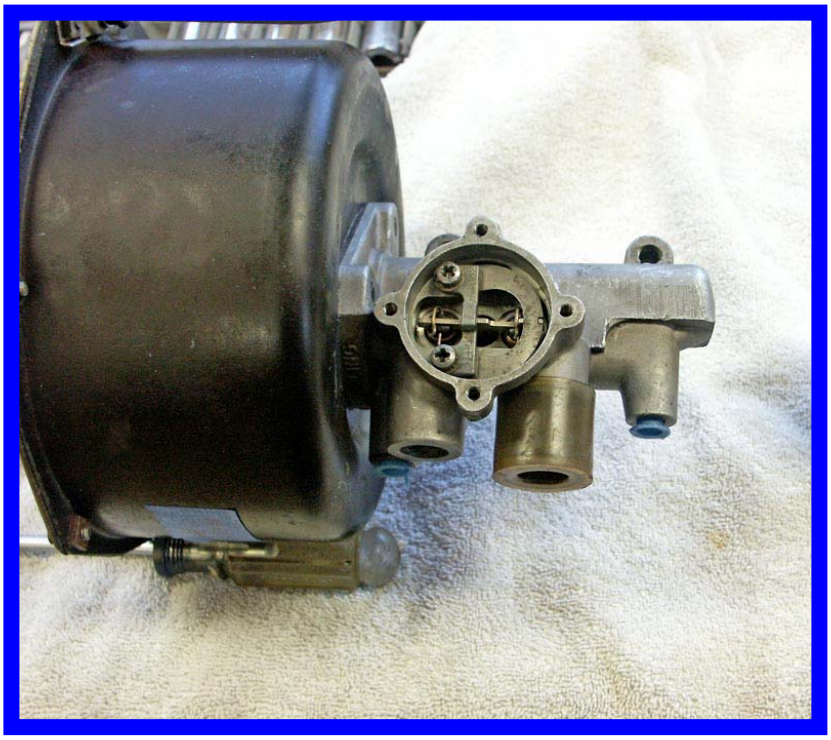
LAMBORGHINI 400 GT 2+2

REBUILDING, THE GIRLING BRAKE BOOSTER ASSEMBLY.



By Jack Riddell
Owner since 1972 of 400 GT 2+2, serial 1033.

Author's disclaimer: I have written this narrative for the purpose of passing on my experiences in performing brake booster rebuilds on my own car. It is written to aid other owners of the classic Lamborghinis and serve as a guide for doing your own work. Constructive feedback from users of this manual is welcomed. Contact me at lambojack@cox.net with your comments.

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Using this Interactive Electronic Technical Manual (IETM)

This manual was originally created in MS Word® and later converted to a Portable Document Format (PDF). The PDF format was selected because is retains my original hyperlinks and it is viewable in the readily available Abobe Reader® on virtually any computer. Hyperlinks are used throughout the manual. Any place where you see a reference where the text color is blue and underlined, you have a hyperlink. Left clicking on such text will immediately jump to the referenced table or figure (or in some cases – narrative). All the Table of Contents entries are hyperlinks as are the List of Figures and List of Tables. To return to the point of the original hyperlink, use the "back" arrow key on the top menu bar in Abode Reader.

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Rebuilding the Girling Mk II Brake Booster Assembly

Before you begin any disassembly of the booster, you should understand how it works. The following paragraphs and figures are provided to fulfill that purpose. In addition, several of the common booster-related problems you may encounter are explained below.

Background

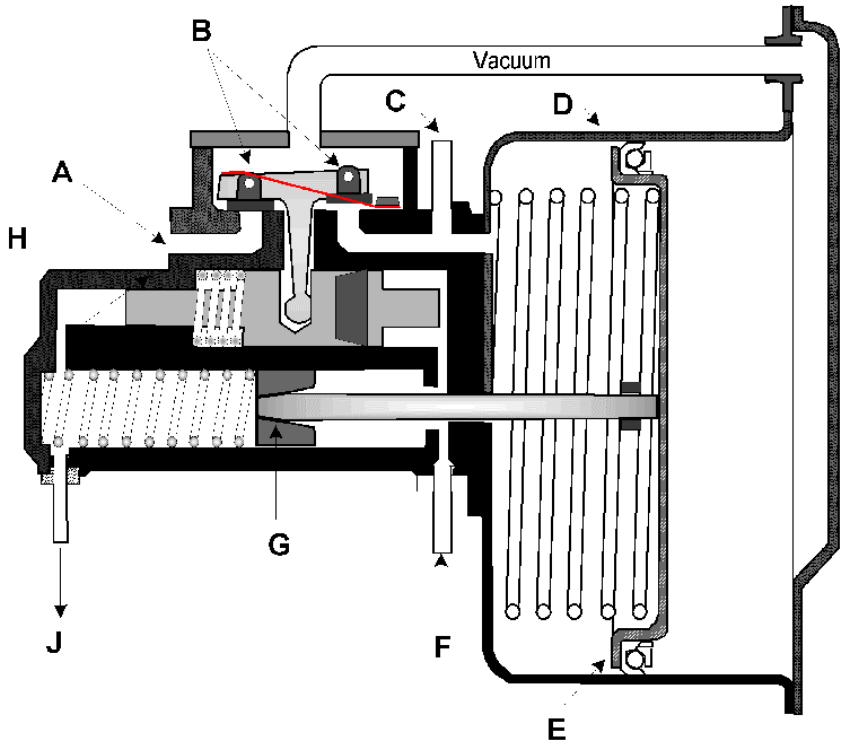
Whenever the owners of the early Lamborghini models get together at events, one topic that invariably comes up related to problems with the car's brake system. More often than not, the complaints focus on ***too much*** stopping rather than not enough. One of the more vexing of those problems is the one where the brakes, once applied, stay applied. Another common problem is when the brakes self-apply with no action of the driver. Either of these can result in premature graying of the hair.

