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GIRLING

VACUUM SERVO UNITS



**Providing
Power assistance to
Hydraulic Braking Systems**



APPLYING POWER ASSISTANCE TO BRAKING SYSTEMS

A driver can apply the same force to the brake pedal whether he, or she, is in a bubble car or a family saloon, in a sports car or a heavy limousine, and one of the problems of brake design is to equate the limited strength of the driver with the tremendous braking forces that sometimes are involved.

The Girling Vacuum Servo Unit provides some of the answers to this problem. It takes otherwise wasted power from the engine and uses it to boost the hydraulic pressure in the brake system in an exact and controlled manner.

In brake systems which have been designed to take full advantage of the extra power available the Unit forms part of the equipment originally fitted to the car. A unit called the Powerstop has been designed with the same basic principles for fitting into brake systems not equipped originally with a servo unit. This provides the opportunity for any car owner to have the luxury of ample power at the brake pedal.

This booklet describes the principle by which the Girling Vacuum Servo Unit operates, provides instructions for dismantling and assembly and also includes a simple guide for testing and diagnosing faults.

GIRLING VACUUM SERVO UNITS

The unit is installed in the hydraulic system between the master cylinder and the wheel cylinders, with the outlet pipe from the master cylinder connected to the Servo hydraulic inlet and the Servo hydraulic outlet connected to the wheel cylinders. The force required to augment the driver's effort is obtained by admitting atmospheric pressure to a vacuum cylinder containing a piston.

The pressure difference thus obtained across the vacuum piston produces a thrust load which is used to increase the hydraulic pressure available at the wheel cylinders.

In the Girling Servo Unit, and the "Powerstop", the piston in the vacuum cylinder is normally subjected to vacuum on both sides and this principle is known as "Suspended Vacuum" system.

This method induces a more rapid response than the "direct" or "non-suspended" vacuum type of cylinder, in which the piston is normally subjected to atmospheric pressure on both sides and the vacuum is introduced to one side when a pressure difference is required.

HOW IT WORKS When air is admitted to the vacuum cylinder by the control valve, the piston drives the piston rod and plunger down the hydraulic cylinder, providing a considerable increase in pressure of fluid to the wheel cylinders.

The control valve operated by the fluid from the master cylinder exercises a precise control over the pressure increase and the brakes are operated exactly in proportion to the effort applied to the pedal.

Illustration 1 shows diagrammatically the unit in the "at rest" position with no pressure in the hydraulic system. The valve is open to the vacuum tank or inlet manifold and the vacuum on both sides of the piston is equal.

When the foot pedal is applied, hydraulic pressure is exerted throughout the whole system and equally on both ends of the composite valve control piston. As one end of the piston is larger than the other, an equal pressure per square inch on both ends causes a proportionately greater thrust to be exerted on the large end and the piston moves (to the left as drawn), and the "T"-shaped lever opens the valve to the atmosphere. The air admitted to the right-hand end of the vacuum cylinder drives the piston to the left and the piston rod first seals the centre hole in the output piston and, continuing the movement, applies pressure on the fluid proceeding to the wheel cylinders and to the small end of the valve-control piston. See diagram 2.

This movement of the output piston continues until the thrust on the small end of the plunger, by the high fluid pressure, overcomes the thrust by the low pressure fluid on the large end. The

valve control piston is thus moved back, closing the air valve. At this point both valves are closed as diagram 3 and the brakes are being held on. If the foot pedal is released the fluid pressure is reduced at the large end of the control piston, which moves to the right, the valve rocker opens the vacuum valve, air is drawn out of the cylinder, the vacuum piston returns and with it the output piston, relieving the pressure to the wheel cylinders as diagram 4. The piston rod is withdrawn from the output piston, allowing flow of fluid between supply tank and wheel cylinders.

If the force on the pedal is increased after arriving at the position shown on diagram 3, the valve gear operates to give additional assistance from the vacuum piston until the thrust on each end of the control piston is balanced or until the limit of available vacuum is reached. Conversely, if the foot pedal force is reduced the valve gear operates to reduce the pressure at the brake cylinders until again a state of balance of the control piston is reached.

The difference in area between the two opposed ends of the control piston determines the proportion of assistance provided by the unit. If, for example, the large end is twice the area of the small end, the hydraulic pressure output is built up to twice that of the input from the master cylinder before the control piston moves back to close the air valve. Such a unit therefore would have an output of twice the pressure of the input, throughout the range of the unit.

In this way, the pressure in the wheel cylinders varies in proportion to the effort at the pedal and full and precise control of the brakes is always at the command of the driver.

Some units have an output of $2\frac{3}{4}$ to 1, some have an output ratio of 2 to 1 and others have an output ratio of $1\frac{1}{2}$ to 1.

Between the engine inlet manifold and the vacuum reserve tank or, if a tank is not fitted, between the manifold and the servo unit, is a non-return valve, Fig. 5. This valve prevents the entry of air and petrol vapour into the tank or servo unit.

In the end cover of the Powerstop is fitted a piston return stop, Fig. 6, which determines the gap between the output piston and piston rod when fully returned. The gap governs the flow of fluid through the unit when at rest and the smoothness of the application of power.

The position of the stop is set and locked during final test and should not be disturbed in service.

A design modification renders unnecessary the external piston stop and units being manufactured at the present time do not incorporate this feature.



