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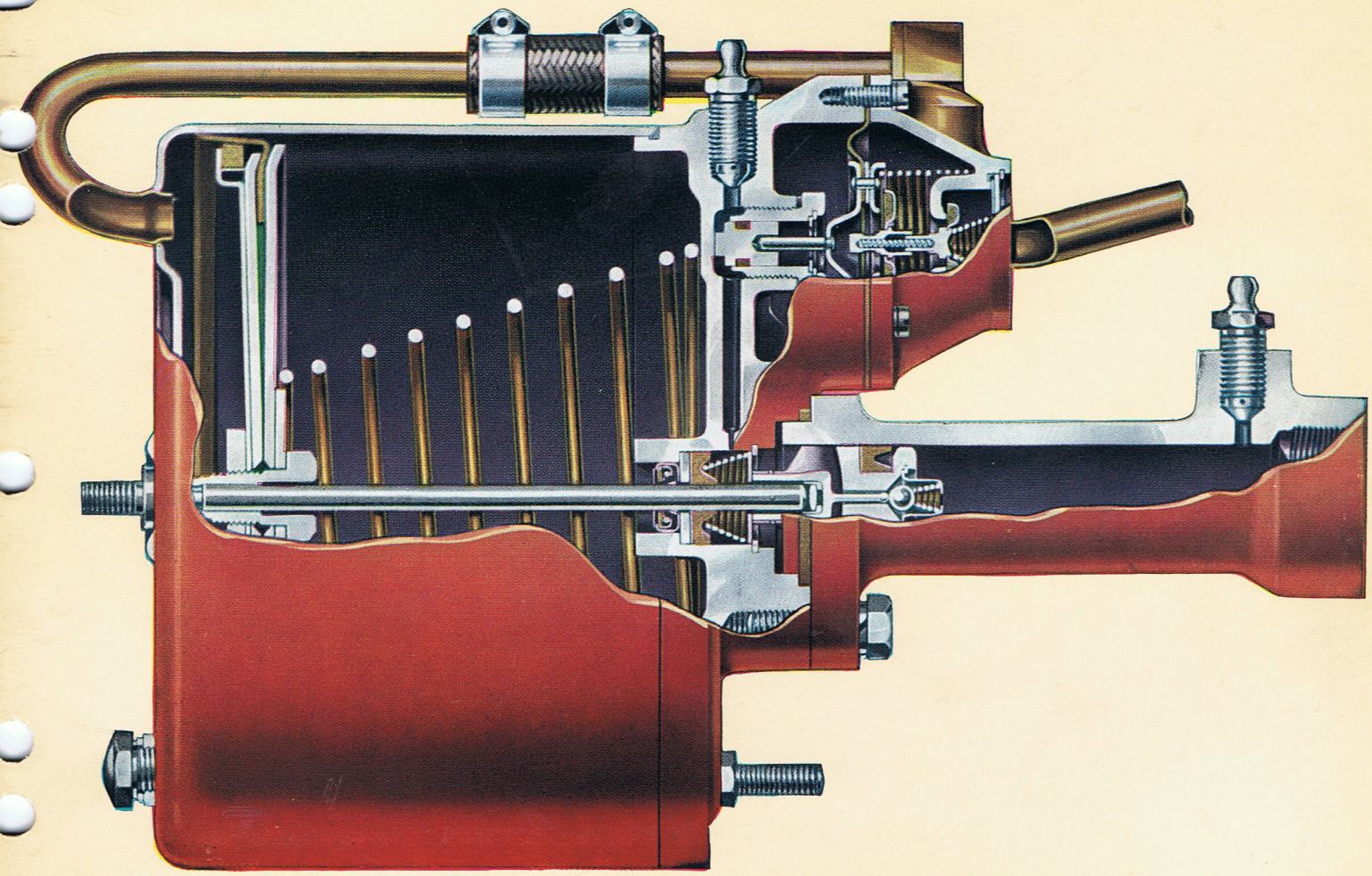
S.118/2

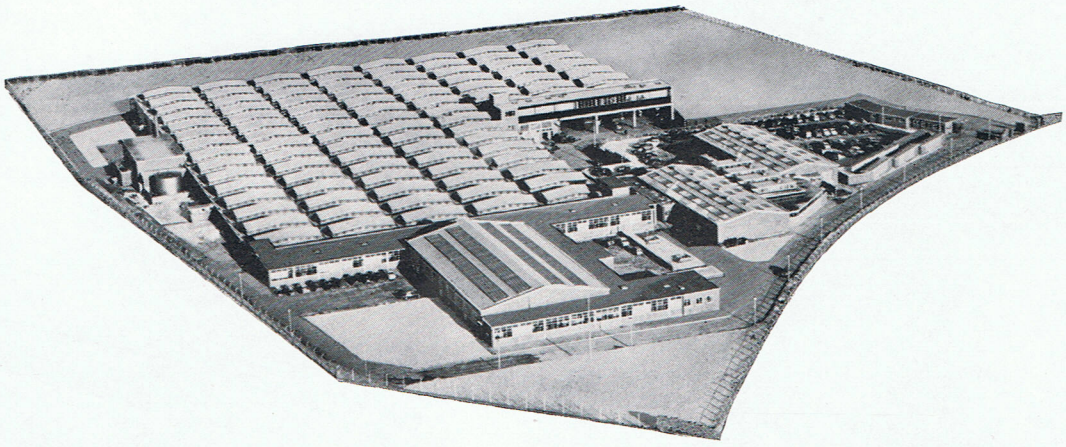
LOCKHEED* HYDROVAC*

* REG'D TRADE MARK.

SERVO BRAKING UNITS



SERVICE MANUAL



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INTRODUCTION

THE HYDROVAC is a unit which provides the driver with assistance when applying the brakes, and so reduces the effort required at the brake pedal; it is installed in the line between the master cylinder and the brake assemblies. Two main types of Hydrovac are available—the 'Single' unit and the 'Tandem' —and the design of each is very similar. The unit consists mainly of a control-valve, a slave cylinder and a booster piston (two of these pistons being fitted in the instance of the tandem unit), and power for its operation is provided by atmospheric pressure and by vacuum from the engine's inlet manifold (in the instance of petrol-engined vehicles) or from a separate exhauster unit (with diesel-engined vehicles).

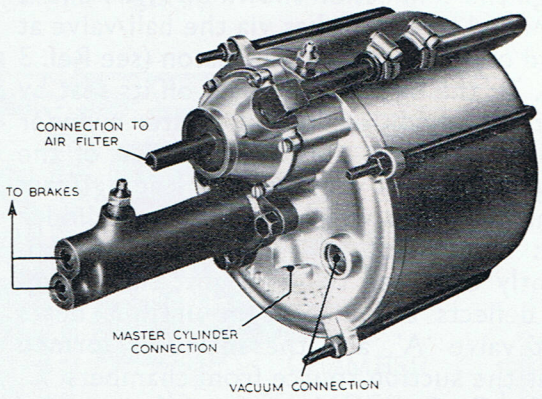


Fig. 1. 'Single' Hydrovac.

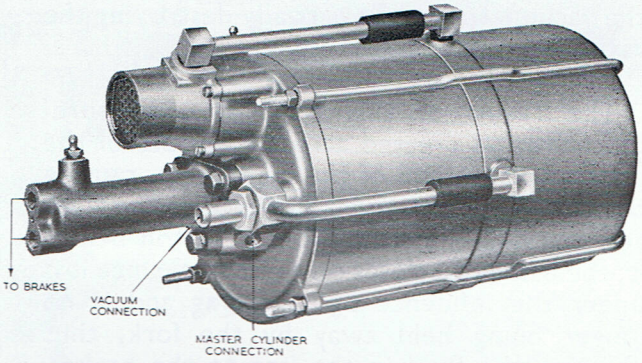


Fig. 2. 'Tandem' Hydrovac.