How it Works

There is a comprehensive narrative dealing with the operation of the Mk 2 Girling Brake Booster on the internet at http://www.head2head.free-online.co.uk/Rover/servo.htm. Unfortunately, this narrative fails to provide an explanation on how the T-valve works to initiate boost and then to remove boost once the brake pedal is released. I believe it is important to understand how that process takes place. I recreated their cutaway drawing in Figure 1. In that drawing, I show the T-valve with one side open. The following is a short explanation on how it works. Refer to Figure 1 for reference.

1. With no brakes applied, vacuum from the engine (entering at point C) is present at both sides of the large vacuum piston (E). This is true because the T-valve is tilted (as shown in the figure) such that the right side is open, allowing engine vacuum from point "C" to reach the right side of the vacuum piston. The red line shown in the drawing represents the spring plate that ensures a tight seal on the left side.
2. The vacuum piston is at equilibrium with vacuum on both sides, and the large internal spring keeps the vacuum piston towards the right.
3. When you apply pressure on the brake pedal, the hydraulic system in the master cylinder transfers fluid pressure to point "F" on the drawing.
4. This causes the control piston (H) and the output piston (G) to move left.
5. As the control piston moves left, the T-valve is tilted such that the right side closes and the left side opens.
6. As the left side of the T-valve opens, air (via point A) is allowed to enter the right side of the vacuum piston. Since there is still vacuum on the left side, the piston is pulled to the left, applying hydraulic pressure to the primary output piston (G). Not shown in Figure 1 is the air filter that ensures clean air enters the booster.
7. The hydraulic pressure is then transferred (via point J) to the wheel calipers. The total boost creates a pedal force multiplication of approximately 2.8.

NOTE: This illustration depicts the booster assembly with no brakes applied.



A - Air inlet (atmospheric pressure)

B - T-Valve (regulates air vs. vacuum to vacuum cylinder

C - Vacuum (from inlet manifold)

D - Vacuum cylinder

E - Vacuum piston and seal

F - Hydraulic pressure from Master Cylinder

G - Primary Output Piston

H - Control Piston (controls the T-valve which controls the movement of the piston in the vacuum cylinder)

J - Boosted hydraulic pressure to wheel cylinders.

Figure 1 Cutaway View of the Girling Booster

Common Problems

Fluid in the Vacuum Body

I once had an experience with my 400GT 2+2 where I applied my brakes at a Stop sign and the brakes would not release. They were tightly locked and no amount of pressing on the brake pedal or tapping on the boosters had any effect. I was forced to call a tow truck to get the car back home to my garage. In this instance, the culprit was a faulty seal on the control piston. (see Figure 1). When a seal leaks, brake fluid seeps into and accumulates in the vacuum cylinder. A common warning signal for this problem is low brake fluid levels in the filler reservoirs yet no sign of leakage on the floor of the garage. The fluid has to be going somewhere – and it is – right into your vacuum cylinder. When enough fluid leaks into the cylinder, the brake boost will remain on regardless of any action you might take with the brake pedal. The brake fluid simply does not compress!

So any time you find yourself having to frequently fill the reservoirs and no leaks are visible at the calipers, you are probably losing fluid into the vacuum cylinder.

