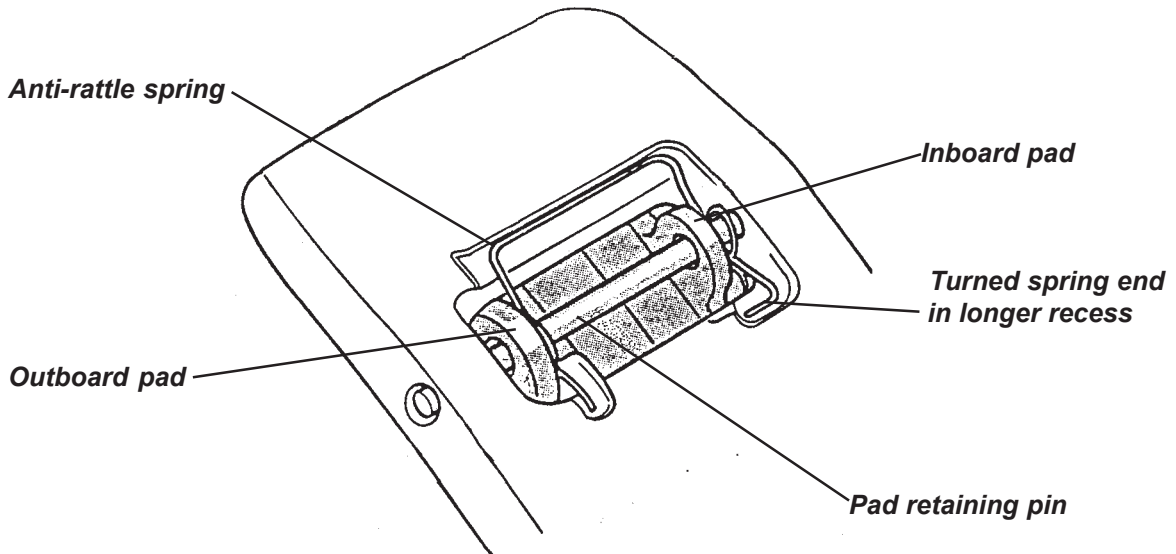


Bottom surface of bridge including inner surface in contact with pad backplate



i188

- Slide the brake pads into the calliper. Position the pad anti-rattle spring in the calliper aperture, with the spring ends located in the recesses provided. Ensure that the spring is fitted the correct way up, with the turned spring end in the longer recess. Press the spring eyes into alignment whilst the pad retaining pin is inserted through the calliper from the outside. Ensure that the pin passes through both eyes of the anti-rattle spring, and both brake pads, and that the pin is fully installed with the snap ring seated in the outboard side of the calliper.



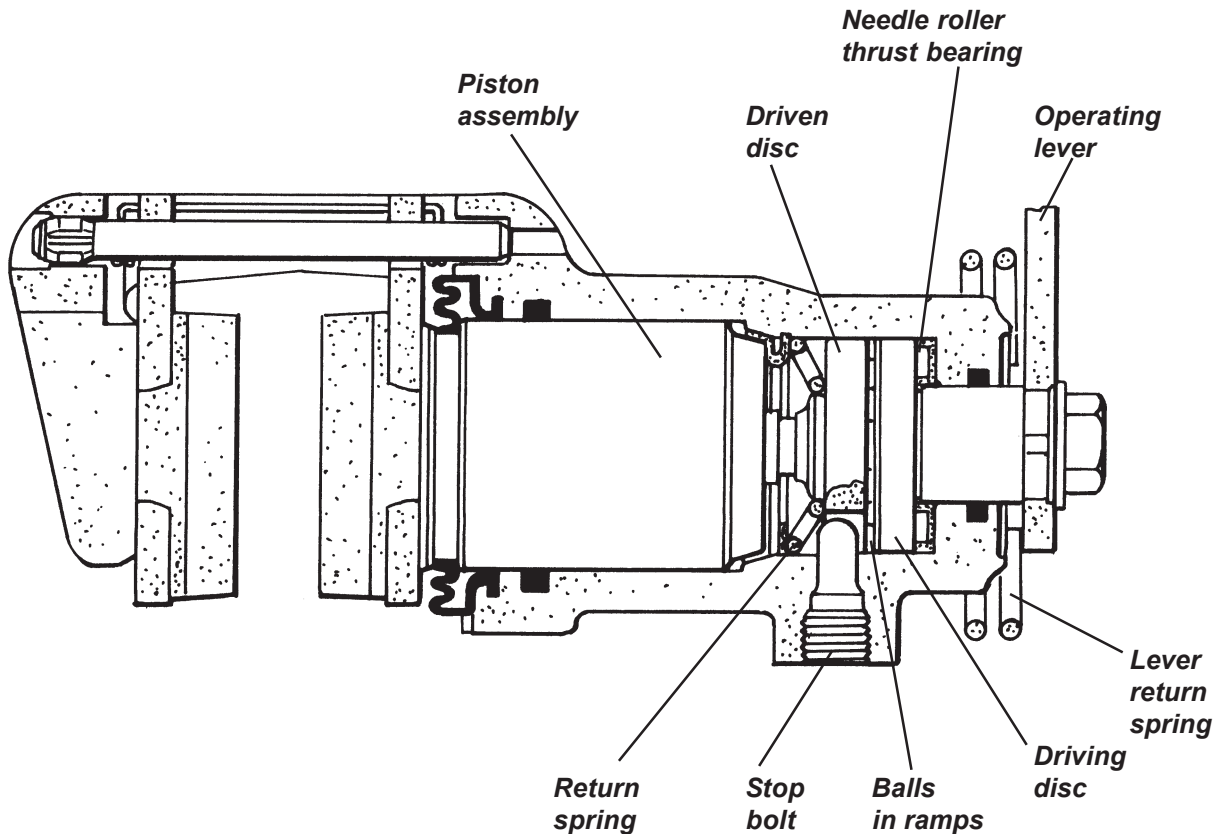
i124

- Refit the roadwheels and press the brake pedal several times to set the brake pad position. Before switching on the ignition, check the fluid level in the reservoir and top up if necessary.
- Ensure the customer is made aware that maximum braking efficiency will be achieved if, for the first few hundred miles, needless heavy braking is avoided, and the brake pads are allowed to 'bed in' fully before being used to their full potential.

JJ.6 - PARKING BRAKE MECHANISM

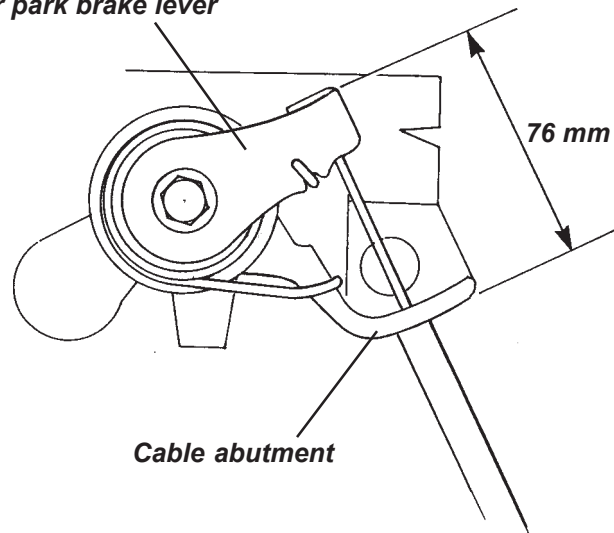
Operation of the parking brake lever applies a pull to a short link cable which connects via a horseshoe compensator to the centre of a single cable linking the two rear callipers. At each calliper, the cable connects to a lever which operates the hydraulic piston by mechanical means:

Movement of the calliper lever causes rotation of one of a pair of steel discs, rotation of the other being restrained by a stop bolt in the cylinder. Hardened balls housed in ramps machined in the discs, force the discs apart, and in so doing, apply an axial force to the piston via a screwthread and nut. The nut is restrained in the piston by a one way clutch which grips the nut when the parking brake is applied, but allows it to turn when the mechanism relaxes, or when the piston is operated hydraulically by the footbrake. In this way, the mechanical mechanism is adjusted automatically to compensate for pad wear.



i126

For the auto adjustment system to function correctly, it is essential that each calliper parking brake lever is allowed to return fully when the brake is released, and is not prevented from doing so by maladjustment of the parking brake cable. To check that the calliper levers are fully returned; with the parking brake 'off', measure the distance between the cable abutment and calliper lever as shown.

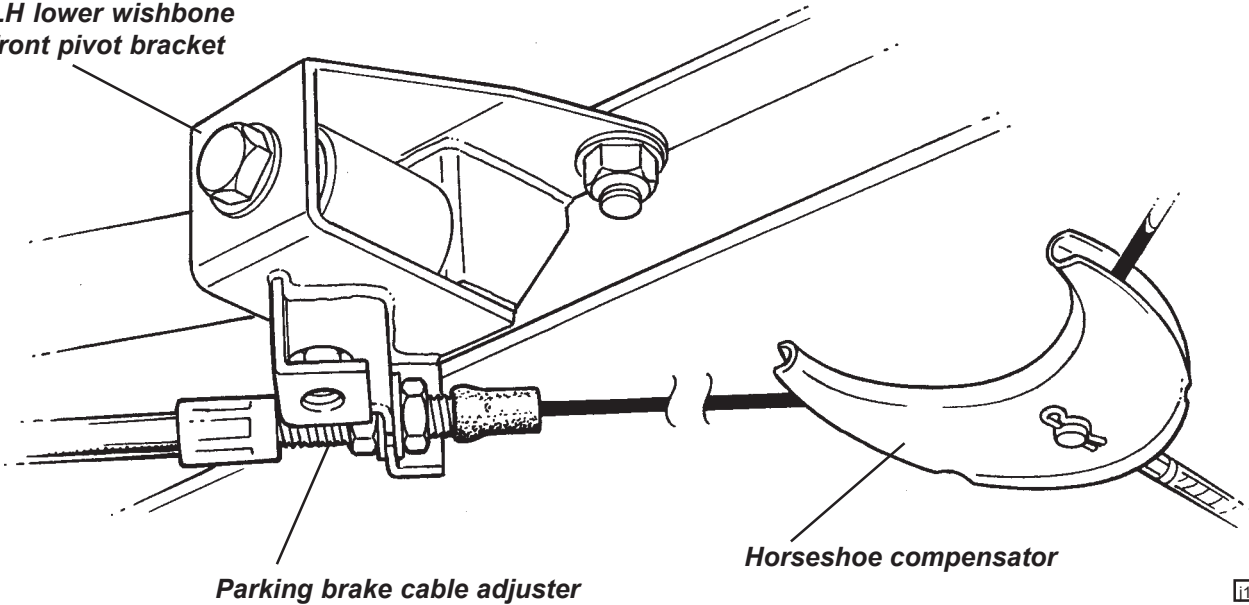
Calliper park brake lever

i139

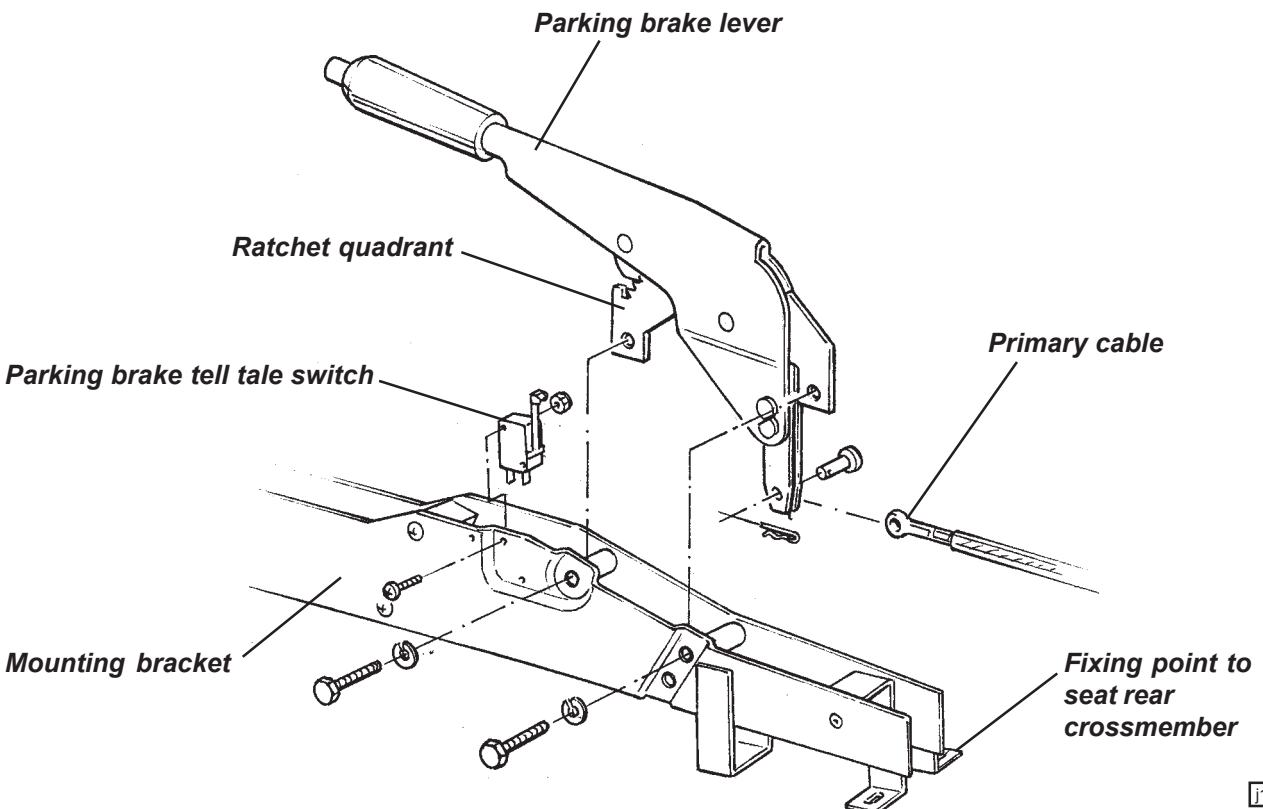


After verifying this dimension, any slack in the rear cable may be adjusted out at the left hand outer cable abutment, which is integral with the pivot bracket for the front leg of the lower wishbone. Remove the engine bay undertray for access. After adjustment, re-check the calliper lever 'off' dimension.