ATMOSPHERE



VACUUM



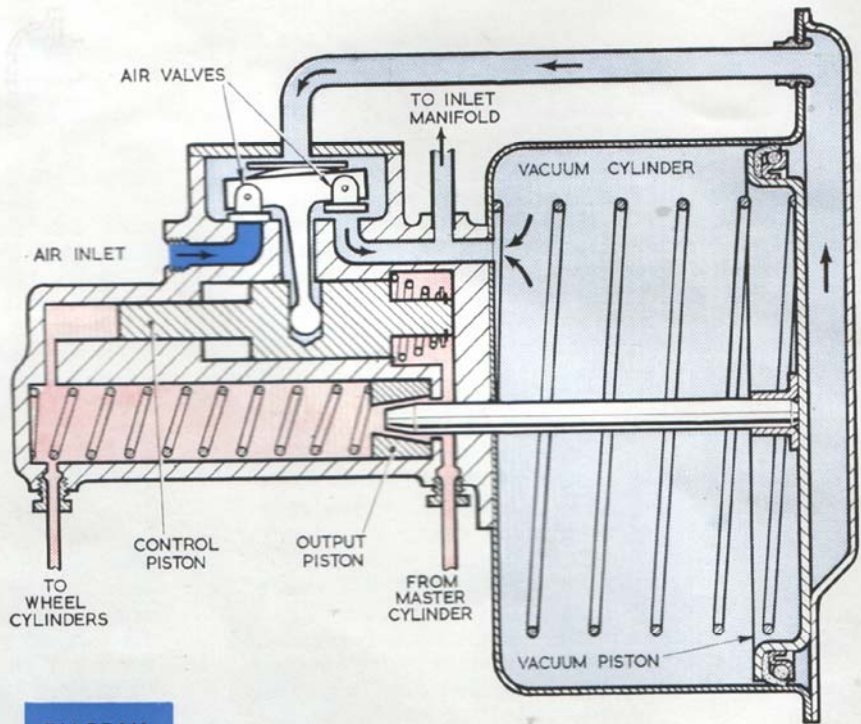
FLUID



LOW PRESSURE FLUID



HIGH PRESSURE FLUID

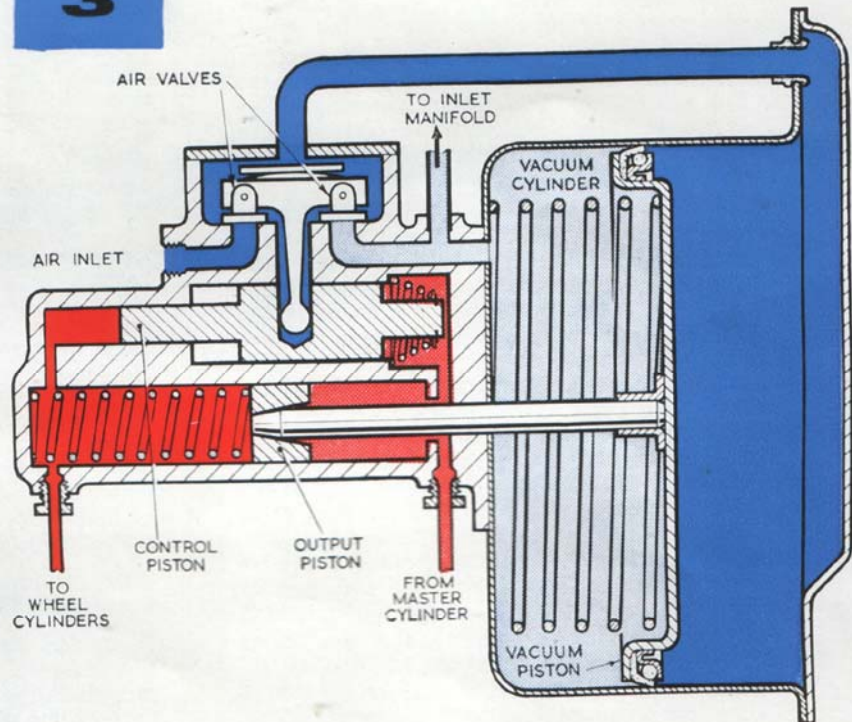


DIAGRAM

1

DIAGRAM

3



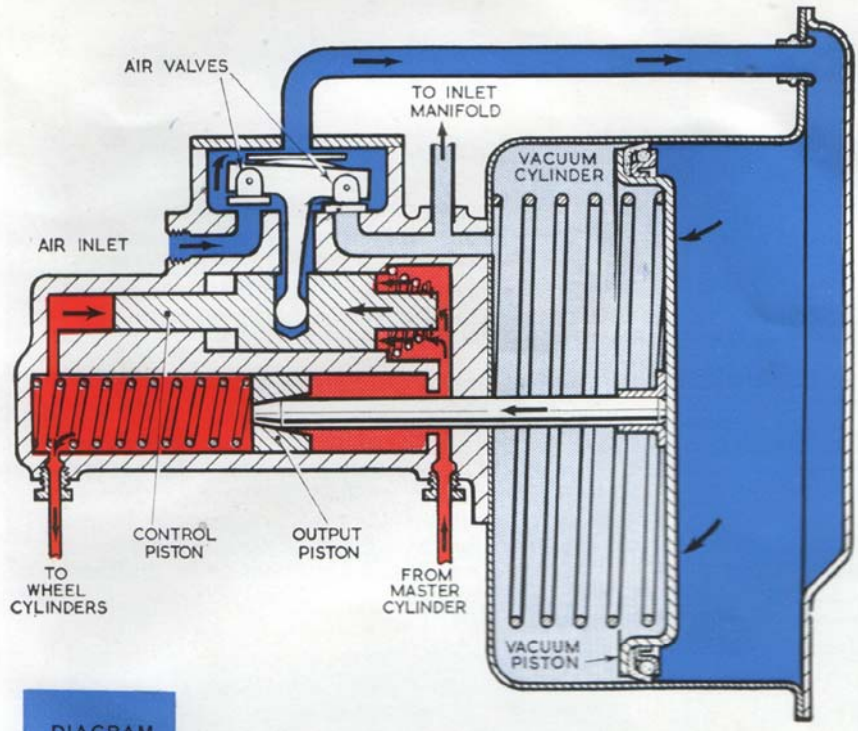


DIAGRAM
2

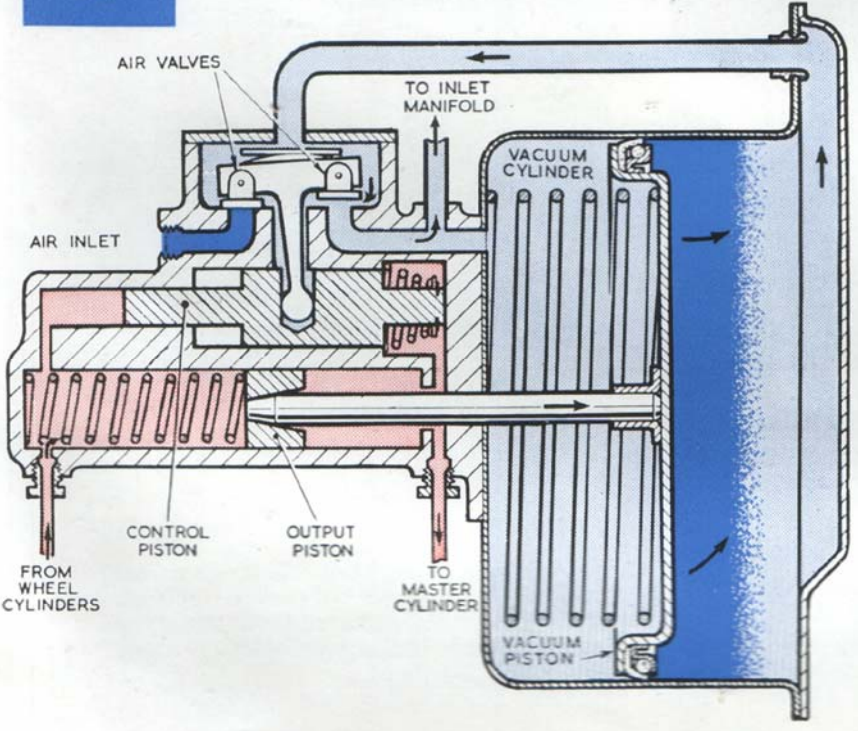


DIAGRAM
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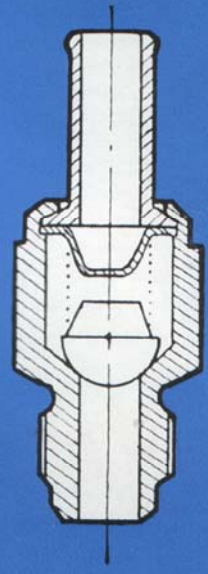


FIG. 5



FIG. 6

SERVICING

All seals and the vacuum hose should be changed at 40,000 miles or three years if this mileage has not been achieved. Whenever possible the servo unit should be returned to Girling for replacement, but if this is not possible the replacing of all seals as contained in the service kit should provide a satisfactory unit providing **the internal working surfaces are in good condition.**

There should be no sign of corrosion, pitting, scoring or steps on piston rod, pistons or bores and the surfaces should be smooth to the touch.

When dismantling, absolute cleanliness is essential. Wash the hands and lay out a clean sheet of paper on which to work and place the parts. Take care of all highly finished working surfaces on pistons, rods and bores. Clean hydraulic parts with Girling Cleaning Fluid, Alcohol or Castrol Girling Brake and Clutch Fluid (Crimson) and do not allow any other fluid, oil, or grease to touch them. Special care should be exercised when removing and fitting the circlip in the hydraulic output cylinder and when assembling the vacuum cylinder to the body. Particular attention is directed to the remarks in the sections concerned.

FIG. 7



The unit may be considered in five parts:-

- 1 The Air Filter.
- 2 The Vacuum Cylinder which supplies the force to operate the output cylinder.
- 3 The Valve Chest which houses the valves, controlling the movement of air to and from the vacuum cylinder.
- 4 The valve control piston occupying the upper bore of the body.
- 5 The hydraulic output cylinder from which the pressure is applied to the brakes.

THE AIR FILTER.

Fig. 7

The element, of moulded cellular construction, should be changed whenever replacement brake shoes are fitted and on the occasion when the servo unit is overhauled.

The current type of filter is shown inset.

