

of hose, and that end of hose is smooth.

4. Blow out hose with air line to remove all cuttings.
5. Place connector nut and sleeve on hose, Fig. 35, being sure that barbs on inside of sleeve point toward end of hose that is being connected.
6. Push gasket into bottom of recess in connector body, Fig. 36.
7. Put end of hose in connector body, making sure that end of hose is against bottom of the recess, Fig. 37.
8. Move sleeve, if necessary, until it is against edge of connector body. Tighten connecting nut only enough to insure an air-tight joint.
9. When installing a hose assembly where both ends are permanently connected, the hose connector at either end is used as a swivel by loosening the nut on one of the connectors. Turn the hose in the loose connector before the connector nut is again tightened. This permits the installation of the hose without kinking or twisting.

## HOSE COUPLINGS

Hose couplings provide an easy and convenient method of connecting and disconnecting air lines between vehicles by hand. The design of the hose couplings is such that when two of them are coupled together, pressure is put on two rubber gaskets, making an air-tight seal.

Dummy couplings are made in two general designs, some being fitted with brackets to permit them to be rigidly mounted on the vehicle, while others are fitted with a chain attaching them to the vehicle. The bracket type is used where the dummy coupling is to serve as a

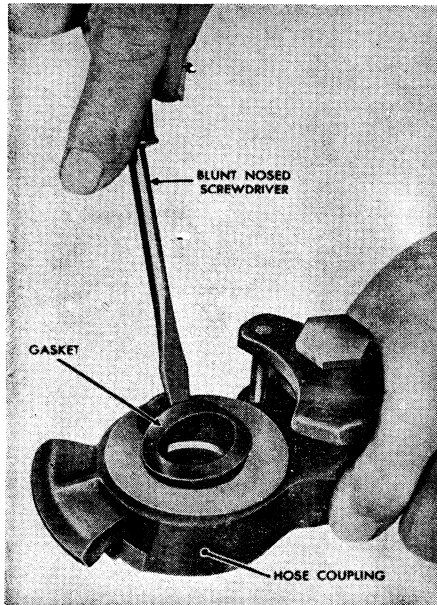


Fig. 39 Push gasket into hose coupling as shown

fastening for holding hose lines when not in use, whereas the chain type is used for blocking off hose couplings rigidly mounted on the vehicle as used on a tractor truck. The purpose of the dummy coupling is to prevent the entrance of dirt or other foreign matter into the air brake lines when the lines are not being used.

### Testing

With the hose couplings connected and brakes applied, coat the hose couplings

all over with soapsuds to check for leakage. No leakage is permissible.

Leakage is usually caused by worn, damaged or improperly installed gaskets. To correct, install new gaskets.

Remove the old gasket by prying out with a screw driver. Before attempting to install a new gasket, be sure the groove in the coupling in which the gasket fits is thoroughly cleaned, otherwise it will be impossible to install a new gasket properly.

To install a new gasket, partially collapse it with the fingers, Fig. 38, and enter one side of the gasket flange in the groove in the coupling. Then use a blunt-nosed screw driver or similar tool to push the gasket into place, Fig. 39. When properly installed the exposed face of the gasket will be flat—not twisted or bulged at any point.

## TUBING

### Operating Tests

If any evidence is found that a tubing line is restricted, remove and blow air through it in both directions to be sure the passage through the tubing is not obstructed in any way. Inspect tubing for partial restrictions such as may be caused by dents or kinks. Damaged tubing must be replaced.

### Leakage Tests

With the air brake system fully charged, the governor cut out, and brakes applied, coat all tubing lines and fittings with soapsuds to check for leakage. No leakage is permissible. Leakage at a tubing fitting is sometimes corrected by tightening the fitting nut. If this fails to correct the leakage, replace the fitting, tubing, or both.

# VACUUM BRAKES

## BENDIX HYDROVAC

### First Series

Hydrovac is a trade name for Bendix "one-unit" vacuum power braking system for use on trucks, tractors and buses equipped with hydraulically actuated brakes. It combines into one compact unit a hydraulically actuated control valve, a tandem-piston power cylinder and a hydraulic slave cylinder, Figs. 1, 2 and 3.

The assembly is a complete self-contained vacuum power brake system which eliminates the need for external levers or linkage. Connections to the vehicle braking system are entirely hydraulic, consisting of a line from the hydraulic master cylinder to the Hydrovac, and a hydraulic line from the Hydrovac connecting to the wheel cylinders of the vehicle braking system.

Contrasted with conventional vacuum power brake systems, the Hydrovac is connected hydraulically instead of mechanically to the braking system.

### Operation

The power cylinder of the Hydrovac, Fig. 1, is divided into two equal compartments, each of which is provided with a piston (certain Hydrovac units which require less power, use a design with only one cylinder and piston in operation otherwise these units work as described). The two pistons work on one piston rod so that the effect is that of two cylinders placed end-to-end with pistons connected in tandem. A conical spring serves to return the pistons to released position when the air pressures on both sides of each piston are balanced.

Hydraulic pressure from the master cylinder acts upon the hydraulic piston in the control valve assembly, Fig. 2, and forces its diaphragm towards the valves. This movement of the diaphragm moves the valves into the applied, holding or released positions.

The hydraulic slave cylinder, Fig. 3, is provided with a piston and rubber cup similar to the vehicle master cylinder. In that way, fluid is forced to the vehicle

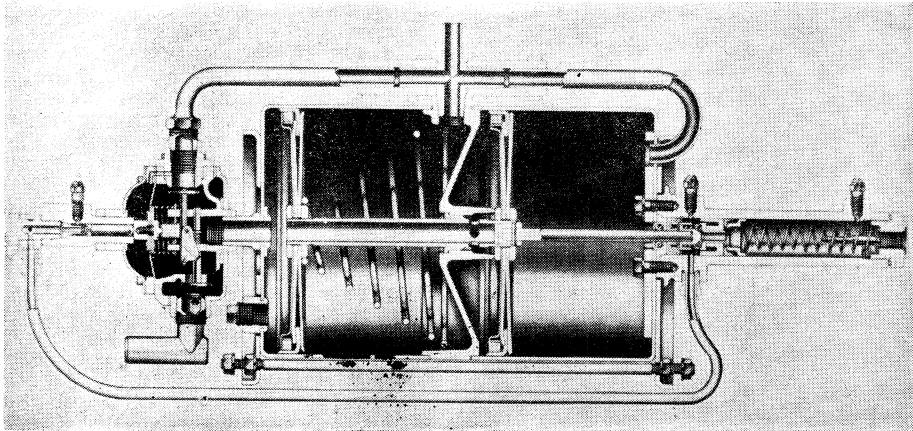
wheel cylinders to apply the brakes.

The end of the piston push rod fits into a tapered valve which seats against the hydraulic piston. A passage through the hydraulic piston allows fluid to pass through when the valve is off its seat, that is, when the power cylinder pistons are in released position.

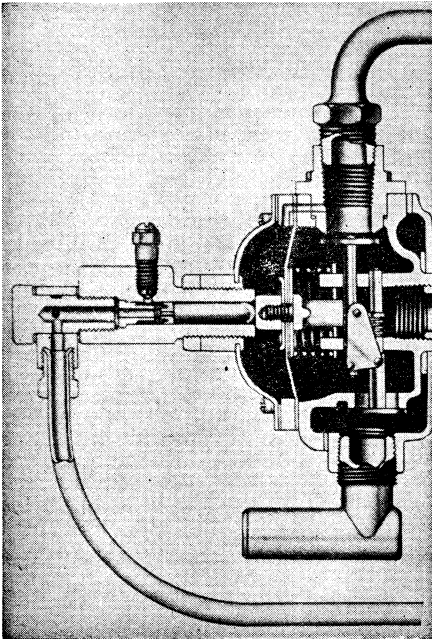
In the released position, Fig. 4, the vacuum valve (A) is open, atmospheric valve (B) is closed, and vacuum is present on both sides of the power cylinder pistons (C, D, E, F).

When the driver first steps upon the brake pedal, the passage through the hydraulic piston is open because the power cylinder pistons are in released position. As hydraulic pressure builds up, the control valve moves into applied position, causing the power cylinder piston to act. The first movement of the piston rod closes the passage through the hydraulic piston. Further movement in the applied direction forces the hydraulic piston further into the cylinder and thus applies the brakes.

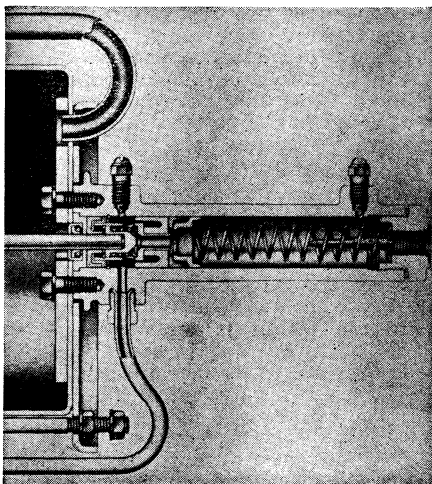
# VACUUM BRAKES



**Fig. 1** Showing inside working parts of First Series Hydrovac. The three basic units are the power cylinder (center), control valve (left), and hydraulic slave cylinder (right)



**Fig. 2** Detail of control valve mechanism on First Series Hydrovac



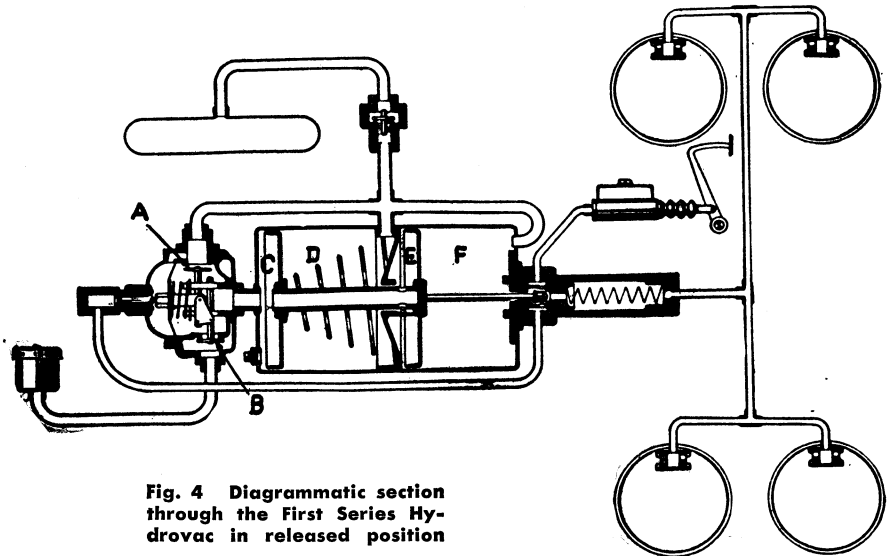
**Fig. 3** Detail of hydraulic slave cylinder on First Series Hydrovac

Note that during brake application the hydraulic force from the vehicle master cylinder, necessary to operate the control valve, is automatically added to the force of brake application, since it also acts on the Hydrovac hydraulic piston.

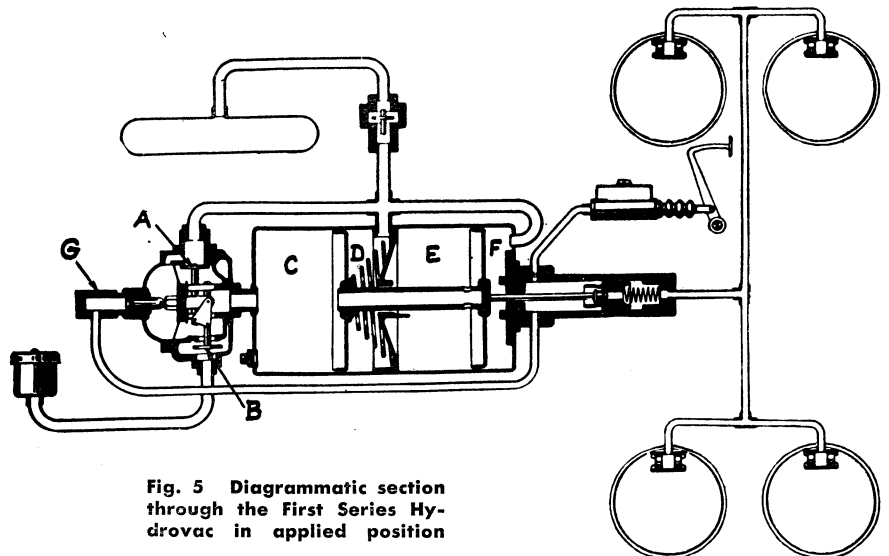
In the applied position, therefore, Fig. 5, hydraulic pressure from master cylinder is applied to the control valve piston (G), moving vacuum valve (A) to the closed position and opening atmospheric valve (B). This admits atmosphere to cylinder chambers (C) and (E) while vacuum is maintained in chambers (D) and (F).

Should the vacuum system become inoperative due to damaged lines or other accidental cause, the power cylinder pistons return to released position and the vehicle hydraulic system returns to physical operation. Hydraulic fluid then flows through the hydraulic piston, through the slave cylinder and to the wheel cylinders.

In the holding position, when the brake



**Fig. 4** Diagrammatic section through the First Series Hydrovac in released position



**Fig. 5** Diagrammatic section through the First Series Hydrovac in applied position

pedal is held partially applied and physical pressure is constant, the master cylinder line pressure at point (G), Fig. 6, remains constant. As air is admitted into the valve compartment below the diaphragm, the diaphragm is forced against the piston until valves (A) and (B) are brought into holding position. The diaphragm, therefore, exerts a reactionary force against piston which is exactly proportional to the degree of brake application.

## Disassembly

1. Mark cylinder shells, center plate and hydraulic cylinder with center punch or scribe so these parts can be reassembled in the original relative positions.
2. Remove through bolts which hold cylinder shells and center plate together.
3. Remove hydraulic jumper line which runs from the control valve to the hydraulic cylinder.
4. Loosen hose clamps and hose by turning them slightly with pliers.
5. Separate cylinder shells from center plate, Fig. 7. Hold over a pan to catch the oil as the parts are separated.
6. Remove hydraulic cylinder by taking out four cap screws, Fig. 8.
7. Remove end plug from hydraulic cylinder, Fig. 9, and remove piston and related parts.
8. Compress power cylinder release spring and hold it compressed by inserting a pin through the port holes in the piston rods, Fig. 10. Hold spring compressed in this manner while disassembling rear piston.
9. Remove rear piston by using an offset open end wrench to hold the nut at the front of the piston while the rear nut is being removed.
10. Take out retainer pin from piston rod, Fig. 10, which allows push rod to be removed.
11. Remove temporary pin from port holes, Fig. 10, and slip center plate and release spring off piston rod.
12. Hold lower nut on front piston in a vise and remove this nut from the piston rod, after which remove piston.
13. Remove piston rod leather seal from center plate, Fig. 11, by taking out snap ring and washer.
14. Remove control valve from front cylinder shell.
15. Loosen lock nut and remove small hydraulic cylinder from control valve.
16. Disassemble hydraulic cylinder for inspection, Fig. 12.
17. Remove diaphragm cover and spacer ring, Fig. 13.
18. Remove vacuum valve seat, valve and diaphragm, Fig. 14.
19. To take out diaphragm and triangular linkage, compress spring with fingers, Fig. 15.
20. Take off lower part of valve body and remove atmospheric valve spring and washer, Fig. 16.

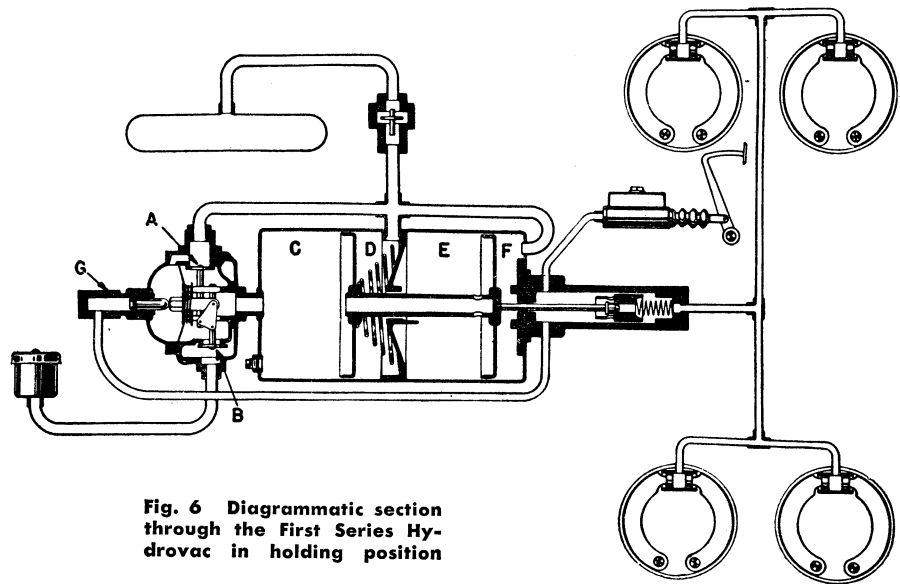


Fig. 6 Diagrammatic section through the First Series Hydrovac in holding position

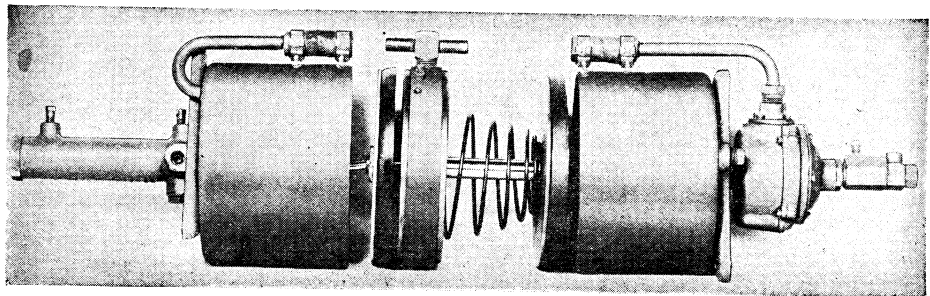


Fig. 7 Cylinder shells removed from center plate

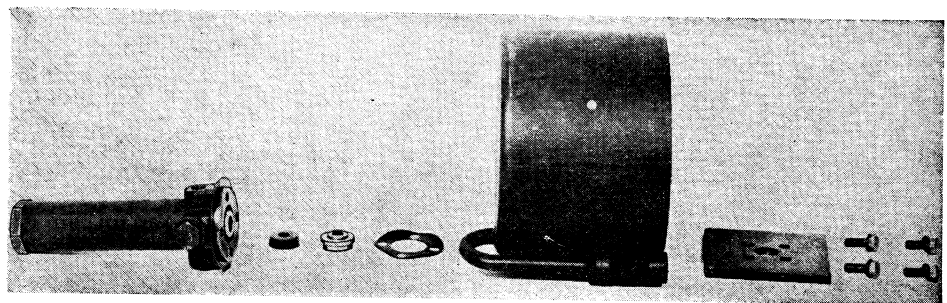


Fig. 8 Hydraulic cylinder removed from rear cylinder shell and push rod seal parts removed

## Assembly

1. Clean all parts thoroughly and inspect for wear or damage. If valve seats are slightly pitted or corroded, they may be cleaned with fine steel wool.
2. Install new diaphragm and gaskets in control valve. Clean all flange surfaces to insure an air-tight fit. Compress diaphragm spring and washer as shown in Fig. 17 to assemble link pins in valve stems.
3. Fig. 18 shows where special washer will be on the pins when the diaphragm is in place.
4. Lubricate the internal linkage of the control valve with Bendix cable lubricant.
5. When assembling the control valve, be sure the by-pass holes in the spacer plate, valve body, diaphragm and gasket all line up as shown in Fig. 13 so that the passage is clear.
6. While tightening diaphragm screws, hold diaphragm down just enough to close vacuum valve, Fig. 19. This prevents buckling of diaphragm between screw holes.
7. If control valve hydraulic cylinder is scored or pitted, replace the cylinder.
8. When assembling the control valve cylinder and plunger, blow out all passages with compressed air and wipe the cylinder clean and dry with a cloth.