In order to smooth out fluctuations of vacuum and to provide a safety factor in the event of braking being required when the engine is stopped, it is usual for a vacuum reservoir to be interposed between the vacuum source and the Hydrovac; some types of Hydrovac have an integral vacuum reservoir in tandem with the booster-piston chamber. A further safety factor, in the event of vacuum failure, is provided by the design of the Hydrovac being such as to permit direct communication between the master cylinder and the brake assemblies, thus allowing brake applications by unassisted foot pressure on the brake pedal.

With the Hydrovac in the released condition, the piston(s) are held 'off' by means of a spring, and whatever degree of vacuum exists at the source is also present on each side of the booster piston(s). When the brake pedal is depressed, fluid pressure created by the master cylinder causes the control valve to admit atmospheric pressure which acts upon the rear face of the piston(s); the consequent pressure-differential causes displacement of the pistons(s), so boosting the pressure within the slave cylinder and the line to the brake assemblies.

PRINCIPLE OF OPERATION

(Refer to Fig. 4)

In order to simplify terminology, the operation of only the 'Single' Hydrovac is explained in full; the operation of the 'Tandem' unit is basically the same but the slight differences are detailed at the end of this section.

When the unit is at rest, the valve piston and the diaphragm are in the 'normal' position, valve 'A' is open and valve 'B' is closed. The line from the vacuum source leads into the end cover of the servo, so that vacuum is present within chamber 'E' and also, by way of a duct in the end cover, within chamber 'D'. With the servo in the released condition, whatever degree of vacuum is present within these chambers is also transmitted to chambers 'C' and 'F' via holes in the centre of the diaphragm , the open valve 'A', and the connecting pipe; the valves 'A' and 'B' are maintained in the position illustrated due to the pressure of the small conical spring and the pressure-difference across valve 'B' (there being atmospheric pressure on the spring side).

Upon depressing the brake pedal, initial fluid pressure from the master cylinder passes through the connection shown on Fig. 1 and is transmitted to the brakes via the ball-valve at the end of the slave-cylinder piston (see Ref. 3 on Fig. 3); the ball is being held off its seat by the fork 2). Additionally, the master cylinder pressure is felt on the left-hand side of the valve piston (via a vertical duct leading from the chamber into which the master cylinder line is connected) and the piston is consequently displaced to the right; this movement deflects the diaphragm until it bears against valve 'A', and the seal thus formed isolates the suction source from chambers 'C' and 'F'. Continued movement of the valve piston opens the valve 'B', permitting air to enter the chambers which are isolated from the vacuum source, so partially destroying the vacuum within these chambers.

The result of this is that a pressure-differential is created across the sides of the booster-piston and of the diaphragm, causing the booster-piston to be displaced to the right and carrying the slave-cylinder piston before it; the ball-valve closes on to its seat, since it is under the influence of its spring and is no longer being held away by the fork, thus trapping the fluid in the line to the brakes. The continued influence of the pressure-differential across the booster-piston will now boost the pressure within the slave cylinder and the brake line.

The pressure-differential across the diaphragm is equal to that across the booster-piston and, when the desired degree of braking is reached, the forces due to the master-cylinder pressure acting on the valve piston and the differential across the diaphragm respectively will balance, and the load of the diaphragm spring will cause the diaphragm to deflect in the direction of the valve piston. Consequently the valve 'B' will close on to its seat and prevent the further entry of air.

Greater effort upon the brake pedal increases the thrust on the valve piston, which causes the valve 'B' to re-open and admit more air, so increasing the pressure-differential across the booster piston and allowing the piston to perform a greater amount of effort; when the opposing forces on the diaphragm are once more in balance, the valve 'B' will again close on to its seat. It will be apparent, therefore, that the diaphragm acts as a "proportioning" device, ensuring that the performance of the servo is progressive.

When the brake pedal is released, pressure is removed from the valve piston, allowing the diaphragm spring to push the diaphragm back to its original position and thereby cause all four chambers of the Hydrovac to be once more communicated with the vacuum source. The booster-piston and the slave-cylinder piston are then able to return to the "off" position, being under the influence of the pressure of the large spring. As the latter piston reaches the end of its stroke, the fork (Ref. 2, Fig. 3) contacts the washer (Ref. 1), which causes the ball-valve (Ref. 3) to open and allows fluid from the brakes to return to the master cylinder.

With the ball-valve off its seat when the brakes are off, it follows that, should the Hydrovac become inoperative (due, for instance, to failure of the vacuum supply) the brakes can still be applied by the pressure created in the master cylinder, although more physical effort would be required. Additionally, this valve allows compensation for expansion or contraction of fluid in the lines beyond the Hydrovac by recourse to the master cylinder by-pass port.

The 'Tandem' Hydrovac, in addition to having two booster-pistons, differs from the single unit in the following respects (refer to Figs. 2, 5). The vacuum-connection in the end cover, and the air connection in the control-valve, are both connected by pipes to a centre-casting fitted between the vacuum-cylinder shells. A hollow push-rod fitted to the rear booster-piston provides a passage for vacuum to pass into the chamber behind this piston; it also provides a passage for atmospheric pressure when the valve 'B' is open.

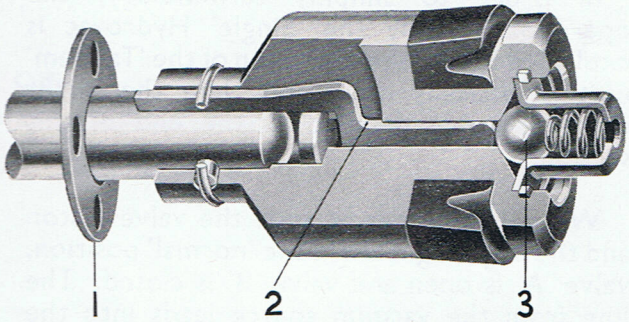


Fig. 3. Sectional view of the slave cylinder piston.