LH lower wishbone front pivot bracket



The parking brake lever is mounted in a steel bracket which also houses the gearchange lever, and is bolted to the seat mounting crossmember at the front, and to the floor rear crossmember. The parking brake lever is secured by two bolts fixing the ratchet quadrant to the bracket. Access to the lever is available after removing the cockpit centre trim panel:





- Unscrew the gear lever knob.
- Release the fixing screw at either side of the gear lever shroud base.
- Remove the single screw retaining the rear bulkhead centre pocket, and then the two screws securing the rear shroud. Disconnect the auxiliary power socket.
- Lift the centre trim panel, label and disconnect the CDL switch and (if fitted) hazard switch, and release the gear lever gaiter.

Note that the parking brake/gearchange lever mounting bracket is not drive handed, but is offset, via alternative fixing holes in the chassis, *towards the passenger side*. The ratchet pawl operates a micro switch to light the 'brakes' tell tale lamp in the instrument panel whenever the ignition is switched on and the parking brake is applied. The short front cable is connected to the lever assembly by a clevis pin with spring retaining clip. When carrying out any work in this area, take care not to damage or misroute the electrical main harness.

JJ.7 - BRAKE DISCS

All four wheel brakes use a brake disc which is sandwiched between the wheel and its hub flange, being centralised by the hub spigot, and transmitting torque via the clamping force of the road wheel bolts. A countersunk screw is used to retain the discs for convenience when servicing.

The same disc is used at each corner of the car, and features cast iron construction with internal curved vane cooling and cross-drilling. The opposite direction of rotation of the curved vanes on each side of the car does not significantly affect the cooling performance of the disc. The condition of the brake disc friction surface is a major factor in brake performance and feel, with a good surface quality and minimal run-out and thickness variation being required. After an extended lay up, some surface corrosion may develop on the discs which will cause a degradation in braking quality until the surfaces are cleaned up by normal brake action. Excessive run-out or thickness variation as a result of overheating or extended wear, may cause brake judder and/or extended pedal travel due to pad 'knock off'. Scoring and ridging of the braking surfaces will be exacerbated by operation in dusty or unmetalled road environments, and will reduce braking performance.

No skimming or re-surfacing of the brake discs is recommended. If the disc becomes badly scored, or is out of specification in any way, it should be renewed. NOTE: Ensure that there is no discernible free play in the wheel bearings before attempting to measure brake disc run-out. If disc run-out exceeds the service maximum, check the hub run-out before replacing the disc.

Brake disc thickness

New	26.0 mm (1.02 in)
Service minimum	24.9 mm (0.98 in)

Runout

New maximum	0.03 mm (0.001 in)
Service maximum	0.10 mm (0.004 in)

Hub

Disc mounting face run-out max.	0.04 mm (0.0015 in)
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Front Disc Replacement

1. Remove the road wheel.
2. Remove the two bolts securing the brake calliper to the hub carrier, and withdraw the calliper from the disc. Secure clear without straining the flexible hose.
3. Remove the single countersunk screw, and withdraw the disc from the hub.
4. Before re-fitting a disc, ensure that the mating face between disc and hub is scrupulously clean. Mount the disc onto the hub and align the wheel bolt holes.
5. Apply Permabond A130 (Blue - A912E7033) to the threads of the calliper fixing bolts. Fit the calliper over the disc and secure to the hub carrier with the two bolts. Tighten to 45 Nm (33 lbf.ft).
6. Refit the road wheel and operate the brakes before driving the car to set the brake pad position.

Rear Disc Replacement

Replacement of the rear discs is similar to that for the front discs, except that if the brake pads are removed, it is not necessary to remove the brake calliper to enable the disc to be withdrawn from the hub.

JJ.8 - BRAKE CALLIPERS

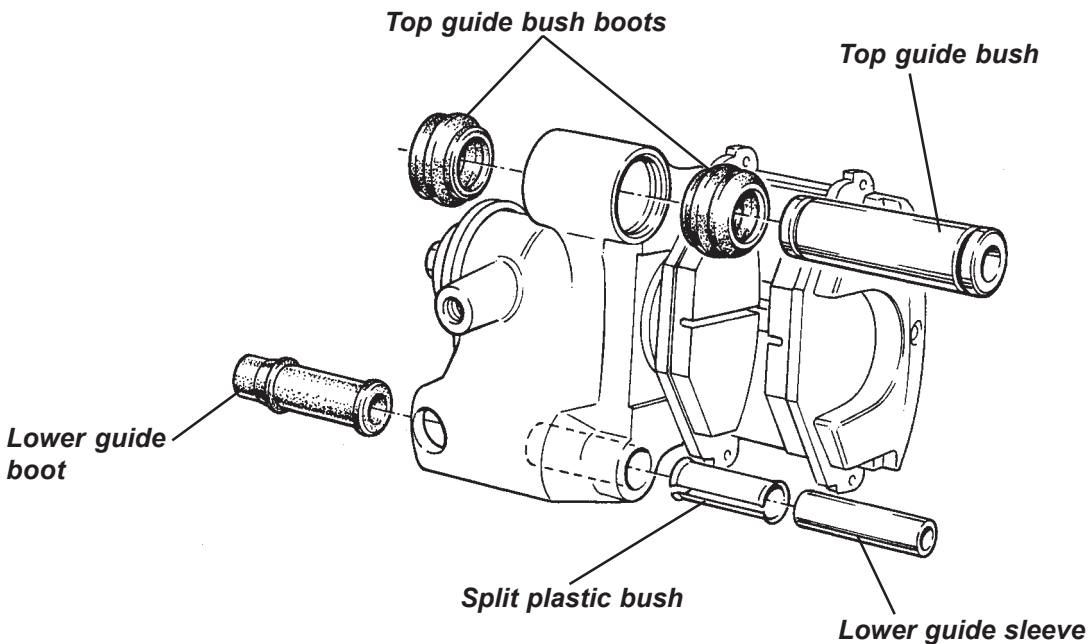
The front brake callipers are manufactured by A.P. Racing, and are to be dismantled or overhauled only by their factory at Wheeler Road, Seven Stars Industrial Estate, Coventry, CV3 4LB.

The Brembo rear brake callipers may have the sliding pins overhauled as detailed below, but any signs of hydraulic leakage from the cylinder indicate that the unit should be replaced.

Rear Calliper Sliding Pins

The sliding bushes and sleeves of the Brembo rear callipers may be replaced without disturbing the hydraulic connection:

- a) Disconnect the parking brake cable from the calliper.
- b) Remove the cap head bolt securing the bottom guide bush to the hub carrier.

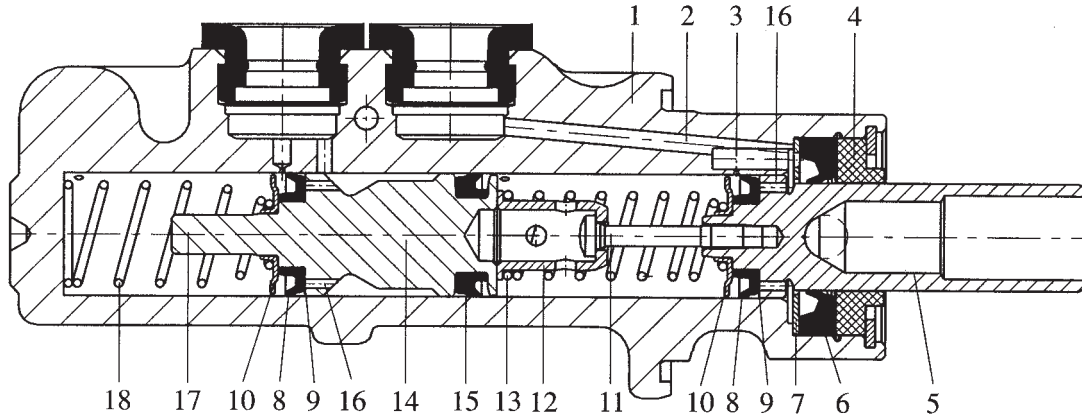


- c) Remove the hex. head bolt securing the top guide bush to the hub carrier, and withdraw the calliper from the car with the brake hose still connected.
- d) Slide out the lower steel guide sleeve and withdraw the bush/boot from the calliper. Pull the boots off the top steel guide bush and slide out the bush from the calliper.
- e) Clean the guide bores in the calliper body with brake cleaner. Lubricate the new bushes and boots with silicone grease provided in the repair kit, and reassemble into the calliper in reverse order to disassembly.
- f) Refit the calliper to the hub carrier using Permabond A134 on the threads of both bolts, torque tightening the two fixings to:

Upper M10 bolt;	45 - 50 Nm (33 - 37 lbf.ft)
Lower M8 caphead;	26 - 30 Nm (19 - 22 lbf.ft)
- g) Reconnect the parking brake cable and operate the footbrake to reposition the pads before driving the car.

JJ.9 - BRAKE MASTER CYLINDER

The tandem brake master cylinder is mounted in the front compartment and is secured to the brake servo by two studs with M8 nuts. The cylinder uses two pistons to supply the independent front and rear brake circuits. The cross-section below is provided for information, but the master cylinder manufacturer does not recommend any dismantling of the unit, and supplies no replacement parts or internal components. If the cylinder is faulty it should be renewed as a complete assembly.



j187

Key to Cross-Section

1.	Body	10.	Spring plate
2.	Passage to rear cylinder	11.	Retaining screw
3.	Rear cylinder inlet port	12.	Stop sleeve
4.	Guide bush	13.	Rear piston spring
5.	Rear piston	14.	Front piston
6.	Lip seal	15.	Secondary seal
7.	Stop washer	16.	Transfer passage
8.	Primary seal	17.	Front piston stop
9.	Washer	18.	Front piston spring

To remove the unit, proceed as follows:

1. Syphon fluid from the reservoir to reduce spillage.
2. Release the two hoses connecting the master cylinder to the fluid reservoir, and the single hose connecting to the clutch master cylinder, and plug all hoses. Disconnect the electrical cables from the reservoir cap, cut the tie wrap and withdraw the reservoir from the mounting bracket.
3. Release the two brake pipes from the master cylinder, and plug the pipes and ports.
4. Release the two nuts securing the master cylinder to the brake servo and remove the cylinder.
5. Refit the master cylinder in reverse order to removal, using NEW locknuts (supplied with a new cylinder) and tighten to the following torques:
 - Master cylinder fixing nuts; 25 Nm
 - Brake pipes to cylinder; 17.5 Nm
6. Fill the reservoir with DOT 4 non-mineral type brake fluid, and bleed the complete brake system of air using standard vacuum assisted, pressure assisted or manual techniques.



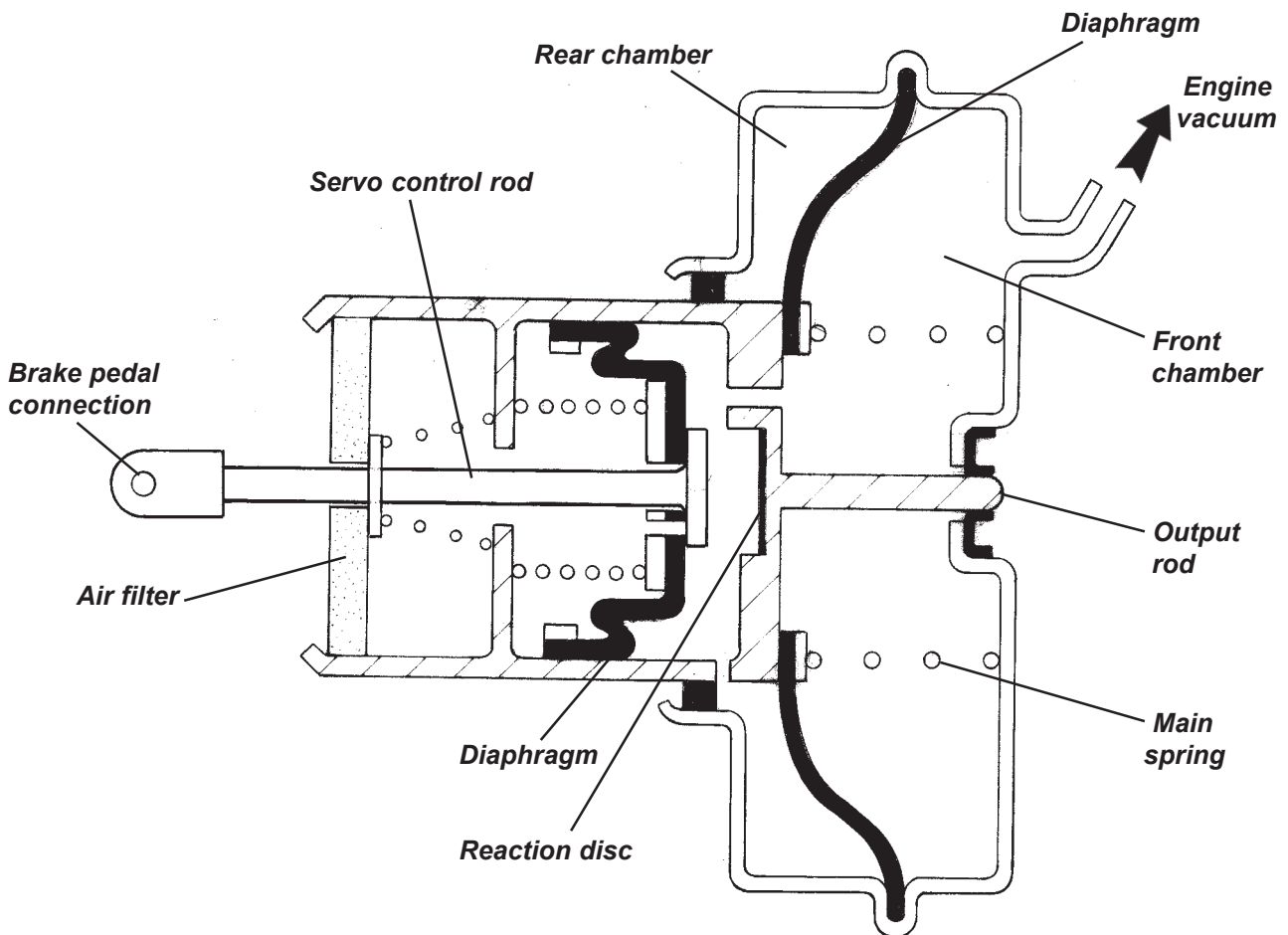
JJ.10 - VACUUM SERVO UNIT

The FTE brake vacuum servo is, with the exception of the air filter and non return valve, a non-servicable sealed unit which if found to be faulty, must be replaced as an assembly. The air filter (surrounds the input push rod) should be replaced whenever the brake system is overhauled, and cleaned or replaced more frequently if the vehicle is operated in dusty conditions. A vacuum non-return valve is incorporated into the vacuum hose elbow connector in the front case of the servo unit, and a second in-line non-return valve is fitted into the supply line close to the engine. The elbow connector valve is a push fit into a grommet in the servo shell, and is supplied complete with the grommet.