# VACUUM BRAKES

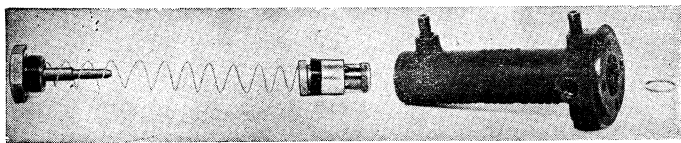


Fig. 9 Hydraulic cylinder with internal parts removed

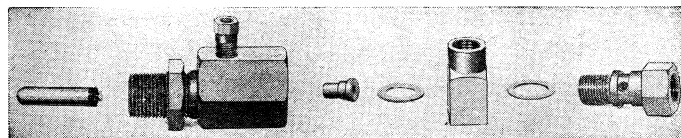


Fig. 12 Control valve hydraulic cylinder with parts removed

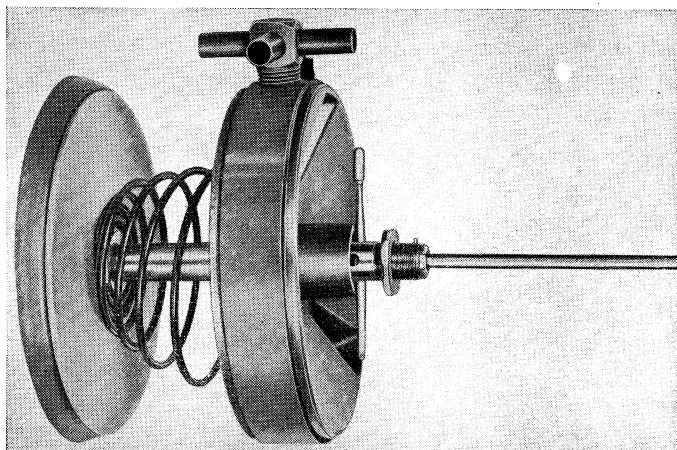


Fig. 10 Center plate held by pin and rear piston removed

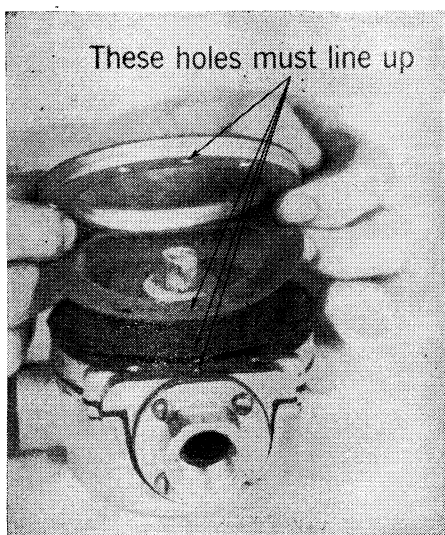


Fig. 13 Removing control valve cover, spacer ring and diaphragm

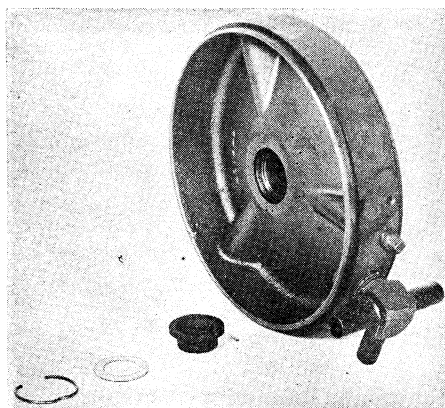


Fig. 11 Leather seal removed from center plate

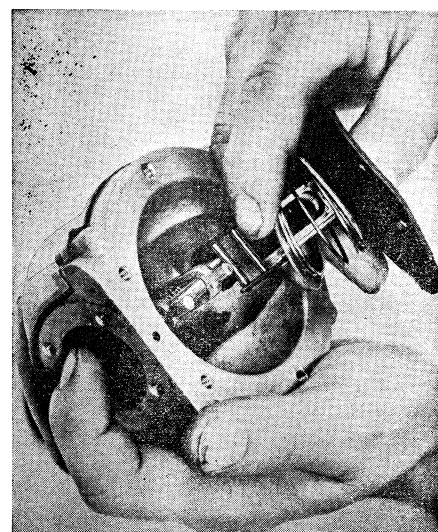


Fig. 15 Removing valve linkage

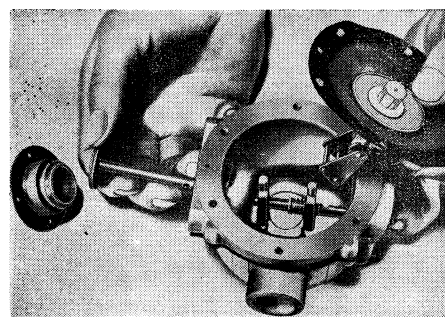


Fig. 14 Removing vacuum valve

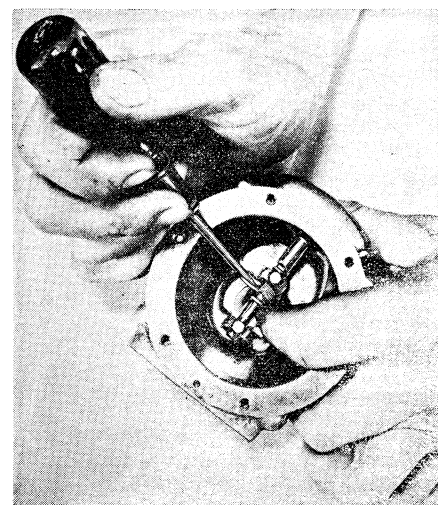


Fig. 16 Removing atmospheric valve spring and washer

9. Assemble piston stop and hydraulic connection, Fig. 12, but do not tighten at this time.
10. Place a few drops of clean hydraulic brake fluid inside the control valve cylinder. Also dip the piston and rubber cup in brake fluid, and assemble these parts.
11. With the lock nut turned up to the end of the threads on the control valve hydraulic cylinder, screw the cylinder all the way into the control valve cover but do not tighten lock nut at this time.
12. Install a new piston rod leather seal in the center plate after soaking the seal in vacuum cylinder oil, Fig. 11. Be sure the seal is seated properly to prevent vacuum leaks.
13. Assemble front piston in assembly ring, Fig. 20.
14. Place the large diameter piston plate in the ring. Brush a generous ring of shellac or sealing compound around the hole in the piston plate.
15. Place leather packing on top of the plate with lip upward.
16. Place smaller diameter piston plate with lip toward leather packing.
17. Install oil felt.
18. Install felt expander ring with grip-

- pers pointing upward and outward as shown in Fig. 21. Hook expander ring securely in notch provided near the loop.
19. Place felt retainer plate over felt and felt expander ring, Fig. 20. Register opening squarely over loop in expander ring.
20. Run piston rod nut down to end of threads on front end of piston rod (port holes are in rear end of rod).
21. Coat threads of piston rod with sealing compound.
22. With piston still in assembly ring, place piston on piston rod.
23. The lip of the leather cup must extend away from piston rod.
24. Remove assembly ring.
25. Turn end nut down until it is just

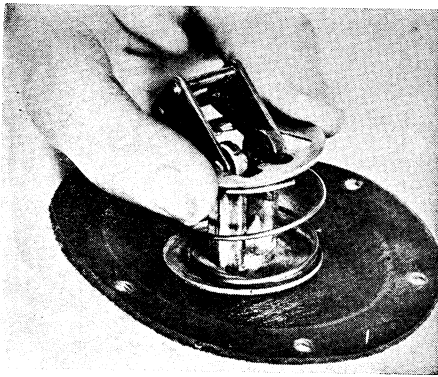


Fig. 17 Assembling spring and washer on diaphragm

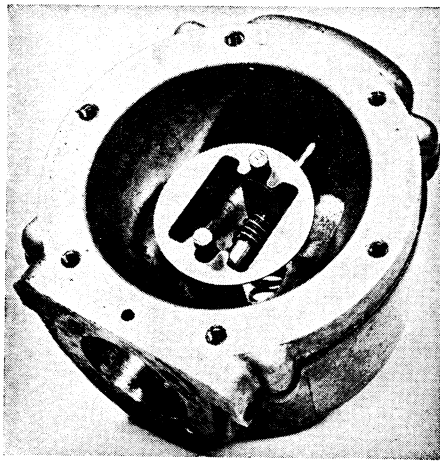


Fig. 18 Showing how flat washer rests on pins in lower body section after diaphragm is in position

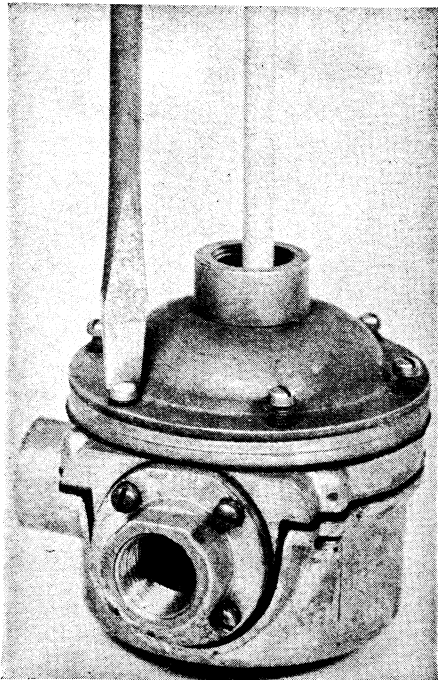


Fig. 19 Hold diaphragm down to relieve tension on flexible material when tightening cover screws

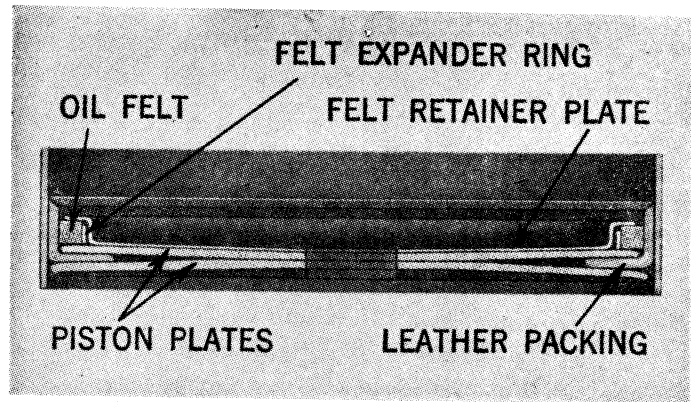


Fig. 20 Piston assembly in assembly ring

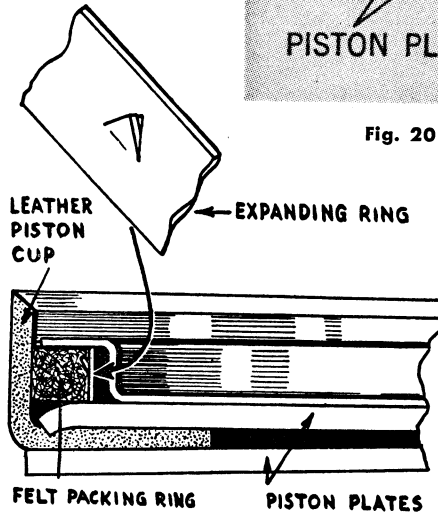


Fig. 21 Expander ring installed firmly against felt packing ring with grippers pointing upward and outward and expander ring hooked securely in notch provided near loop

- flush with end of piston rod. Following this, tighten other nut firmly against piston plate. After final tightening, nut at end of piston rod must be exactly flush with end of piston rod. Stake both nuts in place.
26. Place front piston rod nut in vise with piston rod upward.
  27. Place piston return spring and center plate in position. Be sure center plate is positioned with piston guide boss extending upward.
  28. Again place a pin in port holes as shown in Fig. 10 to temporarily hold the center plate out of the way so the rear piston can be assembled.
  29. Turn inside piston rod nut down to end of threads on piston rod. Coat threads of piston rod with sealing compound.
  30. Assemble rear piston in piston ring and with assembly ring still in place, put piston on piston rod.
  31. Place push rod in position and secure with retaining pin, Fig. 10.
  32. Turn down outside piston nut until it is flush with end of piston rod, then tighten inner nut against piston plate. Remove temporary pin from port holes.
  33. Distance "A", Fig. 22, should be within the tolerances shown. If necessary, readjust nuts to obtain desired result.
  34. Again place temporary pin in port holes, and bring inside piston nut up

against piston plate and tighten securely. Do not stake outer nut at this time.

35. Remove temporary pin from port holes.
36. To check length of piston rod, fit rear cylinder shell in position over piston and against center plate—without gasket.
37. Using special gauge, Fig. 23, check length of push rod by measuring distance from end of cylinder shell to end of push rod, Fig. 24.
38. If push rod is too long or if it lacks more than .030" of touching gauge, reset piston on rod. Lock and stake both piston nuts.
39. Place retainer washer, rubber seal and leather seal in mounting flange end of hydraulic cylinder. Dip rubber seal in brake fluid but do not oil leather seal as it is already oiled enough.
40. Attach hydraulic cylinder to rear cylinder shell.
41. Dip piston and piston cup in brake fluid and place piston cup and spring in hydraulic cylinder.
42. Install stop and end plug.
43. Place new gaskets on both sides of center plate.
44. Dip power cylinder piston leathers in vacuum cylinder oil and apply a liberal coating to the cylinder walls.
45. Place cylinder shells in position over pistons and firmly against center plate.
46. Line up shells and center plate according to marks previously made before disassembly.
47. Tighten through bolts evenly.
48. Place shellac on threads of fitting of front cylinder shell and install control valve.
49. Thread control valve hydraulic cylinder into control valve cover until dimension "A", Fig. 25, is between  $\frac{1}{16}$  and  $\frac{1}{8}$ ".
50. Align hydraulic cylinder in control valve cover so that bleeder screw lines up with bleeder screw in slave cylinder at opposite end of Hydrovac. When aligned, tighten lock nut.
51. Connect hydraulic jumper line.
52. Connect vacuum hoses and tighten clamps.
53. Plug vacuum fitting with cork to prevent dirt entering the unit before it is installed on vehicle.
54. Lubricate power cylinders by inject-

# VACUUM BRAKES

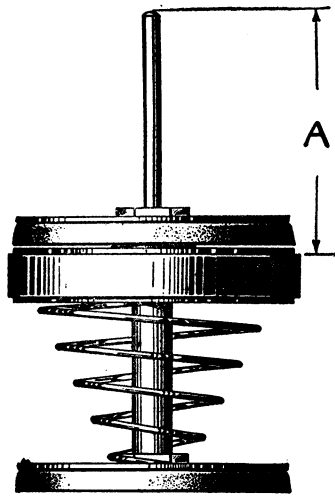


Fig. 22 Setting length of push rod

## FIRST SERIES

Hydrovac Part No.	—Dimension "A" in Inches—	
	Units with Plain Center Plate	Units with Grooved Center Plate
371730	6.360-6.390	6.322-6.342
371830	7.251-7.281	7.197-7.217
372290	6.360-6.390	6.322-6.342
372428	7.251-7.281	7.197-7.217
373380	6.360-6.390	6.322-6.342
373500	6.360-6.390	6.322-6.342

## SECOND SERIES

Hydrovac Part No.	Dimension "A" in Inches
372960	7.142-7.172
373000	6.475-6.505
373050	6.810-6.840
373100	6.270-6.300
373163	7.142-7.172
373330	6.475-6.505
373370	7.142-7.172
373390	7.142-7.172
373636	6.810-6.840
373639	6.270-6.300
373700	7.142-7.172

ing ½ ounce of vacuum cylinder oil into the pipe plug hole in the front shell, and a like amount in the plug hole in the center plate. Both power cylinders should be similarly lubricated every 20,000 miles.

**WARNING**—Do not use more than the prescribed amount of vacuum cylinder oil as an excess will reach the rubber parts and cause deterioration and leaks.

## Bleeding Hydrovac

The Hydrovac must be bled at all three bleeder screws, Fig. 26, before bleeding the vehicle wheel cylinders. Because the hydraulic line from the master cylinder can be connected to the Hydrovac at two different points, the order of bleeding the Hydrovac bleeder valves will vary.

1. If the master cylinder line connects to the control valve, bleed the Hydrovac in 1-2-3 order as shown in Fig. 26.

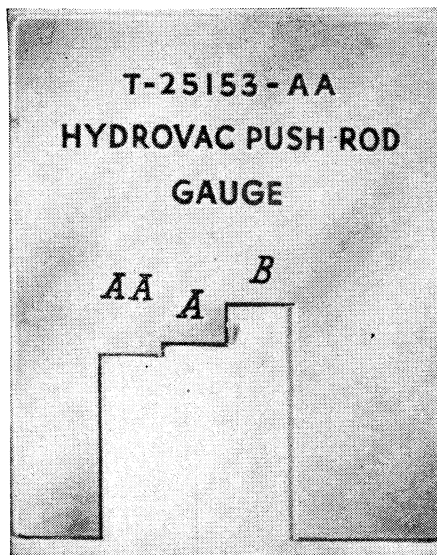


Fig. 23 Use step "AA" in gauge to check push rod for Hydrovacs with  $\frac{1}{16}$ " groove in center plate. Step "A" to check push rod for First Series Hydrovacs without groove in center plate. Step "B" is for Second Series Hydrovacs

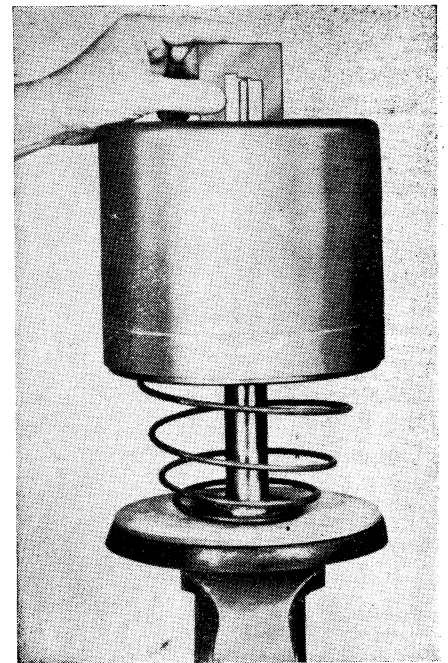


Fig. 24 Showing Hydrovac push rod gauge in use

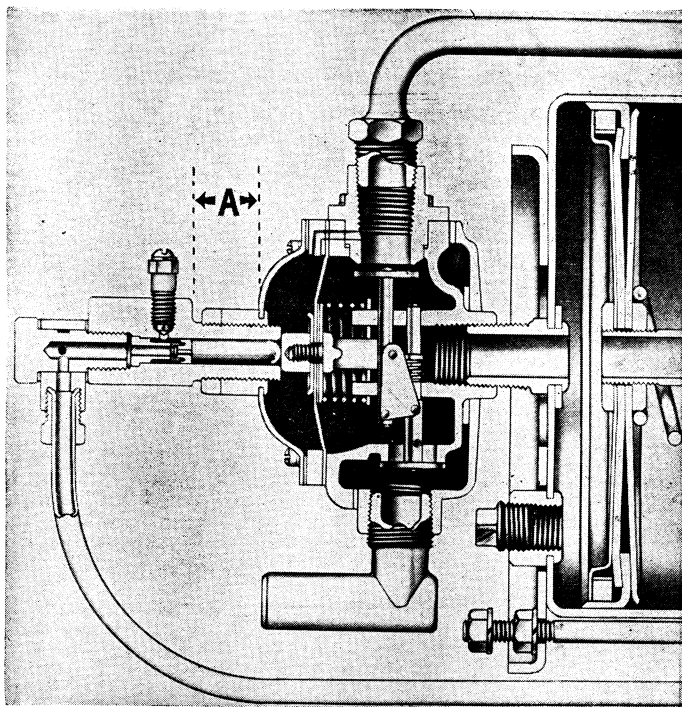


Fig. 25 Detail of control valve mechanism

2. If the master cylinder line connects to the slave cylinder, bleed the Hydrovac in 2-1-3 order.
3. Bleed the hydraulic brake system in the usual manner, with engine not running.