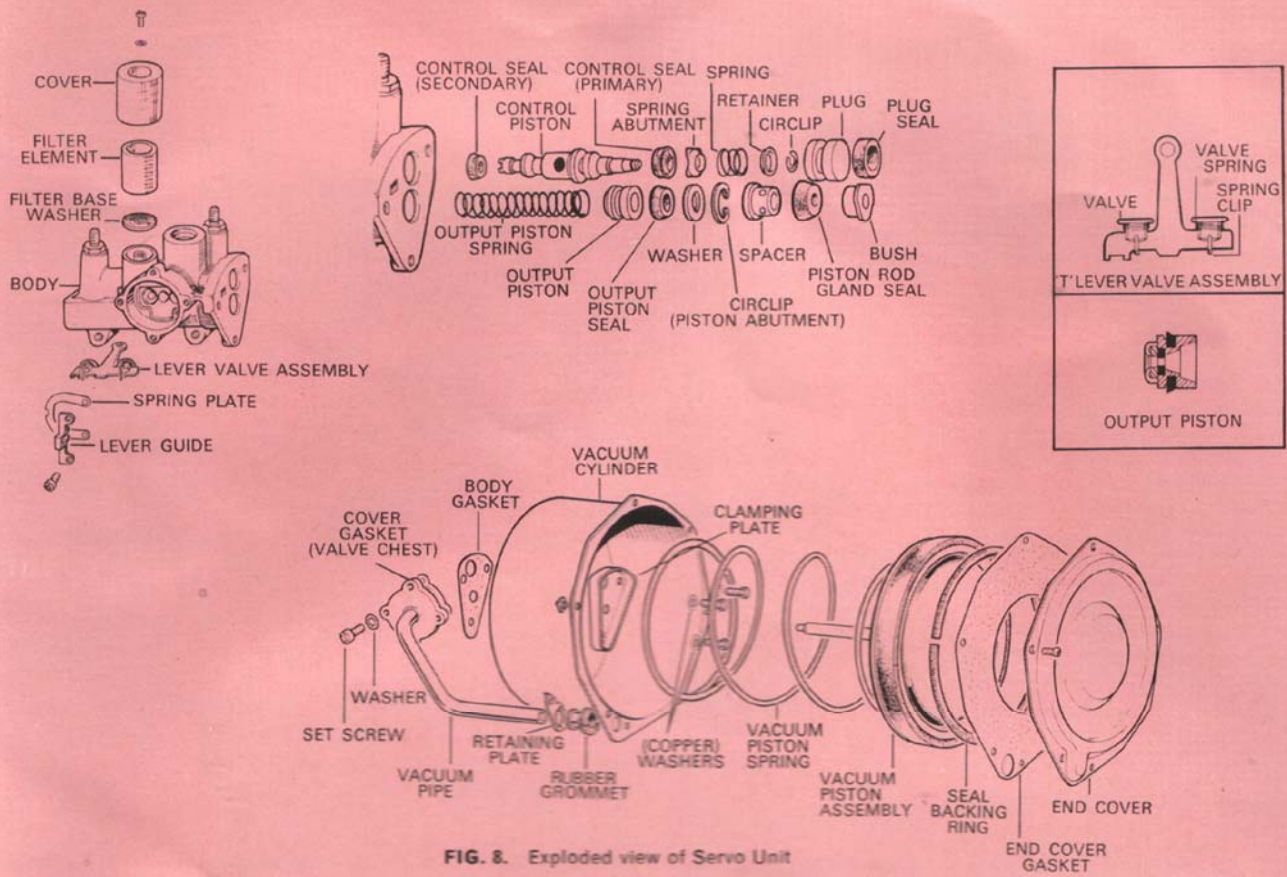


FIG. 8. Exploded view of Servo Unit

DISMANTLING THE UNIT

THE VACUUM CYLINDER. Fig. 9

Hold the unit in a vice by the mounting lugs on the body. Remove the screws in the flange, supporting the cover against the pressure of the piston return spring. Relieve the pressure gradually allowing the spring to push out the piston. Removal of the piston assembly and spring will reveal the set bolts which secure the cylinder base to the body. Remove set bolts; the cylinder, with the now loose clamp plate inside, can be separated from the body.

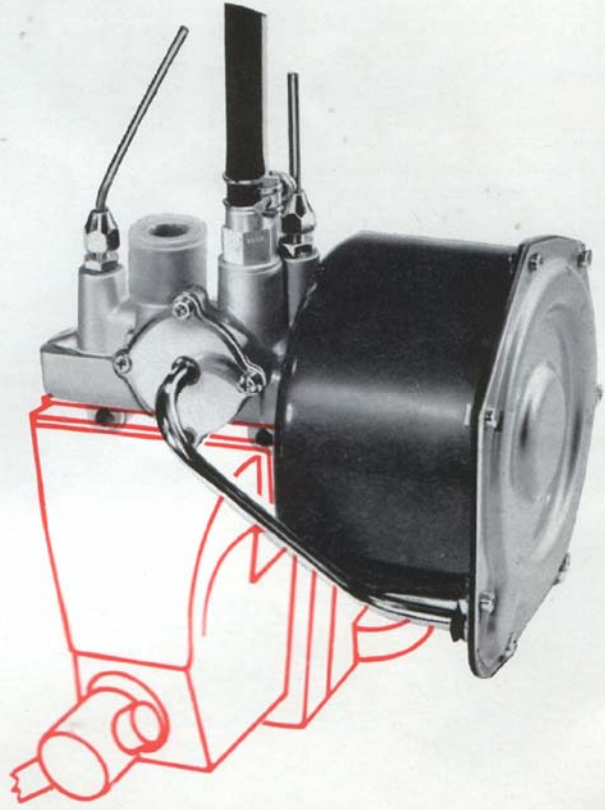


FIG. 9

THE VALVE CHEST.

Fig. 10

With the light alloy body of the unit still in the vice, the Valve Chest should be dismantled.

Proceed in the obvious manner. Remove the four set screws and lift off the cover and tube assembly. Inside, remove the two valve retainer screws and lift out the flat horseshoe spring and valve retainer. The rocking lever with nylon valves attached will be held by the spring-loaded control piston. Apply pressure to the plug in the control cylinder bore to move the control piston sufficiently to release the rocking lever and allow it to be lifted out of the valve chest. Clean all parts with Girling Cleaning Fluid.