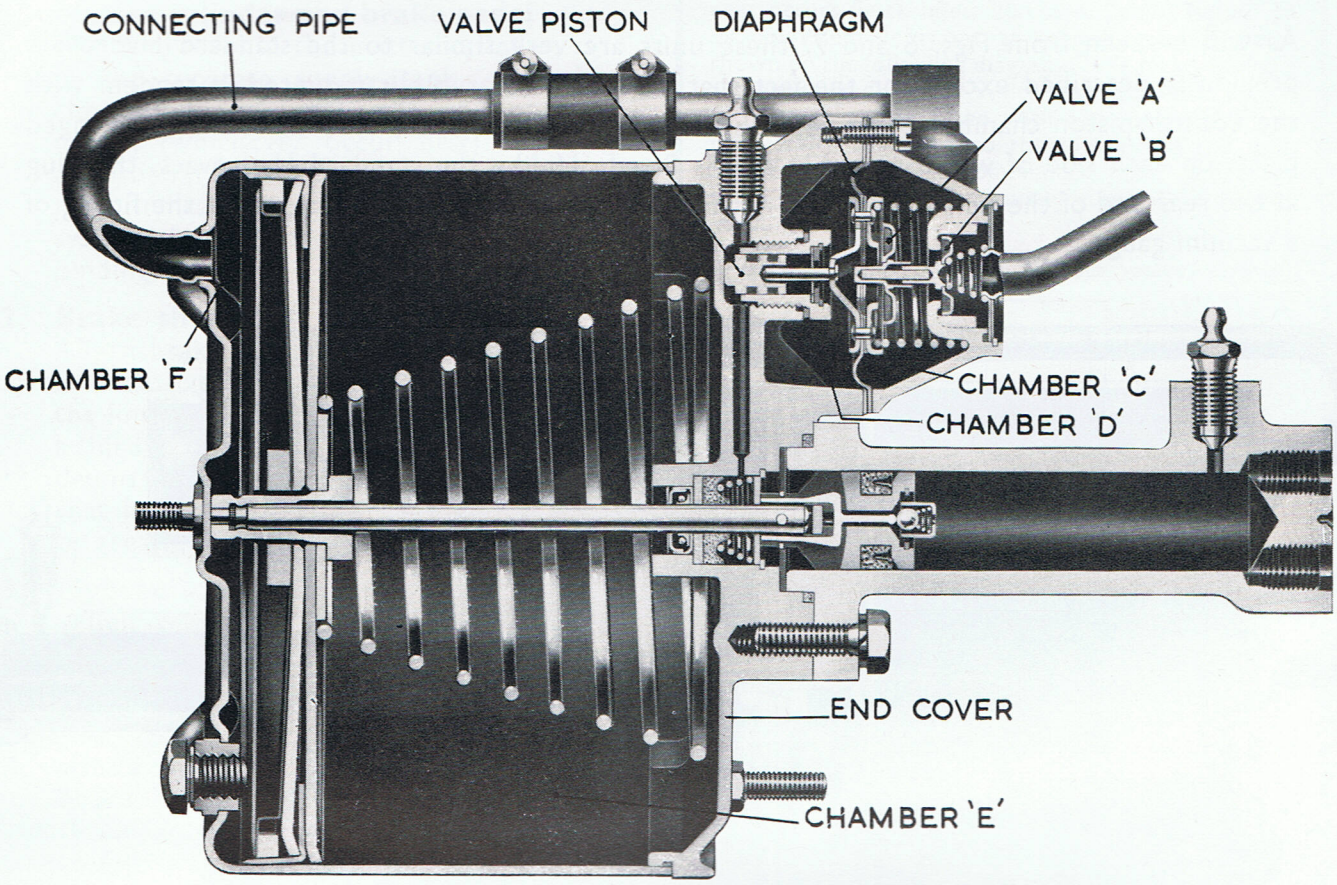


Fig. 4. Sectional view of the 'Single' Hydrovac.

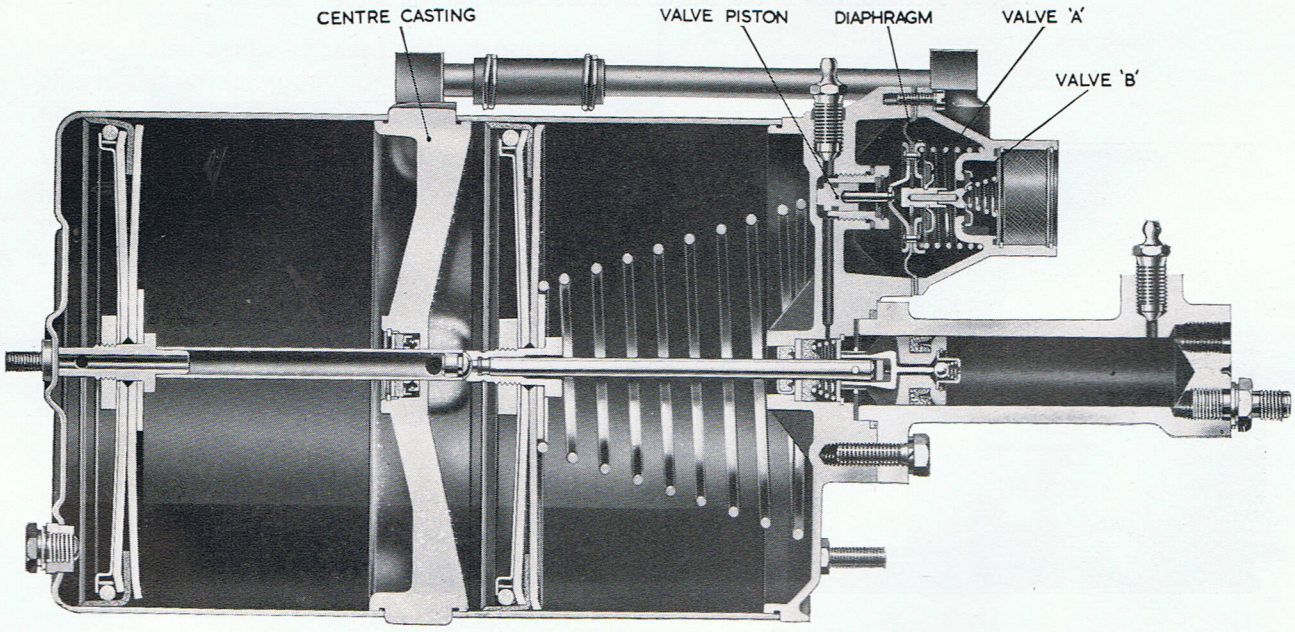


Fig. 5. Sectional view of the 'Tandem' Hydrovac.

HYDROVACS WITH INTEGRAL VACUUM RESERVOIRS

As will be seen from Figs. 6 and 7, these units are very similar to the standard Hydrovacs previously described except for the fact that a vacuum reservoir is mounted in tandem with the booster-piston chamber. This reservoir is separated from the piston chamber by a flanged plate, on each side of which a rubber seal is fitted. Unlike the standard Hydrovacs, the plug at the rear end of the unit is provided not for lubrication purposes but to permit the fitting of a vacuum gauge.

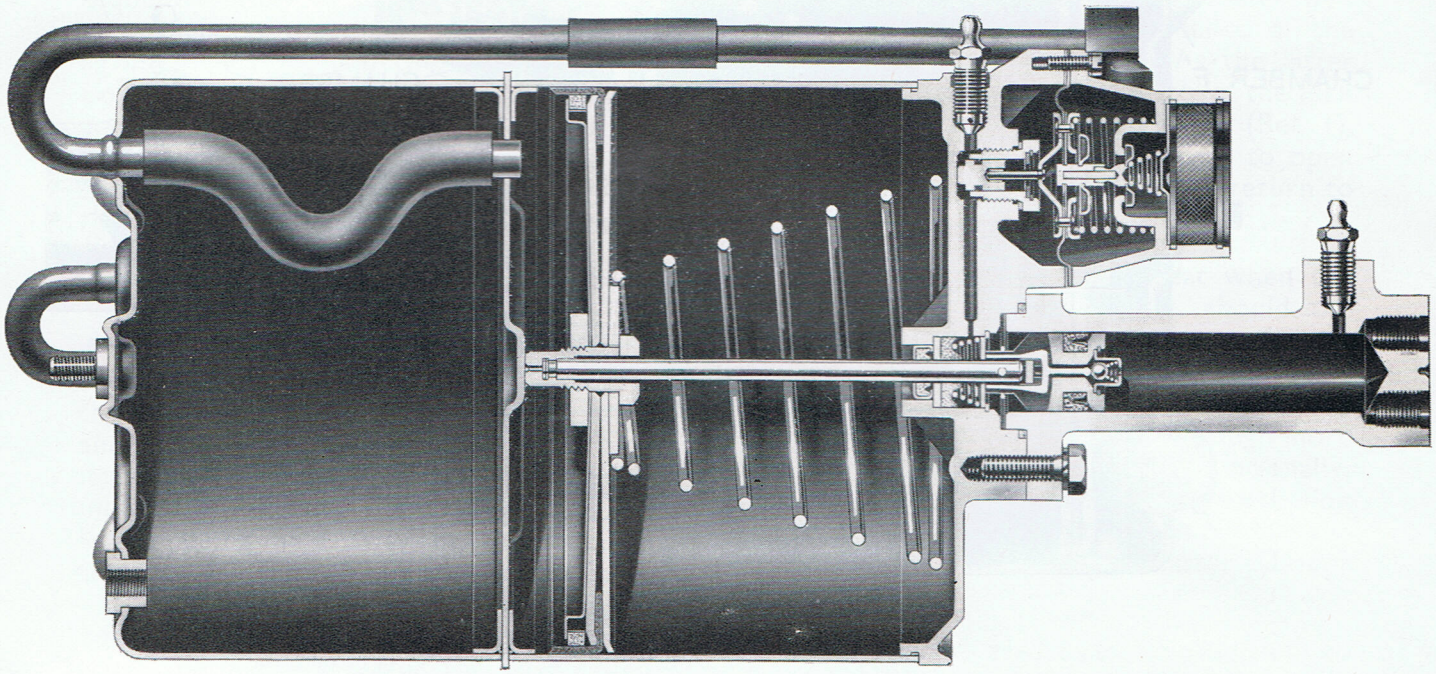


Fig. 6. Sectional view of the 'Single' Hydrovac with integral vacuum reservoir.