Weak Spring Plate on the T-Valve

A problem I recently encountered was traced to weakness in the spring plate. I noticed that when I was driving on the freeways (normal cruising, steady speed), the brakes seemed to be applying themselves. I did not touch the brake pedal yet the brakes were at least partially engaged. Tapping on the pedal a few times normally released the brakes. What I found during disassembly of the booster unit was a spring plate that was not very springy. Instead of maintaining a constant closure on the air inlet side of the T-valve (see Figure 2), the spring plate has weakened at the end tabs where it fastens to the aluminum body. The result was an imperfect seal on the air inlet side resulting in loss of equilibrium in the vacuum cylinder. The brakes literally were applying themselves. I don't know if these spring plates are available any more, but a good temporary fix is to flip the plate over and reinstall it.

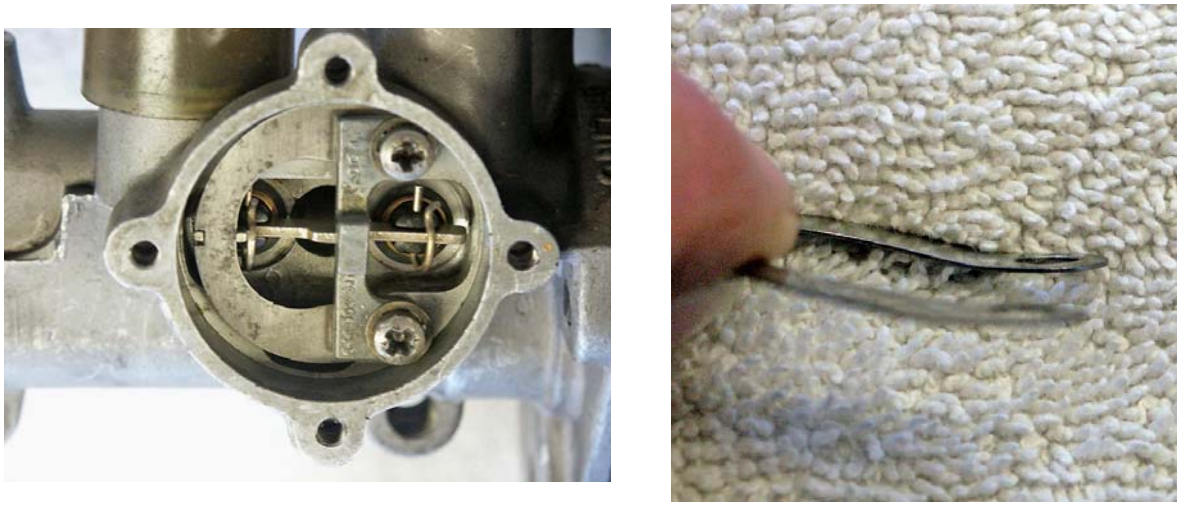


Figure 2 A View of the T-Valve and the Spring Plate Showing Bent Ends

Sticking Vacuum Piston

This problem is usually easy to identify. It is evident when you press on then release the pedal and the brakes remain engaged. What generally causes this is the lubricant on the seal of the vacuum piston. If you use the black colored lubricant that is supplied with the Girling rebuild kits, it tends to dry out over time. When this happens, the piston no longer moves freely in the large cylinder and even the large spring has a problem releasing the boost pressure. Usually, you can free up the piston by re-applying the brakes a couple of times, but ultimately, you will have to pull out the piston, clean the seal and vacuum cylinder, and apply new lubricant. But the best policy if that happens is just to go ahead and rebuild the boosters.

Preparing to Rebuild the Booster – Tools and Materials

Before you start to disassemble the booster, ensure you have the following tools and materials available and your work area is dust-free and clean.

- Phillips Screwdriver with #2 bit (I use a power screwdriver as shown in Figure 3).
- Ratchet drive (3/8" Drive) with medium extension and 13 mm socket.
- Expansion ring pliers. I have two types as shown in the photo. The set on the left seems to work best for this application.
- A hook for pulling seals out of the bores. (I use a dental pick and the other type as shown).

For materials, you will need some cleaning solvent and a container of Castrol LMA brake fluid. You will also need some clean, lint-free rags. You will also need lubricant for the vacuum cylinder which I will address later in this procedure.

Figure 3 Tools Needed for Booster Rebuild

Booster Disassembly Steps

The following narrative defines the steps you need to perform to disassemble the booster. I have used a combination of photographs and line drawings to illustrate each step.

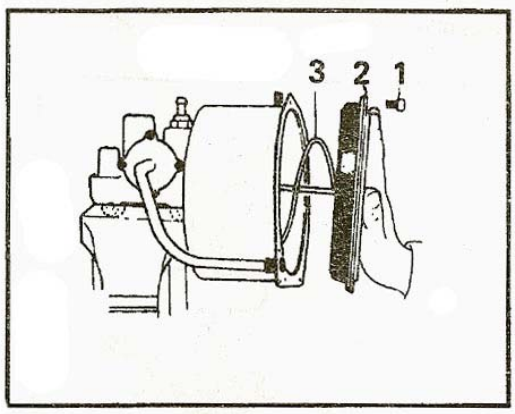
- Install the booster in a shop vise as shown in Figure 4.