It is unlikely that the nylon air valves will need to be renewed, but when it is necessary the faces should be lapped on a piece of glass with fine lapping paste to ensure they are airtight.

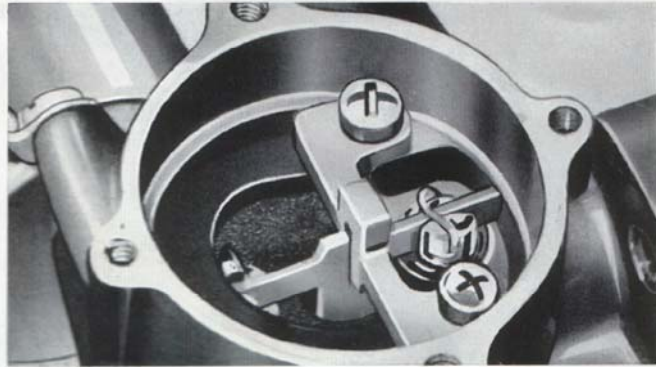


FIG. 10. The Valve Chest.

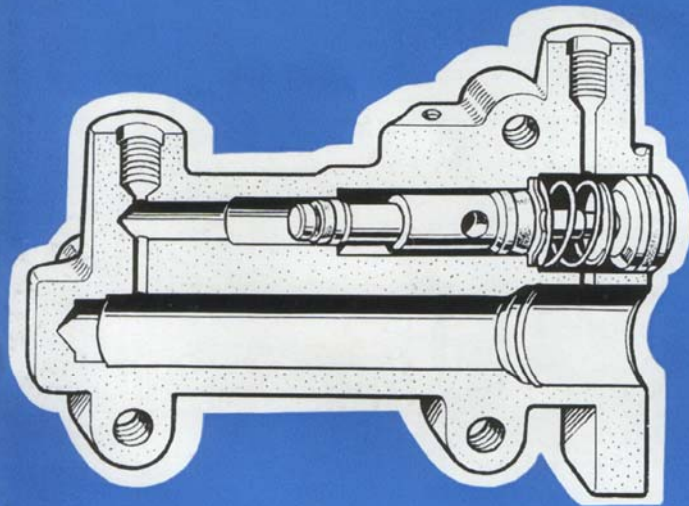


FIG. 11. The control cylinder with new type piston.

VALVE CONTROL CYLINDER. Fig. 11

The valve control cylinder is the upper bore in the body. If the piston spring has not already partly pushed out the plug which seals the end of the control cylinder, tap the face of the body on a wooden surface to jar out the plug. The control piston can then be lifted from the bore.

Dismantle the control piston assembly (Fig. 12) by compressing the spring and pushing off the circlip which releases the retainers and spring. Remove the seals (and the seal from the plug) clean the parts with Girling Cleaning Fluid and lubricate with clean Brake Fluid. Fit the seals with the lips facing away from the centre hole, refit the abutment, spring, retainer and circlip ready for insertion in the body. Clean, and fit a new seal to the end plug.

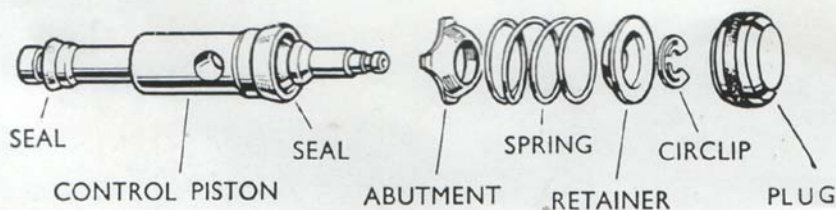


FIG. 12.

If the control piston is in two parts similar to the type shown in Fig. 13 it should be replaced by the later type together with the new end plug, shown in Fig. 12. The new piston and ancillary parts are available as a separate kit.

Discard the two pistons with the seals, the spring, nylon washer, and the end plug. Lubricate the new piston with Brake Fluid and fit the two seals with the lips away from the central hole.

Fit the spring and other parts in the order shown in the illustration (Fig. 12). Fit a new seal to the new end plug.

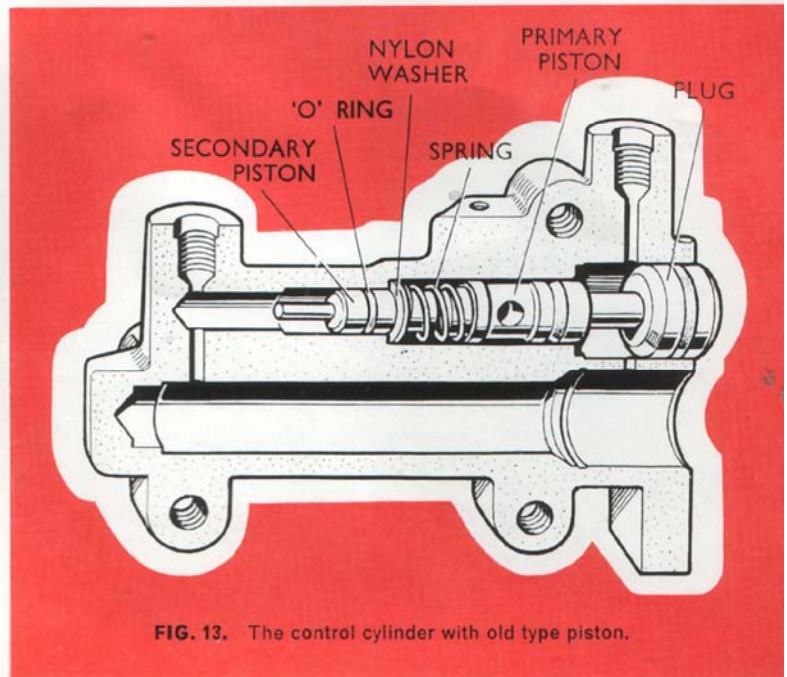


FIG. 13. The control cylinder with old type piston.