## SECOND SERIES HYDROVAC

The second Series Hydrovac is funda-

mentally the same as the First Series except that the control valve is integral with the hydraulic slave cylinder, Figs. 27 and 28.

Where a low initial pedal pressure is required, a Hydrovac unit (second series) which has two hydraulic lines connected to the vehicle master cylinder, Fig. 30, can be used. One line is connected be-

tween the master cylinder check valve outlet "A", Fig. 29, and the slave cylinder port of the Hydrovac. This line supplies fluid through the slave cylinder to the wheel cylinders.

Another line is connected between an outlet in the vehicle master cylinder, located behind its check valve at (B), Fig. 29, and a port in the control valve behind the valve piston. The sole purpose of the second line is to operate the control valve, and in doing so, the residual line pressure in the hydraulic brake system is eliminated from the control valve, thus requiring much less initial pedal pressure to operate the control valve, yet the original residual line pressure in the system through the other line is maintained.

In the released position, this second line at (B) is open to atmosphere through the master cylinder vent. In the first hydraulic line referred to above, there is a ball check valve located in the passage between the slave cylinder piston and the control valve, Fig. 30. The purpose of this check valve is to permit hydraulic fluid to pass from the control valve into the chamber behind the slave cylinder piston whenever the pressure within the former is greater than the pressure within the latter. If this by-pass were not provided, a vibration or pedal chatter might be set up under certain conditions. This is because within time required for the control valve to move from applied to released position the fluid might be forced out of the control valve and into the master cylinder through port (B), Fig. 29.

If the by-pass were incorporated without the ball check valve, it would obviously be impossible to maintain residual line pressure in the brake system because this pressure would escape through the passage and be vented into the master cylinder through port (B).

The check valve is therefore incorporated to maintain residual line pressure within the brake system, facilitating bleeding and filling, and insuring proper performance of the system.

## Disassembly

1. Before dismantling, mark the cylinder shells, center plate and hydraulic cylinder with a punch so that the parts can be reassembled in their original positions.
2. Loosen plug (A), Fig. 31, three turns.
3. Remove plug (B), Fig. 31.
4. Place assembly in vise, Fig. 32, clamping end plug tightly.
5. With end plug turned out three or four turns, rotate Hydrovac to facilitate dismantling.
6. Loosen hose clamps on vacuum lines and slide hose back along tubing.
7. Remove through bolts holding cylinder shells together.
8. Separate upper shell from center plate, Fig. 33.
9. Remove center plate, piston and lower shell, Fig. 34.
10. Remove valve housing cover and spring, Fig. 35.
11. Remove valve housing and release spring, Fig. 36. Two pilot screws can be used as shown to facilitate removal and assembly of gasket and

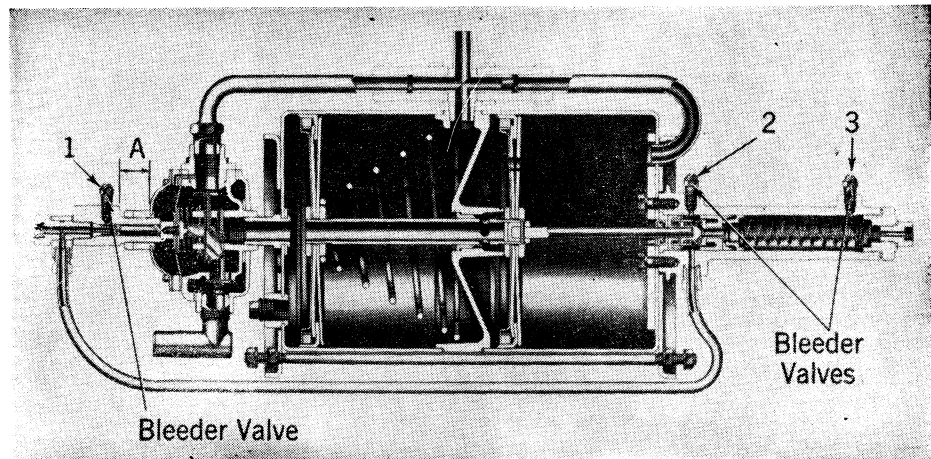


Fig. 26 Bleeder valves on First Series Hydrovac

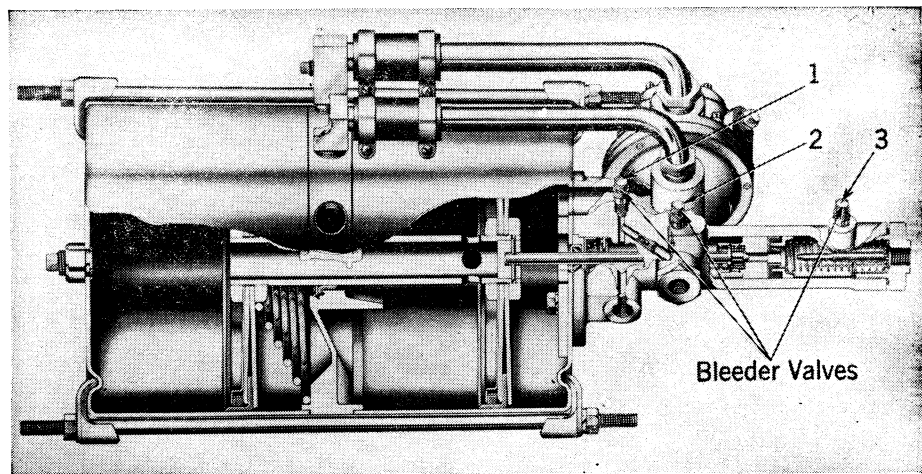


Fig. 27 Section through Second Series Hydrovac with control valve integral with hydraulic slave cylinder, and double piston vacuum suspended power cylinder

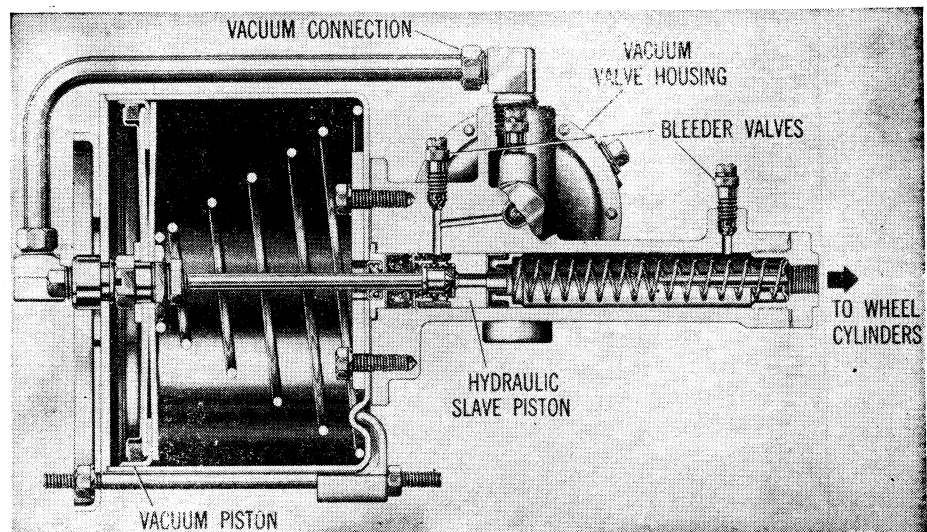


Fig. 28 Section through Second Series Hydrovac with control valve integral with hydraulic slave cylinder, and single piston vacuum suspended power cylinder

# VACUUM BRAKES

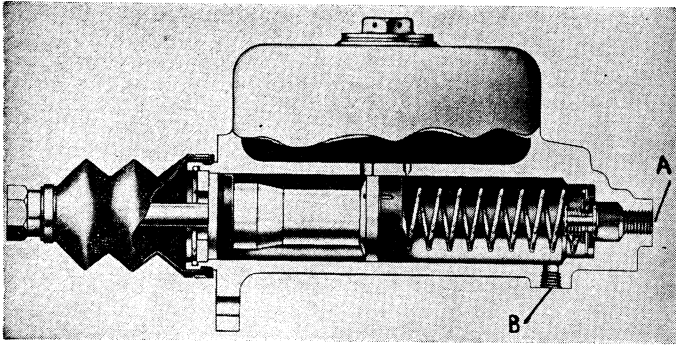


Fig. 29 Sectional view of typical brake master cylinder

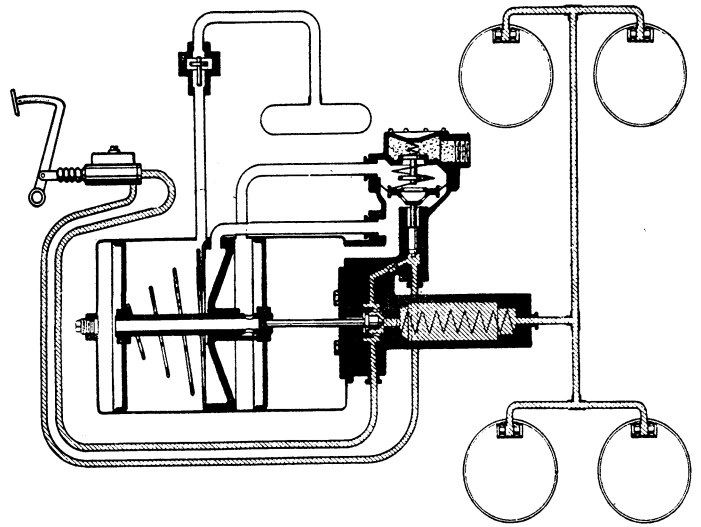


Fig. 30 Diagrammatic section through Second Series Hydrovac with double hydraulic line system in released position

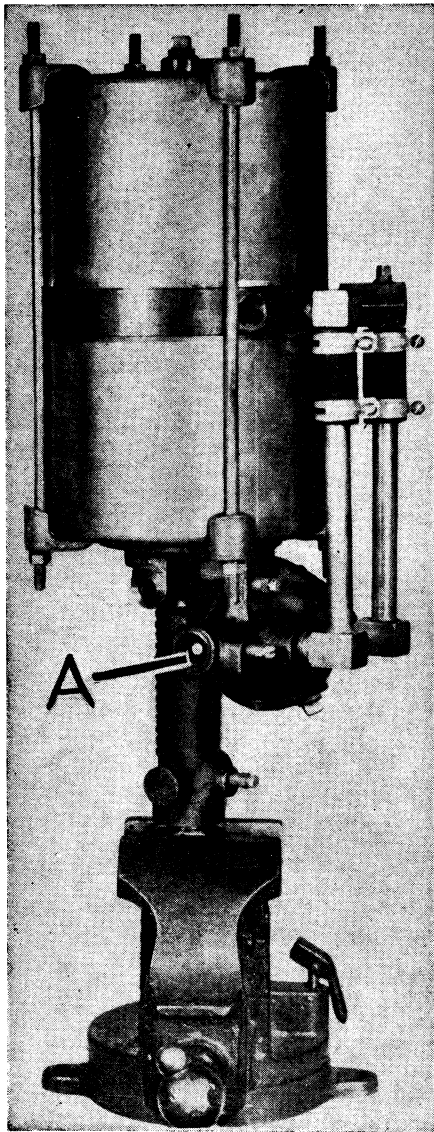


Fig. 32 Correct method of holding Hydrovac in vise

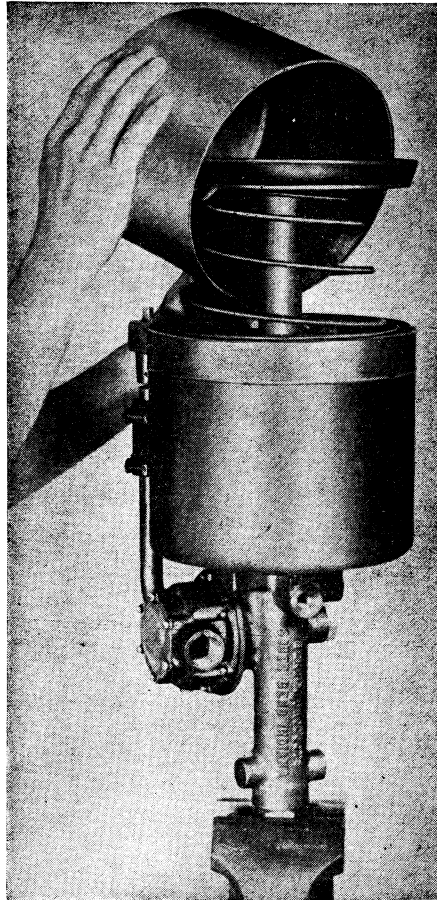


Fig. 33 Upper shell separated from center plate

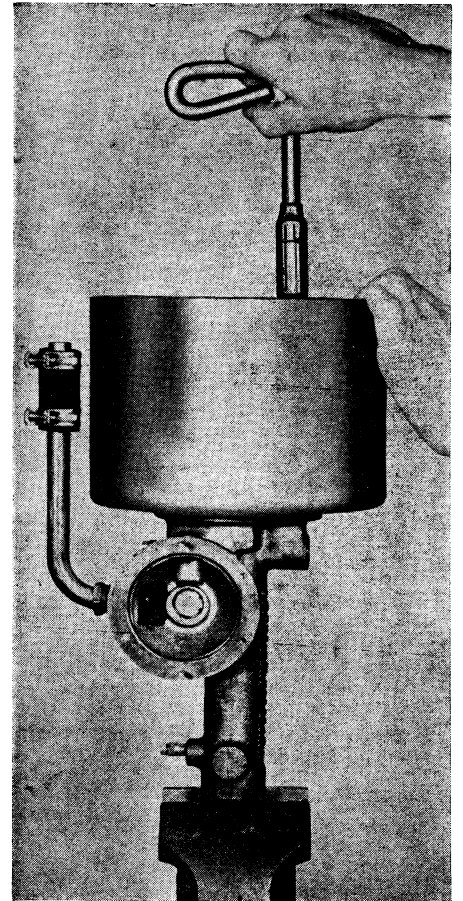


Fig. 34 Lower shell being removed

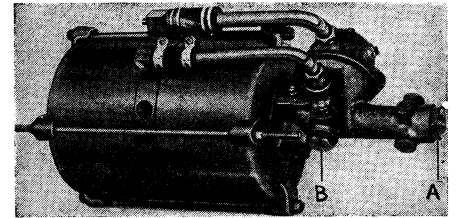
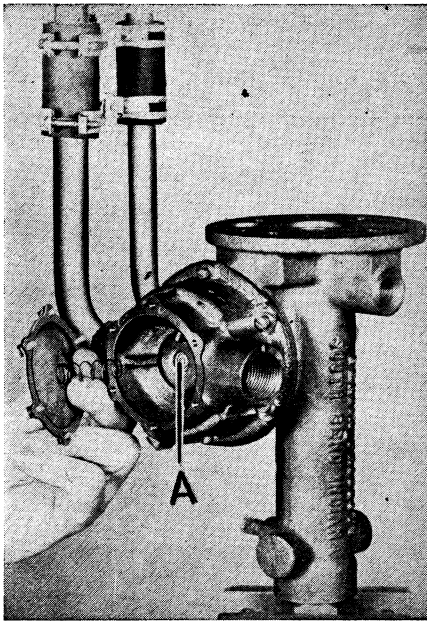
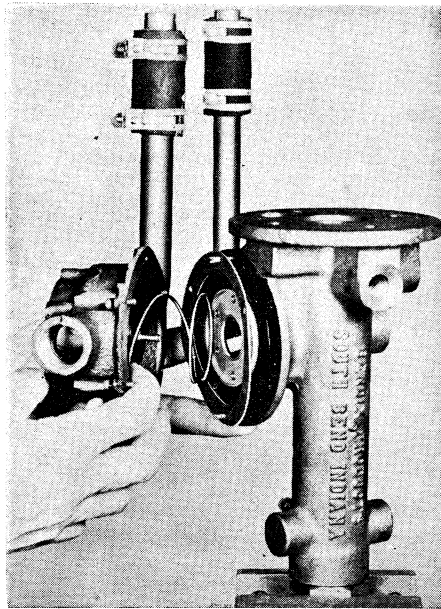