The servo is fitted between the brake pedal and master cylinder and is of the 'suspended in vacuum' type, wherein a flexible diaphragm divides the space inside a steel shell into two chambers. The front chamber is connected, via a non-return valve, to the vacuum produced in the engine's inlet plenum chamber. When the brakes are 'off', this vacuum is also applied to the rear side of the diaphragm, which is held towards the rear of the shell by a spring. The brake pedal is connected to the brake servo control rod, which operates a control valve before pressing against the output rod via a pliant reaction disc.

Brakes Off

In the simplified schematic diagram, with the brakes off, the diaphragm and driving piston are pushed to the left by the main spring, and the input rod is pushed to the left by its own spring, causing the control valve to close off the atmospheric port. Engine vacuum admitted to the the right hand side of the diaphragm is also communicated to the left side of the diaphragm, and the unit is stable.

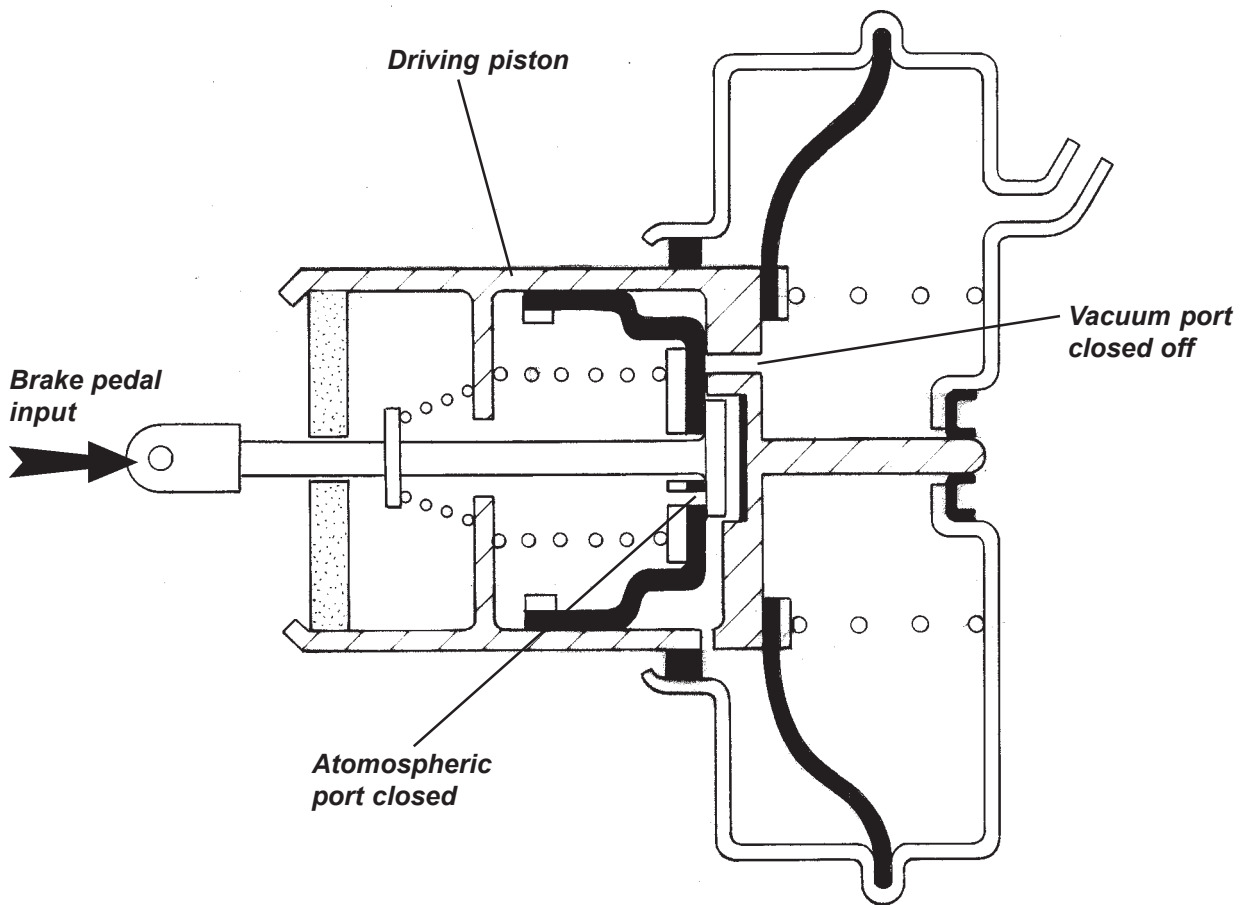


j147a



Initial Movement

Initial movement of the brake pedal causes the input rod to move to the right, and allows the control valve under the action of its spring, to close off the vacuum port in the driving piston. The atmospheric port remains closed.

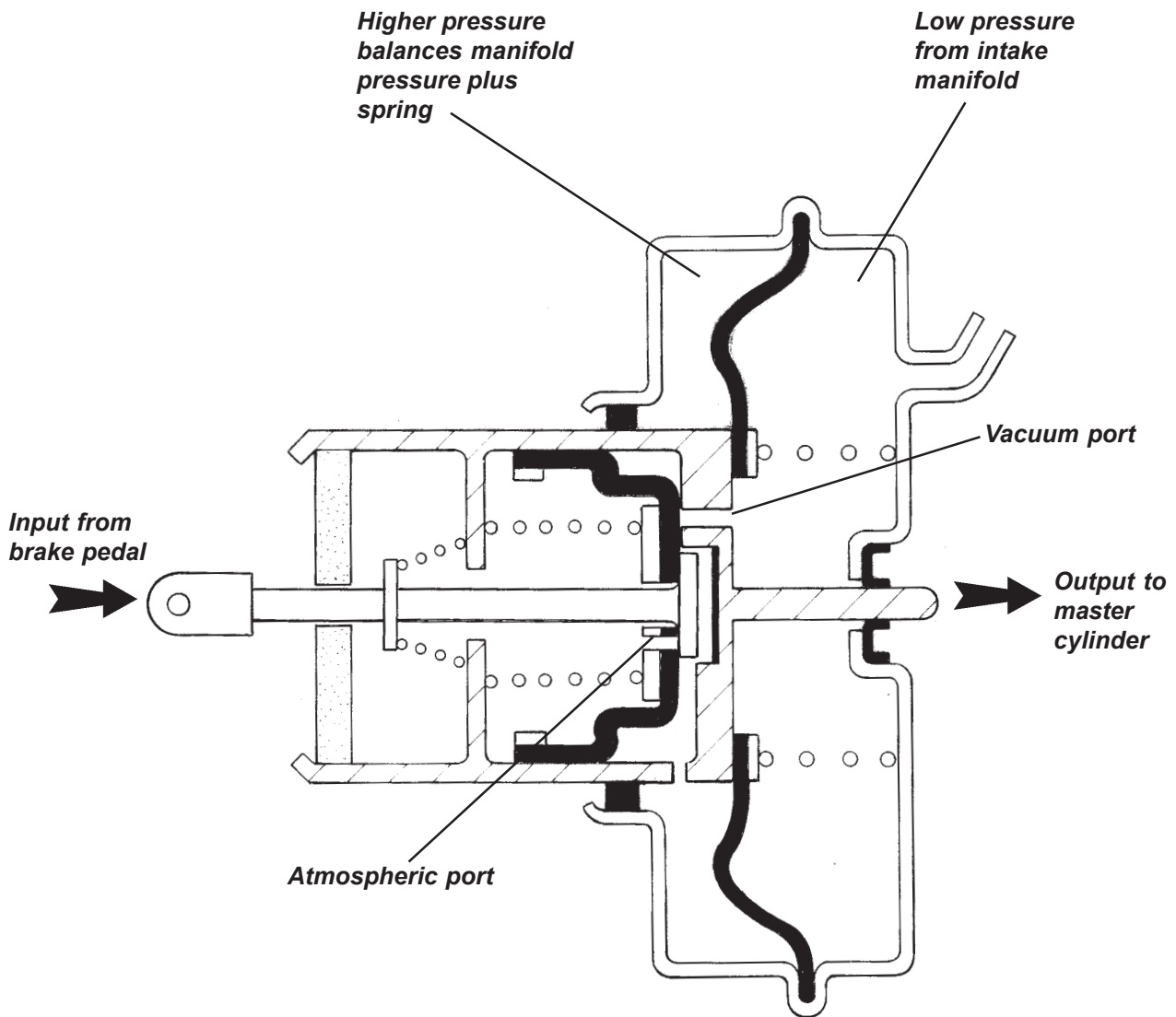




Pressure Balance

Further pressure on the brake pedal opens the atmospheric port and bleeds atmospheric pressure into the left hand chamber. This pressure imbalance causes the driving piston to move to the right, adding assistance to the force applied directly to the output rod (and the master cylinder) via contact between the input and output rods. When the force produced by the pressure differential across the diaphragm balances the reaction force of the main spring and master cylinder, movement of the driving piston ceases, with both control valve ports closed, and the system once again in equilibrium.

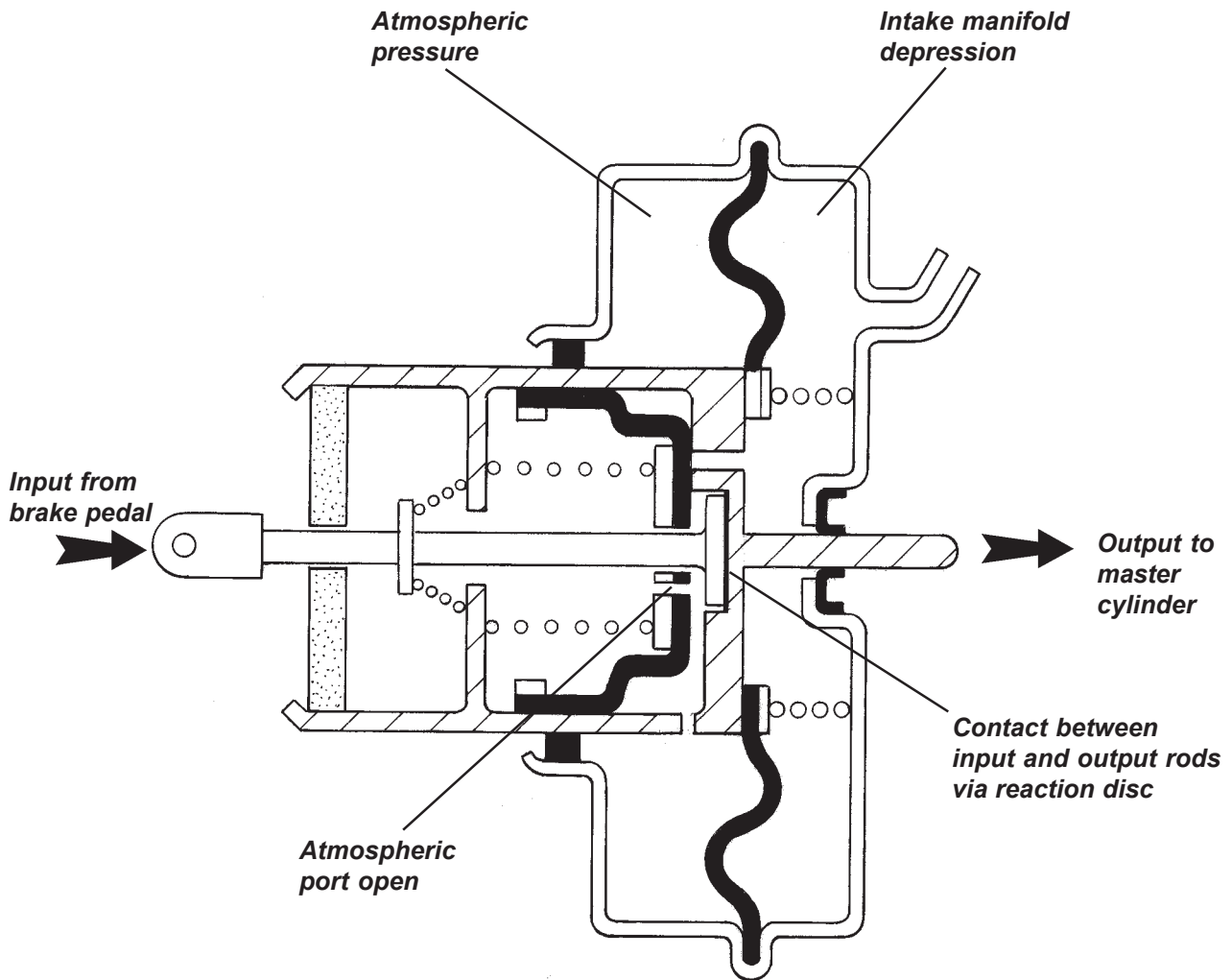
From this position of equilibrium, further pressure on the pedal will tend to open the atmospheric port and allow pressure in the left hand chamber to increase, and move the driving piston to the right before again stabilising. Any reduction in pedal pressure will tend to open the vacuum port and allow the higher pressure in the left hand chamber to bleed off into the right hand chamber, whose depression is kept constant by its connection with the intake plenum. The pressure imbalance is reduced, and the driving piston will move to the left under the action of the main spring, until equilibrium is again restored.





Maximum Assistance

If the pedal is pressed hard, the atmospheric port will be held open, so that the left hand chamber will be subject to full atmospheric pressure. This is full servo assistance which will, with 0.8 bar of vacuum available from the engine, increase the force applied to the master cylinder pushrod by approximately four times.



j147d

When pedal pressure is relaxed, the vacuum port in the driving piston will open and bleed the higher pressure from the left side of the diaphragm into the right hand chamber and thence into the engine plenum, collapsing the pressure differential across the diaphragm. The driving piston is moved fully to the left by the main spring.

The pliant reaction disc fitted between the input and output rods ensures a graduated application of servo assistance and provides pedal feedback and 'feel' to the driver.



