TR250 & TR6 Brakes
Overhauling Brake Servo

These notes describe what I did on my car for my personal use and are provided here for entertainment; they are not meant to be instructions for others to do maintenance on their vehicles.

This section describes how I overhauled the brake servo for my '70 TR6. As mentioned earlier, the car is completely disassembled and I was able to take the servo to the workshop to do the work (it's February, cold in the garage but nice and warm in the basement workshop). As we see later, it is very difficult for the home mechanic to get the servo apart and many repair parts are available only to professionals. However, this exercise did provide an opportunity to really understand how the servo works.

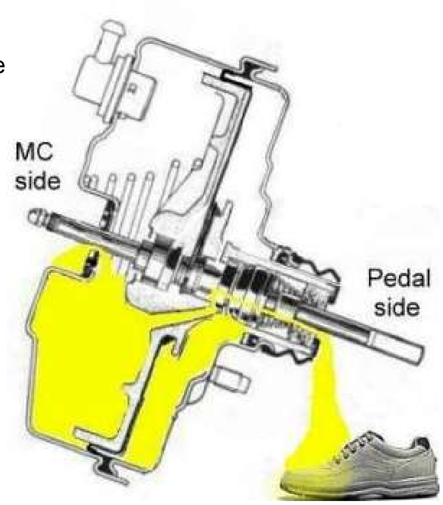
Brake servo rebuild service: Those of you that need a servo serviced might consider Brakes Materials & Parts, 800 Sherman Boulevard, Fort Wayne, IN 46808, 260-426-3331 (which purchased the inventory and equipment from Gary/Partco Automotive, referenced below). This information is offered courtesy of Rich Grayson, 2/3/11.

- They are doing re-builds of servos for Triumphs, and importantly, their re-builds include replacement of the diaphragm, which folks like Apple Hydraulics do not; the overhaul kits from outfits like Moss also do not include diaphragms. Cost is $90 for the re-build plus $15 for return shipping; they can powder coat for another $30.

We start by looking where the servo fits -- between the pedal assembly and the master cylinder unit as shown above. Note that the master cylinder and PDWA are all clean and freshly painted. Also note that the servo is mounted at an angle --- the correct angle is where the top of the MC reservoir is horizontal. One might ask, why are you tearing apart a servo that is working? Good question. First, it looks terrible, no way am I going to put that thing on a freshly rebuild car. So, I want to clean it up and paint it ---- powder coat of course. Since it has rubber and plastic parts inside, it must be disassembled to remove those parts to prevent damage from the 350-degree powder coating curing temperature. And the main reason, I wanted to play with it.

Before I tear this thing apart, I might reflect a bit about how they fail. I've never had a servo fail on one of my cars and that covers three cars, 20 plus years and over 200 K miles. Most failures I've heard of are such that the servo stops giving assistance --- the brake pedal is very hard to push.

At least this system runs on air (or maybe an absence of air is more accurate), and doesn't leak fluid, right? Well, not exactly. My neighbor Bruce and his teenage son Ryan each have TR6s. While discussing the servos recently Ryan mentioned that his dad's servo probably has its days numbered. It seems that a couple years ago it leaked hydraulic fluid onto Bruce's foot. Just can't wait to ask Bruce "have you checked the fluid in your servo lately?" The diagram on the right might explain what was going on. First, hydraulic fluid was leaking past the master cylinder primary piston seal and into the recessed area at the front of the servo. Recall that the when the brakes are released the servo is under a depression of about 1/2 atmosphere or a little more--- 7 to 10 psi. Now what if there was a very small leak between the push rod and the seal at the front of the servo. Normally it would let in a little air that would then be sucked back out via the hose to the intake manifold. If there's fluid there, it'll be sucked in too.



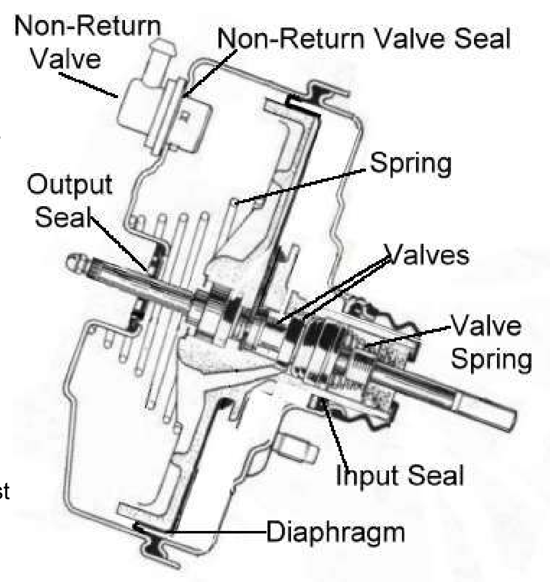
I can see Bruce adding fluid and checking for leaks at the MC, the wheels and the pipes & hoses to see where it was leaking. Nothing --- must be evaporating. Later it became obvious that the servo was storing it for him. After a while the servo got about half full of the yellow DOT4 (not the purple of DOT5) brake fluid as shown in the sketch. Bruce pushes the pedal again and the valve opens to let air into the right chamber. But the input is below the fluid level, so air flows in and fluid passes it going the other way to drip on Bruce's shoes. Bruce did say it it made a gurgling sound when he applied the brakes.