Fig. 31 Second Series Hydrovac, two piston type

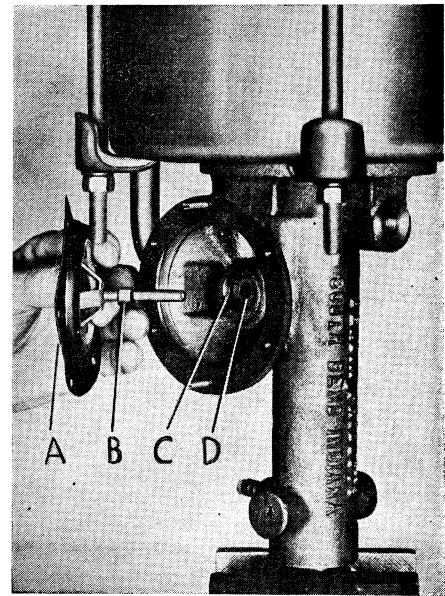




**Fig. 35** Removing valve housing cover and spring



**Fig. 36** Removing valve housing and valve release spring



**Fig. 37** Removing diaphragm assembly and spacer

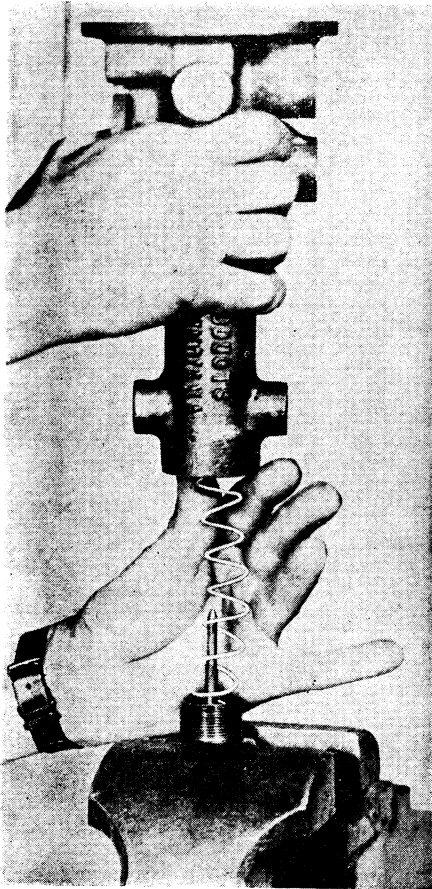
- diaphragm.
12. Remove diaphragm (A), Fig. 37, and spacer (B).
  13. Remove valve operating piston (A), Fig. 32, by inserting a small screw driver through hole (C), Fig. 37.
  14. Take out hydraulic cylinder end plug and piston release spring as shown in Fig. 38.
  15. Push hydraulic piston out through plug end of cylinder by inserting rod or screwdriver in the opposite end as indicated in Fig. 39.
  16. If the Hydrovac has a double hydraulic line, remove the ball check valve with a  $\frac{1}{16}$ " blade screw driver as shown in Fig. 40. Use care to avoid damaging the cylinder wall.
  17. To remove the poppet valve, drill off the head of the valve stem (A), Fig. 35. The service replacement valve stem is threaded at one end, Fig. 41, instead of being riveted to the poppet valve as in production.
  18. Place piston and center plate in vise, clamping piston rod nuts as shown in Fig. 42.
  19. Hold center plate in this position with a C-clamp as shown and insert a rod through piston rod port holes and remove upper piston rod nut, retainer pin and slave cylinder push rod.
  20. Remove lower piston nut, Fig. 43.
  21. Clean and inspect all parts thoroughly. If the vacuum cylinder walls are slightly rusted or corroded they may be cleaned up with fine steel wool or emery cloth. Do not attempt to refinish the bores of either the slave cylinder or hydraulic cylinder of the control valve as to do so might enlarge the bores, necessitating oversize pistons which are not manufactured. If the vacuum valve seat is slightly corroded or rusted, it can be cleaned with fine steel wool. Any nicks or burrs

- on gasket surfaces should be removed with a file.
22. After cleaning and inspecting parts, place them on a clean piece of cloth or paper to prevent picking up dust or dirt.

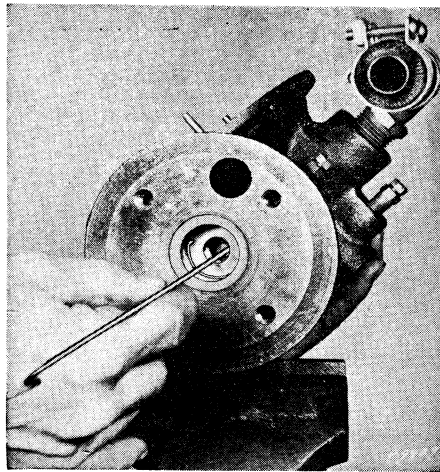
## Assembly

1. Install slave cylinder piston, spring, stop and end plug, Fig. 44. Use new parts included in repair kit. Spread a film of brake fluid over cylinder wall and dip rubber cup in fluid before assembly.
2. Install valve stop washer (C) and lock ring (D), Fig. 37. Be sure lock ring is secured in groove.
3. Install valve operating piston (A), Fig. 32.
4. Assemble new diaphragm (A) and spacer (B), Fig. 37.
5. Install service poppet valve, Fig. 41, being sure to place lead washer under nut as shown. Tighten nut with a 4" wrench, holding end of stem with drill chuck. Be sure the two poppet valves are parallel after lock nut is tightened.
6. Assemble valve housing and release spring, Fig. 36, being sure spring is in recess in both ends. Install the gasket. For convenience, two pilot screws may be used to align the holes of the diaphragm gasket and valve body. Do not use grease or sealing compound on gasket.
7. Install valve cover and spring, Fig. 35.
8. On Hydrovacs having double hydraulic line, install new by-pass ball check valve. Use a new lead gasket when installing this valve and be careful not to scratch the cylinder bore with the screw driver. Tighten nut securely.
9. Install valve cylinder plug (B), Fig. 31, and a new gasket, tightening with a 10" wrench.
10. To assemble the vacuum cylinder, install a new piston rod leather seal in the center plate after soaking the seal in vacuum cylinder oil (see Fig. 11). Be sure seal is well seated to prevent vacuum leaks.
11. Assemble front piston in assembly ring, Fig. 20, and assemble in the same manner as described for First Series Hydrovac.
12. When assembled, clamp the outer piston nut in a vise as shown in Fig. 43.
13. Place piston return spring and center plate in position, with large end of spring resting against center plate. Be sure center plate is positioned with piston guide boss extending upward.
14. Compress spring and hold with C-clamp, Fig. 42.
15. Turn inside piston nut down to end of threads on piston rod.
16. Assemble other piston in piston ring and with assembly ring still in place, put piston on piston rod. Coat threads of piston rod with sealing compound.
17. Place push rod in position and secure with retaining pin.
18. Turn down outside piston nut until flush with end of piston rod.
19. Bring inside piston nut up against piston plate and tighten securely. Do not stake outer nut at this time.
20. Remove C-clamp and allow center plate to come up against piston.
21. Measure distance (A), Fig. 22, and if not within tolerances shown, adjust nuts as required.
22. In checking length of push rod on single cylinder Hydrovacs, the distance (A), Fig. 45, should be as shown. If necessary, the lock nut (B) and push rod (C) may be adjusted to obtain the required dimension.
23. Fit rear cylinder shell over piston,

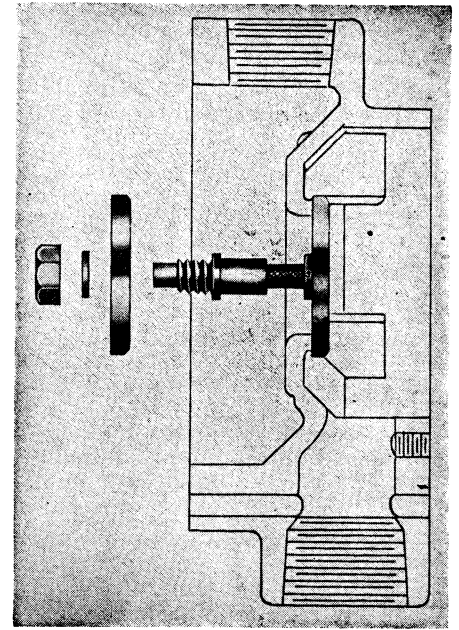
# VACUUM BRAKES



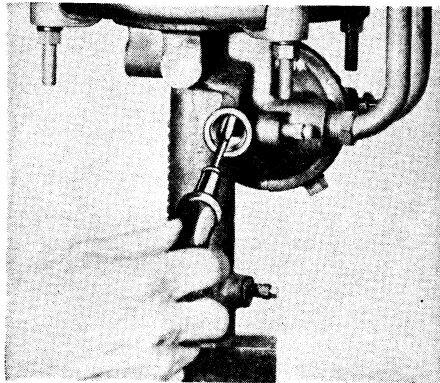
**Fig. 38** Removing Hydrovac cylinder end plug and piston release spring



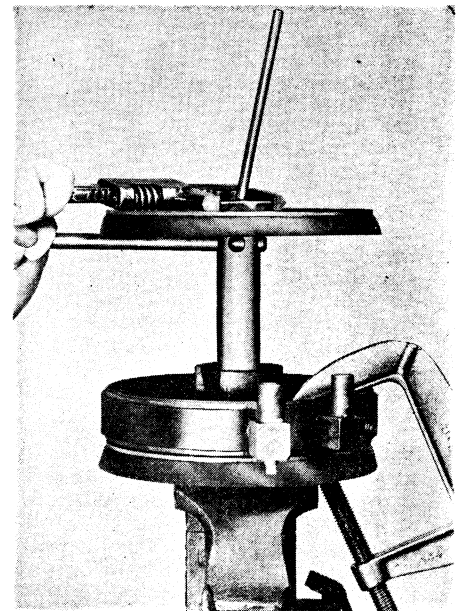
**Fig. 39** Removing hydraulic piston



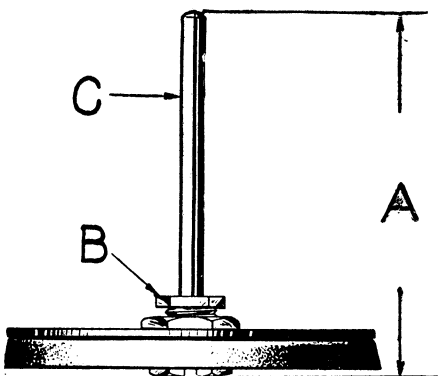
**Fig. 41** Installing service replacement poppet valve



**Fig. 40** Removing ball check valve

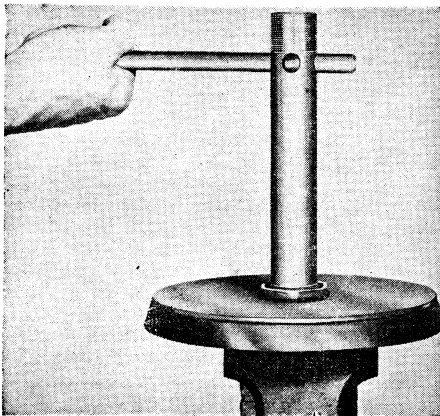


**Fig. 42** Center plate held with "C" clamp compressing release spring

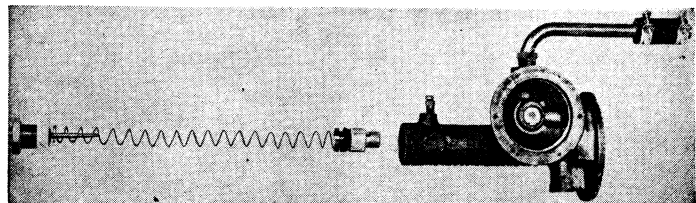


**Fig. 45** Setting length of push rod single cylinder Hydrovac. Lock nut "B" and push rod "C" must be adjusted so that distance "A" is within dimensions given below

Hydrovac Part No.	Dimension "A" in Inches
372774	6.355-6.375
373200	6.605-6.625



**Fig. 43** Removing lower piston nut



**Fig. 44** Slave cylinder piston, spring, stop and end plug

Fig. 24, and against center plate (without gasket). Place gauge, Fig. 24, over end of push rod as shown in Fig. 24. The clearance between the end of the push rod and the notch in the gauge should not be more than .030" or less than .000" (zero). NOTE—Use step "B" for all second series Hydrovacs. If length of push rod does not come within specifications, correct by adjusting the piston nuts.

24. After adjustment, stake both piston nuts in two places after final tightening. When tightening nuts, use an 11" wrench.
25. Figs. 46 and 47 illustrate the first and latest design push rod guide and seal. When repairing units having the first type, use the parts of the latest type.
26. Lubricate both pistons by saturating felt wicks with vacuum cylinder oil. Also apply a little of this oil to the inner walls of both cylinder shells and leather piston packings. Do not allow any of this oil to come in contact with slave cylinder parts.
27. Install center plate and piston assembly, using new gaskets at center plate.
28. Assemble upper cylinder shell, lining up marks previously made on cylinder shells and center plate before disassembly.
29. Install through bolts and clamps and tighten evenly.
30. Slide vacuum hoses on their fittings and tighten hose clamps.

## Bleeding Hydrovac

To bleed the entire braking system, the Hydrovac unit must be bled at all three bleeder screws before attempting to bleed the wheel cylinders.

When bleeding either single or double line second series Hydrovacs, bleed in the 2-1-3 order shown in Fig. 48.

When two Hydrovacs are used with two master cylinders in a single installation, the system should be bled with a pressure bleeder. Be sure to have the engine shut off during the bleeding operation, regardless of whether it is done manually or under pressure.

## THIRD SERIES HYDROVAC

The Third Series Hydrovac, Figs. 49 and 50, consists of three basic units which have been so combined that they function as a single unit, all of which are controlled by hydraulic pressure developed within the hydraulic master cylinder of the vehicle brake system. The three basic units are:

1. A hydraulically actuated vacuum control valve which controls the degree of brake application or release. The control valve consists of a hydraulic actuated piston, a diaphragm, and a vacuum and atmospheric poppet.
2. A vacuum power cylinder which contains either a single or tandem piston and a push rod that connects the vacuum piston to the hydraulic piston of the hydraulic cylinder.
3. A hydraulic slave cylinder which contains a piston with a check valve.

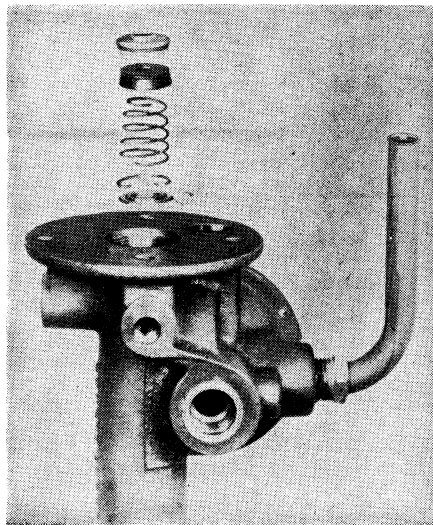


Fig. 46 Replacing push rod guide and seal, rubber cup and spring (1st design)

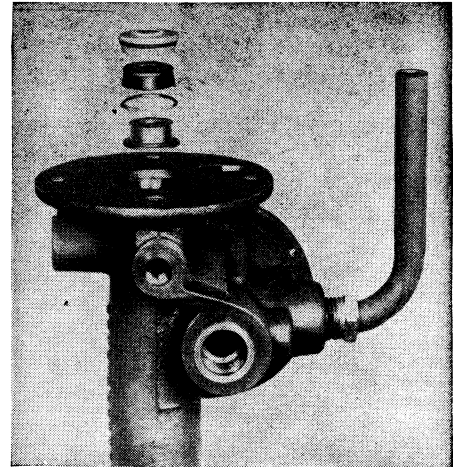


Fig. 47 Replacing push rod guide, seal and rubber cup (2nd design)

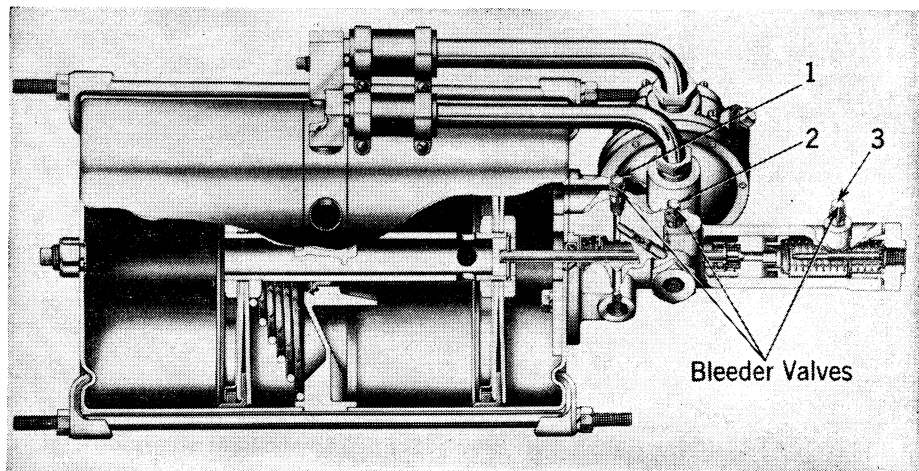


Fig. 48 Location of bleeder valves, Second Series Hydrovac

Some models incorporate a residual line pressure check valve.

## Operation

As the brake pedal is depressed, the hydraulic pressure developed within the master cylinder is transmitted to the hydraulic piston of the control valve and to the hydraulic cylinder. With pressure applied to the control valve piston, the vacuum valve closes and the atmospheric valve opens to admit air to the control side of the vacuum power cylinder. As air is admitted, the forces acting upon the vacuum power cylinder pistons are transmitted directly to the hydraulic piston through the push rod. As the hydraulic piston starts to move, the piston check valve closes, Fig. 51, trapping fluid under pressure ahead of the piston.

The total hydraulic pressure created and transmitted to the wheel cylinders is the sum of the pressure developed as a result of the vacuum power cylinder push rod thrust and the pressure received by the Hydrovac from the master cylinder.

As the brake pedal is released, the

pressure within the control valve hydraulic piston chamber is reduced, allowing the atmospheric poppet to close and re-open the vacuum poppet. The vacuum power cylinder piston is again balanced in vacuum and returns to release position. When the hydraulic piston nears the release end of its stroke, its check valve reopens, Fig. 52, thus permitting the full release of the brakes.

## Single Piston Types Disassembly

Fig. 53. Loosen hose clamps (1) and (2) and slide hose off tube. Loosen lock nut (3) and unscrew hydraulic cylinder (4) from end plate. Hold end cap (7) in vise and unscrew hydraulic cylinder, using open-end wrench on flat part of cylinder. Remove gasket (5) and bleed screw (6) from end cap. If unit has a residual line pressure check valve (11), remove this valve by taking out snap ring (8), washer (9) and spring (10).

Fig. 54. Remove control valve housing and valve parts. Scribe a line across cylinder shell and end plate so these can be reassembled in their original position.