Operational Check

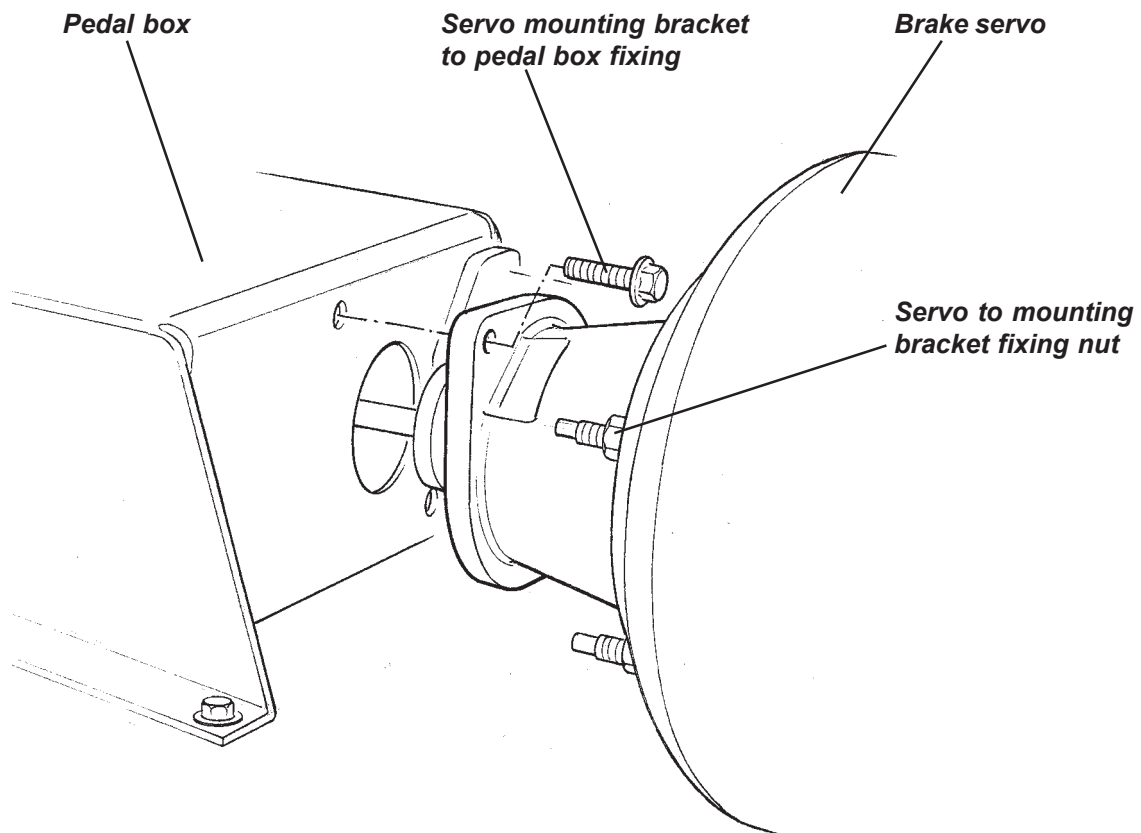
As a quick check of servo operation proceed as follows: With the engine stopped, press the brake pedal several times to exhaust the servo unit of vacuum. Keeping the pedal pressed (which should be 'hard' and 'high'), start the engine; The pedal should drop slightly as the servo vacuum builds up, and extra force is produced. If the pedal does not drop, it is most likely that there is a fault in the vacuum supply line. Check the vacuum hose, all connections and the non-return valve. If the vacuum supply is not defective, the servo unit should be replaced.

Setting brake pedal: It is essential that the servo piston (and master cylinder piston) is allowed to return fully when the brakes are released, and is not pre-loaded by mal-adjustment of the input pushrod. See sub-section JJ.11.

Stop light switch: The stop switch is mounted in a right angle bracket fixed to the underside of the scuttle, and abuts directly against the pedal. The switch is retained in the bracket by a quarter turn mechanism.

To Replace Brake Servo Unit

1. Remove the brake master cylinder (see sub-section JJ.9).
2. From within the footwell, disconnect the servo pushrod from the brake pedal.
3. Disconnect the brake servo vacuum hose, and release the four nuts securing the servo to the pedal box extension plinth. Withdraw the servo assembly.
4. Replace the servo in reverse order to the above, tightening the servo mounting nuts to 25 Nm, and the new master cylinder fixing nuts to 25 Nm. Check pushrod adjustment (see sub-section JJ.11) and bleed the hydraulic system.



j191



JJ.11 - PEDAL BOX

The extruded and welded aluminium alloy pedal box is bonded and rivetted to an aperture in the chassis scuttle. A hollow steel pivot shaft serving all three pedals is bolted to a steel mounting plate, itself bolted to the inside of the pedal box. Each pedal is machined from a common alloy extrusion, with the throttle pedal being of a narrower section than that used for the brake and clutch. An extruded footpad is keyed, bonded and rivetted to the clutch and brake pedals, and is bolted to the throttle pedal. All the pedals use synthetic bushes for maintenance free articulation on the steel pivot shaft, and the clutch pedal uses a cylindrical steel trunnion supported in synthetic bearing rings to actuate the master cylinder pushrod.

In order for the required pedal spacing to be achieved within the packaging constraints of the vehicle, the brake pedal uses a relay lever to move the output plane inboard of the pedal line. A steel relay lever pivots on the common pedal shaft, and is equipped with two legs, one of which is used to connect to the brake pedal via an integral trunnion, whilst the other leg is connected to the brake servo pushrod by a clevis pin.

The throttle pedal actuates the throttle cable directly, which is routed along the cockpit centre, beneath the gear lever and parking brake lever trim panels, beneath the fuel tank bay and up to the front of the engine bay to the throttle body.

Adjustment

Throttle cable:

- The pedal is pulled against a rubber buffer on a steel upstop bracket by an extension spring.
- Adjust the cable outer length at the engine end abutment bracket to allow 2 - 3mm of pedal movement before the throttle is actuated.
- Set the downstop in the pedal footpad such that vigorous full depression of the pedal achieves full opening of the throttle butterfly without allowing the cable to be strained.
- An alternative pedal position which may be preferred for 'heel and toeing' may be achieved by replacing the rubber upstop buffer with a M5x15 hex. head setscrew, with three flat washers beneath the head for a total thickness of around 7mm. The cable must then be re-adjusted at the engine abutment as above. The footpad downstop bolt should then be replaced by an M8x20 setscrew and reset as above.

Brake pedal:

- The pedal is pulled 'off' by an extension spring anchored to a bracket rivetted to the scuttle beam.
- There is normally a gap of approximately 3mm between the brake pedal and the pedal box upstop flange with the pedal released. If preferred, the brake pedal can be raised slightly by adjusting the effective length of the pushrod at its connection to the clevis, but the master cylinder must never be preloaded, i.e. there must always be a small clearance between the pedal and upstop bracket to ensure that the master cylinder piston is allowed fully to return and open the reservoir port.
- After any adjustment, tighten the clevis locknut and check operation of the brake light switch.

Clutch pedal:

- The pushrod, which is captive in the master cylinder, is screwed fully into the pedal trunnion, and controls the pedal height. Rubber buffers are provided to cushion the pedal at full travel.

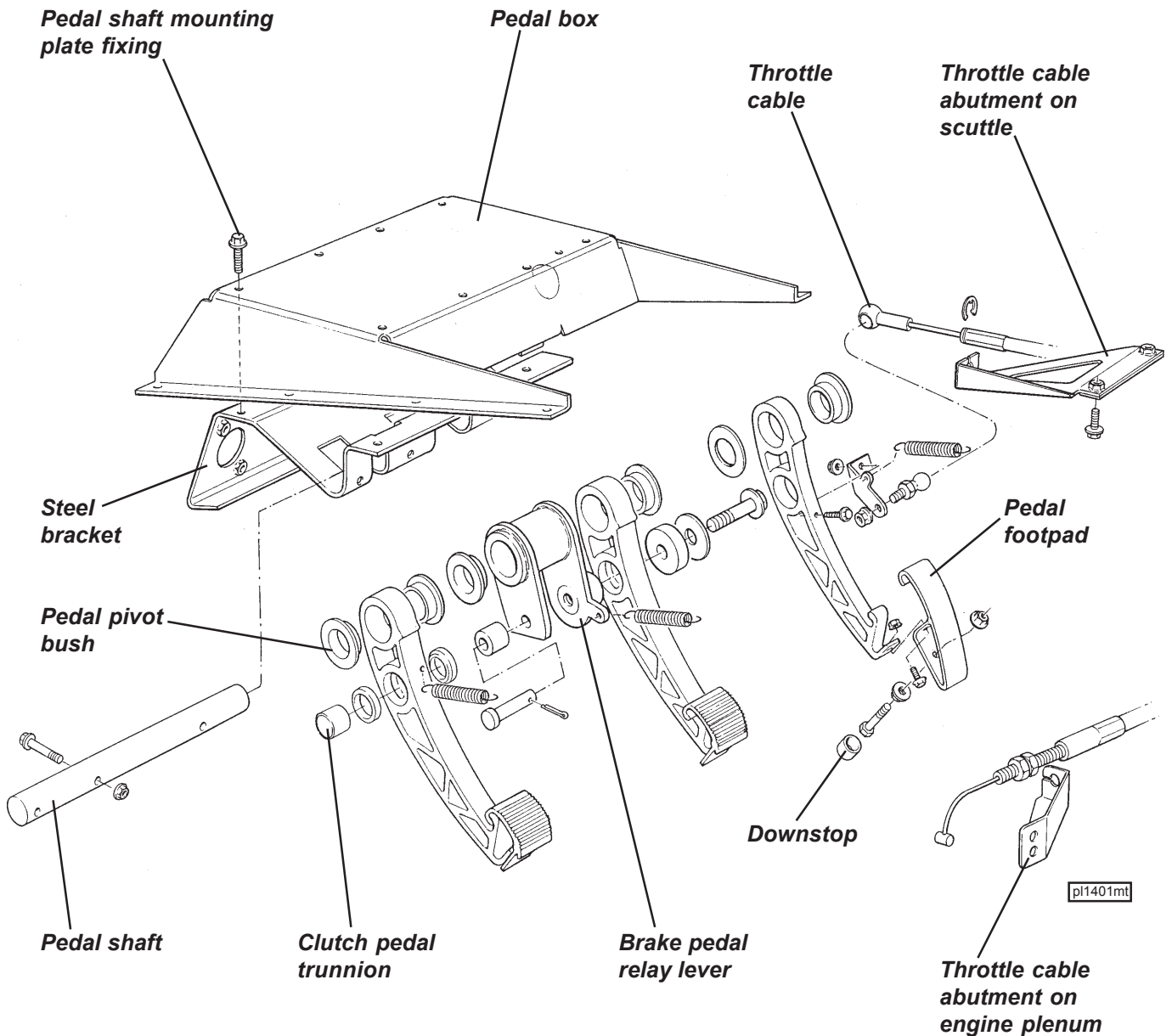
Pedal Removal

To remove a pedal from the pivot shaft, the pedal shaft mounting plate must be removed from the pedal box complete with all three pedals:

1. Remove the intermediate steering column (see Section HG).
2. Disconnect the brake servo clevis pin from the pedal relay lever, and release the throttle cable from the pedal.
3. Remove the two bolts securing the clutch master cylinder assembly to the pedal box and unscrew the pushrod from the pedal trunnion.
4. Remove the two bolts securing the brake servo mounting plinth to the pedal box and provide alternative support for the servo/brake master cylinder assembly.
5. Release the pedal return springs and remove the stop lamp switch.



6. From above, release the six M6 screws securing the pedal shaft mounting bracket to the top of the pedal box, and the single screw in the front face of the pedal box. Withdraw the pedal shaft assembly from inside the pedal box.
7. Remove the three M5 screws securing the pedal shaft to its mounting bracket, and disassemble the pedals from the shaft taking careful note of spacers and washers.
8. On re-assembly, note that the pivot bushes of the brake pedal and relay lever should be lubricated with Syntheso GLK1, or equivalent. Check pedal pushrod and stop switch operation as detailed above.



JJ.12 - ABS THEORY OF OPERATION

The Kelsey-Hayes antilock brake system is an 'add on' type used to supplement the dual circuit, tandem master cylinder, vacuum servo assisted brakes fitted to the Elise. A single electro-hydraulic unit comprising a hydraulic modulator, hydraulic pump, microprocessor and solenoid valve bank, is mounted in the front services compartment and plumbed into the front and rear brake circuit lines from the tandem master cylinder.

The microprocessor (ECM) receives signals from magnetic wheel speed sensors integrated into each of the four road wheel hubs, and interprets the individual wheel acceleration, deceleration, and comparative wheel speeds. From this data, the ECM is able to determine if any wheel is tending to lock up, and if imminent lock up is sensed, the microprocessor commands the relevant solenoid valves firstly to reduce pressure in that particular brake circuit in order to restore wheel speed, and then to modulate pressure to that providing the maximum braking force consistent with continued wheel rotation. The system is able to monitor and independently control each of the four wheel brakes, and is referred to a 4-channel system.