Figure 4 Booster Assembly in Vise Ready for Disassembly

- Remove the air/vacuum tube (see Figure 5) by unscrewing the four Phillips head screws on the T-valve housing and gently rocking the tube free of the rubber grommet on the vacuum cylinder. I remove the tube first (contrary to the Girling instructions) because it makes it easier to ensure that the rubber grommet in the vacuum cylinder does not pull loose from its housing.

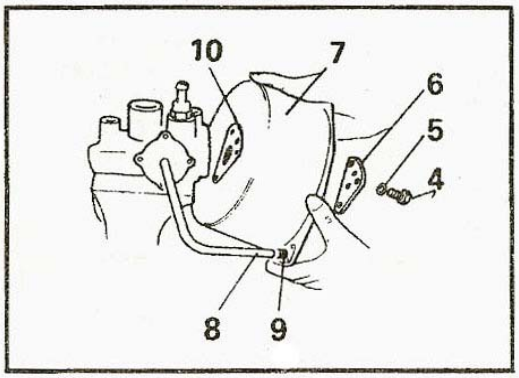
Figure 5 The Air/Vacuum Tube

- Remove the vacuum cylinder cover. See the drawing and photo below.



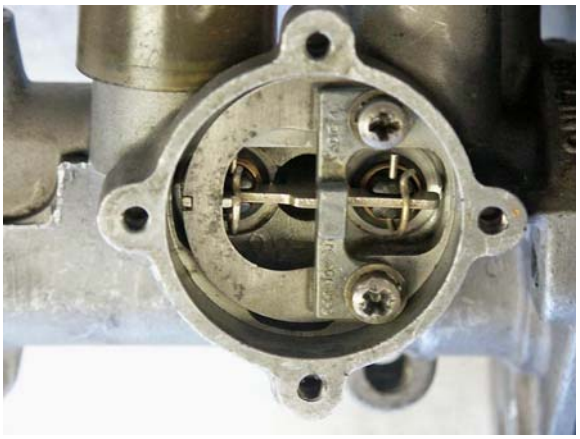
1. Secure unit in a bench vice, before unscrewing end cover bolts (1),steady end cover (2), against the pressure of the spring (3) before the last bolts are removed

- Remove the three 13mm hex head bolts that secure the vacuum cylinder to the aluminum casting. The drawing shows the air/vacuum tube still in place. If you followed my steps, it was already removed.

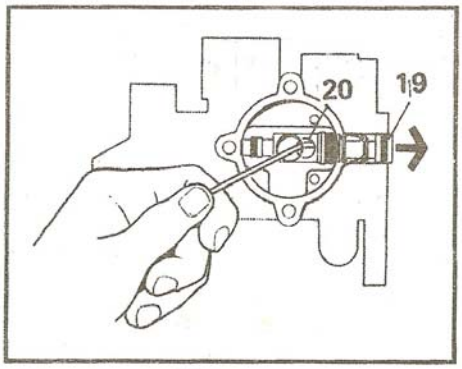


2. Remove bolts, washers, and plate (4,5,6), slowly pull the vacuum cylinder (7), to separate the pipe (8), from the grommet (9).Remove the gasket (10).

- Remove the two Phillips head screws from the lever guide and lift out the lever guide, the spring plate, and the T-valve as shown in the photo below.



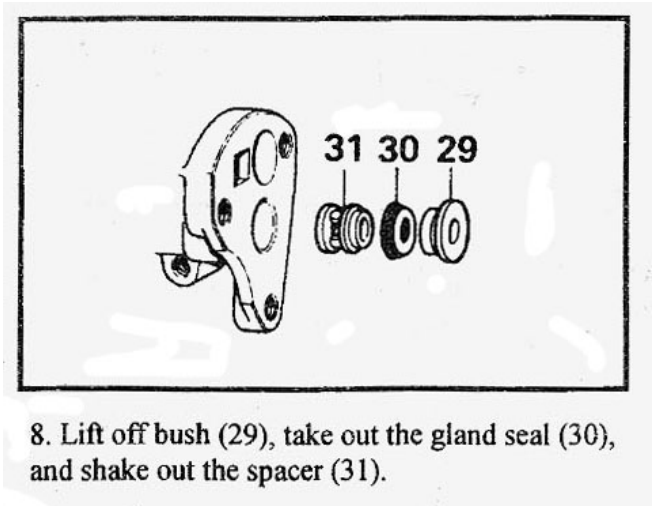
- Using a Phillips head screwdriver or similar sized instrument to gently pry the control cylinder out of the bore as shown below (as you can see, Girling uses a piece of wire. I tried it and the wire just kept bending and never did move the control piston). This will cause the plug to protrude from the bore. Use a large pair of pliers if necessary to remove the plug. The longer the booster has gone between rebuilds, the tougher this plug is to get out. It sticks!