# VACUUM BRAKES

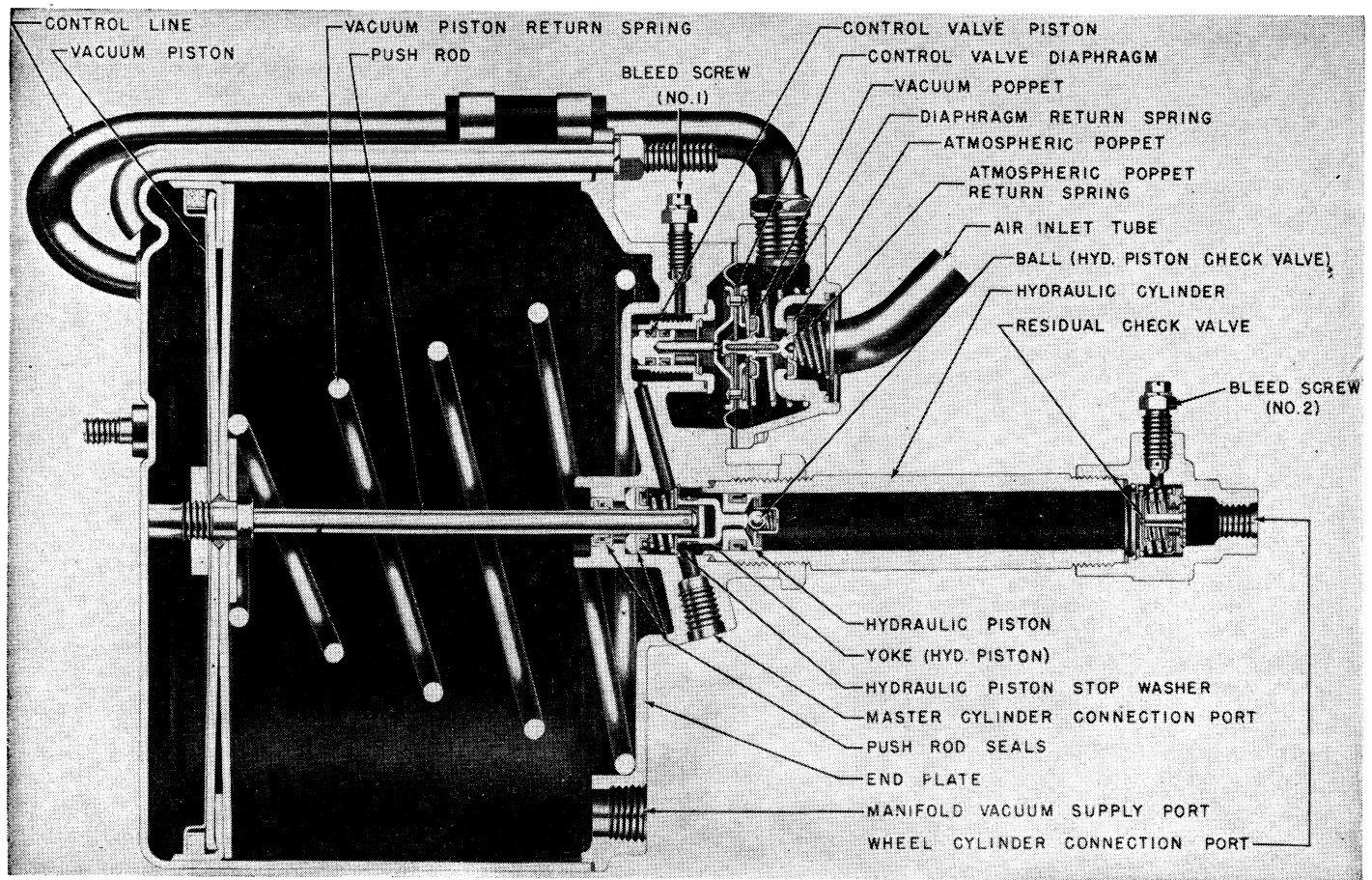


Fig. 49 Sectional view of Third Series Hydrovac with single piston

Remove hook bolts and then cylinder shell.

Fig. 55. Compress piston return spring by pressing down on end plate and install hook clamps as shown (dimensional sketch shows how to make these clamps). Remove hydraulic piston (2) from push rod by sliding snap ring or retainer spring back and removing pin. Remove hook clamps which will allow vacuum piston and spring to come out. If vacuum piston leather or any other part of the piston is damaged, disassemble piston. Disassemble hydraulic piston by first removing snap ring (1). Then remove spring cup, spring and ball.

Fig. 56. Place end plate over pins of end plate holding fixture (inset shows dimensions for making this fixture). Clamp fixture in vise. Remove retainer ring (4), using special tool T-25254, and stop washer (3). Using  $1\frac{1}{8}$ " socket wrench, remove hydraulic valve piston fitting (2). Press out valve piston (1) and remove cup (or cups) from valve piston.

Fig. 57. Remove hydraulic cylinder end seal (3). Remove snap ring (2) and push rod seal cup parts. Lift end plate from fixture and place it upon two wooden blocks. Drive out push rod leather seal (1), using a flat end rod or drift.

**NOTE**—Immerse all metal parts in Bendix Metalclene Parts Cleaner. Dip all metal parts in the hydraulic system in

alcohol before assembly. Use all parts furnished in the Hydrovac Repair Kit for the particular unit being serviced. Repair kits include new rubber parts. Old rubber parts should be discarded. If the bore of the vacuum cylinder shell is corroded or rusted, polish with fine emery cloth or steel wool; if badly pitted or scored, the shell should be replaced.

## Assembly

Fig. 58. Press push rod leather seal into end plate with lip of leather toward hydraulic cylinder side of end plate. Assemble push rod hydraulic seal parts (1) as illustrated; stop washer (2) with chamfered side down, seal cup (3) with lip of cup up, retainer washer (4) with flat side next to cup, small end of spring down. Place stop washer against spring and assemble snap ring in groove.

Fig. 59. Assemble stop washer (4) and retainer ring (5), using special tool T-25254. Dip piston cup or cups in brake fluid and assemble on piston (1). Insert piston into fitting (3) with hole end of piston next to stop washer (4). Place end plate on holding fixture. Use new copper gasket (2) on hydraulic fitting (3) without groove. Use new rubber seal gasket (2) on hydraulic fitting with groove. Assemble fitting into end plate and securely tighten with  $1\frac{1}{8}$ " socket wrench. When copper gasket (2) is used, fitting (3) should be tightened to 1100-1300 inch-pounds of torque.

Fig. 60. If vacuum piston has been disassembled to replace leather piston packing or other parts, reassemble piston and push rod as illustrated. Drill  $\frac{1}{16}$ " hole in bench and place push rod (10) in hole with threaded end up. Assemble piston parts as follows: Flat washer over threaded end of push rod. Larger diameter piston plate (7) with chamfered side of hole up. Guide rubber seal ring (6) over threads. Place assembly ring (8) of correct size over piston plate and assemble following parts: Leather packing (5) with lip of packing up; smaller diameter piston plate (4) with chamfered side of hole down. Cut cotton wicking (3) to required length and assemble against inner face of lip of leather packing; assemble expander ring (2) inside of felt with gripper points up and notch at loop end of expander ring under clip located near opposite end of expander ring; retainer plate (1) with cut-out portion over loop of expander ring; thread nut (9) onto push rod finger tight. Clamp hexagonal section of push rod in vise and securely tighten nut. Care must be taken to prevent retainer plate from shifting while tightening nut. Stake nut at two places.

Fig. 61. Place vacuum piston return spring over push rod with small end of spring next to vacuum piston and carefully guide push rod through leather seal in end plate. Use hook clamps illustrated

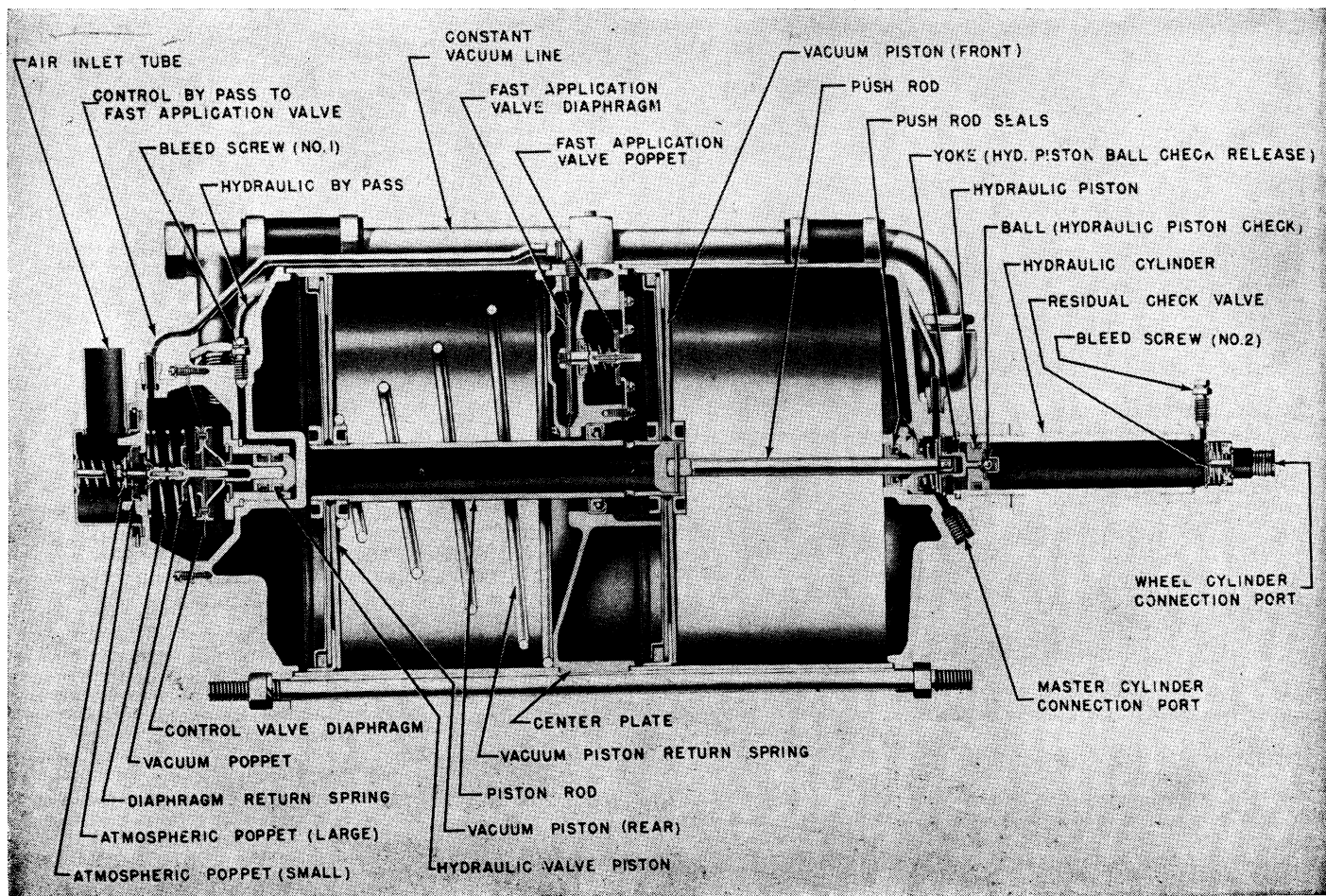


Fig. 50 Sectional view of Third Series Hydrovac with tandem piston

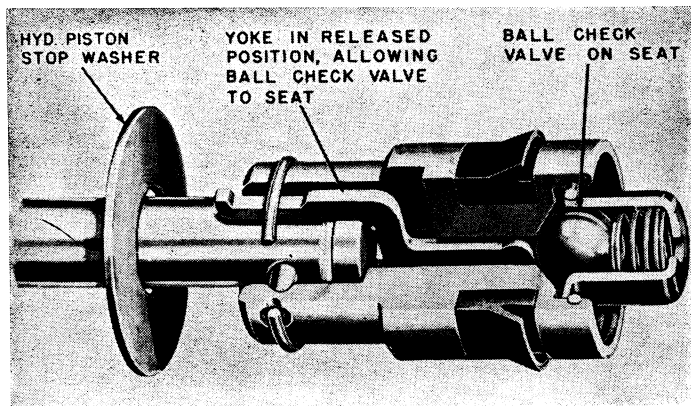


Fig. 51 Hydraulic check valve in applied position

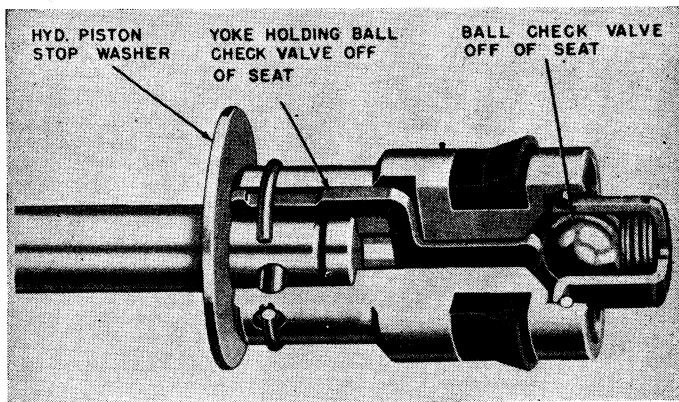


Fig. 52 Hydraulic check valve in released position

to hold end plate and piston together. Wash hydraulic cylinder piston parts in alcohol and assemble parts as shown in inset. Dip hydraulic piston cup (1) in brake fluid before assembly. Lip of piston cup extends toward check valve end of piston. Attach hydraulic piston (5) to push rod by means of retainer pin (3). Slide snap ring (4) or pin retaining spring (2) over hole in piston to hold retainer pin in place.

Fig. 62. If the Hydrovac is of the type having a residual line pressure check valve, assemble check valve parts

(2) into end cap (3) as illustrated in inset. Be sure lock ring (1) is in its groove. Place new gasket into end cap (7) and thread hydraulic cylinder (5) into end cap with milled flats next to end cap. Securely tighten. Assemble bleed screw (6) and thread lock nut (4) on cylinder to limit of threads.

Fig. 63. Place hydraulic cylinder end seal (2) in end plate against shoulder and guide lip of piston cup (1) into bore of cylinder (3). Thread cylinder in by hand until end of cylinder bottoms firmly against end seal. Do not tighten cyl-

inder or lock nut at this time.

Fig. 64. Place gasket (1) on end plate. The rubber ring gasket furnished in the repair kit is for use with Hydrovacs having a gasket retaining groove in the end plate; if the end plate is not grooved, use Vellumoid gasket of the correct size. Dip piston leather in vacuum cylinder oil and allow excess to drain off. Coat inside of cylinder shell with vacuum cylinder oil. Insert piston into cylinder by tipping piston as shown. Line up end plate with scribed marks previously made before disassembly. Attach hook

# VACUUM BRAKES

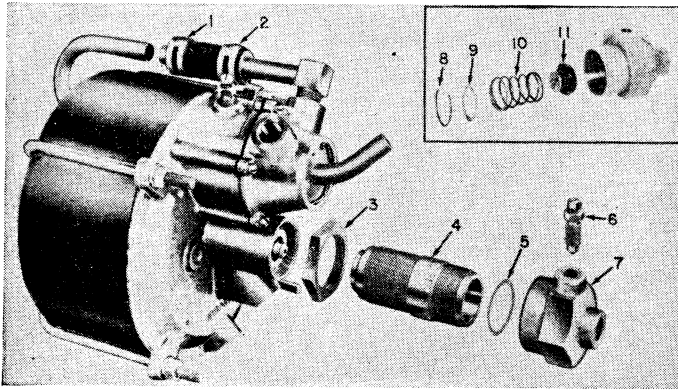


Fig. 53 Disassembly of hydraulic cylinder. Inset shows end cap with residual line pressure check valve

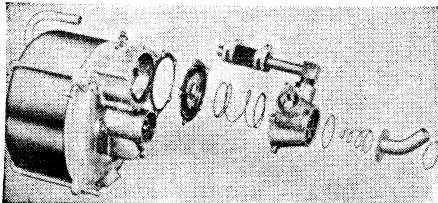


Fig. 54 Disassembly of vacuum control valve

bolts and tighten each bolt evenly until all are uniformly tight.

Fig. 65. Place guide pins (2) in end plate as shown and carefully assemble control valve parts. Remove guide pins one at a time and replace with a screw and lock washer. When assembling diaphragm (5), return spring (6) and control valve body (7), extreme care should be taken not to distort the diaphragm in compressing the spring. Assemble vacuum hose (4) in place and tighten clamps. Tighten hydraulic cylinder to align bleed screw (8) in end cap with bleed screw (1) in end plate. Tighten lock nut (9) securely.

## Tandem Piston Types Disassembly

Fig. 66. Remove control valve cover and valve parts (1). Some Hydrovacs have a vacuum by-pass tube which must be removed before the valve housing can be taken off. The inset shows removal of control valve poppets.

Fig. 67. Force vacuum cylinder pistons forward by inserting the special return spring compressing tool (1) through opening in end plate. Attach flange (2) of tool to end plate, using three of the valve cover screws. (Details for making tool shown in Fig. 68.) Loosen hydraulic cylinder check nut and remove cylinder (8). Remove hydraulic piston (7) from push rod by sliding snap ring (6) or push rod pin retaining spring back on piston, then remove retainer pin (10). Hold end cap (9) in vise and remove hydraulic cylinder. Disassemble residual line pressure check valve parts (4). Loosen vacuum hose clamps (3) and slide both hoses toward center of vacuum tube. Remove hydraulic by-pass tube (opposite side of Hydrovac from that illustrated).

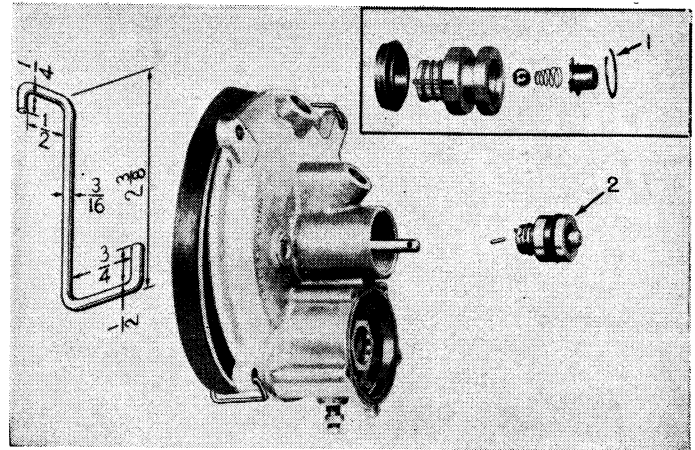


Fig. 55 Removal of hydraulic piston from push rod. Inset shows disassembly of hydraulic piston

Fig. 69. Remove four cylinder studs (6) and disassemble end plates (1) and (4), cylinder shells (2) and (3), and center plate (5).

Fig. 70. Compress piston return spring by forcing center plate and vacuum piston (1) together. Insert rod (2) through hole in piston rod to hold spring compressed as shown. Place assembly ring (SER-434) over piston (5) and remove piston rod nut (7), push rod pin (3) and push rod (6). Lift off piston assembly, keeping piston parts assembled within the assembly ring. Remove piston rod nut (4), press down on center plate to remove rod (2). Then remove center plate and piston return spring from piston and piston rod (1).

Fig. 71. This operation and the one shown in Fig. 72 apply only to Hydrovacs having the fast application valve in the center plate. Remove fast application valve cover. Hold valve shaft (2) with screw driver in slot provided when loosening nut (1) and disassemble diaphragm parts.

Fig. 72. Continue on Hydrovacs having fast application valve in center plate as follows: Turn center plate over and remove valve seat plate (1), gasket (2), poppet valve (3), and spring (4).

Fig. 73. On all models, place front end plate on bench, flat side down, and remove ring seal (1), snap ring (2), retainer washer (3), push rod seal spring (4), flange washer (5); push rod rubber cup seal (6), and guide washer (7). Drive out push rod leather seal (8).

Fig. 74. Place end plate over pins of holding fixture (inset). With holding fixture clamped in vise, remove retainer ring (1), using special tool T-25254, and remove stop washer (2). Using a 1/8" socket wrench, remove hydraulic valve fitting (3), push out hydraulic piston (4), and remove piston cups (5). Remove gasket (6) from fitting.