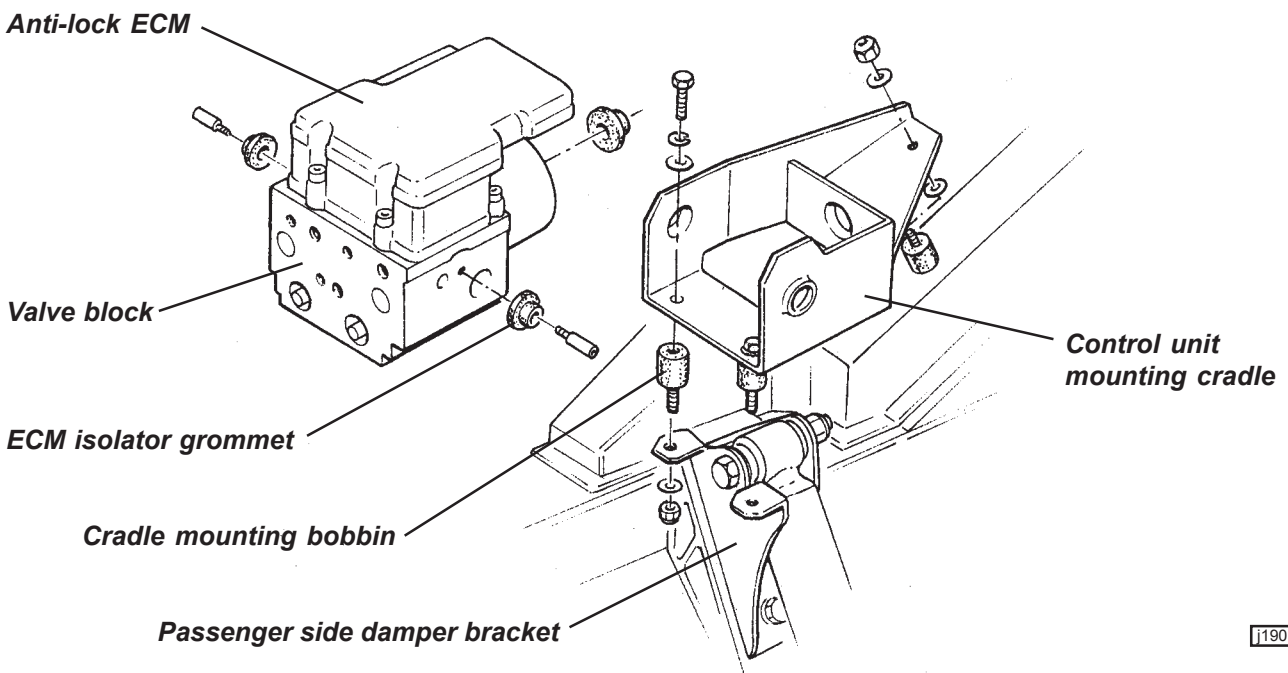
In order to achieve the required pressure modulation, three basic modes are used:

- Pressure hold;
- Pressure reduction;
- Pressure increase;

In order to maintain the safety provision of two entirely independent hydraulic circuits, one for the front brakes, and one for the rear, the hydraulic elements of the control unit are doubled up, with no part of the system shared between the two circuits. For the pressure hold function, four isolation solenoid valves are used, one in the hydraulic circuit for each wheel brake. The pressure reduction function is achieved by a separate dump solenoid valve in each of the four wheel brake circuits, and the pressure increase provided for by a single electric motor operating two hydraulic pumps, one serving the front, and one on the rear brake circuit. Separate low pressure accumulators are used for the front and rear circuits.

Electro-Hydraulic Control Unit

The electro-hydraulic control unit comprises an alloy valve block containing the four isolation valves, four dump valves, two hydraulic pumps and two accumulators, with the single pump motor screwed to the housing, and with a solenoid block and ECM unit attached to the topside. The complete assembly is flexibly mounted via three rubber isolator bushes to a steel cradle, which is itself mounted on three rubber bobbins to the passenger side front chassis. The eight solenoid valves are grouped in two rows, with the valve plungers protruding in sealed canisters from the topside of the unit where each one is surrounded by a solenoid coil. The isolation and dump valves share a similar construction, but the spring loaded isolation valves are normally open, and the dump valves normally closed.



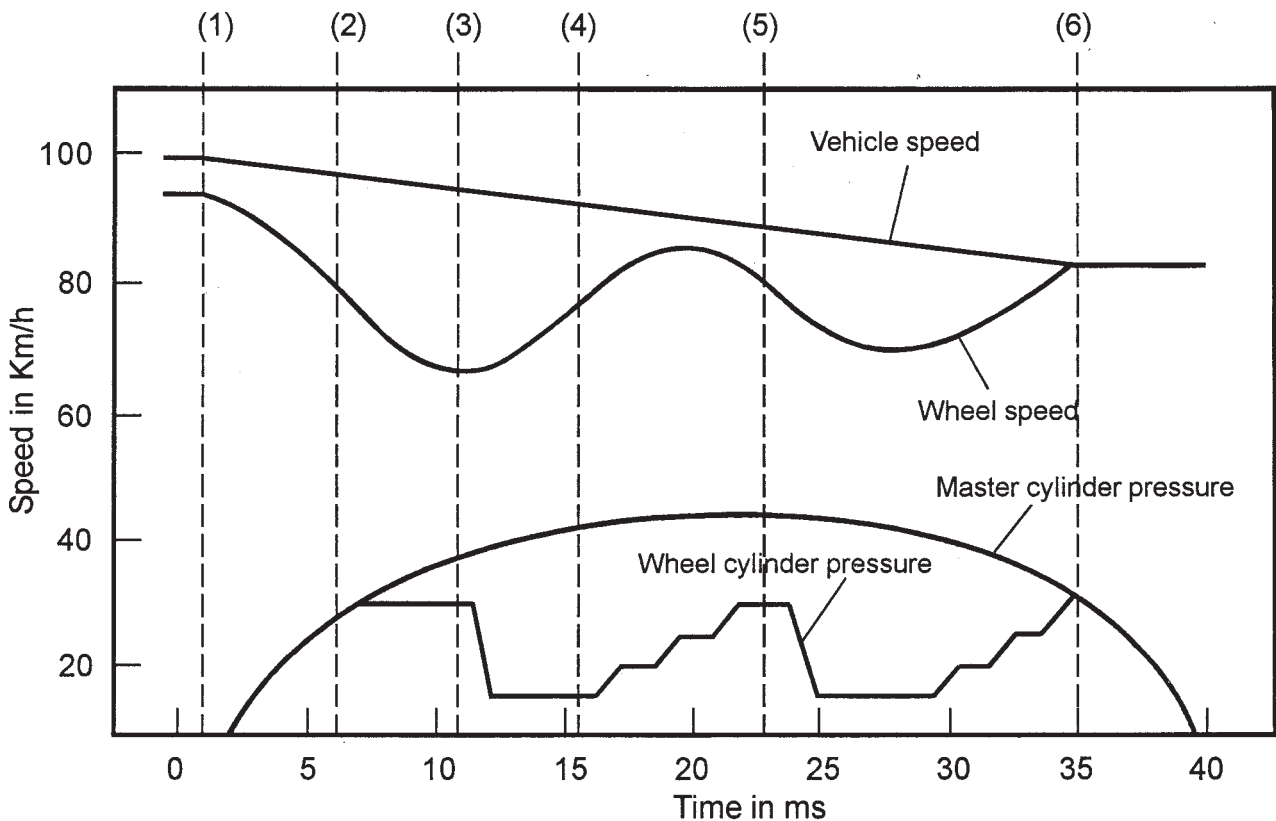


Anti-Lock Braking

Maximum braking force is provided from a tyre when there is around 15% slippage, dependent on road surface conditions and tyre characteristics. The function of the ABS is to limit tyre slippage when braking to around this figure in order to provide optimum grip, and also, by preventing wheel lock, to ensure that steering control of the vehicle is retained.

A high brake pedal pressure (or low road surface friction) may initiate the locking of one or more wheels. In the diagram below, a typical control strategy is shown:

1. Normal braking occurs until, as the applied pressure increases, the wheel speed signals received by the ECM indicate that the left hand front wheel (for example) is tending to lock. i.e. its deceleration is too rapid, with too great a speed differential with the other wheels.
2. The connection between the master cylinder and the LH front brake circuit is interrupted (by the isolation valve), and the rate of slip increase is reduced.
3. If the wheel speed continues to depart significantly from vehicle speed, the dump valve is energised to reduce pressure in the LH front circuit until wheel speed begins to increase. The dump valve is then closed, as is the isolation valve.
4. As wheel speed approaches that providing optimum grip, the isolation valve is pulsed open to allow a stepped pressure increase.
5. As wheel speed begins to drop off and depart from vehicle speed again, a new cycle starts, repeating steps (1) to (4).
6. When wheel speed increases sufficiently to meet vehicle speed, ABS intervention ceases, although monitoring is continued throughout each braking event.





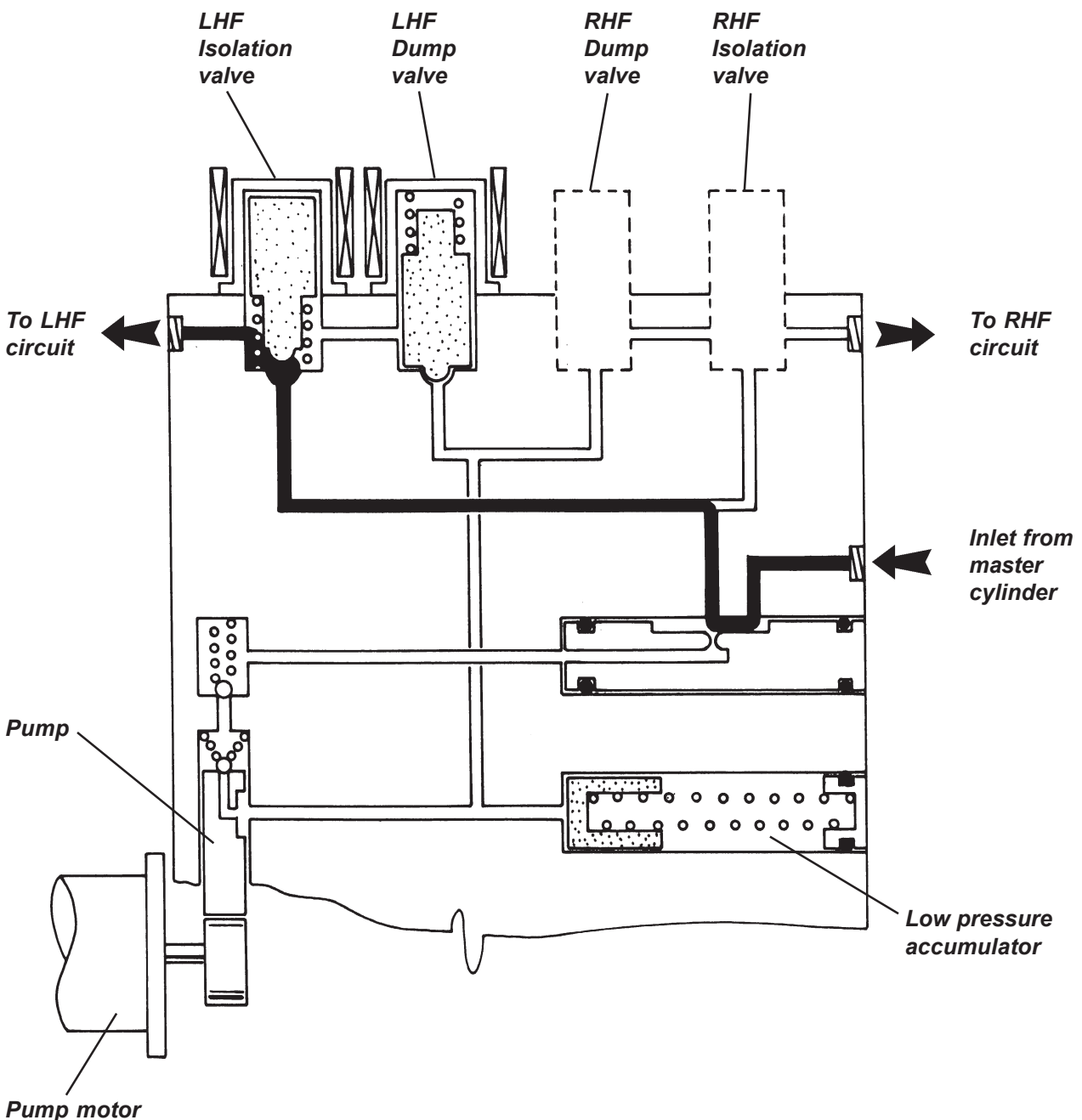
Sequence of Operation

In the following diagrams, one half of the hydraulic modulator is shown schematically, representing the front brake control circuit, with the sequence of operation described for the left hand front wheel brake. This sequence would be similar for any of the other three wheel brakes. A typical emergency braking event is described where, in this example, the left hand front wheel tends to lock. Note that the complete system is duplicated for the rear brake circuit, which remains completely independent of the front circuit.

Normal Braking

During normal braking, when the wheel speed sensors indicate no imminent wheel locking, the ABS is inactive. The solenoids are unenergised, so that the isolation valves are sprung open, and the dump valves are sprung closed.

Hydraulic fluid from the master cylinder enters the modulator via the inlet port, by-passes the attenuator orifice, passes through the open isolation valve and out to the LH front wheel brake.

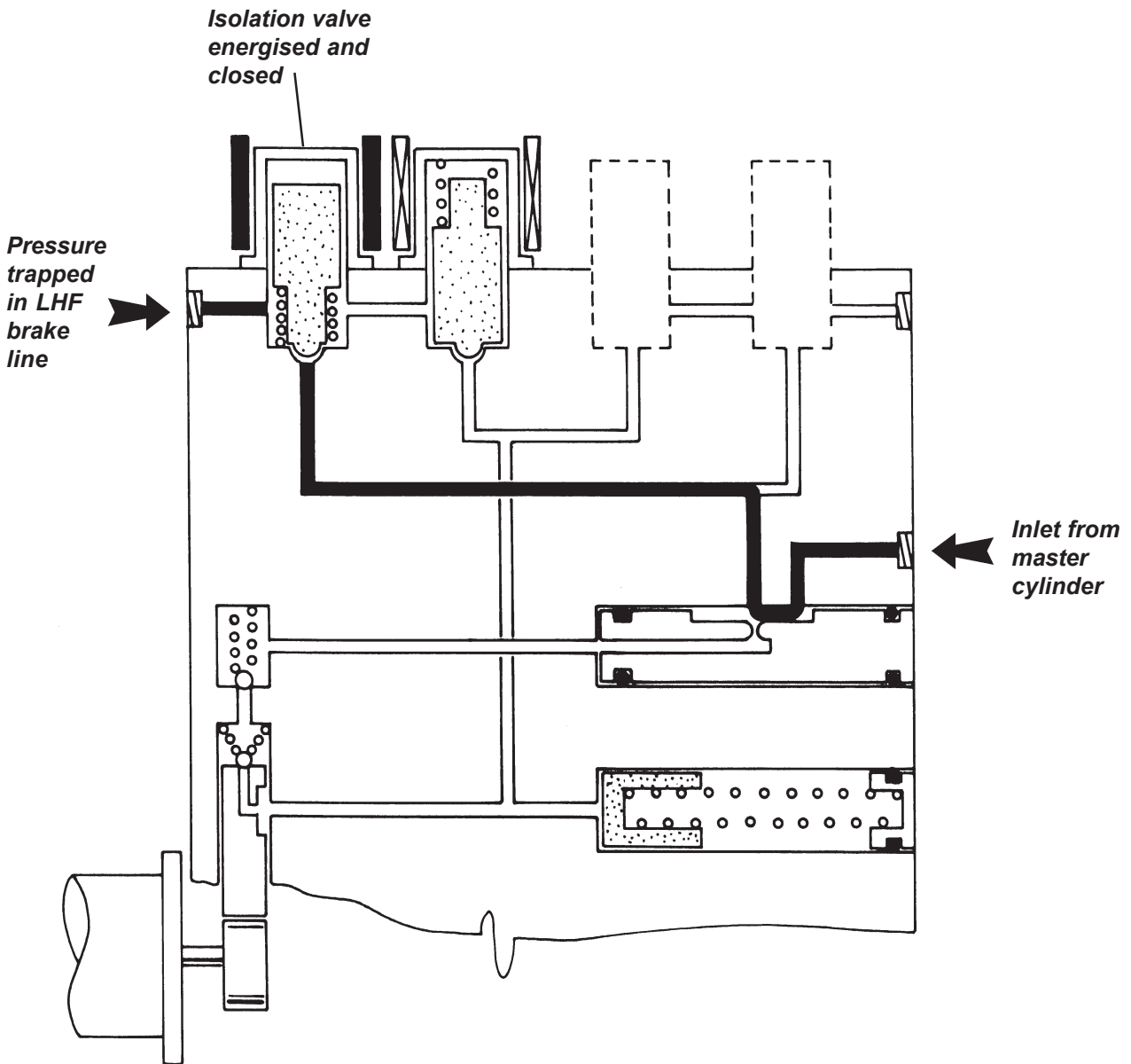


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Pressure Isolation (Pressure Maintain)