THE OUTPUT CYLINDER. Fig. 14

The shouldered end of the piston rod bearing bush stands proud of the body face, which enables the bush to be lifted from the bore. Immediately below it, is the gland seal which is removed by a hooked wire. The nylon seal spacer can be shaken out of the bore.

The circlip and the abutment washer it retains can now be seen. Circlip pliers and a special spring compressing tool described on page 8 will be needed.

Press on the piston (through the abutment washer) with the round end of the compressing tool and clip the ends of the tool under the edge of the body (see Fig. 16), relieving the spring pressure on the circlip. Locate the ends of the pliers in the holes in the circlip.

Squeeze the circlip pliers until the circlip is fully compressed and, holding the pliers tightly, carefully lift out the circlip, *making quite sure the bore is not damaged in the process*, otherwise a brake failure may result.

Release the compressing tool and the piston spring will push out the washer and piston. Discard the piston.

Thoroughly cleanse the body with Girling Cleaning Fluid, or alcohol, and lubricate the bores with Girling Rubber Grease before assembly. Examine the surfaces of the cylinder bores as described on page 4.

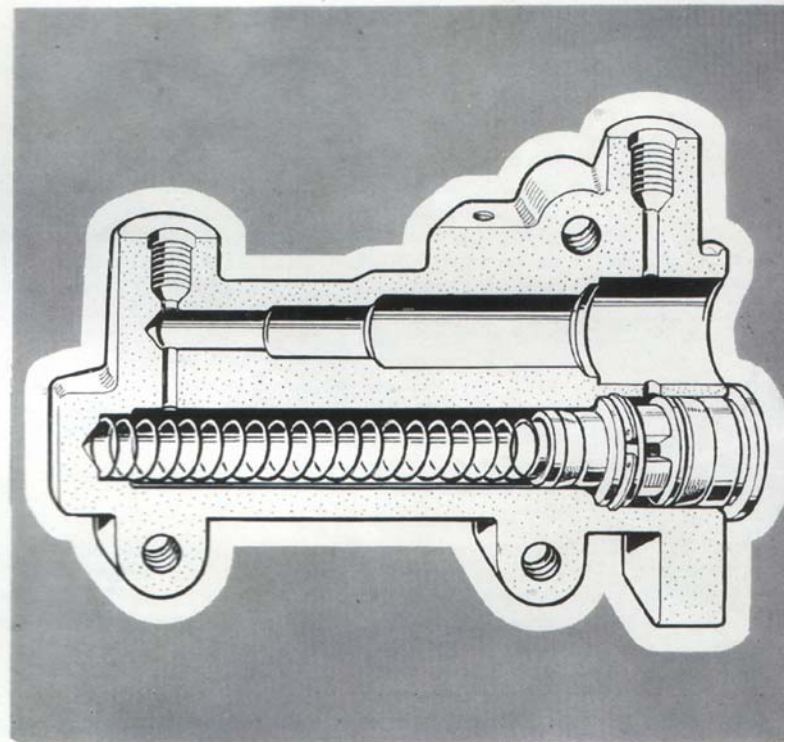


FIG. 14. The output cylinder.

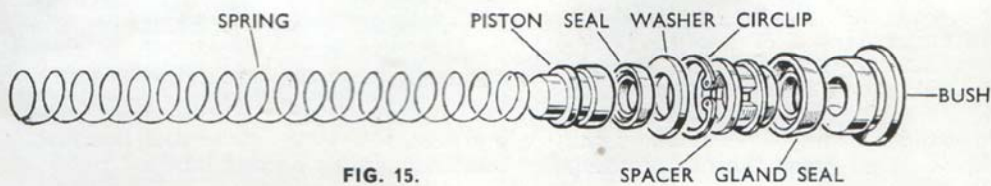


FIG. 15.

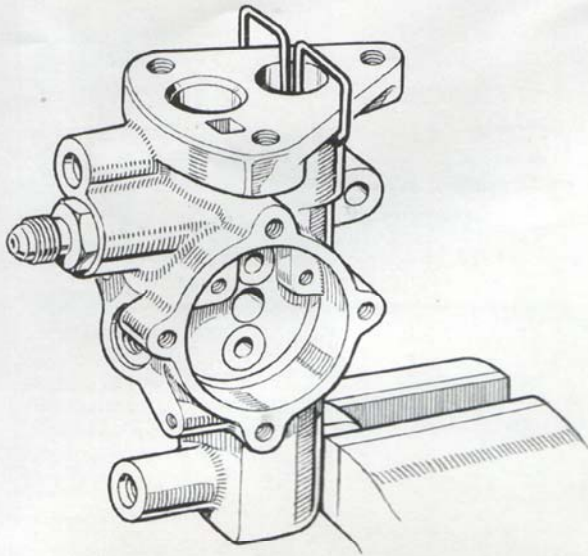


FIG. 16. Removing the output piston.