Bruce's experience does raise the questions of how do we know if the seals are leaking and how much of a leak is too much? Guess I better devise a test for question and then measure a few to get an idea of what is normal.

Failure points: I've flagged parts on the sketch that might be failure points:

- The seals around the input and output shafts and around the non-return valve.
- The valves on input shaft and non-return valve.
- The diaphragm
- The springs.

The big three suppliers carry a minor repair kit with the output seal. TRF has the valve and poppet assembly and Moss as well as TRF list the non-return valve. No one lists the diaphragm. (Gary at Partco Automotive said he frequently finds bad diaphragms. He said in a recent week he repaired two TR6 servos with ruptured diaphragms; one had brake fluid in it and the other gasoline. How did the gas gasoline get there --- did someone put gasoline in the master cylinder reservoir? He always replaces the diaphragm.) The seals are clearly the parts most subject to wear and failure, followed by the valves. Replacements for these are available. So, with a few spare units for parts, I should be able to get one running.



Test Setup: The photo shows the setup I used to test the servo. The pump is a two-stage unit used to evacuate air conditioning systems that I borrowed from a friend. When I first brought it home I set it on the workbench, turned it on and went to find the vacuum gauge. The workshop cat was nearby checking it out. I cautioned her about tails, pulleys and belts. When I came back a few minutes later she was gone. I was really concerned that she was sucked into the pump. I shut off the motor and listed for a meow from the pump. Nothing. A little later I found her resting on a shelf so I guess she just got bored.

This shows the plumbing in more detail. The valve is between the pump and the servo. This allows the hose to the pump to be sealed and the rate of depression loss observed. The gauge is a compound gauge that reads both pressure and depression. Another setup will be to supply compressed air at a low pressure, close the valve and observe the rate of loss of pressure as an indicator of the non-return valve health.

Bench Test: The first thing I did was to plug the hose and determine the maximum depression I could create --- 21" Hg. I then closed the valve to determine how long it could hold it ---- slowly bled down (or I should say up) to half the starting depression in 2 minutes. After checking around I figured out that one of the pipe fittings was leaking slightly. Fixed that and it held the depression

I next hooked up to the old servo and found the best the pump could pull was 19" HG. When I closed the valve it bled down to half in ~ 18 seconds. Next I pushed the pedal side rod in and the output rod moved, but the depression dropped to about 5" Hg and that was the best it would hold. Notice the scabs on the extended MC side push rod in photo on right. I think I understand why the seals leaked. Next, I put about 10 psi pressure in the input hose, closed the valve and watched pressure decay to half in about 20 seconds --- the non-return valve leaked too.

Test in Car: I next moved the valve, gauge, etc to the garage and put it in series with the hose from the manifold to the servo on my '76 TR6 as show on right. This worked just as well as the pump in the workshop. At idle I read 18.5" Hg with valve to servo open or closed. Closed the valve and observed that the system bled down to half in about 5 minutes. I then pressurized the system and observed that the non-return valve bled down to half in about 5 minutes too.

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Tools to open Servo: A couple days after the tests described above I hosted a Buckeye Triumphs "Brake Tech Session". Club member Jim Vanorder brought a set of "server opening" tools (shown below) that a friend had made for him. Several others brought servos to be opened. The servo canister has two half-shells that are joined by bringing the half-shells together and then twisting slightly so that the lip of the rear half-shell is locked under tabs on the front half-shell. The outer edge of the rubber diaphragm is locked between the two half-shells at this joint to both secure it as well as seal the half-shells. So, all that is needed is a way to grasp the two half shells and rotate them a few degrees. The upper tool bolts to the master cylinder side of the servo and the lower tool bolts to the pedal side as shown below.