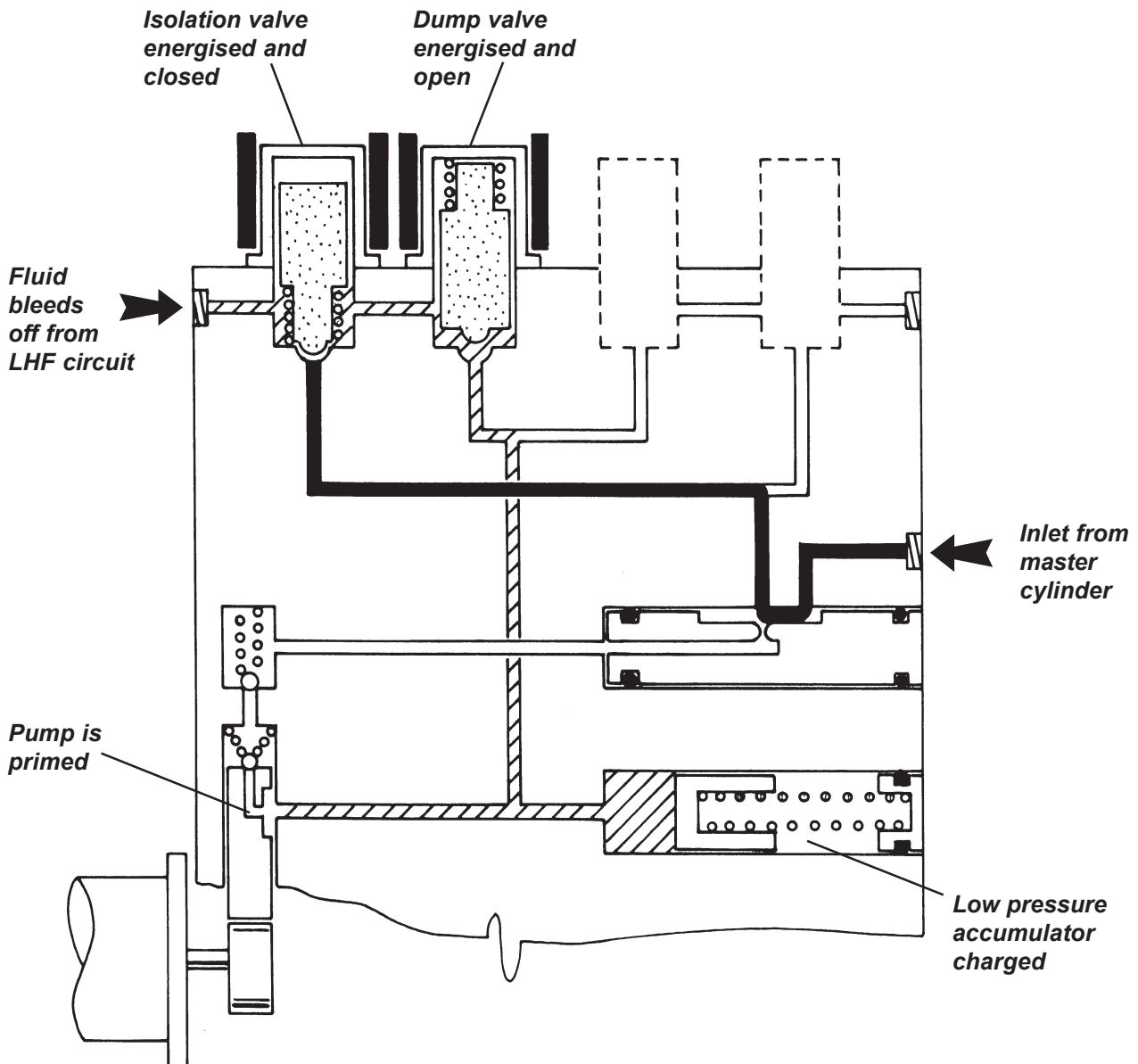
If signals received from the wheel speed sensors indicate imminent lock up of the LH front wheel, the first step in the anti-lock sequence is to isolate that wheel brake circuit from the master cylinder. The ECM energises the isolator valve solenoid, which closes the valve against spring pressure and maintains existing pressure in the left hand front brake circuit regardless of any increase in pedal pressure.





Pressure Reduction

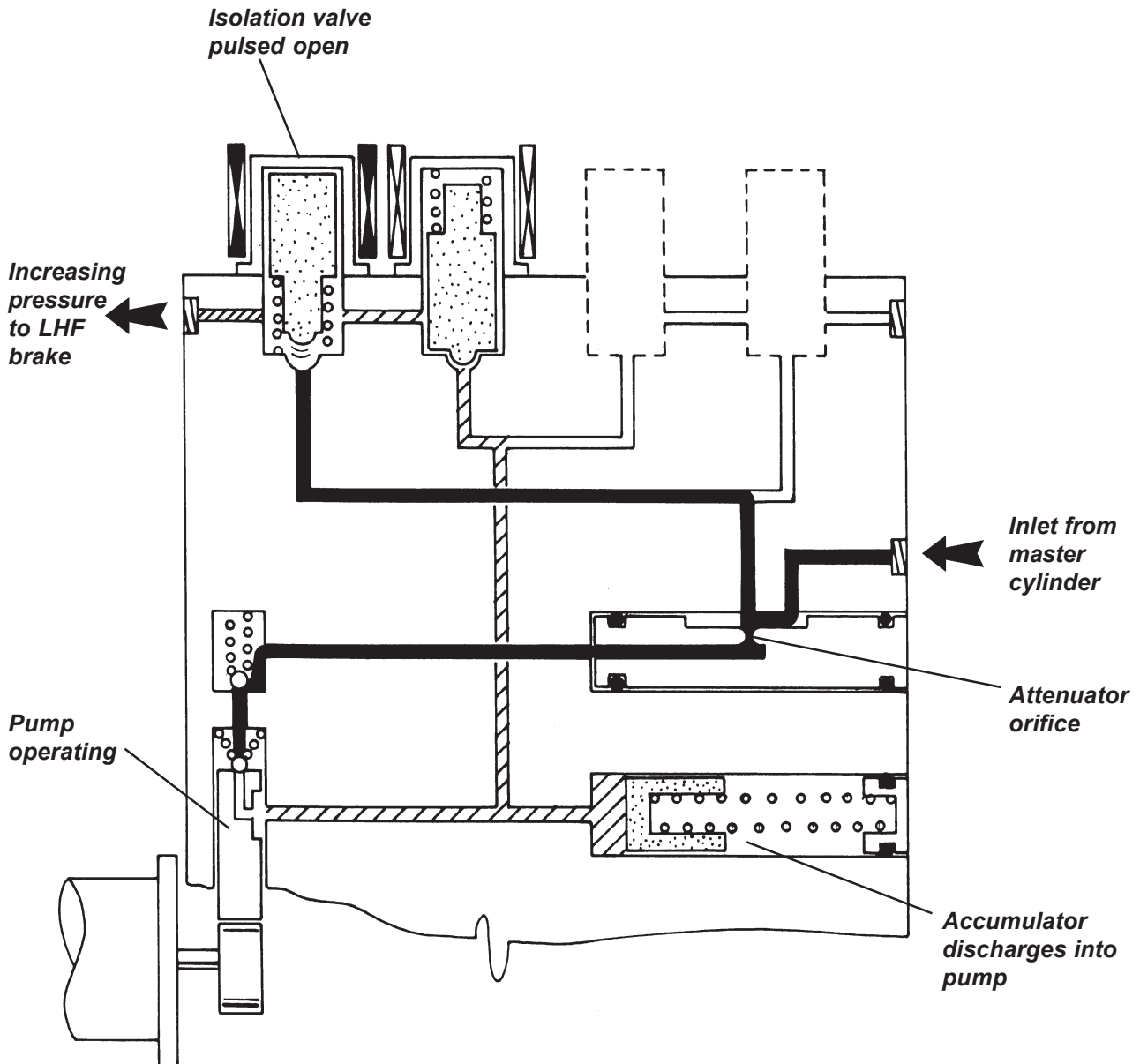
Once the LH front wheel brake circuit has been isolated from the master cylinder, the pressure must be reduced in order to allow wheel speed to be restored. This pressure reduction is achieved by the ECM energising the dump valve solenoid, which then opens against spring pressure and bleeds off some of the fluid into the low pressure accumulator shared with the RH front circuit. Very short activation pulses are used to maintain close control of the pressure reduction, and to limit the reduction to that required to restore wheel speed. Fluid displaced from the wheel brake circuit is stored in the front brake accumulator against spring pressure, and is also used to prime the hydraulic pump.





Pressure Increase (Re-apply)

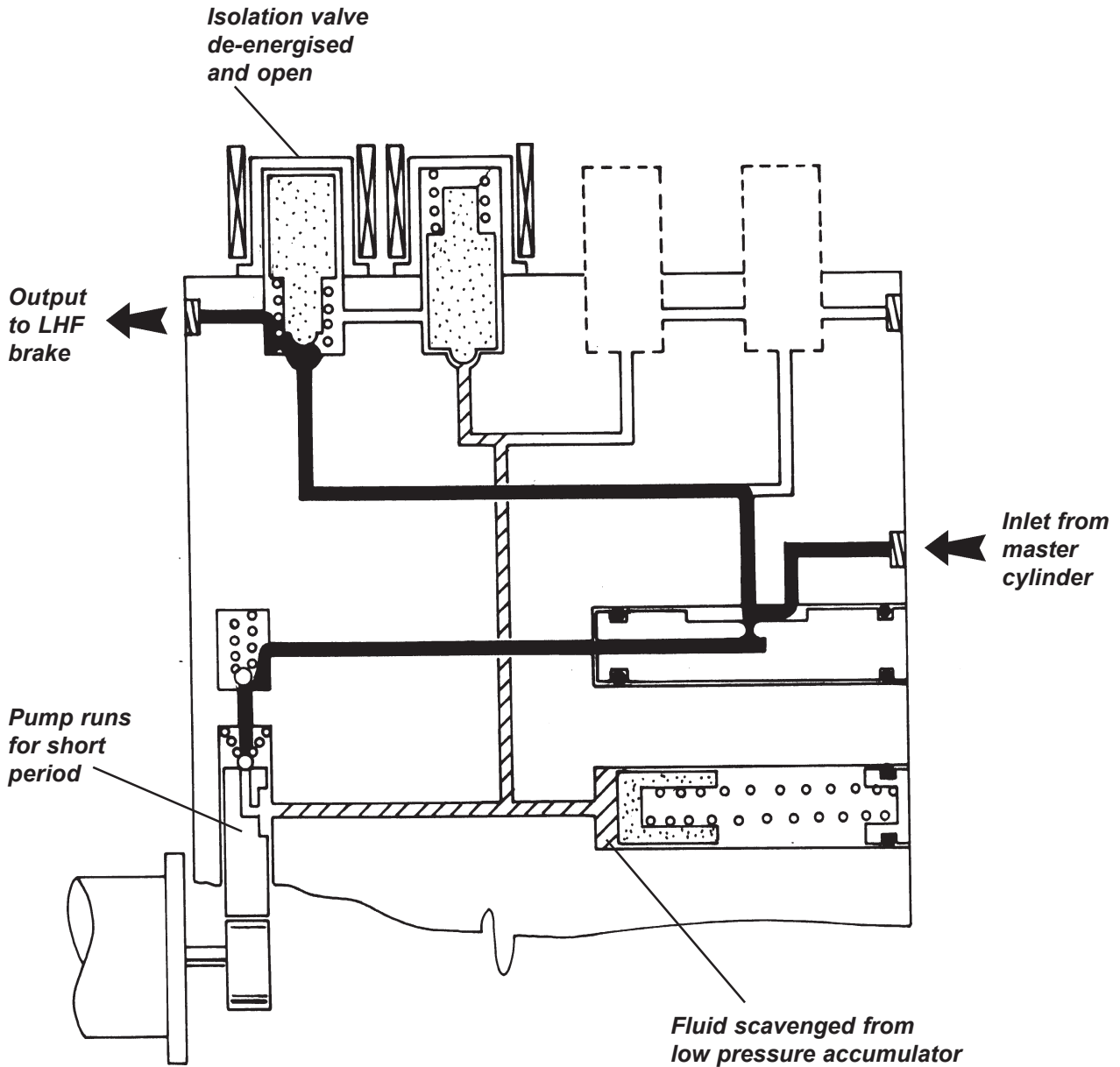
As soon as imminent wheel lock is detected by the ECM, and the ABS control system is activated, the pump motor is energised. When the dump valve is opened, and fluid is allowed to bleed off from the wheel brake circuit into the low pressure accumulator, this fluid is scavenged by the pump and returned back into the input circuit through an attenuator orifice. This action is the origin of the 'pedal pushing back' sensation felt by the driver, with the pressure pulsations from the pump damped and quietened by the restriction of the orifice. When wheel speed has been restored and the brake pressure is required to increase, the isolation valve is momentarily opened, to allow master cylinder/pump pressure to raise the pressure in the wheel brake circuit in increments. If imminent locking is again sensed, the isolation valve closes, the dump valve opens and the cycle repeats, with the whole process occurring several times a second.