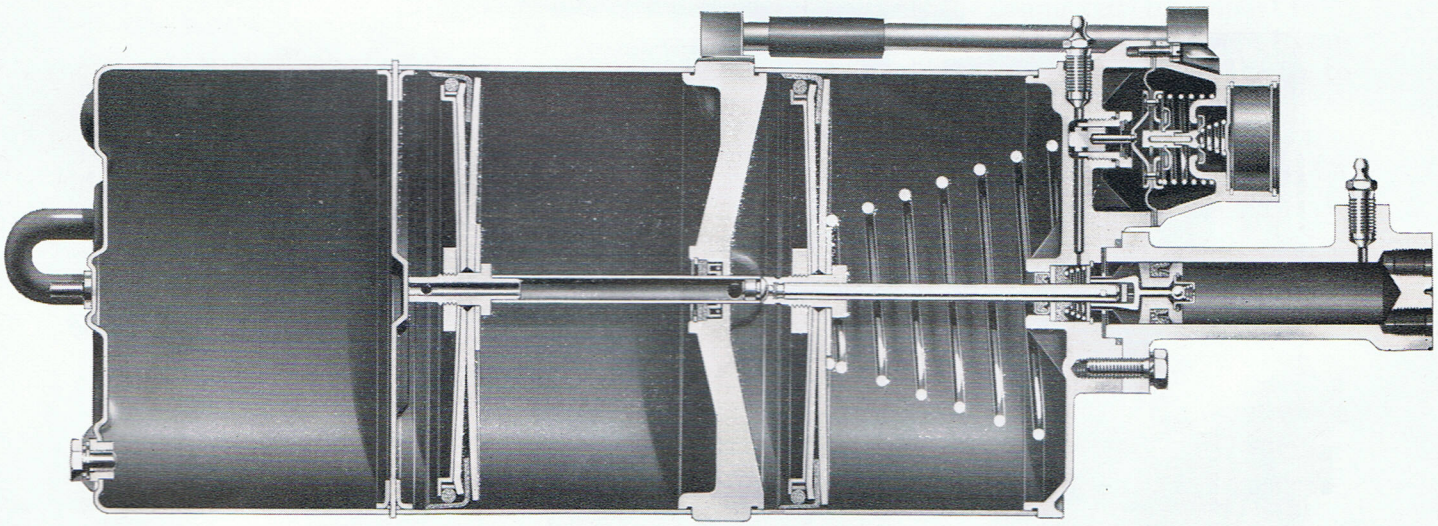


Fig. 7. Sectional view of the 'Tandem' Hydrovac with integral vacuum reservoir.

ROUTINE MAINTENANCE

1. **Master cylinder and brake pedal**
The fluid level in the master cylinder, or in the separate supply tank, must be checked every 1,000 miles or once a month (whichever occur first) and replenished if necessary. Excessive fluid loss may indicate leakage in the braking system. Inspect pedal pivots or linkage for binding.

2. **Brake shoes and drums**
Adjust brake shoes whenever pedal travel is excessive. Every 5,000 miles examine the linings and renew if worn to less than a third of original thickness. Check brake drums for excessive wear and make sure that linings are not contaminated by oil or grease.

3. **Hydraulic components**
When the brake linings are inspected, check also for any hydraulic leakage from the master cylinder, wheel cylinders and Hydrovac slave cylinder.

4. **Brake hoses**
Brake hoses must be inspected every 10,000 miles for any signs of leakage, chafing or general deterioration. If there is any doubt, renew the hose. It is recommended, in any case, that hoses are renewed at least every 3 years or 40,000 miles (whichever occurs first).

5. **Metal pipes**
When the brake hoses are inspected, check the metal pipes for chafing, looseness and general condition.

6. **Vacuum line**
Inspect for loose connections; the line must be free from obstruction or restriction and show no signs of collapse.

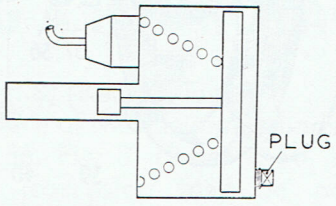
7. **Rubber cups and seals**
Renew all rubber cups and seals throughout the system at intervals of 3 years or 40,000 miles or at each third change of the brake-shoe linings (whichever occurs first)

8. **Hydrovac air filter**
Every 10,000 miles or at six-monthly intervals (whichever occurs first), the filter is to be washed in commercial methylated spirit and blown through with an air line. Do not lubricate the filter.

LUBRICATION

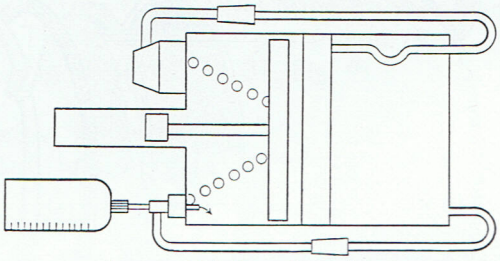
On initial installation of the Hydrovac, and thereafter every 10,000 miles or at six-monthly intervals (whichever occurs first), inject 20 c.c. of Shell "Tellus" 33 or equivalent lubricant at each lubrication point shown on the following diagrams. We make available a convenient dispenser which is graduated in 20 c.c. increments and is fitted with a flexible polythene tube which reaches into the interior of the unit. Before lubrication is commenced pump the brake pedal (with engine or exhauster stopped) to destroy vacuum.

SINGLE-PISTON HYDROVAC (without vacuum reservoir)



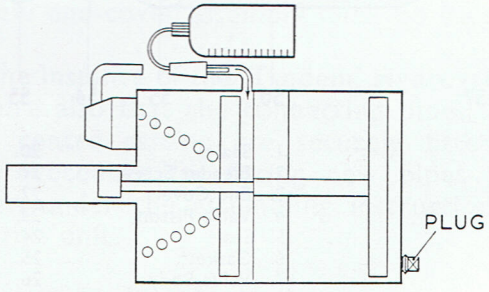
Lubricate through plug hole.

SINGLE-PISTON HYDROVAC (with vacuum reservoir)



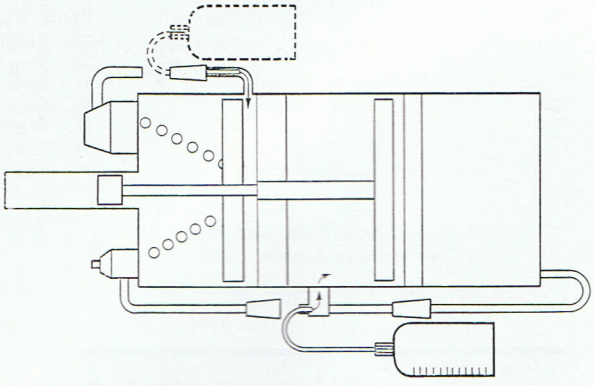
Remove vacuum hose and lubricate through vacuum connection.