5. Bend 1/8 in (3mm) welding wire and insert into the control piston hole (20), lever the piston until the plug is pushed out (19), lift out piston.

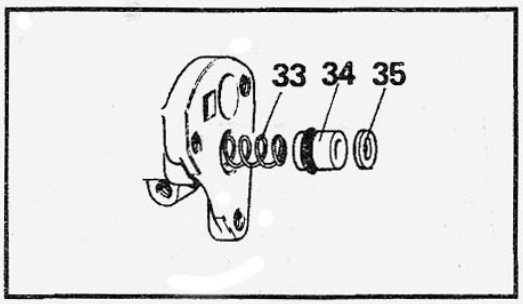
- When the control piston is out, disassemble as shown in the diagram below.

- Remove the plastic bushing (29) and using a hook device (be careful not to scratch the bore when you do this), remove the seal (30) and the spacer (31) from the bore.



8. Lift off bush (29), take out the gland seal (30), and shake out the spacer (31).

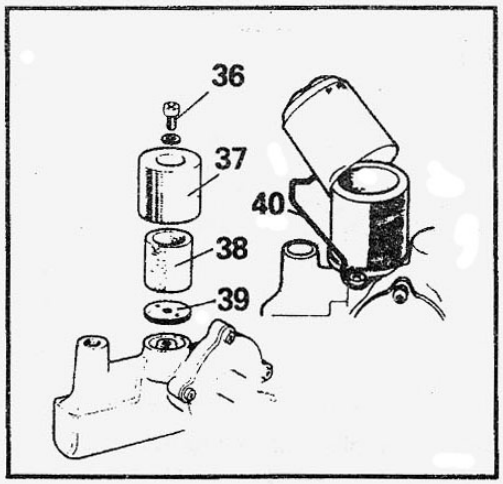
- There is an expansion ring in the bore of the output piston as shown in the photograph below. When this ring is removed, spring pressure will abruptly force the output piston to pop out of the bore. The Girling instructions call for using a special wire retainer to prevent this but if you are careful, you can remove the spring clip without using the special tool. Refer to Figure 3. You will need to use an expansion ring tool with long fingers to reach down into the bore and engage the holes in the ring. Be VERY careful not to scratch or gouge the bore when you perform this step!



11. Remove the tool to release the spring (33), piston (34), and washer (35).

- Once the ring is out, you can remove the flat washer and the output piston with its attached spring (see photo below).

- Remove the air filter from the aluminum housing as shown in the drawing below.



12. Unscrew the set screw (36) and remove the air filter (38),cover (37),and base washer (39), the early air filter covers were held on by a clip.

That completes the disassembly of the booster assembly. At this point, you need to remove all the parts that will be replaced; i.e., the items that are provided in the rebuild kit. This will include the rubber components and gaskets, for example.

Leave the foam rubber seal on the circumference of the vacuum piston in place and clean the piston thoroughly using clean solvent. Wipe everything clean with a lint-free cloth.

One of the problems frequently reported with regard to the Girling boosters is an overly tight fit of the vacuum piston in the cylinder caused by a too-rigid foam seal. Ron Karp (a well-know rebuilder of the Girling boosters), uses his own design – a length of cotton rope, for a seal. Unless you know Ron's "secret" rope, I recommend that if the old seal is still in reasonably good condition, you can re-use it. This seal has already taken a set in the cylinder and should provide a good seal but not too tightly.

Booster Reassembly Steps

Before you begin the reassembly process, you must ensure that all the parts are very clean. I have included the instructions from Girling regarding cleanliness.

CLEANING.
Cleanliness is now very important. wash your hands and lay out some clean paper to place all the parts on.The new parts in this kit will indicate which old parts are to be discarded. Clean the remaining old parts with a recognised cleaning fluid or unused brake fluid and let stand to dry.Look at each part to make sure that it is undamaged and in working order.Check the piston and bores to make sure there is no sign or corrosion , pitting ,scoring or ridges,if there is fit a new unit.

Refinish the Bores

Every booster unit that I opened for rebuild showed signs of corrosion in the bores. The aluminum alloy used for the Girling boosters seems to be particularly susceptible to oxidation caused by moisture in the hydraulic fluid. The DOT 3 brake fluid that was originally specified for use in our cars is very hydrophilic. "Hydro" is the Latin root for water and "Phylic" is the Latin root for "love of." So all these years, we have been using a brake fluid that loves moisture. Today, we have better technology and Girling makes a fluid that is superior to the early fluids in its resistance to moisture. This is the Girling LMA Brake Fluid and the one that you **should use** with our boosters. LMA stands for Low Moisture Absorption.