All that is needed it to lock the tool on the master cylinder side (on the bottom in above photo) in a bench vise and then grab the handles on the other tool and turn. Yea, right --- in your dreams. That sucker wouldn't budge. Next step was to put long handles on the two tools to get more leverage. There was about a dozen of us working on this project so we had plenty of muscle. It was at about this time that several of those observing asked for the address and phone number of Partco, the outfit I mentioned earlier that does servo rebuilds.

Not to be deterred, the three engineers huddled, and I then went to the shed and got tool number three pictured below. At this point there was considerable commotion among those gathered to determine whose servo was under assault. Once the owner was identified, everyone else relaxed and few more asked for Partco's address. This tool worked. By tapping on the handles of the upper tool with all the swing that could be mustered in the confined space, the top half-shell started to move ever so slightly. A few dozen swings and it was turned far enough to open. There were obvious signs of brake fluid on the inside and the diaphragm had a big hole. The owner took the pieces to his car before we could snap a few photos. I suspect he wanted to get it out of our reach while there was still some hope that it could be successfully rebuilt by a professional.

After everyone left I put some long (> four feet) handles on the tools and then tried to open another servo. The seal proved stronger than the handles. In frustration I locked the vise really tight and tried the big hammer again. It worked at once, but only a little movement with each whack. So, with perseverance, got another this one open and found it a little low, but not out of brake fluid as shown in photos below. (This one belongs to friend Ryan who obviously left it here by mistake.)

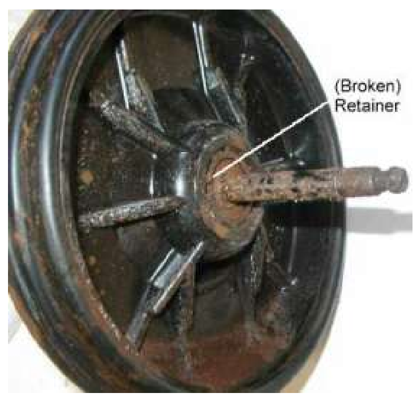
Fresh with a couple successes and the technique well understood I next attacked my own servo, the one tested earlier. I was about halfway through the procedure when the wife showed up in the workshop and inquired as to what I was doing. She said that the whole house was shaking (she didn't use exactly those words). The project was readily completed a little later when she was out. This servo turned out to be dry on the inside but contained about a half cup of rust powder and dust, possibly loosened during the opening procedure. The following describes the disassembly and overhaul of this servo.

Disassembling the Front Half-Shell: The left photo below shows the inside of front (MC side) half-shell. This servo came off a '73 I junked a number of years ago. The upper photo on the right shows the removed MC push rod seal (tapped out from the inside) and the non-return valve. When the non-return valve was pressed out it came apart. It seems to snap back together with no problem. The little pile of debris fell out of the valve, which probably explains why it leaked a little. It looked like foam rubber. When I disassembled the pedal side a little later I realized that the air filter was missing. Further inspection revealed that apparently the filter disintegrated and was sucked through the system and into the engine. After blasting the half-shell I found a little hole in the bottom. Apparently if had water or water logged brake fluid set in it at some time. I had another servo that I got with a piece of TR250 years ago (that red one pictured in the theory section). I considered it junk since the no-return valve was broken. It was the first servo I'd taken apart and I broke the diaphragm plate in the process. The half-shell looked good so I decided to use that half-shell and switch the non-return valves.

Non-return valve variations: Not so fast on the swapping the non-return valve. The original servos had a bayonet style retainer (push & turn) as shown in upper right photo. Apparently servos for the later TR6s and replacement servos came with a push-in valve that is locked with serrations on the side like pictured above and in lower right photo. Further, one of the folks brought a replacement servo with a smaller push-in non-return valve, so there are at least 3 variations. It looks like the hole for the bayonet style can be enlarged to fit the larger of the push-in valve. Moss lists both type valves. The seal on the push-in valve shown is not in very good shape so I decided to get a replacement valve. The bayonet style is very hard to get out (that's how the one sample of the bayonet style got broke). However, the seal is a readily available O-Ring and Moss lists that seal separately. The push-in style seal is a custom job, comes with the new valve and is not listed separately. Several of the other guys have servos with missing push-in type valves but good seals who might be able to use my spare valve, so I ordered a new bayonet style valve with seal from a Moss reseller to match the upper half-shell that hasn't rusted through.