TANDEM HYDROVAC (without vacuum reservoir)

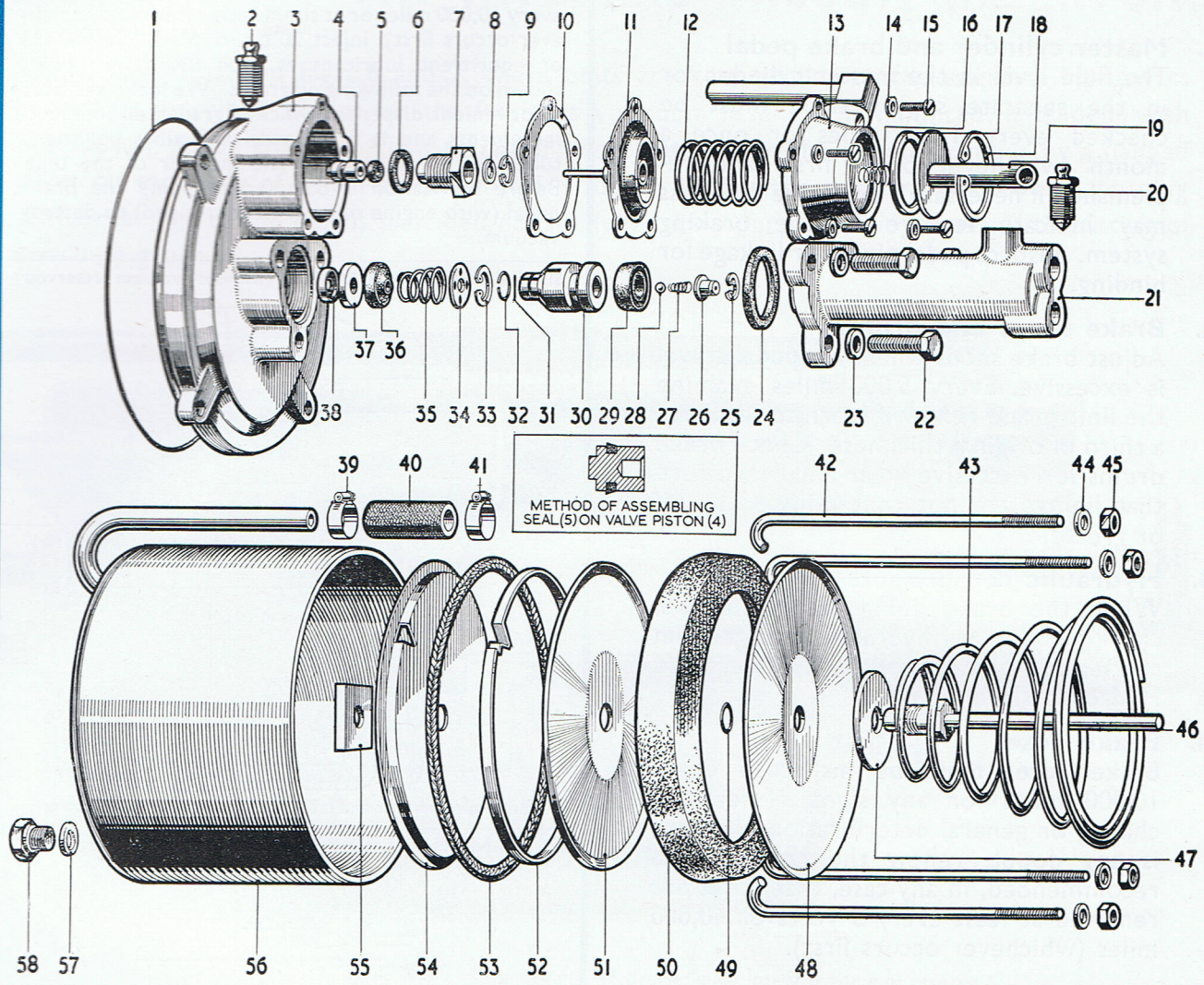


Lubricate rear piston through plug hole. To lubricate front piston, pull back hose on air pipe and inject through elbow.

TANDEM HYDROVAC (with vacuum reservoir)



Lubricate by pulling back hoses on air pipe and vacuum pipe, and injecting through elbows.



1. Seal†
2. Bleeder Screw
3. End Cover
4. Valve Piston
5. Seal†
6. Gasket†
7. Valve Body
8. Stop Washer
9. Circlip†
10. Gasket†*
11. Diaphragm†
12. Spring
13. End Cover Assembly*
14. Spring Washer
15. Screw
16. Spring
17. Seal†
18. Circlip†
19. Air Filter Connection
20. Bleeder Screw
21. Slave Cylinder
22. Bolt
23. Spring Washer
24. Seal†
25. Circlip†
26. Spring Retainer
27. Spring†
28. Ball
29. Rubber Cup†
30. Slave-Cyl. Piston
31. Pin†
32. Circlip†
33. Circlip†
34. Stop Washer
35. Spring
36. Rubber Cup†
37. Washer†
38. Seal†
39. Hose Clip‡
40. Hose†
41. Hose Clip‡
42. Clamp Bolt
43. Spring
44. Spring Washer
45. Nut
46. Piston-Rod
47. Washer
48. Piston Plate
49. Seal††
50. Leather Cup††
51. Piston Plate
52. Wick Retainer
53. Wick††
54. Retainer
55. Nut
56. Vaccum-cylinder Shell
57. Gasket††
58 Plug

† Contained in Hydrovac Repair Kit
†† Contained in Booster-Piston Repair Kit
* Contained in Air-Control Valve Repair Kit
‡ Not fitted on current Hydrovacs

Fig. 8. Exploded view of 'Single' Hydrovac.

REMOVING THE HYDROVAC FROM THE VEHICLE

1. Disconnect the hydraulic lines from the Hydrovac, and plug the open ends of the lines to prevent loss of fluid and the entry of dirt.
2. Disconnect the vacuum line from the Hydrovac.
3. Separate the Hydrovac from its mounting brackets and clean the dirt off the unit.

GENERAL NOTES ON OVERHAULING A HYDROVAC

1. Prior to dismantling a Hydrovac, the appropriate repair kits should be obtained (details of which are obtainable from Lockheed stockists). These kits include perishable items such as rubber seals, as well as gaskets, circlips and other parts which will need to be renewed.

2. After the Hydrovac has been dismantled all of its components part should be washed, using Methylated Spirit. In the instance of the 'Tandem' Hydrovac, the wire-mesh air filter (Ref. 28, Fig. 9) is to be washed in Methylated Spirit then blown through with an air pressure line; this filter is not to be lubricated.

3. When all parts have been washed they should be thoroughly dried, using a clean lint-free cloth, and the various ducts are to be blown through with an air pressure line. Then place all parts on clean paper to prevent dirt from being assembled into the Hydrovac.

4. Inspect all metal parts, with particular reference to those listed below, and make renewals where necessary.
   (*a*) The valve piston (Ref. 4, Fig. 8) (Ref. 13, Fig. 9).
   (*b*) The bore of the valve body (Ref. 7, Fig. 8) (Ref. 16, Fig. 9).
   (*c*) The bore of the slave cylinder (Ref. 21, Fig. 8) (Ref. 32, Fig. 9).
   (*d*) The bore of the vacuum-cylinder shell (Ref. 56, Fig. 8) (Refs. 4, 60, Fig, 9). Slight corrosion may be polished away by using fine emery cloth or steel wool, but in the case of bad pitting the shell(s) must be renewed.
   (e) The stem of the piston-rod (Ref. 46, Fig. 8) (Refs. 70, 87, Fig. 9).

5. Renew all rubber parts, and also the piston leather (Ref. 50, Fig. 8) (Refs. 66, 83, Fig. 9) if this part shows signs of hardening or cracking. If the rubber valves in the air-valve end cover (Ref. 13, Fig. 8) (Ref. 22, Fig. 9) are faulty, or if the connecting pipe in this cover is insecure, a new end-cover assembly must be used.

6. In the instance of the 'Tandem' Hydrovac, ensure also that the connecting pipes in the centre casting are securely fitted; the procedure for fitting new pipes is given under the assembling instructions for this unit.

7. Also, with the 'Tandem' Hydrovac, the felt washer (Ref. 73, Fig. 9) is, prior to assembly, to be soaked in Shell "Tellus 33" or equivalent lubricant for 10 hours, and allowed to drain for 2 hours; the lubricant must not be allowed in contact with any rubber parts.

DISMANTLING THE 'SINGLE' HYDROVAC *(Refer to Fig. 8)*

1. Remove the plug (58) from the end of the Hydrovac, and hold the unit vertically to allow any lubricant to drain away. Screw a suitable nut on to the fixing stud, and hold the unit vertically in the vice, gripping on the nut (the size of nut required will be $\frac{5}{16}$in. B.S.F. in some instances, and $\frac{5}{16}$in. U.N.F. in others).