**NOTE**—Clean all metal parts in Bendix Metalclene Parts Cleaner. Dip all metal parts used in hydraulic system in alcohol before assembly. Use all parts furnished in Hydrovac Repair Kit for the model being serviced. Discard old rubber parts. If bore of vacuum cylinder shell is corroded or rusted, polish with fine emery cloth or steel wool. If badly pitted or

scored, the cylinder shell should be replaced.

## Assembly

Fig. 75. If the rear vacuum piston has been disassembled to replace leather piston packing or other piston parts, reassemble piston as illustrated. Drill a 1/8" hole in bench for piston rod. Thread nut (10) onto piston rod with flat side up. Drop piston rod (11) in hole of bench with by-pass hole end down. Assemble larger diameter piston plate (7) on piston rod with chamfered side of hole up. Guide rubber seal ring (5) over threads of piston rod. Place assembly ring (8) (SER-434) over piston plate and assemble piston parts as follows: Leather packing (6) with lip of packing up; smaller diameter piston plate (4) with chamfered side of hole down. Cut cotton wicking (3) to required length and assemble against inner face of lip of leather packing; assemble expander ring (2) inside of wick with gripper points up and notch at loop end of expander ring under clip located near opposite end of expander ring; retainer plate (1) with cut-out portion over loop of expander ring; thread nut (9) onto piston rod until flush with end of piston rod. Stake nut securely at two places. Clamp outer or staked nut in vise and securely tighten inner nut (10) against piston plate.

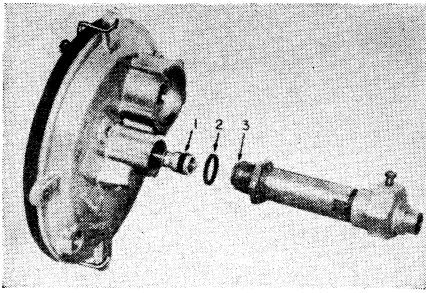
Fig. 76. Press leather seals (1) and (2) into place in center plate. Seal (1) should be flush with bottom of hole and seal (2) should rest against shoulder in center plate. On Hydrovacs without fast application valve seal (1) is not used and seal (2) should be pressed into center plate until flush with bottom of hole.

Fig. 77. Assemble fast application valve poppet into center plate. Be sure small end of return spring (4) is up. Place bullet nose tool (3) (T-25255) on poppet valve shaft at threaded end to prevent shoulder on valve shaft from damaging leather seal when assembling shaft. Install gasket, valve seat plate (1) with seat down and replace screws and lock washers.

Fig. 78. Turn center plate over and assemble diaphragm parts as illustrated, noting the following: Rounded edge of



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lic cylinder into end plate  
Fig. 63 Assembly of hydrau-

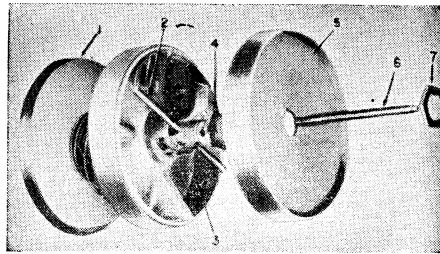


Fig. 70 Disassembly of push rod,  
vacuum pistons and center plate

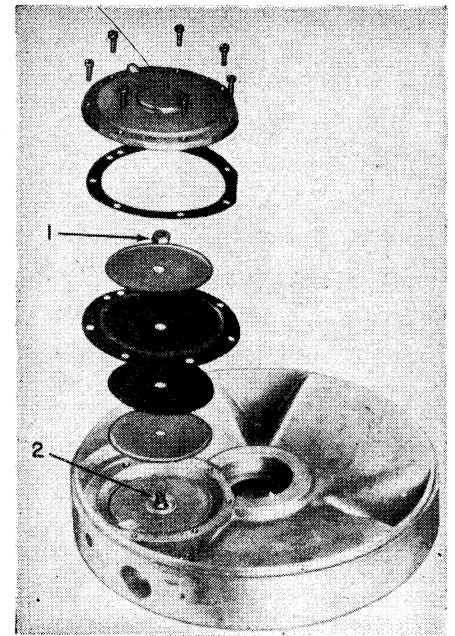


Fig. 71 Disassembly of fast application  
valve cover and diaphragm assembly

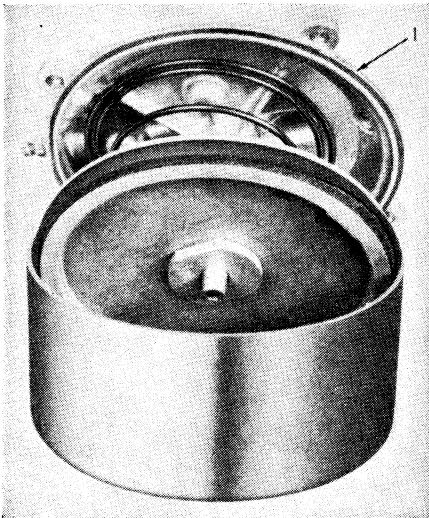


Fig. 64 Assembly of vacuum  
piston into cylinder shell

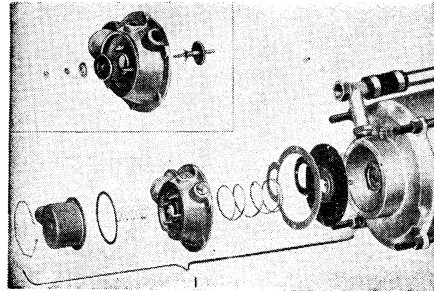


Fig. 66 Disassembly of vacu-  
um control valve and poppets

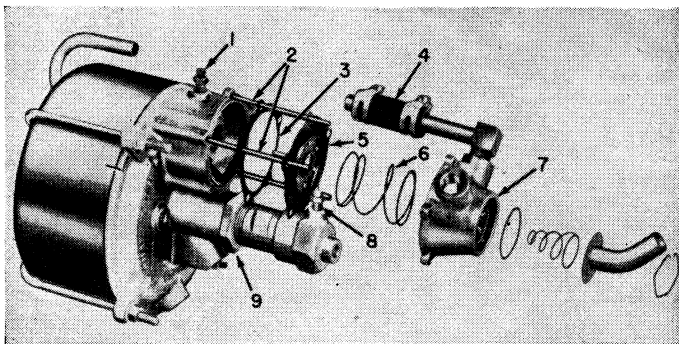


Fig. 65 Assembly of diaphragm, con-  
trol valve housing and air cleaner tube

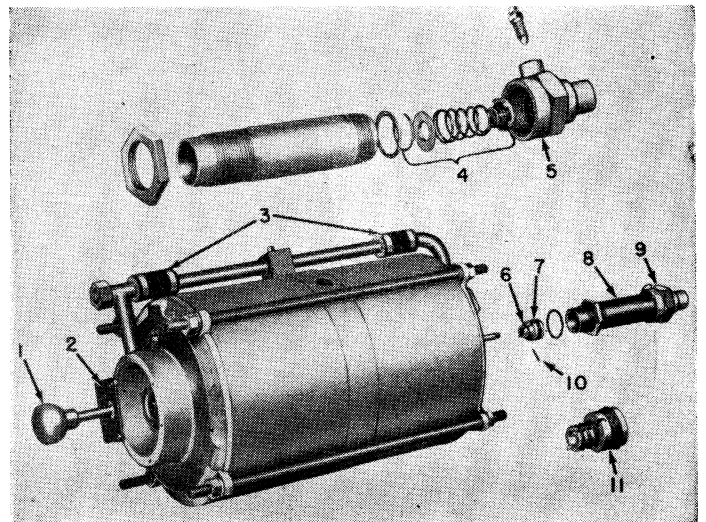


Fig. 67 Removal of hydraulic cylinder and piston  
(No. 11 shows piston with spring type retainer)

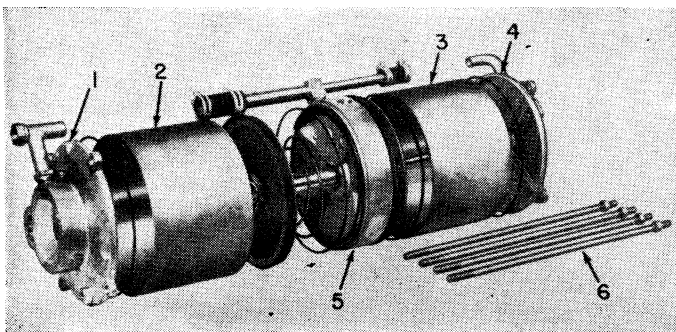


Fig. 69 Removal of cylinder studs, end plates,  
cylinder shells, center plate and pistons

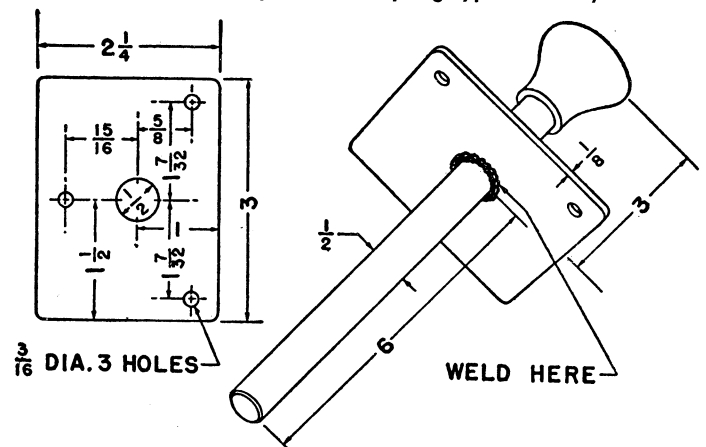
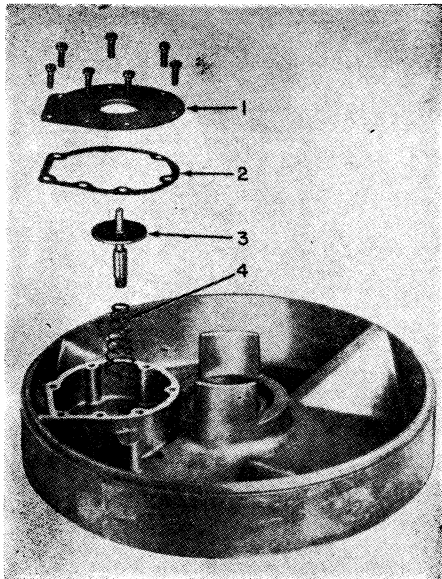
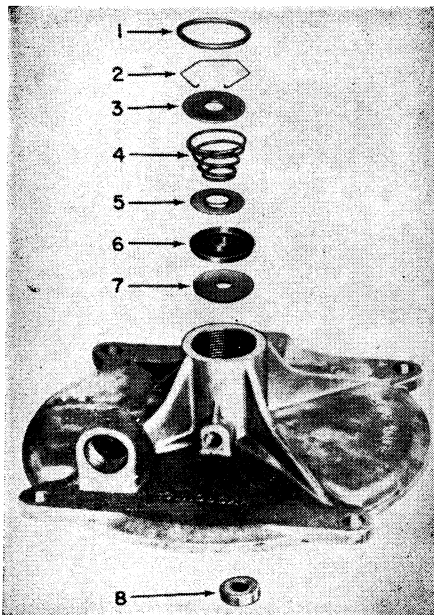


Fig. 68 Vacuum piston return spring compressing tool





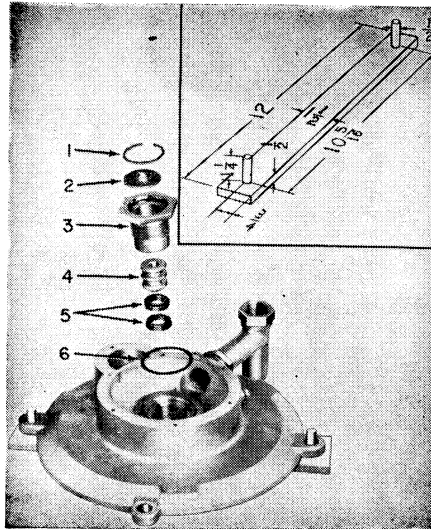
**Fig. 72 Disassembly of fast application valve seat and poppet**



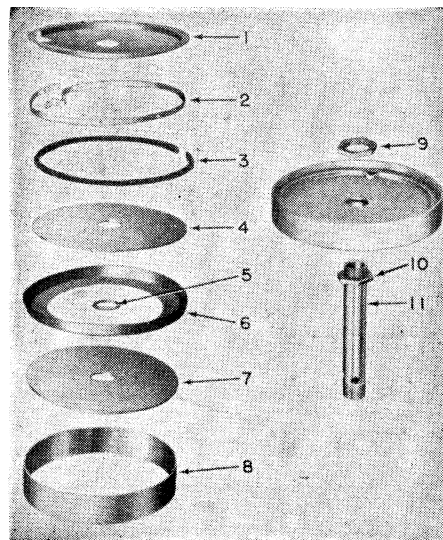
**Fig. 73 Disassembly of hydraulic cylinder end seal, hydraulic and vacuum push rod seals**

diaphragm plate (7) is up; place diaphragm gasket (6) on plate; assemble diaphragm (5) so that screw holes and by-pass hole lines up with holes in center plate (8); rounded edge of diaphragm plate (4) is down. Assemble nut (3), hold valve shaft with screw driver as nut (3) is tightened; stake nut at two places. Assemble cover gasket (2) and cover plate (1) with screws and lock washers.

Fig. 79. Place piston return spring (6) over piston rod with small end of spring next to piston. Carefully guide piston rod through leather seal in center plate (5), having piston stop flanges of center plate up. Press down on center



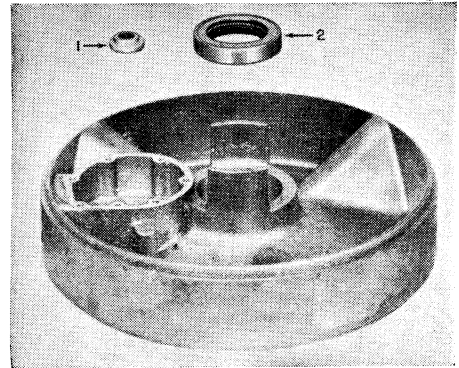
**Fig. 74 Disassembly of hydraulic control valve fitting and piston**



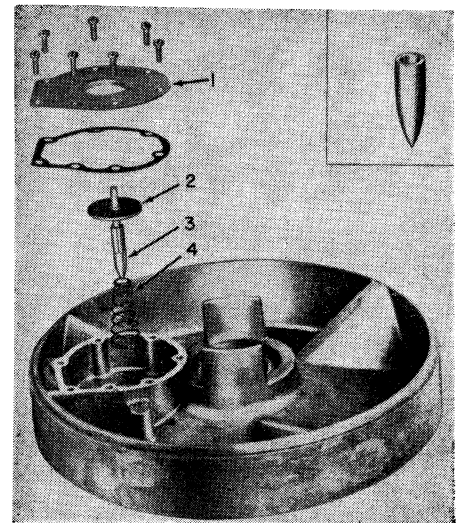
**Fig. 75 Assembly of vacuum piston and piston rod**

plate and insert rod (4) through hole in piston rod. Thread piston rod nut onto piston rod to limit of threads with flat side of nut up. If forward piston has been disassembled to replace leather piston packing or other parts, reassemble piston parts in assembly ring as shown in Fig. 75. Hold piston parts in assembly ring and turn assembly ring over. Remove outer or larger diameter piston plate (1) and seal ring (2). With assembly ring (3) still in place, guide remaining piston parts over end of piston rod up against piston nut. Carefully guide seal ring (2) over threads of piston rod and assemble larger diameter piston plate (1) over piston rod with chamfered side of hole down.

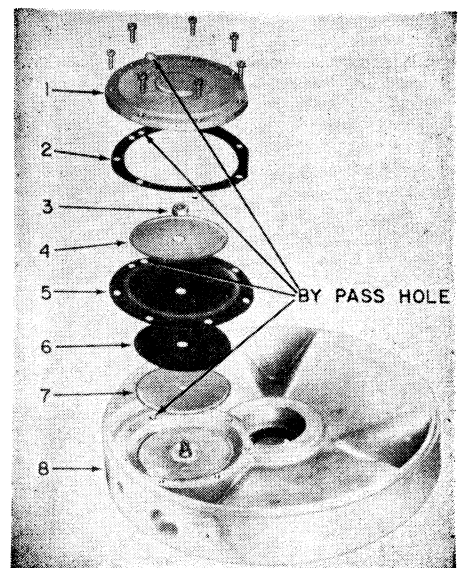
Fig. 80. Assemble large end of push rod (1) in end of piston rod and replace retainer pin (2). Thread piston rod nut (3) onto piston rod with flat side down until nut is flush with end of piston rod. Stake nut securely in two places. Hold



**Fig. 76 Installing fast application valve and piston rod seals in center plate**

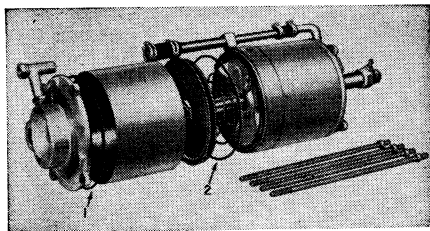


**Fig. 77 Assembly of fast application valve poppet and seat**

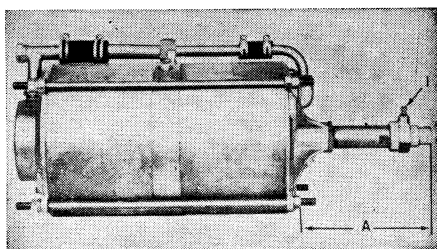


**Fig. 78 Assembly of fast application valve diaphragm and cover**

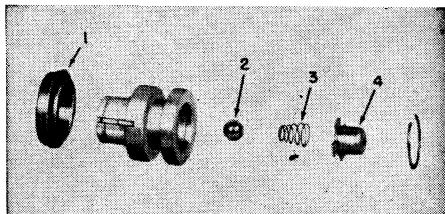




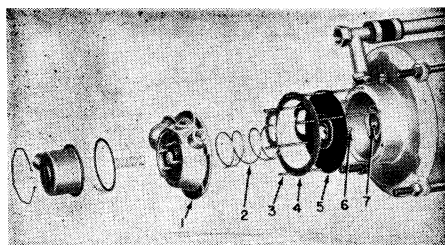
**Fig. 86** Assembly of rear cylinder shell, end plate and cylinder studs



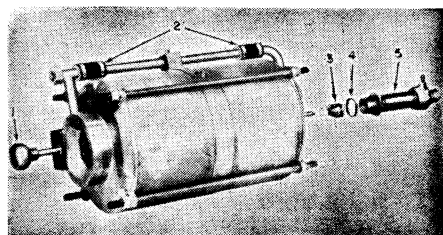
**Fig. 89** Cylinder stud to hydraulic cylinder end measurement



**Fig. 87** Assembly of hydraulic piston check valve and piston cup



**Fig. 90** Assembly of vacuum control valve diaphragm, valve housing and air cleaner cover



**Fig. 88** Assembly of hydraulic piston and cylinder assembly

of center plate. Guide push rod (4) carefully through seal in end plate. Align vacuum tube on center plate with vacuum tube on front end plate.