I devised a simple method of cleaning the bores using a drill motor, some steel wool (#2) and a long drill bit. For the small bore of the control piston, I used a long, narrow, carbide tipped bit as shown in the photos below.

Cut a small blanket of steel wool as shown. Lay it against the drill bit and slowly pull the drill trigger while wrapping the steel wool around the bit. Leave about ½ inch of extra steel wool at the tip to prevent the tip of the drill bit from making contact with the end of the bore you are cleaning.

Make sure the bore is clean and dry – no solvents and no brake fluid should be present. Ease the end of the steel wool covered bit into the bore while running the drill motor at low speed. When the steel wool is all the way into the bore, increase the speed of the drill motor. I used and in/out motion to make sure I was completely in the bore I was trying to clean.

You can use a larger diameter bit to perform this procedure on the bigger bores. It works very well. You can repeat this procedure as much as you need to produce some very shiny bores. I even performed a second cleaning using #0 steel wool instead of #2. Two of the boosters I rebuilt had brass inserts from a previous rebuild in a shop. The brass ended up looking like highly-polished gold! No scratches, and virtually no pits were left. If your bore still has significant pitting after you perform the above procedure, it is time to send your booster off to a rebuilder for resleeving. Rebuilders can resleeve in either brass or stainless steel. I don't have any recommendation to offer here except I think stainless steel is less susceptible to moisture damage. There are several places listed in the VLG database to choose from (Ron Karp's, White Post, etc.).

Reassemble the Booster

Reassembly is essentially the reverse of the disassembly process. I have included the steps recommended by Girling for reassembling the booster. The only point where I differ from their procedure is in the case of the air/vacuum tube. I believe it should be the last item of reassembly.

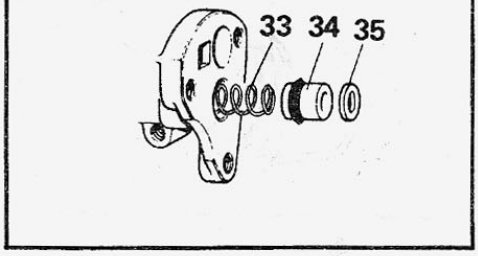
Before you start the reassembly process, make sure your hands are clean and your workspace is clean. Apply some clean LMA fluid into the bores of the aluminum housing. Likewise, coat the assembled pistons (control and output) with some LMA fluid.

One note of advice – don't reuse the rubber components; i.e., the hydraulic seals. Use new seals on the pistons and where they serve as plugs. They are reasonably easy to install if you wet them (and the pistons) with some clean brake fluid.

The steps for reassembly are noted in the following.

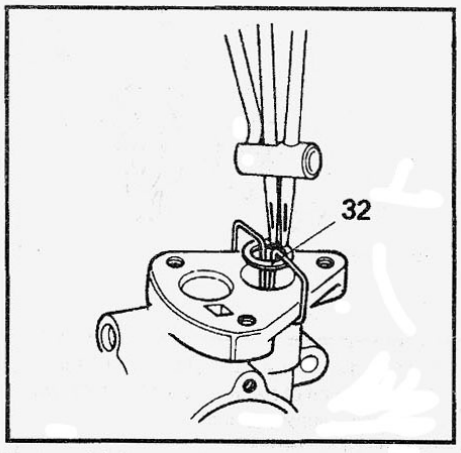
- Install the output piston into its bore as shown in the drawing. The raised lip of the seal must be facing into the bore.

RE-ASSEMBLY



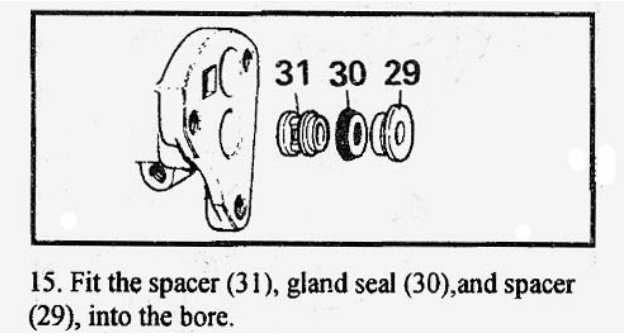
13. Fit new seal to piston (34), lubricate bore and seal with unused fluid and inset the spring (33) into the bore.place the washer onto the piston (35).

- Install the expansion ring (the circlip in the figure below) using the expansion ring tool.