Dismantling the 'Single' Hydrovac (continued)

2. Unscrew the three bolts and withdraw the slave cylinder (21) from the unit.

3. Slacken the worm-drive clips (39, 41) (if applicable) and pull the hose (40) down on to the pipe on the vacuum cylinder shell (56), exercising caution to avoid disturbing the positioning of the pipe.

4. Remove the five screws (15) and spring washers, and take off the air-valve end cover (13), collect the gasket and extract the spring and the diaphragm (11).

5. Remove the circlip (18) from the end cover and remove the pipe (19), the spring and the seal (17); do not attempt to unscrew the other pipe or to remove the two valves from the end cover.

6. Scribe a line across the vacuum-cylinder shell and the end-cover (3), to facilitate re-assembly. Unscrew the nuts (45) evenly and equally to take up the spring-load, and remove the clamp bolts (42).

7. Tap the end cover (3) off the shell, and pull out the complete piston assembly.

8. Rest the piston assembly on its back, arranging it so that the piston leather is not crushed during the following operation. Press down on the end cover with one hand and, with the other hand, remove the circlip (32) and the pin (31) from the slave-cylinder piston (30); slide the piston off the piston-rod. Release the pressure and lift off the end cover and the return spring.

9. To dismantle the slave-cylinder piston, take out the circlip (25) and remove the spring retainer (26), the spring and the ball; carefully remove the piston cup (29) from its groove.

10. Remove the seal (1) from the end cover, spring the circlip (33) out of its groove and collect the washer (34) and the spring; hook out the rubber cup (36). Tap out the oil seal (38) and the washer (37), from the rear of the cover.

11. Hold the cover on the fixture illustrated on Fig. 10, with the fixture held in the vice; unscrew the air-valve body (7), collect the gasket and push out the valve-piston (4), and ease the seal (5) out of the groove on the piston.

12. Hold the booster-piston in the vice, gripping it by the hexagon on the piston-rod and taking great care to avoid damage to the surface finish of the rod. Unscrew the square nut (55), remove the retainer (54), disengage the wick-retainer (52), and take the various parts off the piston-rod, including the small seal (49).

DISMANTLING THE 'TANDEM' HYDROVAC

Since the 'Tandem' Hydrovac differs from the 'Single' unit only in duplication of vacuum-cylinder shells and booster-pistons, the instructions given for the 'Single' unit can be applied to the 'Tandem', with the following additional points:

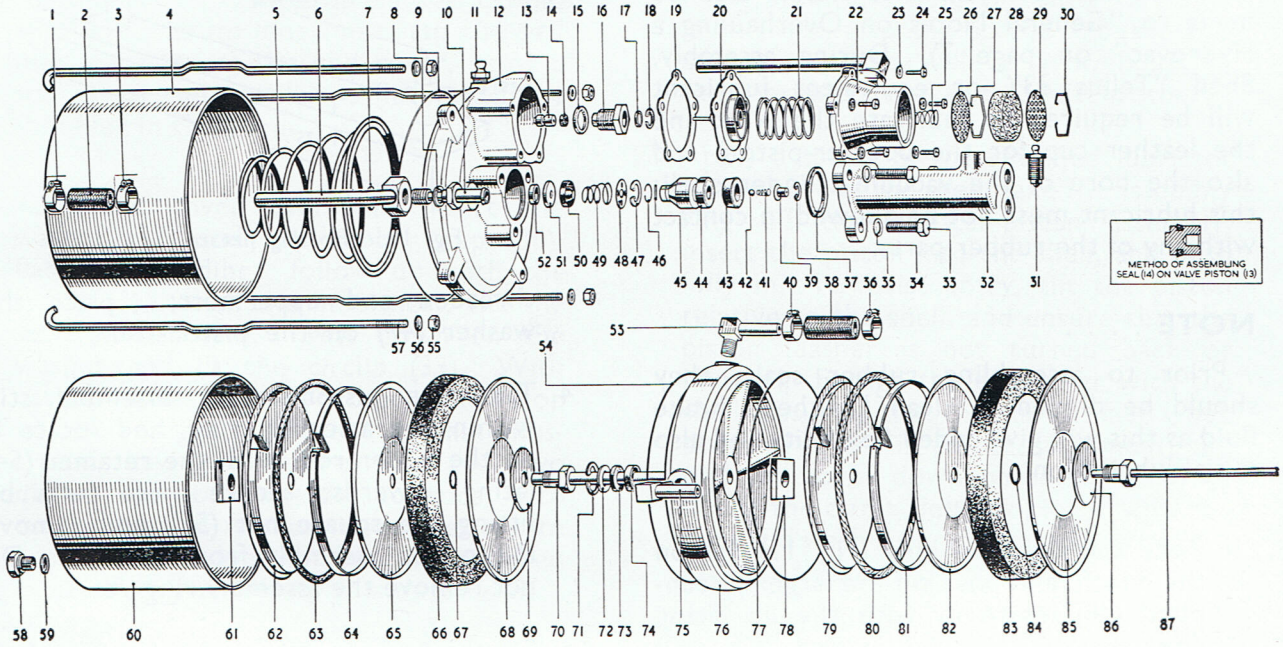
1. The nut used to hold the unit in the vice is $\frac{5}{16}$in. U.N.F.

2. After removal from the vacuum-cylinder end cover, the air-valve end cover is dismantled as follows (refer to Fig. 9):—
   (*a*) Extract the outer circlip (30), withdraw the outer gauze filter (29) and the wire-mesh filter (28).
   (*b*) Remove the inner circlip (27) and the inner gauze filter (26), and extract the spring.
   (*c*) Do not attempt to unscrew the pipe or to remove the two valves from the end cover.

3. Prior to removing the clamp bolts, in addition to scribing an alignment mark across the end-cover (Ref. 12, Fig. 9) and the forward vacuum-cylinder shell, make a similar mark across the centre casting (Ref. 76, Fig. 9) and both shells.

4. The centre-casting is dismantled as follows (refer to Fig. 9):—

Dismantling the 'Tandem' Hydrovac (continued)



1. Hose Clip‡
2. Hose†
3. Hose Clip‡
4. Vac-cyl. Shell
5. Spring
6. Banjo and Pipe
7. Gasket†
8. Gasket†
9. Seal†
10. Banjo Bolt
11. Bleeder Screw
12. End Cover
13. Valve Piston
14. Seal†
15. Gasket†
16. Valve Body
17. Stop Washer
18. Circlip†
19. Gasket†*
20. Diaphragm†
21. Spring
22. End Cover Assy.†
23. Spring Washer
24. Screw
25. Spring
26. Gauze Filter
27. Circlip†
28. Wire-mesh Filter†
29. Gauze Filter
30. Circlip†
31. Bleeder Screw
32. Slave Cylinder
33. Bolt
34. Spring Washer
35. Seal†
36. Hose Clip‡
37. Circlip†
38. Hose†
39. Spring Retainer
40. Hose Clip‡
41. Spring†
42. Ball
43. Rubber Cup†
44. Slave-Cyl. Piston
45. Pin†
46. Circlip†
47. Circlip†
48. Stop Washer
49. Spring
50. Cup†
51. Washer†
52. Seal†
53. Pipe and Elbow
54. Seal†
55. Nut
56. Spring Washer
57. Clamp Bolt
58. Plug
59. Gasket††
60. Vac.-Cyl. Shell
61. Nut
62. Retainer
63. Wick††
64. Wick Retainer
65. Piston Plate
66. Leather Cup††
67. Seal††
68. Piston Plate
69. Washer
70. Piston-Rod
71. Circlip†
72. Washer
73. Felt Washer†
74. Seal†
75. Pipe and Elbow
76. Centre Casting
77. Seal†
78. Nut
79. Retainer
80. Wick††
81. Wick Retainer
82. Piston Plate
83. Leather Cup††
84. Seal††
85. Piston Plate
86. Washer
87. Piston-Rod

† Contained in Hydrovac Repair Kit
†† Contained in Booster-Piston Repair Kit
* Contained in Air-Control Valve Repair Kit
‡ Not fitted on current Hydrovacs

Fig. 9. Exploded view of the 'Tandem' Hydrovac.