Brake Release

When no further wheel locking is sensed by the ECM, the ABS becomes inactive with the isolation valve open (solenoid de-energised) to allow direct communication between the master cylinder and wheel brake circuit, and the dump valve closed (solenoid de-energised) to seal off the pressure relief circuit. The pump will remain running for a short time to help drain any fluid from the accumulator, whose piston is returned to its start position under the action of the spring, and return the fluid to the master cylinder reservoir.



JJ.13 - ELECTRO-HYDRAULIC UNIT

The electro-hydraulic unit is located on the driver's side in the front services compartment, and is flexibly mounted in a support frame via three isolator rubber bushes. The support frame itself is fixed to the front suspension damper top mounting bracket and windscreen frame butress via another three rubber bobbins. A single 27 pin electrical connector plug is provided with a sliding retainer to aid its mating with the vehicle harness.

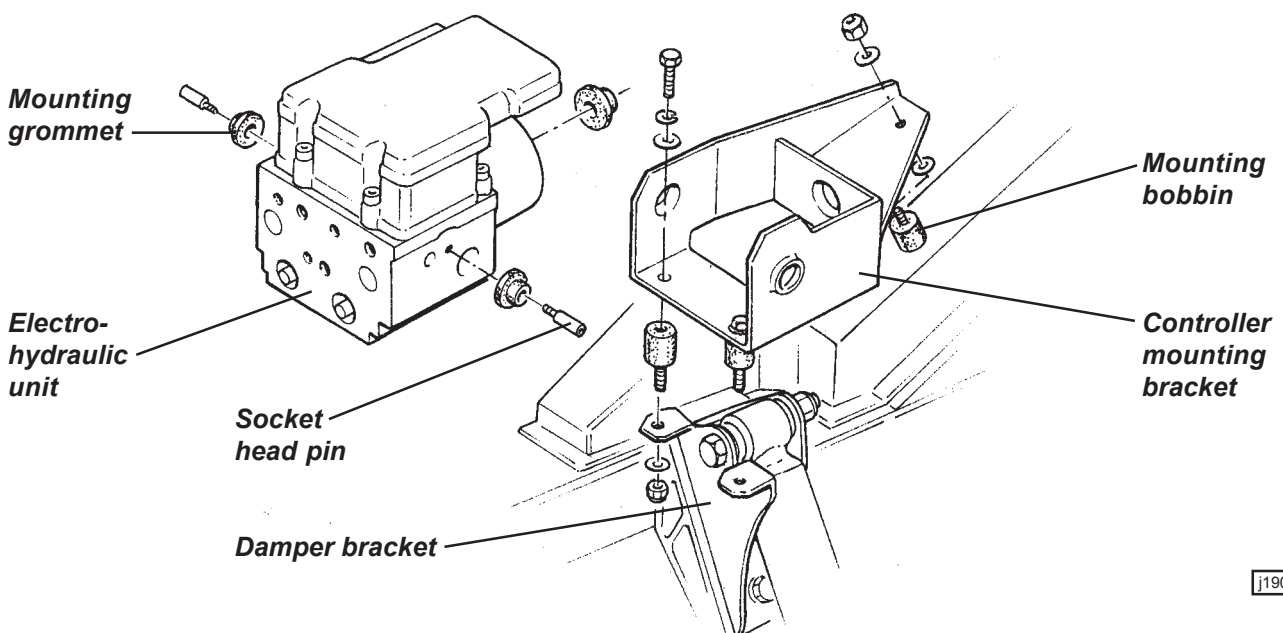
CAUTION: Do not disconnect or connect the main connector plug with the ignition switched on. Switch off the ignition and disconnect the main connector plug before carrying out any electrical welding operations on the car.

Hydraulic pipe connections to the unit comprise two input pipes from the master cylinder (one for the front circuit, one for the rear) and four output pipes, one for each of the wheel brakes. Note that all hydraulic connections are identified by engraved markings on the unit, with further protection against incorrect connection provided by the use of two different brake pipe union sizes: M10 x 1.0 and M12 x 1.0.

To Remove Electro-Hydraulic Unit

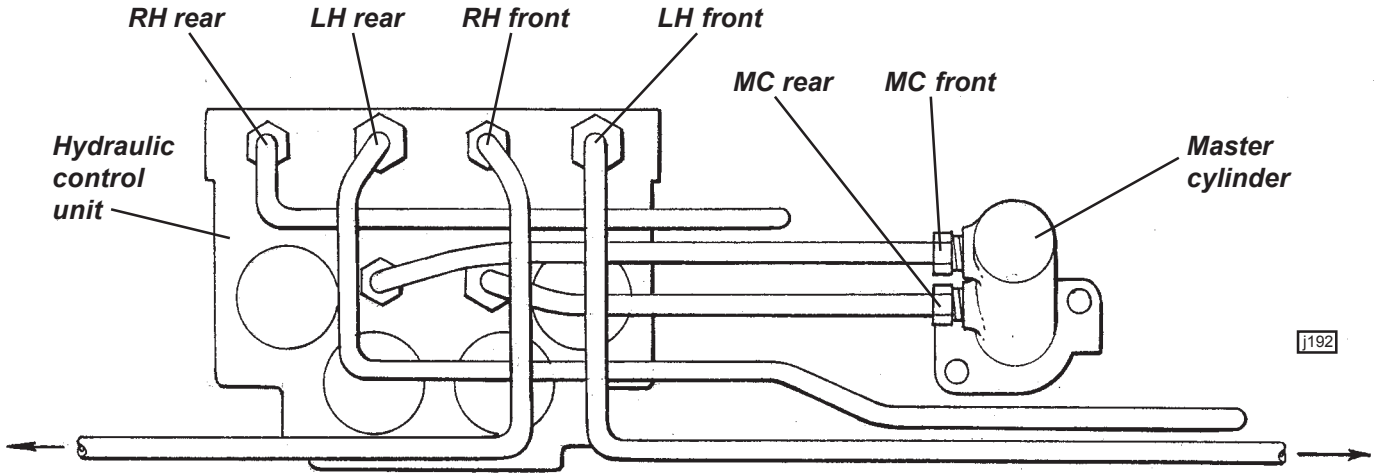
When removing the unit, beware of dripping brake fluid and take appropriate precautions to prevent damage to paintwork.

1. Remove the driver's side front access panel, radiator outlet louvre and wheelarch liner.
2. Switch off the ignition before drawing out the retainer slide from the connector plug to release the harness from the unit.
3. Label each of the hydraulic pipes before disconnecting from the unit and immediately capping the pipes and plugging the ports to reduce the spillage of brake fluid, and to prevent the ingress of dirt.
4. Release the three fixings securing the controller mounting bracket to the damper bracket and windscreen frame butress, and withdraw the unit and mounting cradle.
5. To remove the controller from the cradle, unscrew the two socket head pins supporting the sides of the unit, and withdraw the unit from the third grommet at the end of the motor casing.



j190

- To refit, reverse the removal procedure, tightening the two socket head mounting pins to 9 Nm, and the brake pipe unions (both sizes) to 16 Nm, taking care to connect the brake pipes to the correct ports on the hydraulic block - see diagram. Press in the retainer slide to connect the harness plug.



- Bleed the unit using the procedure detailed in sub-section JJ.3.
- Verify correct connection by using the 'Lotus Scan' tool in actuator tests with the car on a wheel free lift. Check that operation of each solenoid valve affects the appropriate wheel.

Service Breakdown of Electro-Hydraulic Unit

Service parts for this unit are limited to; the hydraulic modulator with pump motor; and the coil integrated module which comprises the ECM and solenoid pack.

To separate the module from the hydraulic block, release the 'Torx' screws and withdraw the module from the solenoid valve spigots. When refitting, check that the gasket is correctly located around the solenoid coil cluster, before mating with the hydraulic block and fitting the screws.

Note that component parts are calibrated specifically for the Lotus Elise. Do not use parts from other sources.

JJ.14 - WHEEL SPEED SENSORS

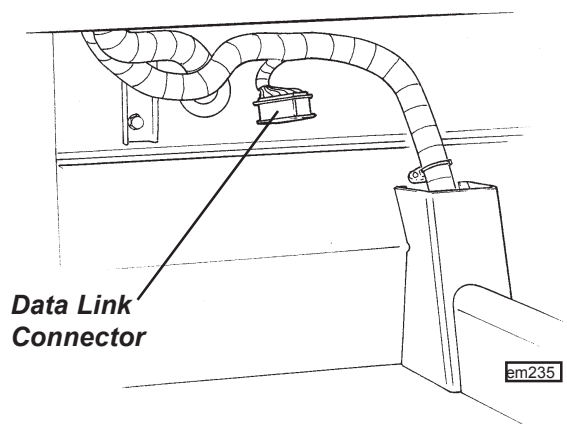
A wheel speed sensor is integrated into each of the four hub bearing assemblies and supplies a signal to the ABS control module. The module outputs a road speed signal to the engine ECM, and also to the instrument pack for speedometer operation.

Output from each wheelspeed sensor can be checked using the Scan 2 tool, and if found to be faulty or absent, the complete hub assembly should be renewed - refer to sub-section CI.5 (front) or DH.4 (rear).

JJ.15 - DATA LINK CONNECTOR (DLC)

The Data Link Connector (DLC) is a 16 terminal electrical connector plug, complying with SAE J 1962, which provides a means of communication with the ABS and engine management electronic control units. The connector is used in service to connect electronic diagnostic equipment such as the 'Lotus Scan' hand held scanner tool which allows system interrogation including the reading of trouble codes.

The DLC is either tied to the main harness at the front of the passenger footwell, or secured to the centre underside of the scuttle beam.

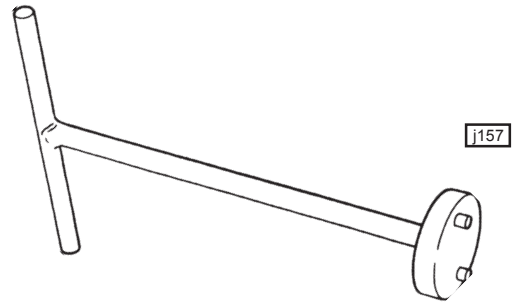




JJ.16 - SPECIAL TOOLS

Retraction Tool, Rear Calliper Piston T000T1242

Used to retract the rear calliper pistons and enable fitment of new brake pads.



Lotus Scan Tool T000T1418F

In order to provide for communication with the engine management system electronic control module, a hand held electronic scanner 'Lotus Scan' (part number T000T1418F), may be plugged into a special 16 terminal harness connector socket, known as a Data Link Connector (DLC), located at the front of the passenger footwell. Note that this tool may also be used on previous Elise models (excluding Exige '00 M.Y, 340R and 160 models).

Amongst the operations available using the 'Lotus Scan' tool are:

- Clear fault codes
- View fault codes/wheel speeds/valve activities
- Generate valve/motor activities
- Read EEPROM contents
- Read ECU identification

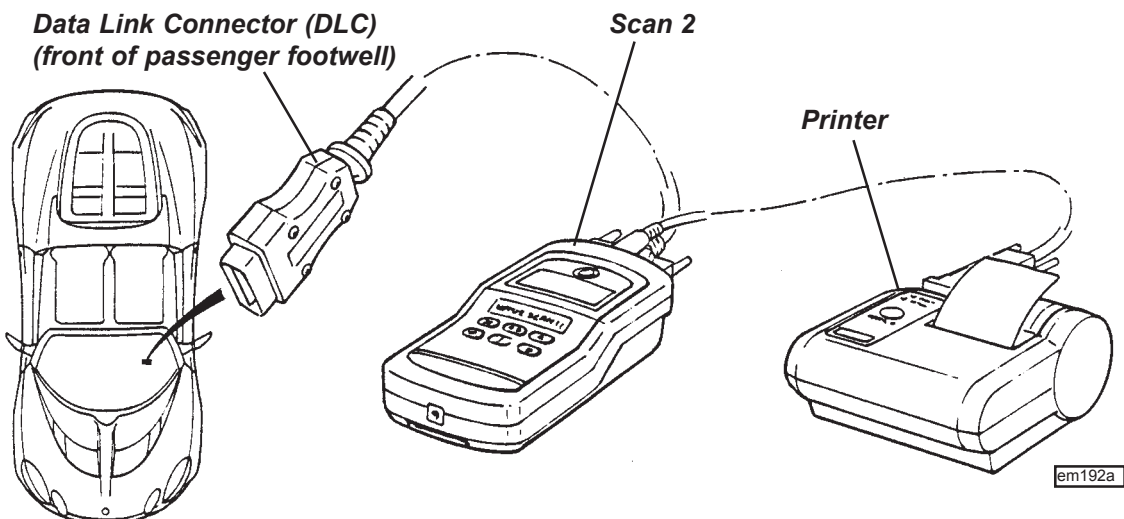
Operating instructions are provided with the tool.

Important Note

The power supply transformer is used for overnight charging of the printer, and also for powering the Lotus Scan tool during software downloading from a PC (personal computer). For the software download operation, the Scan tool requires a power supply from the mains via the transformer and an inverter. Two types of inverter have been used; early kits used an adaptor lead to plug into the bottom end of the Scanner tool. Later kits use an adaptor plug fitting into the top end of the scanner.

When charging the printer, **it is most important that the inverter is NOT used**, or damage to the transformer may be caused. Incorrect connection is possible only with the early type adaptor lead, with which extra care should be exercised.