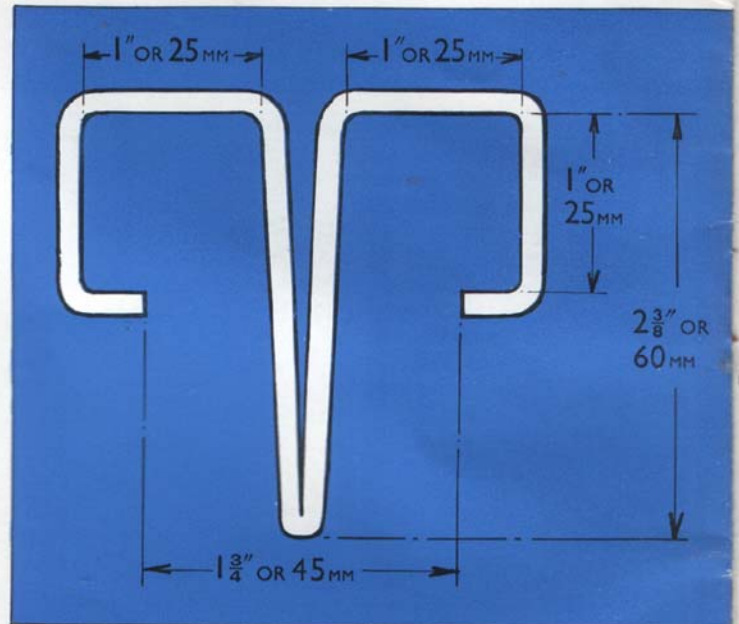


FIG. 17

The compression tool (Fig. 17) for the output cylinder is made from iron wire about $\frac{1}{8}$ in. (or approximately 3 mm) in diameter and a piece of 12 in. (30 cm) long will be needed. Bend the wire back on itself in the centre making the middle "leg" of the tool. Follow with the other bends as illustrated, finally cutting the two ends so that there is $1\frac{3}{8}$ in. or 45 mm between them. The centre "leg" is inserted in the output cylinder bore and pressed down until the two ends can be sprung apart and clipped under the body flange. The tool is then pushed towards the control cylinder opening to allow room to insert the circlip pliers.

ASSEMBLING THE UNIT

THE OUTPUT CYLINDER. Fig. 14

A new piston should be used when overhauling the unit because the piston rod seal is fitted into the piston during manufacture and cannot be replaced. Confirm that the seal around the piston has the larger diameter nearer the reduced end of the piston. Fit the new piston into the end of the spring and smear the piston with Girling Rubber Grease. Insert the spring into the bore, and place the abutment washer on top of the piston. With the round end of the wire spring compressing tool in the end of the piston, ease the piston into the bore. Take care to keep the piston "square" or it will cross-bind. It should be "worked" into the bore so that the seal enters without damage. No undue force should be used. Press the compressing

tool down until it can be clipped under the edge of the body as shown. With the circlip around the tool in the bore, fit on to the circlip pliers and compress the circlip fully.

Whilst holding the circlip fully compressed, carefully insert it into the bore and when it is resting on the abutment washer release the pliers. Confirm that the circlip is correctly seated in the groove and remove the wire tool.

This operation should not be hurried; the circlip pliers should be quite secure on the circlip before the circlip is removed or replaced, as there is considerable danger of damaging the bore if care is not exercised. A damaged bore can result in a brake failure.

Drop the seal spacer into the bore, large end first, ease in the gland seal, lips first, and finally fit the bearing bush.

THE CONTROL CYLINDER. Fig. 11

Lubricate the bore with Girling Rubber Grease and insert the control piston, aligning the hole in the piston with that in the valve chest. Press in the sealing plug.

THE VALVE CHEST. Fig. 10

Insert the rocking lever with the valves attached so that the spring location above one of the valves is furthest from the retaining screws. The round end of the lever should fit into the hole in the control piston. Press in the control cylinder plug to enable the lever to enter easily.

Place the spring and valve retainer in position, insert the screws with lock-washers and tighten home.

Place a new cover gasket in position and fit the cover, with pipe attached. Insert and tighten the four fixing screws.

THE VACUUM CYLINDER. Fig. 9

The assembled body must be in the vice, the mounting face uppermost with a new gasket placed in position.

Locate the vacuum cylinder on the mounting face with the centre hole over the projecting bearing bush, and the vacuum pipe in the new rubber grommet in the flange. Confirm that there will be space over the grommet for the passage of air when the end cover is fitted.

Position the clamp plate inside the cylinder and insert the three set bolts with new washers and screw in just finger-tight.

Before tightening the set bolts place the piston and piston return spring in position and push it down through the full stroke several times to align the bearing bush. Remove the piston and spring and tighten the three set bolts, taking care not to move the vacuum cylinder in the process. If this is not done carefully, the cylinder may be misaligned and cause the brakes to "hang on".

Tighten the four screws securing the valve chest cover.

Remove the sponge rubber backing ring from the piston washer and fit the new one from the kit. Smear the piston rod with Girling Rubber Grease before inserting, and apply the special lubricant supplied in the kit to the leather seal on the piston.

Place the cover plate (with new gasket) on top of the piston and press down, taking care the piston rod enters the bush without damage. Fit the nuts and bolts round the flange and tighten securely. The unit is now complete and ready for fitting to the car. If it is not fitted immediately the ports should be plugged or taped over to prevent the entry of any foreign matter.

RE-SETTING THE PISTON STOP

If the piston return stop in the centre of the end cover of the Powerstop has been disturbed, it can be re-set whilst the unit is in position on the vehicle.