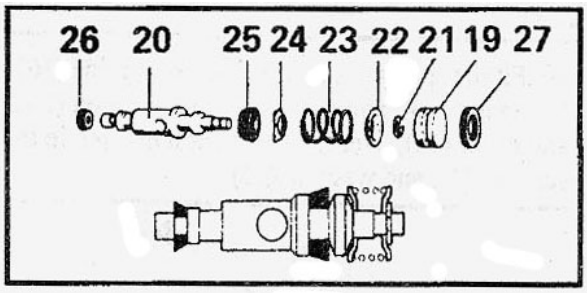
14. Ease the piston and seal into the bore and clip the special tool under the flange.
REMEMBER THE CIRCLIP (32) MUST NOT DAMAGE THE BORE SO TAKE EXTRA CARE

- Install the spacer, seal, and the plastic plug into the output piston bore as shown in the figure below.



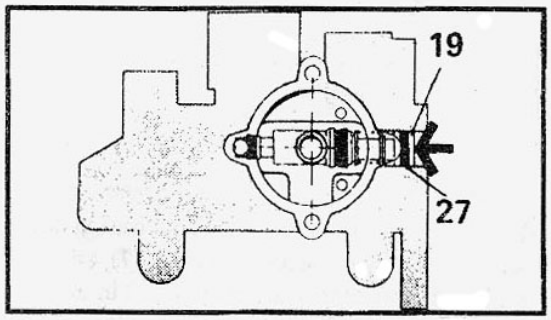
15. Fit the spacer (31), gland seal (30),and spacer (29), into the bore.

- If you haven't already done so, assemble the control piston as shown in the figure below. Install the plug (19) with its installed seal last.



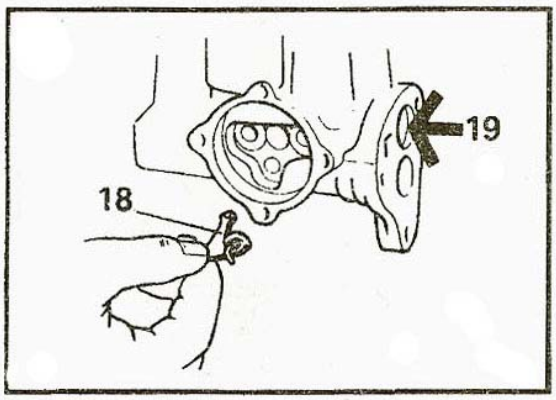
16. Fit new seals (25,26), to the control piston (20), fit the spring and spring seats,secure with the circlip (21), lubricate the bore and seals with unused fluid.

- Insert the assembled control piston into its bore as shown in the figure below. Make sure the hole in the piston body is aligned with the hole in the T-valve housing (as shown in the photo).



17. align the control piston hole with that in the valve chest, insert the piston into the bore. Fit the seal (19) onto the plug (27), and push into the bore.

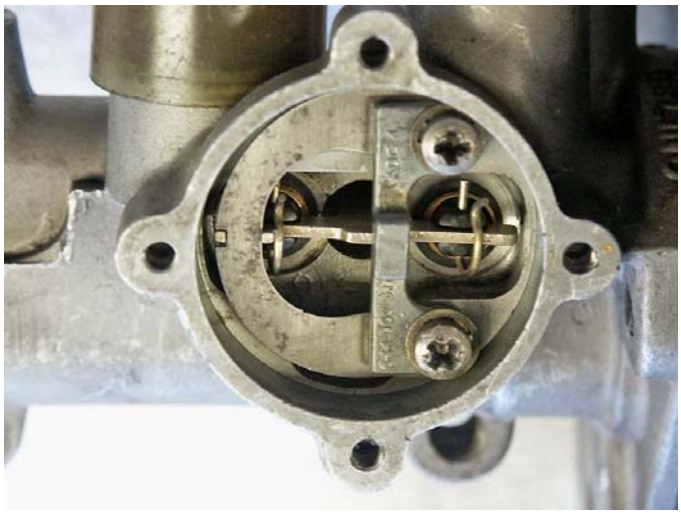
- Inspect the plastic cups on the T-valve and make sure they have no cracks of chips. If they do, you must replace them. Assuming they are OK, install the T-valve through the hole in the aluminum housing and into the hole in the control piston. If you have a problem getting the T-valve into the piston hole, try pushing on the plug as shown in step 19 of the figure.