(*a*) Ease the seals (54, 77) out of their grooves on the outer diameter of the casting.

(*b*) Remove the circlip (71) and hook out the metal washer (72), the felt washer (73) and the oil seal (74).

5. Each booster-piston is dismantled in an identical manner to that previously described.

ASSEMBLING THE 'SINGLE' HYDROVAC

(Refer to Fig. 8)

The following procedure is recommended for assembling the Hydrovac, using new parts as required (reference should also be made to "General Notes on Overhauling a Hydrovac" on page 7). During assembly, Shell "Tellus 33" or equivalent lubricant will be required to lubricate the wick and the leather cup for the booster-piston, and also the bore of the vacuum-cylinder shell; this lubricant must not be allowed in contact with any of the rubber parts.

NOTE . . . .

Prior to assembling rubber seals, they should be dipped in clean Lockheed brake fluid as this will give added flexibility and also initial lubrication.

1. Place the assembly ring (Fig. 11) flat on the bench, and position the larger piston-plate (48) inside it, with the lip facing downwards. Dip the leather cup (50) in the specified lubricant, allow the excess to drain off, and place the cup on the plate, with the lip of the cup facing upwards. Place the small round-section seal (49) in the chamfer at the centre of the plate, and locate the other piston plate (51) on top of it, with the lip facing downwards.

2. Dip the wick (53) in the specified lubricant and squeeze it to drain away the excess. Fit the wick inside the leather cup, bend the wick-retainer (52) into a circular form (with the barbs outer-most), locate the retainer inside the wick and push the bent end of the retainer inwards and backwards to engage the fork with the tongue. Place the retainer (54) on the assembled parts, with the raised side downwards and with the cut-away over the bent end of the wick-retainer. Leave the assembly within the assembly ring.

3. Whilst taking care to avoid damage to the high surface finish of the piston-rod (46), hold the rod vertically in the vice (gripping on the hexagon) with the threaded end uppermost; place the washer (47) on the piston-rod.

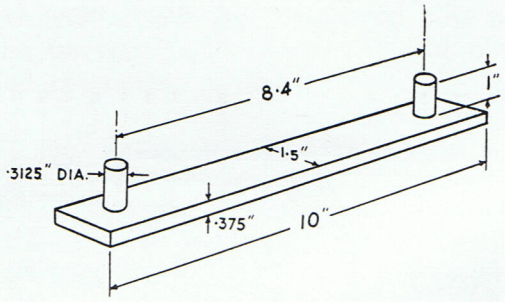


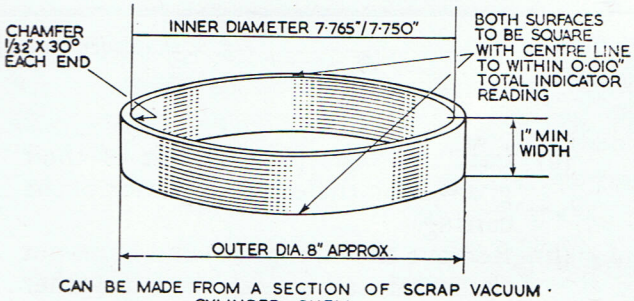
Fig. 10. Holding fixture.

4. Take the piston-leather assembly, still within the assembly ring, and locate it on the piston-rod, with the retainer (54) facing upwards; secure these parts by fitting the square nut (55), and remove the piston assembly from the vice. Do not remove the assembly ring yet.

5. Fit the washer (8) in the large end of the valve-body (7) and secure it with the circlip (9). Ease the tapered seal (5) into the groove on the valve-piston (4), so that the larger end of the seal is facing the smaller end of the piston. Insert the piston, drilled end leading, into the smaller end of the valve body.

6. Place the end-cover (3) on the Holding Fixture illustrated on Fig. 10, with the fixture held in the vice. Place a new gasket (6) on the valve body (7), and screw the body into the end cover. Take the assembly off the fixture and ease the seal (1) into the groove in the cover.

Fig. 11. Assembly ring.



CAN BE MADE FROM A SECTION OF SCRAP VACUUM-CYLINDER SHELL.

Assembling the 'Single' Hydrovac (continued)

7. Rest the end cover on the bench, so that the side on which the seal is fitted is uppermost. Take the seal (38) (this is the one which is fitted in a metal casing) and, with the lip innermost, tap the seal into the bore of the end cover, using a soft metal rod, until it is flush with the shoulder in the bore.

8. Turn the cover over and insert the washer (37) and the rubber cup (36), flat face leading; follow up with the spring (35), small end innermost, and the stop washer (34). Press down on the washer and fit the circlip (33). With earlier types of Hydrovac, the stop washer is lightly different to that illustrated, having a centre hole and two diametrically-opposite flat portions, with such a type of washer it is necessary to ensure that it does not become displaced inside the spring when it is depressed.

9. Assemble the slave-cylinder piston in this manner. Insert the spring (27), large end first, into the spring retainer (26), followed by the ball (28); offer up these parts to the larger end of the piston (30), and secure with the circlip (25). Position the circlip (32) on the small end of the piston, so that it lies just off its groove. Ease the rubber cup (29) into the groove on the piston, with the lip facing the ball-valve.

10. Take the booster-piston assembly and hold it with the piston-rod uppermost, locate the return spring (43), small end downwards, on the piston. Rest the end-cover assembly on the spring, and press downwards on it, guiding the piston-rod through the seals at the centre. When the piston-rod protrudes a sufficient amount, maintain the pressure with one hand and, with the other hand, fit the slave-cylinder piston (30) on the rod; align the cross-drillings, fit the pin (31) and ease the circlip (32) into its groove. Slowly release the pressure on the end cover.

11. Fit the plug (58) (together with its gasket) at the end of the vacuum-cylinder shell (56), screw a suitable nut on to the fixing stud, and hold the shell vertically in the vice, gripping on the nut (the size of nut required will be $\frac{5}{16}$in. B.S.F. in some instances, and $\frac{5}{16}$in. U.N.F. in others).

12. Apply a smear of the specified lubricant to the bore of the shell, take the assembly ring off the booster-piston assembly, insert the piston into the shell, and push fully in. To assist entry, tilt the piston relative to the shell, and ensure that the piston leather is not turned back or buckled. Engage the end-cover with the shell, ensuring that the marks made when dismantling are in correct alignment, and pull the cover down on to the shell by fitting the clamp bolts (together with the nuts and washers) and tightening the nuts evenly and equally.

13. Fit the seal (17), spring (16) (small end innermost), disc and pipe (19) into the air-valve end-cover (13), and secure with the circlip (18). Push the hose (40) down the pipe on the vacuum-cylinder shell and loosely fit the two worm-drive clips (39, 41) (if applicable).

14. Make three guide-pins from $2\frac{1}{2}$in. lengths of $\frac{3}{16}$in. dia. rod, with about $\frac{1}{2}$in. of each threaded No. 2 B.A.

15. Screw the guide pins into three of the five tapped holes in the end-cover (3), spacing them equally. Slide a new gasket (10) and the diaphragm (11), spindle leading, down the guide pins, and locate the spring (12) within the diaphragm. Slide the air-valve cover on to the guide pins, ensuring that it is correctly aligned with the pipe on the vacuum-cylinder shell, remove the guide pins one at a time and replace them with the screws and washers (15, 14), fit the two remaining screws and washers. Slide the hose over the junction in the pipes, and tighten the worm-drive clips (if applicable) at each end.

16. Ease the seal (24) into the recess in the end-cover (3), and fit the slave cylinder (21) over the slave-cylinder piston, easing the cup into the bore by using the fingers only. Ensure that the bleeder screw (20) at the end of the slave cylinder is pointing in the direction of the pipe at the side of the unit, and fit the three bolts (22) and washers (23). Fit the bleeder screw (2) in the end cover.

17. Inspect the unit to make sure that all nuts, bolts, washers and screws are in place and securely assembled. Remove the unit from the vice and take the nut off the mounting stud at the rear of the unit.