All connections should be secure, the engine stopped and the front wheels jacked up clear of the ground. Confirm that the wheels spin easily.

Loosen the locknut in the centre of the end cover and turn the stop (the centre screw) clockwise, until the operation of the brake pedal causes the brakes to lock on. Turn back the stop slowly (anti-clockwise) until the wheels become free. Confirm that the exact position has been reached by repeating the procedure; turn the stop clockwise a quarter turn, "pump" the brakes to lock them on and turn the stop anti-clockwise slowly until the wheels again become free. From this point turn the stop anti-clockwise one complete turn and while holding the position tighten the lock nut.

TESTING EQUIPMENT

To make comprehensive tests of the Servo Unit requires complex and expensive equipment and this kind of testing obviously is outside the capacity of many service stations.

Some simple tests can be made when the unit is installed which give some useful information and these tests are described overleaf. The only piece of equipment is an adaptor to fit into the hydraulic inlet port. The adaptor is shown in Fig. 18, and it can be made from a suitable pipe union ($\frac{3}{8}$ in. x 24 UNF).

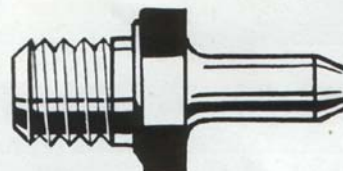


Fig. 18

TESTING THE SERVO UNIT

The use of these tests will assist in diagnoses and will provide assurance after servicing, but the tests are not exhaustive and obviously cannot equal the quality of testing which is done in the factory by the specially designed equipment. If a Servo Unit gives cause for doubt it is always best to replace it by a factory-tested unit whenever possible.

It is assumed that any faults connected with the brake system, such as contamination, lack of adjustment, air in the system, fluid leaks, etc., have been recognised and eliminated.

TEST 1 Fit the completed unit to the mounting brackets and, before connecting the pipes, fit a bleed screw in the hydraulic outlet port and an adaptor shown in Fig. 18, into the hydraulic inlet port. Connect the Vacuum hose to the adaptor and remove the filter element. While the engine is "ticking over" place fingers over the air inlet and vacuum ports to determine if there is any suction at either orifice. If suction can be detected it indicates that the bores are scored or the components incorrectly assembled.

TEST 2 Connect up the hydraulic and vacuum pipes and bleed the system. Run the engine and, while the brake is being applied, it should be possible to hear the hiss of the air inlet and, with a hand on the vacuum cylinder, feel the movement of the unit working.

TEST 3 Run the engine for half-a-minute, switch off and leave for two minutes. Apply the brake and the Servo unit should operate and the operation should be detected as detailed in test 2.

TEST 4 Run the engine and apply the brake hard, and hold it for fifteen to twenty seconds. There should be no perceptible creep of the pedal. If there is it indicates leaks or scored bores in the components.

TEST 5 Jack up the front wheels and with the engine running apply the brake and release. The wheels should be free to move half-a-second after the release of the pedal.

Tests 2 to 5 can be used to test a suspect Servo unit before it is removed from the car.
If the result is unsatisfactory on—

TEST 2 It means the unit is not working at all which could be caused by a lack of vacuum, possibly a faulty non-return valve, or a fault within the unit.

TEST 3 It indicates leaking gaskets, air valve or rubber grommet. Clamp the vacuum hose and repeat Test 3. If satisfactory the non-return valve is faulty. To test for a leaking air valve run the engine and place the finger over the air inlet. If the suction is only slight the air valve is satisfactory and the leak is elsewhere.

TEST 4 The source of trouble can only be found by elimination. Check for leaks. If no leak of hydraulic fluid is evident clamp each hose successively and repeat test each time. Finally plug the master cylinder outlet and test. If creeping of the pedal is evident when the hoses are clamped and the pedal is solid when the master cylinder outlet is plugged, the Servo Unit is faulty.

TEST 5 If the brakes remain on, disconnect the vacuum pipe, operate the brakes to eliminate all vacuum in the Servo Unit and make the test again. If the brakes remain on, the fault is not in the Servo Unit. If the brakes now release normally, the fault is in the Servo Unit and the vacuum piston alignment is suspect. See page 9.

FAULT FINDING CHART

| FAULT | CAUSE | ACTION |
|--|---|---|
| Hard Pedal — apparent lack of assistance with engine running. | Lack of vacuum. Restricted hose. Blocked air inlet. Rubber grommet swollen. Faulty output piston. Major fault in unit. | Check vacuum connections. Check hose and replace if necessary — fit parts from Service Kit — examine filter and air inlet — fit new unit. |
| Brakes hanging on. | Misaligned vacuum piston (after servicing unit). Swollen rubber grommet or swollen backing ring. Maladjustment of piston return stop. | Check as Test No. 5. Replace parts as necessary. Reset piston stop, see page 9. |
| Slow action of Servo Unit. | Swollen rubber grommet. Blocked filter or restricted air inlet. | Check and replace as necessary. Tighten vacuum connections. Replace hose. |
| Lack of assistance on heavy braking. Servo operating only when engine is running. Poor slow running of engine. | Air leak in servo low vacuum. Air leaks in gaskets or air valve. Vacuum hoses or faulty non-return valve. | Dismantle and replace all parts in Service Kit. Tighten vacuum connections. Replace vacuum hose or replace non-return valve. |
| Loss of fluid. | Failure of a seal or seals in unit or scored bores. | Replace unit or fit a Service Kit of seals and gaskets. |



SALES AND SERVICE

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