**Fig. 86.** Assemble rear cylinder shell and related parts. Assemble gasket (2) on center plate. Coat inside of cylinder shell with vacuum cylinder oil. Tip cylinder shell to about 45° to prevent damage to leather packing and assemble in position. Place gasket (1) on ledge of rear end plate. Align and assemble end plate. Install cylinder studs and tighten evenly.

**Fig. 87.** Assemble hydraulic piston parts, noting the following: Large end of spring (3) goes in retainer cup (4). Lip of piston cup (1) extends toward check valve ball (2). Dip piston cup (1) in hydraulic fluid before assembling.

**Fig. 88.** Assemble vacuum hose (2) and hydraulic by-pass tube (on opposite side of Hydrovac from that shown). Remove hydraulic cylinder (5) and insert spring compressing tool (1). Attach flange of spring compressing tool with three screws. Assemble hydraulic piston (3) to push rod, being careful that locking ring or retaining spring is in position over retainer pin. Assemble hydraulic cylinder end seal (4) in groove of end plate.

**Fig. 89.** Thread hydraulic cylinder into end plate by hand until dimension "A" corresponds to the measurement given for the Hydrovac being serviced. For Atlas models the dimension is  $7\frac{3}{4}$ "; Mogul models  $8\frac{1}{4}$ "; Dreadnaught models

$10\frac{5}{8}$ "—all measurements to be correct within plus or minus  $\frac{1}{2}$  turn. Align bleed screw located in end cap with bleed screw located in control valve, holding dimension "A" to the nearest half-turn. Securely tighten lock nut. Remove spring compressor tool.

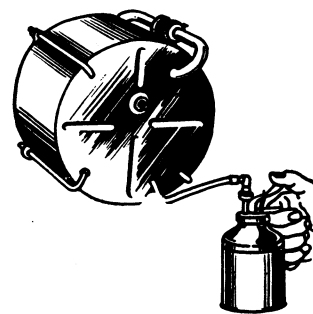
**Fig. 90.** Place guide pins (3) in end plate and carefully assemble parts. Remove guide pins one at a time and replace with a screw and lock washer. When assembling diaphragm (5), diaphragm gasket (4), return spring (2) and control valve body (1), extreme care should be taken not to distort the diaphragm in compressing the spring. Diaphragm stem (6) fits into hole of hydraulic control piston (7). If Hydrovac being repaired has a fast application valve, replace the fast application valve vacuum control tube.

## Lubrication

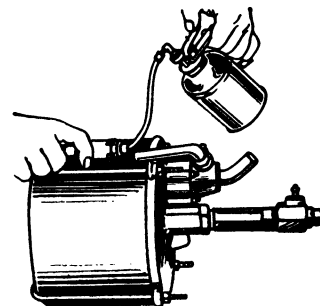
Do not lubricate a Hydrovac until it is permanently installed on the vehicle. If lubricated beforehand, handling of the Hydrovac may cause oil to flow into the hydraulic portion of the unit and ruin the rubber parts. Have engine shut off and brakes released when adding vacuum cylinder oil.

All Model C single or tandem piston Hydrovacs should be lubricated on a mileage or time basis. Lubricate all  $6\frac{3}{4}$ " Model C Hydrovacs every 20,000 miles or once a year whichever occurs first; all  $9\frac{1}{2}$ " single piston Hydrovacs every 10,000 miles or every six months whichever occurs first; all  $9\frac{1}{2}$ " tandem piston Hydrovacs every 20,000 miles or once a year whichever occurs first. Early type Model C Hydrovacs do not have lubrication plugs.

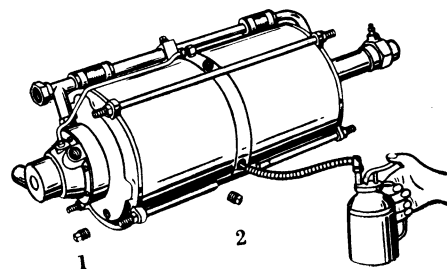
To lubricate single piston Hydrovacs with lubrication plugs, remove lubrication plug and inject vacuum cylinder oil through the fitting up to the point where the oil begins to run out of the port—



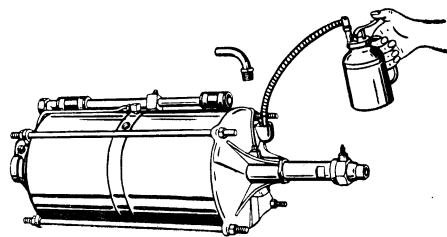
**Fig. 91** Single piston with lubrication port



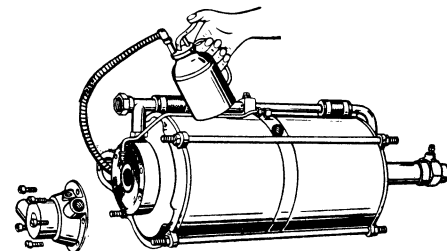
**Fig. 92** Single piston without lubrication port



**Fig. 93** Tandem piston with lubrication ports



**Fig. 94** Tandem piston without lubrication ports (lubrication of forward piston)



**Fig. 95** Tandem piston without lubrication ports (lubrication of rear piston)

# VACUUM BRAKES

See Fig. 91. Replace and tighten plug.

To lubricate single piston Hydrovacs without lubrication plugs, loosen hose clamps and slide hose on tube connecting control valve with vacuum cylinder shell. On 6 $\frac{3}{4}$ " diameter Hydrovacs slide hose toward control valve. On 9 $\frac{1}{2}$ " diameter Hydrovacs slide hose away from control valve end. Using gun type of oiler, inject specified quantity of vacuum cylinder oil into the Hydrovac through the control line tube. The spout of the oil gun should be inserted well down the bend of the tube to insure that all oil enters the vacuum cylinder—See Fig. 92. Use one ounce in all 6 $\frac{3}{4}$ " and two ounces in all 9 $\frac{1}{2}$ " single piston type Hydrovacs.

To lubricate tandem piston type Hydrovacs with lubrication plugs, remove pipe plugs (1) and (2)—See Fig. 93, and inject vacuum cylinder oil through each port up to the point where the oil just begins to run out of the port. Replace pipe plugs and securely tighten.

To lubricate the forward piston of tandem piston Hydrovacs without lubrication plugs, remove the vacuum line tube elbow—See Fig. 94, and inject two ounces of vacuum cylinder oil into the front chamber, using care not to direct the oil onto the push rod. Replace tube elbow and reconnect vacuum line.

To lubricate the rear piston, remove the control valve housing—See Fig. 95, and inject two ounces of vacuum cylinder oil through the passage in the rear end plate. Replace the control valve housing.

## Air Cleaner Service

The air cleaner should be inspected every 1,000 miles and disassembled for cleaning. Where operating conditions are unusually dirty, perform this service more frequently.

Remove air cleaner cover screw, remove hair filter element and screens and wash in cleaning solvent. Dry, then saturate with light engine oil. Reassemble and install.

Air cleaner hose should be inspected for damage, and hose clamps secured to prevent leakage.

## Vacuum Connections

Remove vacuum connection fitting from the intake manifold every 10,000 miles and inspect the elbow and vacuum line or tubing for possible obstruction. Also inspect hose fittings each 10,000 miles for tightness, and vacuum hose for damage or deterioration due to extreme conditions.

## Bleeding Hydrovac, Manual

Manual bleeding requires filling the master cylinder reservoir and pumping the brake pedal to force the fluid through the lines to expel air from the system. This operation must be done with the engine shut off and no vacuum in the power brake system.

With the master cylinder reservoir filled, open No. 1 bleed screw on the Hydrovac (see Figs. 49 and 50) and depress the brake pedal to expel air. When the brake pedal has reached the toe board, close the bleed screw before returning pedal to release position. Repeat this

procedure until solid fluid, free from bubbles, comes from the bleed screw. Check the master cylinder frequently to insure an ample supply of fluid.

Using this method, bleed No. 1 and No. 2 bleed screws on the Hydrovac and then proceed to the vehicle wheel cylinders.

## Pressure Bleeding

This operation must be done with the engine shut off and no vacuum in the power brake system. Make certain there is sufficient brake fluid in the bleeder tank before starting and that the pressure is from 10 to 30 pounds per square inch.

With bleeder tank prepared, fill master cylinder reservoir before attaching hose from bleeder tank to the reservoir. With pressure from the bleeder tank applied to the master cylinder, bleed the Hydrovac first, starting with the bleed screw on the control valve (bleed screw No. 1). When a solid stream of fluid (free from bubbles) is obtained, close bleed screw securely and then bleed the Hydrovac hydraulic cylinder (bleed screw No. 2). Finally, proceed to the vehicle wheel cylinders and bleed them in like manner.

## MODEL "C" DIAPHRAGM TYPE HYDROVAC

This device, Fig. 96, is a self-contained hydraulic-vacuum unit which consists of:

1. A vacuum power chamber which consists of a power diaphragm and a push rod that connects the power diaphragm to the hydraulic piston.
2. A hydraulic cylinder which contains a hydraulic piston and check valve.
3. A vacuum control valve which controls the power output of the vacuum power chamber in accordance to the hydraulic pressure developed within the brake master cylinder.

## Disassembly

Use care in handling hydraulic system parts to prevent their coming into contact with mineral oil or greases. Do not handle hydraulic cups and seals with greasy hands.

Loosen check nut and unscrew hydraulic cylinder from end plate. Remove piston, cup and spring. Clamp end cap in vise to loosen hydraulic cylinder. Then remove check nut seal, check nut, hydraulic cylinder and gasket from end cap.

Scrub lines across two halves of diaphragm chamber and across end plate and control valve housing to assure correct reassembly.

Loosen hose clamps on control tube and slide hose toward control valve end. Remove end plate attaching nuts and lockwashers. Separate end plate assembly from vacuum power chamber and remove return spring. Remove snap ring, guide bearing, tube seal, push rod seal and stop washer from end plate.

Remove control valve housing and valve parts starting with lock ring. Remove control valve piston fitting lock ring and washer. With a socket wrench,

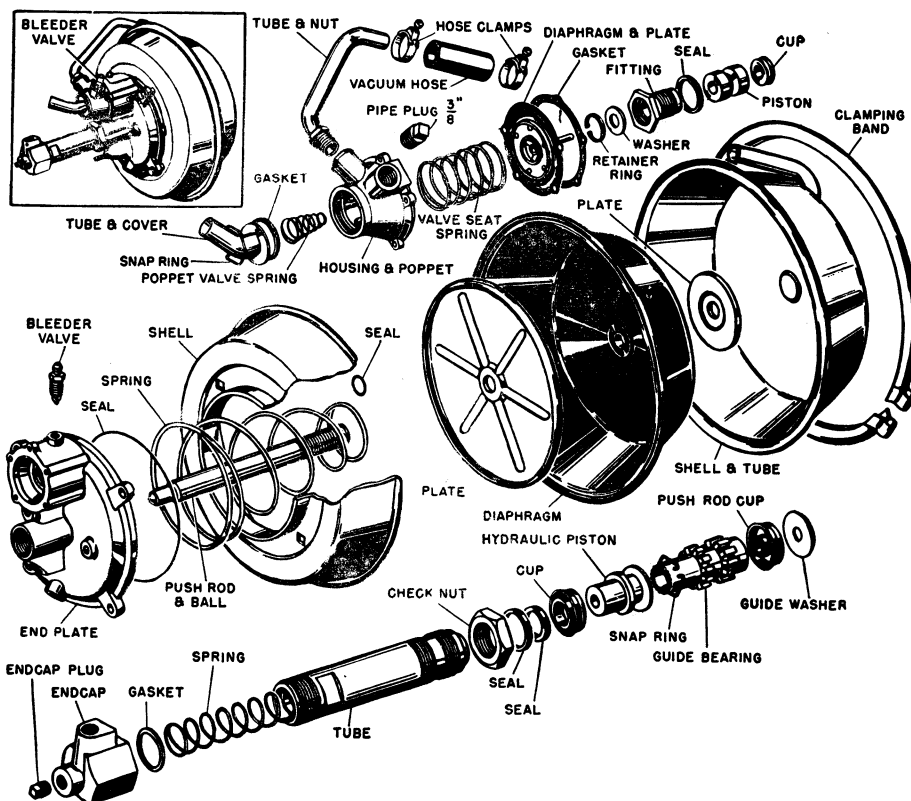


Fig. 96 Bendix Diaphragm Type Hydrovac

# VACUUM BRAKES

remove fitting and press out piston. Remove cup from piston and seal ring from fitting.

Remove nut, lockwasher and bolt from clamp band and remove band. Remove diaphragm shell, diaphragm and push rod. Drive out attaching bolts and remove seals.

Clamp push rod nut in vise and remove nut, cupped washer, diaphragm, diaphragm plate and guide washer. If replacement of push rod is necessary, remove nut from push rod.

## Cleaning

All parts that are to be reused should be thoroughly cleaned by immersion in an approved parts cleaner. After cleaning, those parts which come into contact with hydraulic brake fluid should be re-washed in clean alcohol before assembly. Use all parts furnished in the Hydovac Repair Kit. Discard all old rubber parts.

## Reassembly

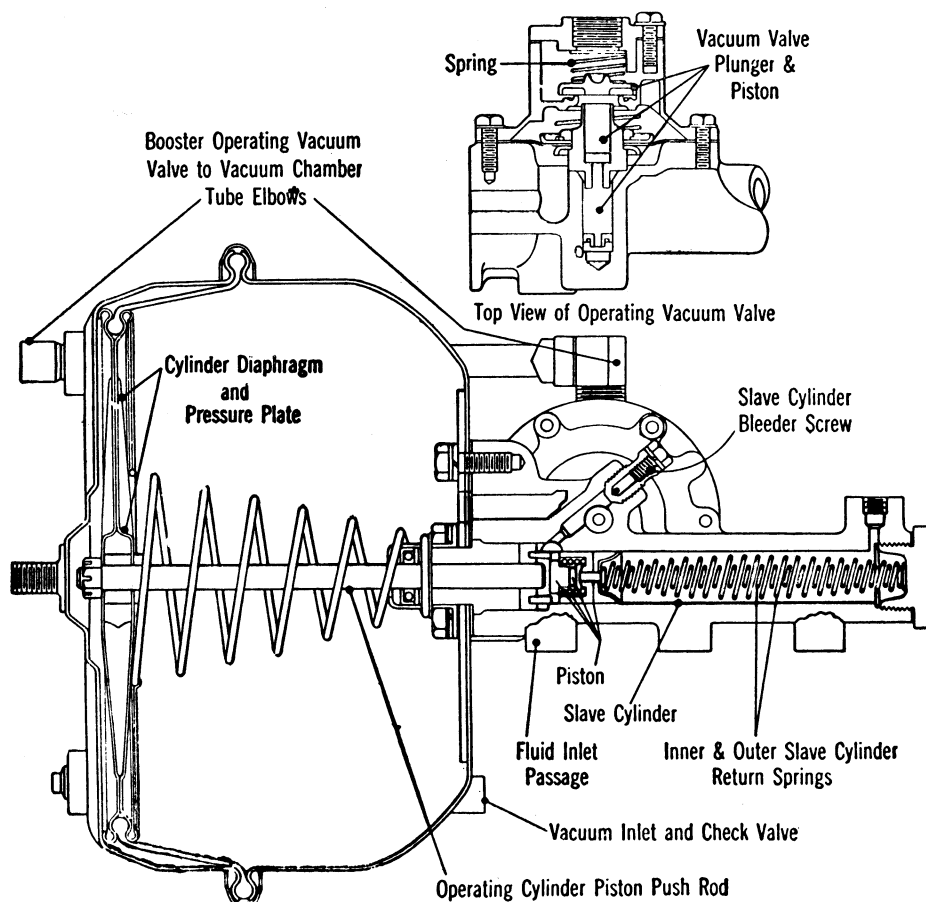
Thread push rod nut onto push rod to limit of thread. Assemble guide washer; diaphragm plate with flat side next to diaphragm; diaphragm with cupped side next to diaphragm plate; large washer with concave side next to diaphragm and nut. Securely tighten nut and stake in place.

Install new rubber seals on bolts and assemble bolts in shell; stake bolts in shell. Place rear shell on bench and assemble diaphragm and push rod assembly and front shell. Align shells to scribe marks and bead on diaphragm with rim of shells. Assemble clamp band over rim of shells and assemble bolt, washer and nut. Securely tighten nut.

Dip piston cup in brake fluid and assemble on piston with lip of cup away from hole end of piston. Insert piston in fitting from threaded end with hole end of piston first. Place seal on fitting and screw fitting into end plate. Tighten fitting with a socket wrench. Install washer and lock ring in fitting (Truarc pliers No. T-25254 is recommended for this operation). Examine poppets in control valve; if damaged replace with Poppet Replacement Kit. Then assemble control valve parts as shown, noting the following: Stem of diaphragm goes into hole of valve piston; end of spring goes within rim of diaphragm flange; line up valve housing and end plate to scribe marks; small end of spring goes in recess of poppet.

Install new ring seal in groove of end plate flange. Place small end of return spring over guide washer of diaphragm. Align end plate and diaphragm chamber shells to scribe mark and attach end plate to diaphragm chamber, using washers and nuts. Tighten nuts securely. Slide control line hose over control tube and tighten hose clamps. Assemble stop washer over end of push rod (chamfered side first), push rod seal cap with flat side next to washer, hydraulic cylinder tube seal, push rod guide bearing with serrated end up. Press guide bearing down in end plate over push rod and assemble snap ring in groove of end plate.

Thread check nut onto hydraulic cylinder tube to limit of thread. Assemble



**Fig. 97 MIDLAND vacuum booster with single diaphragm.** This device allows the vehicle master cylinder to perform initial braking. After pressure in the system reaches 40 lbs., air is admitted to the power chamber and the diaphragm forces the slave cylinder forward to boost the pressure to wheel cylinders

check nut seal ring over thread against check nut and thread hydraulic cylinder tube into end plate (finger tight). Dip piston cup in brake fluid and assemble cup onto piston with lip of cup toward small diameter end of piston. Slide end of return spring over small end of piston and insert piston and spring in hydraulic cylinder. Install new gasket in end cap and thread end cap onto cylinder tube. Hold end cap in a vise and securely tighten cylinder tube into end cap, using open end wrench on flats of cylinder tube. Align outlet of end cap with bleed screw in control valve body and tighten check nut securely.

## MIDLAND BRAKE BOOSTER

**Fig. 97**—The vacuum chamber is divided into two halves which are held together by a clamping ring. The outer edge of the diaphragm is clamped between the two halves of the chamber. A push rod is fastened to the diaphragm and extends into the slave cylinder and butts against the slave cylinder piston.

The vacuum control valve is actuated by hydraulic pressure from the brake master cylinder piston.

The slave cylinder is somewhat similar to the brake master cylinder in that it contains a piston, piston cup and a spring to force the piston back when the brakes are released. The piston is made in two parts, one inside the other. A coil spring inside the outer half tends to force the two halves apart, the inner half being prevented from coming entirely out of the outer half by a snap ring.