18. Remove plug from rear face of Hydrovac and inject approximately 20 c.c. of the specified lubricant.

HYDROVACS MUST BE STORED IN THE UPRIGHT POSITION, *i.e.* WITH THE SLAVE CYLINDER POINTING UPWARDS.

ASSEMBLING THE 'TANDEM' HYDROVAC

Since the 'Tandem' Hydrovac differs from the 'Single' unit only in duplication of vacuum-cylinder shells and booster-pistons, the instructions given for the 'Single' unit can be applied to the 'Tandem', with the following additional points:

1. If new pipe assemblies are being used in the centre casting (Ref. 76, Fig. 9), or if the original pipes have been disturbed apply Bostik 692 Jointing Compound to the mating surfaces and allow to set for 72 hours before assembling the centre casting to the unit.

2. Each booster-piston is assembled in an identical manner to that previously described.

3. Assemble the various parts in the air-valve end cover in the following manner (refer to Fig. 9):—
   (*a*) Insert the spring (25), small end innermost, into the end cover (22), followed by the inner gauze filter (26), ensuring that the raised side engages the spring; fit the inner circlip (27).
   (*b*) Insert the wire-mesh filter (28) and the outer gauze filter (29), in that order, and secure with the outer circlip (30).

4. Assemble the centre-casting as follows (refer to Fig. 9):—
   (*a*) Insert the oil seal (74) into the centre casting (76), so that the lip is innermost (this seal has a small spring fitted inside it), followed by the felt washer (73)* and the metal washer (72); secure these parts with the circlip (71).
   (*b*) Ease the two seals (54) into the grooves on the outer diameter of the casting.

5. The nut used to secure the rear vacuum-cylinder shell in the vice is $\frac{5}{16}$in. U.N.F

6. Complete the assembly of the unit in the following manner:—
   (*a*) Position two worm-drive clips (if applicable) and the remaining length of hose on the pipe (Ref. 6, Fig. 9).
   (*b*) Locate a new gasket on each side of the banjo at the end of the pipe, pass the adaptor (Ref. 10, Fig. 9) through the banjo, offer up the assembly and screw the adaptor into the end cover.
   (*c*) Inspect the unit to ensure that all nuts, bolts, washers and screws are in place and securely assembled.

**See paragraph 7 of "General Notes on Overhauling a Hydrovac" on page 7 for lubrication details.*

BLEEDING THE BRAKE SYSTEM

"Bleeding" (*i.e.* expelling air) is not a routine operation and should be necessary only when some portion of the hydraulic equipment has been disconnected or when fluid has been drained off. The procedure is as follows:—

1. It will be necessary to ensure that the engine is not running during the following procedure. It will also be necessary to pump the brake pedal in order to destroy any vacuum in the system and thereby prevent the Hydrovac from operating whilst "bleeding".
2. Fill the supply tank with Lockheed brake fluid and maintain at least one quarter full throughout the operation; otherwise, air will be drawn in, necessitating a fresh start.
3. If the vehicle master cylinder is provided with a bleeder screw, that unit must be bled first.
4. Attach a rubber tube to the bleeder screw in the Hydrovac end-cover, and allow the free end to be submerged in brake fluid contained in a clean glass jar; slacken the bleeder screw one complete turn. Depress the brake pedal slowly and allow it to return unassisted; watch the flow of fluid in the jar and repeat the pumping operation with a slight pause between each operation When air bubbles cease to appear from the tube, hold the brake pedal down firmly and, whilst doing so, securely tighten the bleeder screw.
5. Repeat this operation with the bleeder screw at the end of the slave cylinder.
6. Bleed the brake wheel cylinders, dealing with the shortest line last.

THE VACUUM CHECK-VALVE

(Refer to Fig. 12)

This valve is installed between the vacuum source and the Hydrovac and its purpose is to retain vacuum in the Hydrovac when there is minimum vacuum at the source; this prevents fluctuation in the performance of the Hydrovac due to variations in vacuum.

Dismantling

Remove the four thread-cutting screws (1), lift the hose connection (2) off the body and collect the gasket. Shake the valve out of the body and remove the seal (5).

Cleaning

Wash the metal parts in any recognised solvent and dry thoroughly with a clean, lint-free cloth; the rubber seal should be discarded.

Assembling

Using the fingers only, carefully ease a new seal (5) into the recess in the valve (4). This operation will be facilitated if the seal is first soaked in brake fluid and assembled wet. Place the valve, seal downwards within the body and attach the hose connection (2), fitting the gasket (3).

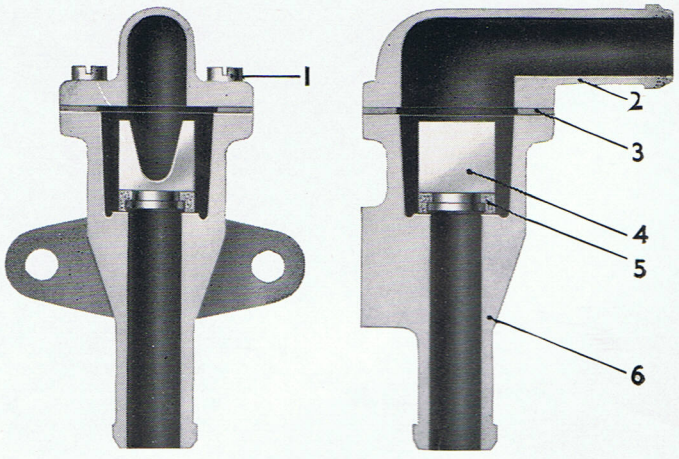


Fig. 12. The vacuum check valve.

FAULT FINDING ON HYDROVAC SERVO BRAKING UNITS

The five most likely symptoms of trouble, and the causes, are listed below. Related parts of the braking system should be checked before dismantling the Hydrovac if trouble is experienced.

1. PEDAL FEELS HARD

(*a*) Low vacuum from the vacuum source.
(*b*) Collapsed, restricted or disconnected vacuum line from the vacuum source.
(*c*) Binding pedal.
(*d*) Glazed brake-shoe linings.
(*e*) Grease or brake fluid on brake-shoe linings.
(*f*) Faults in servo as follows:—
  i One or both of the valves in the air-valve end cover is faulty.
  ii Faulty diaphragm.
  iii Air leak past the leather cup or past the round-section seal on the booster piston.
  iv Excessive friction between booster piston and vacuum-cylinder shell.
(*g*) Restriction in the air filter.

2. "GRABBING" BRAKES

(*a*) Grease or brake fluid on brake-shoe linings.
(*b*) Linings not "bedded-in."
(*c*) Linings incorrect type.
(*d*) Scored drums.
(*e*) Faults in servo as follows:—
  i Excessive friction between valve-piston and body.
  ii Excessive friction between booster piston and vacuum-cylinder shell.

3. PEDAL TRAVEL EXCESSIVE

(*a*) Brakes need adjusting.
(*b*) Brake shoes need relining.
(*c*) Cracked brake drum.
(*d*) External leak between master cylinder and servo, or between servo and wheel cylinders.
(*e*) Leaks past the rubber cups in the master cylinder or wheel cylinders.
(*f*) System needs bleeding (refer to page 13).
(*g*) Master cylinder needs replenishing with fluid.
(*h*) Faults in servo as follows:—
  i Faulty seal between slave cylinder body and vacuum-shell end cover.
  ii Faulty seal(s) in the end cover, through which the piston-rod passes.

4. BRAKES FAIL TO RELEASE

(*a*) Binding pedal.
(*b*) Master cylinder by-pass port choked (or covered by main cup due to lack of clearance between pedal push-rod and master cylinder piston).
(*c*) Brakes improperly adjusted.
(*d*) Faults in servo as follows:—
  i Excessive friction between valve-piston and body.
  ii Excessive friction between booster piston and vacuum-cylinder shell.
  iii Ball in slave cylinder piston not being lifted off its seat when the booster piston returns.

5. PEDAL SURGES

Faults in servo as follows:—
(*a*) Ball in slave-cylinder piston not seating properly
(*b*) Excessive friction between booster piston and vacuum cylinder shell.

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