1. Reading data from vehicle



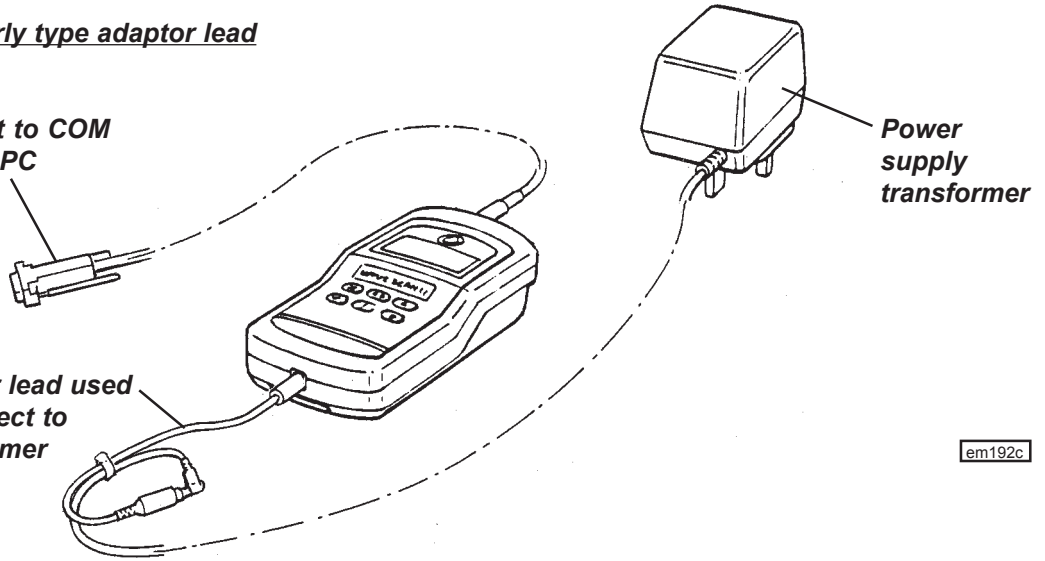


2. Downloading software from P.C.

With early type adaptor lead

Connect to COM port on PC

Adaptor lead used to connect to transformer



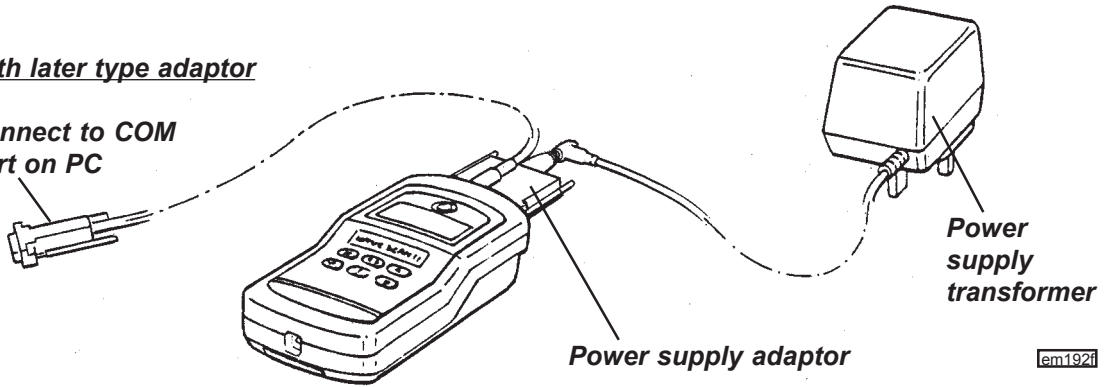
em192c

With later type adaptor

Connect to COM port on PC

Power supply adaptor

Power supply transformer



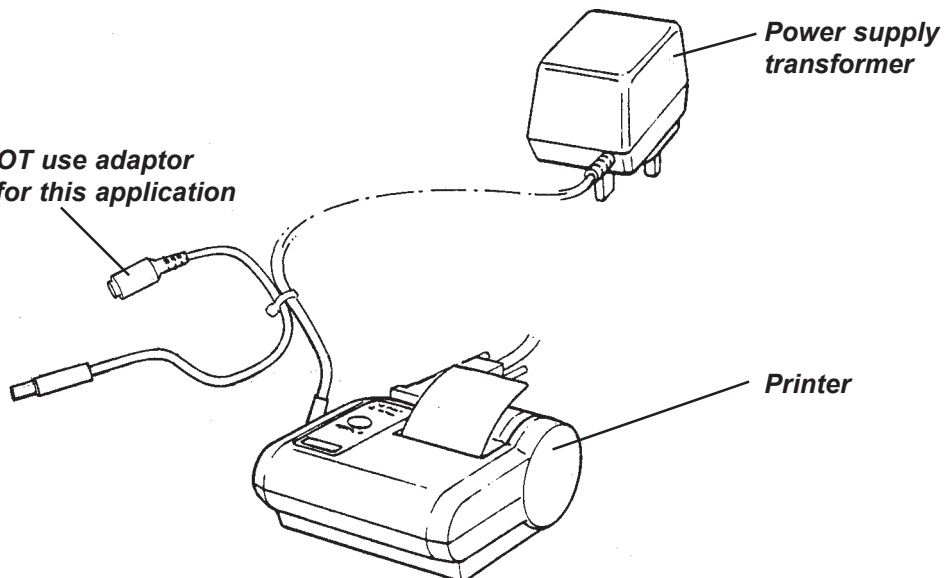
em192f

3. Charging printer

Do NOT use adaptor lead for this application

Power supply transformer

Printer





JJ.17 - 'LOTUS SCAN' CHECKING PROCEDURES

1. **Trouble Codes**

When the ABS controller detects a fault in the system, the following events occur;

- i) The ABS tell tale is lit;
- ii) The anti-lock system is switched out;
- iii) A trouble code is stored in the non volatile random access memory i.e. memory which is retained when the power supply is interrupted, or the battery disconnected.

Trouble codes may be either Condition Latched, or Ignition Latched:

Condition Latched; With this type of fault, which is generally low or high voltage, the ABS tell tale will light, and the anti-lock system switch out, until such time as conditions return to normal, at which point the light will be extinguished, and the anti-lock be reinstated. The trouble code will be stored only whilst the fault is present.

Ignition Latched; This type of fault, of which are most categories, will cause the tell tale to be lit and the anti-lock to be inhibited until such time as the fault is no longer detected at the moment of a subsequent switching on of the ignition. At this point, the lamp will be extinguished, and the ABS restored, but the trouble code will be retained in the memory for the next 20 drive cycles i.e. ignition switched on and a minimum road speed of 5 mph attained.

Access to the diagnostic codes is available only by using the 'Lotus Scan' tool connected to the DLC (see JG.15). The 'Lotus Scan' is a hand held electronic scanner tool with an LCD display panel which is able to display any stored trouble codes and sensor readings as well as allowing manual operation of actuators.

The facilities available include:

- View fault codes/wheel speeds/valve activities
- Clear fault codes
- Generate valve/motor activities
- Read EEPROM contents
- Read ECU identification

Important Notes

- Whenever the Lotus Scan tool is connected, the ABS tell tale is lit and the anti-lock function is inoperative.
- Never connect or disconnect the DLC to/from the control unit with the ignition switched on.
- Before charging or quickcharging, disconnect the battery from the vehicle electrical system.
- Never disconnect the battery from the vehicle electrical system with the engine running.
- Never use a quick-charger for starting.
- Take care when touching energised parts of the ignition system.
- ECMs must be removed prior to welding operations, or subjecting to oven temperatures above 80°C.
- When voltage testing, use only a high-resistance type meter.
- During test steps which involve the connection of contacts from harness plugs or control units with ground or battery voltage (+12V), exercise great care as incorrect contact can cause permanent damage to the ECM internal circuits.
- When measuring resistance from ground bearing wires to vehicle ground, the nominal value of 'less than 2 ohms' sometimes cannot be achieved. In this case, disconnect the negative (ground) post of the battery and measure the resistance to the vehicle earth lead.
- Always erase trouble codes from any control unit after a test is done.



2. Abbreviations & Definitions

BATTERY VOLTAGE	System voltage
BRAKE LIGHT SW.	Brake light switch
FL WHEEL SPEED	Front left wheel speed
FR WHEEL SPEED	Front right wheel speed
RL WHEEL SPEED	Rear right wheel speed
RR WHEEL SPEED	Rear right wheel speed
FRONT WHL SPEEDS	Front wheel speed
REAR WHL SPEEDS	Rear wheel speed
VALVE RELAY CMD	Valve relay command
VAVLE RELAY FDBK	Valve relay feedback
RETURN PUMP CMD	Return pump command
RETURN PUMP FDBK	Return pump feedback
FL HOLD SOL. CMD	Front left solenoid hold command
FL HOLD SOL. FDBK	Front left solenoid hold feedback
FL REL. SOL. CMD	Front left solenoid release command
FL REL. SOL. FDBK	Front left solenoid release feedback
FR HOLD SOL. CMD	Front right solenoid hold command
FR HOLD SOL. FDBK	Front right solenoid hold feedback
FR REL. SOL. CMD	Front right solenoid release command
FR REL. SOL. FDBK	Front right solenoid release feedback
RL HOLD SOL. CMD	Rear left solenoid hold command
RL HOLD SOL. FDBK	Rear left solenoid hold feedback
RL REL. SOL. CMD	Rear left solenoid release command
RL REL. SOL. FDBK	Rear left solenoid release feedback
RR HOLD SOL. CMD	Rear right solenoid hold command
RR HOLD SOL. FDBK	Rear right solenoid hold feedback
RR REL. SOL. CMD	Rear right solenoid release command
RR REL. SOL. FDBK	Rear right solenoid release feedback

3. ECU Identification

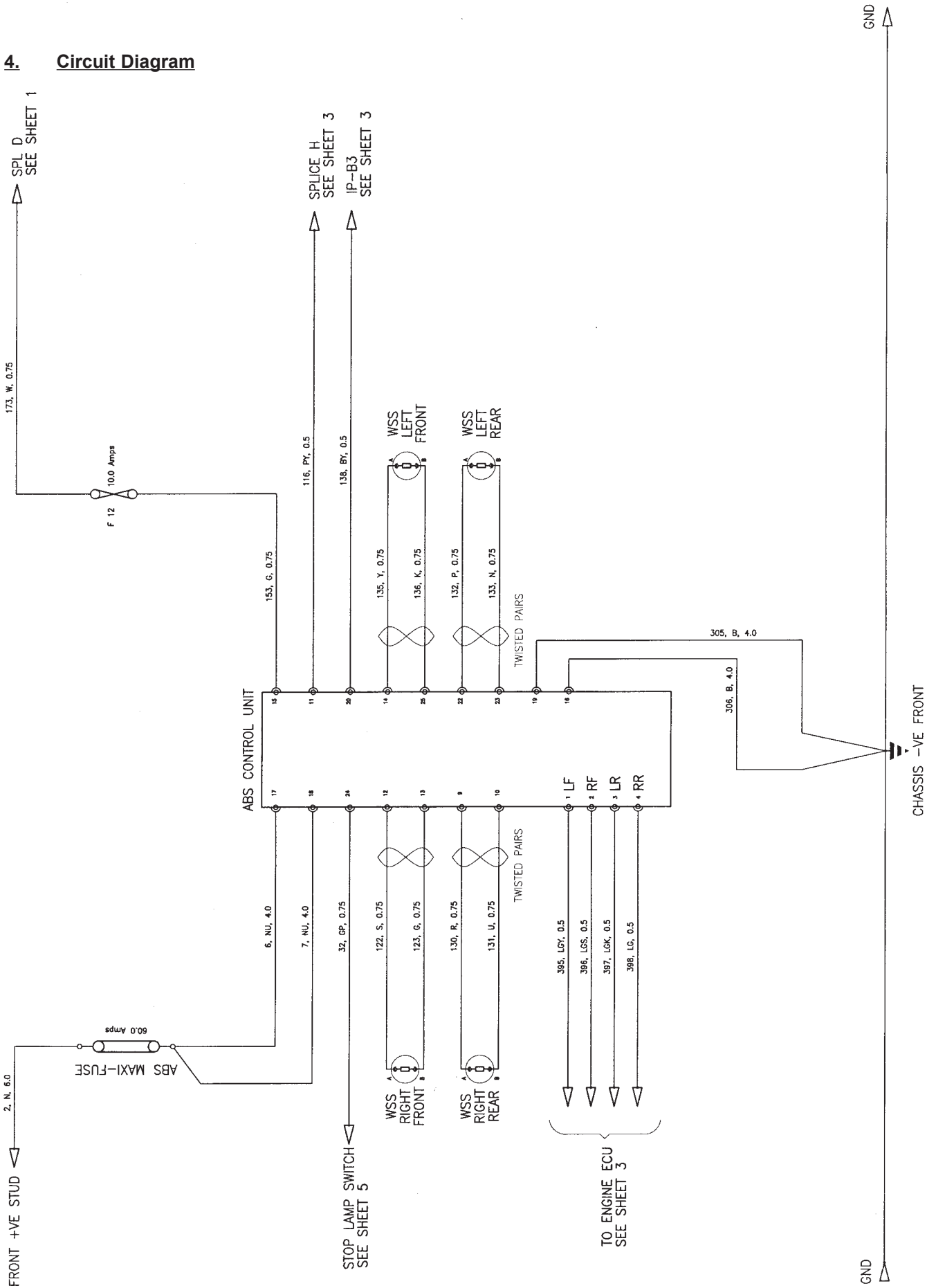
The ECU identification number for the Elise/Exige is: A120J6000F

Supplier ECU Hardware Number: EBC 430

Supplier ECU Software Number: LCFWDQ04K2K



4. Circuit Diagram



**5. Diagnostic Trouble Codes**

DTC	Diagnostic Trouble Code Storage Condition	Remedy
C0035	Front left wheel speed sensor: Short circuit or circuit open; No signal;	C-04 C-04
C0040	Front right wheel speed sensor: Short circuit or circuit open; No signal;	C-05 C-05
C0045	Rear left wheel speed sensor: Short circuit or circuit open; No signal;	C-06 C-06
C0050	Rear right wheel speed sensor: Short circuit or circuit open; No signal;	C-07 C-07
C0060	Front left outlet solenoid valve circuit malfunction;	C-12
C0065	Front left inlet solenoid valve circuit malfunction;	C-12
C0070	Front right outlet solenoid valve circuit malfunction;	C-12
C0075	Front right inlet solenoid valve circuit malfunction;	C-12
C0080	Rear left outlet solenoid valve circuit malfunction;	C-12
C0085	Rear left inlet solenoid valve circuit malfunction;	C-12
C0090	Rear right outlet solenoid valve circuit malfunction;	C-12
C0095	Rear right inlet solenoid valve circuit malfunction;	C-12
C0110	Return pump: circuit open or shorted; locked or shorted;	C-10 C-10
C0121	Valve relay circuit malfunction;	C-09
C0161	Brake light switch fault;	C-11
C0232	Brake system telltale voltage: high or open circuit; low;	C-13 C-13
C0245	Wheel speed: sensor erratic signal;	C-08
C0245	error;	C-08
C0252	Replace electronic control unit;	C-02
C0550	Replace electronic control unit;	C-02
C0550	Brake system or electronic control unit malfunction;	C-12
C0556	Replace electronic control unit;	C-02
C0561	Replace electronic control unit;	C-02
C0563	Replace electronic control unit;	C-02
C0564	Replace electronic control unit;	C-02
C0800	Switched battery voltage: high (valve relay) low (valve relay)	C-03 C-03

For remedial procedures, see Lotus Scan tool display.