When it is desired to use the tractor brake pedal to operate both the tractor and trailer brakes, a synchronizing valve should be used to control the trailer brakes. This valve properly synchronizes the tractor and trailer brakes. If it is not used, the tractor brakes will not only start to brake before the trailer but also most of the braking will be done by the tractor brakes.

The valve is not necessary when a hand control is used to control the trailer brakes.

## Operation

A tube from the engine intake extends to a check valve and then to the front side of the vacuum chamber so that vacuum is present on the slave cylinder side of the vacuum chamber diaphragm at all times that the engine is running.

# VACUUM BRAKES

A tube from the rear side of the vacuum chamber extends to the vacuum control valve and, when the brakes are not applied, there is an open passage through the control valve to the front side of the chamber. Thus, when the brakes are not applied, the two sides of the chamber are directly connected and there is vacuum present on each side of the diaphragm.

A brake tube extends from the regular master cylinder to the vacuum control valve. When the brakes are applied, brake fluid is forced through a passage in the control valve to a space under the control valve diaphragm piston. The pressure then moves the piston against the air intake valve, closing the vacuum passage and opening up an air passage to the rear side of the vacuum chamber.

The difference in pressure on each side of the chamber diaphragm—vacuum on one side and air on the other—forces it toward the slave cylinder.

At the time the brakes are first applied, brake fluid is forced through passages in the control valve and slave cylinder into the space between the two halves of the slave cylinder piston and through a hole in the piston into the slave cylinder and brake lines to the wheel brake cylinders.

As the chamber diaphragm push rod moves into the slave cylinder, it presses the inner half of the piston into the outer half, closing the hole in the piston and trapping the brake fluid in the slave cylinder and brake lines. Then as the chamber diaphragm push rod continues to move the piston, the brakes are applied.

If at any time the booster does not function when the brake pedal is depressed, the brake fluid will simply pass through the hole in the slave cylinder piston and pressure can be applied through the master cylinder the same as if there was no booster on the vehicle.

When the brake pedal is released, a spring forces the vacuum control piston back, closing the air passage and opening the vacuum passage to the rear side of the vacuum chamber. The diaphragm is pushed to the rear end of the chamber by a spring, thus relieving pressure on the slave cylinder piston and releasing the brakes.

## Testing for Leakage

1. Depress brake pedal with full pressure and, while holding the pedal in this position, start the engine. The pedal should then move downward. If not, disconnect the manifold-to-booster chamber tube at the booster. Insert a vacuum gauge and reconnect the tube. Start the engine and check the vacuum—which should be 18 to 21 inches. If normal, the difficulty is located in the booster unit.
2. Remove the pipe plug from the rear half of the booster chamber and install a vacuum gauge.
3. With engine running, depress brake pedal with sufficient pressure to show a zero reading on the vacuum gauge. Shut off the engine and hold the pedal in this position for one minute. A kickback of the pedal indicates a vacuum leak. Do not attempt to locate the leak until step

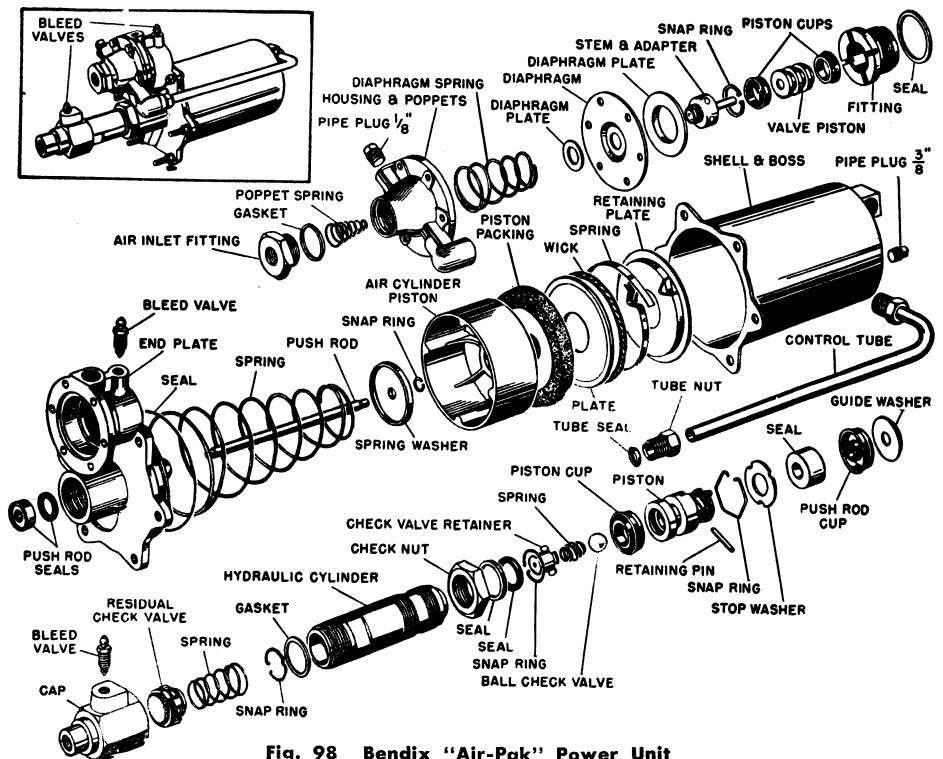


Fig. 98 Bendix "Air-Pak" Power Unit

4. Start the engine to create vacuum in the system. Then stop the engine and observe the vacuum gauge—the drop in vacuum should not be more than one inch per minute. If more than this, a vacuum leak is present. Leakage in test No. 3 but not in No. 4 indicates that the booster unit itself is at fault. Leakage in tests 3 and 4 may be located in the check valve on dash, vacuum tube connections, or booster unit itself.

## Disassembly

1. Remove large nut at end of slave cylinder and remove piston spring and metal cup.
2. Scratch mark both halves of vacuum chamber so that they can be assembled together in their original position.
3. Punch mark flanges of control valve and slave cylinder (marks opposite each other) so that they can be assembled together in their original position.
4. Remove control valve-to-vacuum chamber tube.
5. Remove ring which clamps two halves of vacuum chamber together and remove rear half of vacuum chamber and diaphragm.
6. Remove screws which fasten front half of vacuum chamber to slave cylinder. Remove seal retainer and front half of vacuum chamber.
7. Remove screws holding valve cover to control valve and take off cover. Lift out valve spring and air valve.
8. Remove control valve. Lift off diaphragm spring and diaphragm.
9. Remove rubber piston seal from rear end of slave cylinder.

10. Using the vacuum chamber diaphragm push rod, push slave cylinder piston and rubber piston cup out of front end of cylinder.

## Reassembly

Reverse the order of the disassembly procedure to reassemble, being sure to line up the two halves of the vacuum chamber as well as the control valve and slave cylinder according to the marks made prior to disassembly.

The control valve diaphragm and vacuum chamber diaphragm can be installed in any position.

## BENDIX AIR-PAK POWER UNIT

The Bendix Air-Pak is a combination compressed air, hydraulic power brake unit for use on vehicles having hydraulic brakes and a source of compressed air for brake operation. The device consists of three basic units, Fig. 98.

1. A compressed air cylinder, which includes an air pressure-operated piston and a push rod.
2. A hydraulic cylinder, which includes a hydraulic piston with a built-in check and a residual check valve at the output end of the cylinder.
3. An air pressure control valve, which includes a hydraulic pressure-operated piston, an air pressure poppet valve, an atmospheric pressure poppet valve, and an air pressure control diaphragm.

## Principles of Operation

As the brake pedal is depressed, fluid

is displaced under pressure by the master cylinder piston to the hydraulic cylinder and to the hydraulic piston chamber of the control valve of the "Air-Pak". When sufficient pressure develops, the hydraulic piston of the control valve moves, closing off the atmospheric poppet valve and opening the air pressure valve to admit air under pressure to the air pressure side of the "Air-Pak" air cylinder.

The air pressure, acting upon the air cylinder piston, is transmitted through the push rod to the hydraulic cylinder piston, moving the piston in the applied direction. As soon as the piston begins to move, the check valve in the hydraulic piston closes to prevent the return of fluid to the master cylinder.

Any increase in fluid pressure or piston travel is transmitted to the wheel cylinder pistons to actuate the brakes. The hydraulic pressure at the wheel cylinder piston is the sum of the pressure developed by the air power cylinder piston.

A diaphragm in the control valve, which is subject to atmospheric and application air pressure, controls the degree of braking by setting up an opposing force which resists the movement of the control valve hydraulic piston in the applied direction.

With the release of pressure applied to the brake pedal, the hydraulic pressure within the master cylinder and control valve piston cavity decreases, causing the air pressure poppet to close and the atmospheric poppet to reopen. As the atmospheric poppet opens, the pressure on both sides of the air cylinder pistons are again balanced. The return spring then returns the air cylinder and hydraulic cylinder pistons to their released positions.

As the hydraulic cylinder piston approaches its fully released position, the check valve in the hydraulic piston reopens to permit the fluid displaced by the hydraulic piston of the "Air-Pak" to return to the master cylinder, releasing the brakes.

## Disassembly

Use extreme care in handling hydraulic system parts to prevent their coming in contact with mineral oil or greases. Do not handle hydraulic piston cups or seals with greasy hands.

1. Loosen control tube nuts and remove control tube and gasket.
2. Scribe marks across end plate and cylinder shell and also across end plate and control valve housing to assure correct reassembly.
3. Remove end plug, gasket and spring from control valve housing. Then remove six capscrews, lift or pry off housing and remove return spring, diaphragm assembly and stop washer.
4. Clamp nut in vise and with a drift inserted through hole in adapter, remove adapter, diaphragm and washer.
5. Clamp end cap firmly in vise and loosen check nut. Then remove six nuts, washers and bolts and the short bolts.
6. Tap cylinder shell with soft hammer to break bond between end plate and cylinder shell and remove shell and

air piston.

7. Clamp nut of air piston in vise. Place end of push rod in hole of piston and compress return spring sufficient to assemble hook clamps (5 $\frac{5}{8}$ " long) over piston and end plate.
8. With spring held compressed, remove hydraulic cylinder assembly from end plate.
9. Compress retainer spring on piston, remove retainer pin and hydraulic piston from push rod.
10. Press down on end plate, remove hook clamps, end plate, spring and push rod. Then remove piston from vise.
11. To disassemble piston, remove snap ring, retainer cup, spring, ball and then remove piston cup from piston.
12. Clamp end cap rigidly in vise and loosen hydraulic cylinder tube with an open end wrench. Then remove check nut seal, check nut, hydraulic cylinder tube and copper gasket.
13. To dismantle the residual check valve, remove snap ring, stop washer, return spring, residual check valve and bleed screw.
14. Loosen control valve piston fitting with a suitable offset wrench. Then remove lock ring, fitting and gasket.
15. Remove hydraulic tube seal, snap ring, stop washer, seal retainer, push rod cup and stop washer.
16. Remove push rod leather seal and gasket.
17. To remove seal, thread a  $\frac{1}{4}$ " pipe top into seal and drive seal out from opposite end.
18. Press out control valve piston from fitting and remove cups from piston.

## Cleaning & Inspection

Clean all metal parts except the control valve housing and poppets in an approved parts cleaner. After cleaning, wash all hydraulic system parts in clean alcohol before assembly. When overhauling an "Air-Pak", always use a repair kit.

Inspect all parts for excessive wear or damage. If the bore of the air cylinder shell is corroded or rusted, polish with fine emery cloth or steel wool. When cylinder shell is badly scored or pitted, it should be replaced.

Inspect the condition of poppets and seat in control valve housing. If either are damaged, replace the control valve housing and poppets assembly.

## Reassembly

1. Assemble new rubber gasket and leather seal in end plate. Lip of leather goes next to gasket.
2. Assemble stop washer with chamfered side next to seal; push-rod cup, with flat side next to stop washer; seal retainer with counter-board side next to cup; stop washer; snap ring and rubber seal.
3. Wash control valve piston cups, fitting and piston in clean alcohol and then dip cups in brake fluid. Then assemble cups on piston. **NOTE**—Cut with red dot goes on hole end of piston.
4. Insert piston and cups in fitting from end opposite lock ring groove.

Use new gasket on fitting and securely tighten fitting into end plate. Replace lock ring in fitting.

5. Assemble residual check valve in end cap. Place new copper gasket in end cap and then thread hydraulic cylinder tube into end cap with milled flats on tube next to end cap.
6. With end cap held firmly in vise, securely tighten cylinder tube into end cap.
7. Assemble check nut and seal on cylinder tube and turn nut down to end of threads.
8. Dip hydraulic piston cup in brake fluid and assemble cup into piston with lip of cup toward check valve.
9. Clamp air piston nut firmly in vise and insert lock ring end of push rod in hole of piston.
10. Assemble retaining washer on push rod with cup side up and assemble return spring with small diameter end next to retainer washer.
11. Guide end plate over push rod, compress return spring and hold spring compressed with the hook clamps used for disassembly.
12. Compress retainer pin spring on piston and attach piston to push rod with retainer pin. Make certain pin is held in position by spring.
13. Carefully guide hydraulic cylinder over lip of piston cup and thread cylinder into end plate (hand tight only).
14. Compress return spring and remove hook clamps.
15. Saturate air piston leather and cotton wicking in Bendix Vacuum Cylinder oil. Allow excess oil to drain off. Also apply a light coating of oil to inside of cylinder shell.
16. Install new end plate gasket in groove of end plate. Place piston on end of push rod.
17. Assemble air cylinder over piston and align to scribe marks. Attach air cylinder to end plate. Tighten each bolt evenly until all bolts are uniformly tight.
18. With check nut loose, adjust length of hydraulic cylinder to the following dimensions, measuring from extreme end of end cap to end plate:

Part No.	Dimension*
375440	7 $\frac{1}{2}$ "
375756	7 $\frac{1}{2}$ "
375757	10 $\frac{1}{4}$ "
375817	7 $\frac{1}{2}$ "
375844	10 $\frac{1}{4}$ "
375901	7 $\frac{1}{2}$ "

\*Plus or minus  $\frac{1}{8}$ ".

19. Assemble nut, washer, diaphragm and adapter (flat side of washer goes next to nut, concave side of diaphragm goes next to washer). Hold nut in vise and securely tighten adapter.
20. Thread two guide pins into end plate (make from  $\frac{1}{4}$ -20 screw, 2 $\frac{1}{2}$ " long). Place stop washer in recess of end plate (flat side out) and assemble diaphragm, return spring and control valve housing, with housing aligned to scribe marks.
21. Assemble capscrews and lockwashers. Tighten screws uniformly.
22. Place new gasket on fitting. Assemble small end of spring over end

# VACUUM BRAKES

of air poppet and thread fitting into end plate and tighten fitting.

23. Place new gasket on air control tube and attach tube to control valve and air cylinder, securely tightening nuts.

## Lubrication

Do not lubricate "Air-Pak" until it has

been permanently installed on the vehicle. This is a safeguard against lubricating oil entering the hydraulic section of the "Air-Pak" which might cause damage to the rubber cups and seals.

The "Air-Pak" should be lubricated every 10,000 miles or every six months, whichever occurs first, with Bendix Vacuum cylinder oil.

To lubricate the "Air-Pak", remove the 1/8" pipe plug from the air cylinder shell and inject the oil through the fitting up to the point where the oil begins to run out of the port. Replace and tighten the plug.

*During lubrication, the engine should be shut off and the "Air-Pak" should be in the released position.*

# ALLISON AUTOMATIC TRANSMISSION

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## DESCRIPTION

This transmission, Fig. 1, called Powermatic by Chevrolet and Transmatic Drive by Ford, and Torqmatic by Dodge, is a hydraulically-operated automatic transmission with six forward gear ratios and one reverse ratio. It is made in two versions, a lighter unit for medium duty trucks and a heavier one for heavy duty trucks. The two models differ chiefly in the hydraulic control system.

The transmission consists basically of a torque converter, a planetary gear train and a hydraulic control system for shifting gears.

The torque converter operates as a hydraulic torque multiplier and a fluid coupling between the truck's engine and the gear train. The torque multiplying phase of the converter operates when the truck starts moving from a standstill and when a heavy load slows down

the truck. When no torque multiplication is needed, the fluid coupling phase starts operating automatically.

If the truck should slow down and the converter turbine resists turning, such as when climbing hills or driving in stop-and-go traffic, the converter operation automatically changes from a fluid coupling phase to a torque multiplication phase. This phase occurs after the gears have shifted into third gear ratio (when driving in Drive or Intermediate ranges) or first gear ratio (when in Low range).

At certain engine speeds when the action of the torque converter is no longer needed, an automatic lockup clutch in the converter locks the engine directly to the gear train for greater efficiency, Fig. 2. The hydraulic system which operates the lockup clutch automatically disengages the clutch each time an auto-

matic or manual upshift or downshift is being made.

A pedal-operated hydraulic retarder in the transmission assists the service brakes in controlling the truck's speed during long downhill braking or when slowing down in stop-and-go traffic. When the retarder pedal is depressed and the retarder valve opens, transmission fluid flows into the retarder cavity located between the converter and transmission housings. The cavity contains a rotor, which is connected to the turbine output shaft, and stationary reaction vanes on both sides of the rotor. When the fluid fills the cavity, it churns against the reaction vanes and slows down the rotor. The retarding effort is transmitted to the drive line and slows down the truck.

The retarder will continue to operate

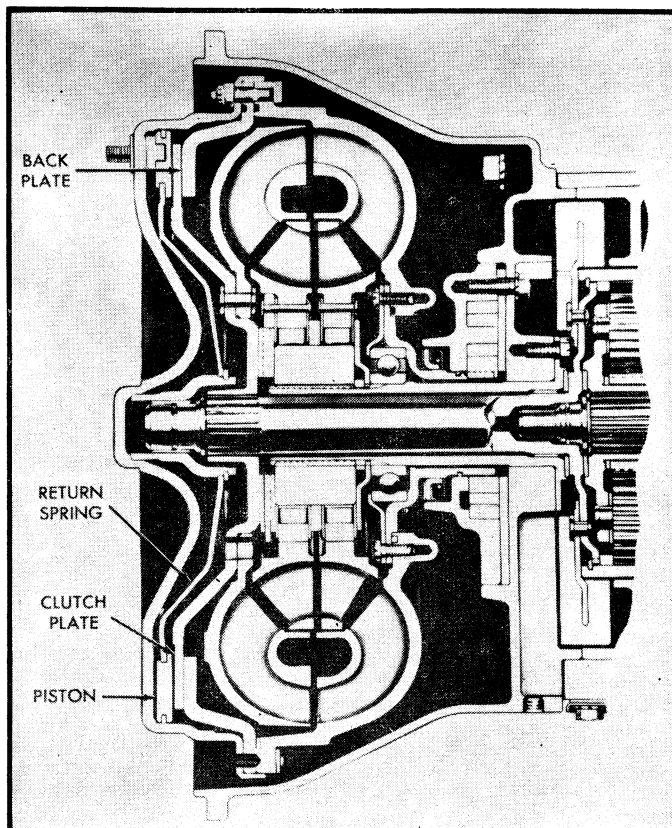


Fig. 2 Lockup clutch