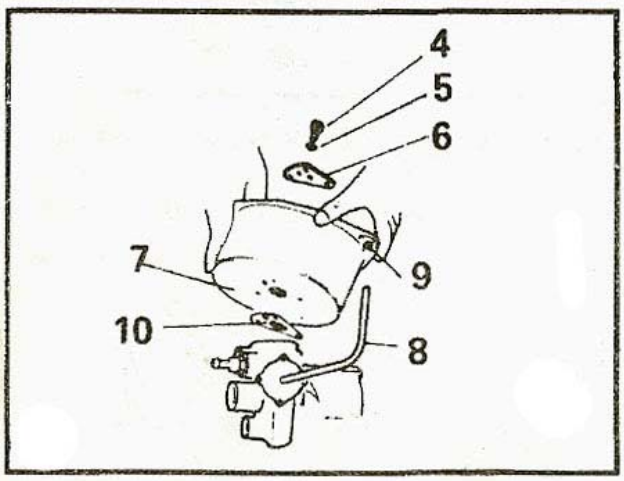
18. To insert 'T' lever valve (18) press in plug (19) so the round end of the lever fits easy in the hole when in the control position

NOTE: Before proceeding, carefully inspect the spring plate. If the tabs with the mounting holes show signs of being permanently bent, (see Figure 2), flip the spring plate over when you perform assembly. This will restore some of the pressure lost due to the bending. Unfortunately, the spring plate will sooner or later loose their tension and release some of the pressure on the air input side of the T-valve. And as I pointed out in the first paragraphs, this can cause the brakes to self-apply. I don't know of any way to fix this problem short of re-manufacturing spring plate from better materials.

- Complete the assembly of the T-valve by installing the spring plate and the lever guide using the two screws as shown in the photo below.



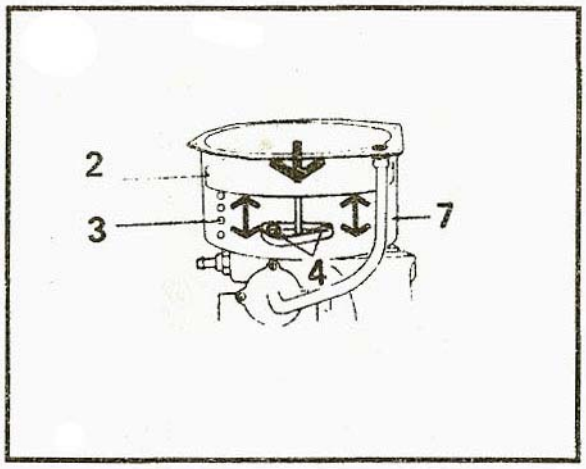
- Install the gasket for the vacuum cylinder (10 in the following figure), the vacuum cylinder, the triangular plate (6) and install the three hex head bolts finger tight.



20. Secure unit in bench vice, and position new gasket (10), locate vacuum cylinder (7), on the gasket (10) place the vacuum pipe (8) in the new rubber grommet (9), replace the plate (6) and with the bolts (4) and new copper washers (5) **ONLY TIGHTEN THE BOLTS FINGER TIGHT.**

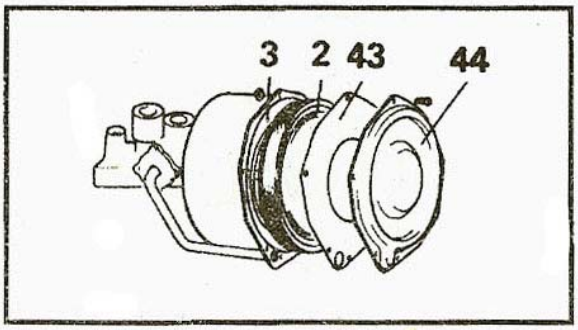
- Apply a thin film of "Corrosion Block" lubricant (see www.learchem.com) to the inside of the vacuum cylinder. Also apply lubricant to the leather seal on the vacuum piston as shown in the photo below. This lubricant is the same one used by Mike Pierce on the bearings of the Weber carburetors he rebuilds. It is a synthetic lubricant that is a moisture block, doesn't dry out and is friendly to leather. I found it at a local marine (boat supply) store called West Marine. Otherwise, it is available at the web site noted.

- Perform the steps noted in the figure below. These steps ensure the vacuum piston is properly centered in the cylinder before you tighten the bolts.



21.With bolts in place but don't tighten them, replace the piston return spring (3) and piston (2) in place,push down through the stroke a few times to line up the bearing bush,try not to move the vacuum cylinder (7) when you remove the piston and spring, tighten the bolts.

- Complete the assembly of the vacuum cylinder as shown in the steps below.



23. Refit the spring (3) and piston (2). Fit a new gasket (43) to cover the plate (44), place the plate on top of the piston ,press down and secure with the nuts and bolts.

Cover the open ports with tape, if this unit is not being used immediately.

- The final step is install the air/vacuum tube (see Figure 5). To facilitate this process, apply a small amount of Corrosion Block to the rubber grommet on the vacuum cylinder and a thin film on the end of the tube where it enters the grommet.

- Once the tube is installed in the grommet, align the T-valve cover with its mounting holes, position the gasket and install and tighten the four retaining screws.

This completes the rebuild process. If you are not planning on immediately installing the booster in your car, plug all the holes in the booster body to prevent contaminants from entering the bores.