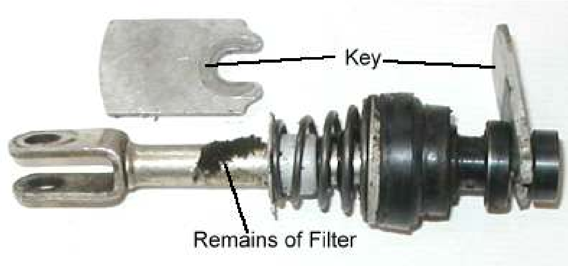
Disassembling the Rear Half-Shell: The inside of the rear (pedal side) half shell is shown on the right. This half-shell also had some rust but cleaned up quite nicely with no holes. The parts below were removed before the blasting. The dust cover stretches over a collar on the pedal side of the half-shell. The retainer, then washer and seal were pried out of the center cylinder without difficulty.

Removing MC Push Rod: The plastic diaphragm plate with rubber diaphragm attached is shown on right. The MC push rod also listed as the ***Valve Push Rod Assembly*** in the TRF catalogue is held in place by a small spring retainer. The retainer on this unit was rusted through on one side as can be seen in the photos. The retainer was pried out with a small screwdriver. The pushrod was held is place pretty firmly (stuck) and I had to resort to tapping the end from side to side with a small hammer to get it loose. The reaction disk is made of rubber and was pried out with the small screwdriver. This is another view of the heavily corroded push rod that makes a seal impossible.



Removing the valve: The inside of the diaphragm stretches over a groove in the back side of the diaphragm plate as shown on the right. It comes off with just a little tugging and stretching. The dust cover retainer also slides out over the pedal pushrod. One thing is clear, the dust cover retainer has nothing to do with retaining the dust cover, which fits over it. The filter fits behind that retainer so maybe whoever typed the list up some decades ago skipped a line or two. It's probably really the filter retainer. One might ask why worry about retaining that filter, the air movement is always into the servo through the filter and valve assembly. This is true, however, as shown previously, the fluid drains out this hole to reach the operator's shoes.

The valve assembly is retained in the diaphragm plate by a little key that is visible after the diaphragm has been removed. The key is easily removed by pushing the pedal push rod in and tapping the diaphragm plate on the table with the key pointed down. The lower photo on right shows two keys, the one on the right is the position when the valve in installed ion the diaphragm, plate. Note the remains of the filter that didn't make it to the non-return valve.



Painting the Half-Shells: I powder coated both the inside and outside of the half-shells in gloss black. The areas on both half-shells that grasps and is next to the diaphragm was masked and not painted. Fred Thomas told me that Gary of Partco requested these areas not be coated as the additional thickness prevents closure of the half-shells.

Replacement Non-Return Valve: I mentioned earlier that I ordered the bayonet type replacement valve from a Moss reseller. The actual valve I received is shown on the right, clearly the push-in style. I reconsidered my plan and decided to keep this valve since it is easier to remove and replace without opening the servo. I enlarged the hole for the valve in the half-shell to the 1.075-inch diameter required for the push-in valve.

I emailed the Moss reseller to see why I got the wrong valve. The reseller immediately air shipped a replacement. We got that stopped and he then checked to see if the catalogue numbers and descriptions were accurate. They are. There were signs that the box had been opened and resealed with tape, so my guess it was a prior return in the wrong box.

Minor Rebuild Kit: The parts in the minor rebuild kit are shown on the right. The top row is the air filter and boot that go around the pedal pushrod. The master cylinder push rod seal is on the lower left. The two rings are seals for between the servo and master cylinder and are not used in the TR250/TR6 application. The little packet contains grease to be used on the seal. The same grease that was packed with the non-return valve pictured above. Note that all these parts can be replaced without opening the canister.

Reassembly: The two powder coated half shells are shown below. I first installed the check valve by applying some of the grease packed with it on the seal, pushing the seal in the hole and then putting some grease on the valve and pushing it position. When the valve is seated it makes a very tight joint with the seal and half-shell. The seal around the master cylinder push rod was then coated with grease and pushed into position with metal plate towards the inside. The large seal that goes in the rear half-shell was covered with grease and inserted into the half-shell followed by the washer and retainer clip.

The next step was to install the poppet valve assemble. I had purchased a new poppet valve assembly that looked like it had been on the shelf a while. Part of the metal end that forms the valve to the outside air was corroded. I installed the foam filters on the pushrod as shown on the right. I then coated all the rubber surfaces with grease, pushed it into position and inserted the retaining key. The diaphragm was then stretched over the inner lip on the rear side on the diaphragm plate.

Recall that the master cylinder push rod was heavily corroded. It cleaned up real nice with blasting. The rod was then finished with gun bluing.

The reaction disk was then inserted into the recess in the front side of diaphragm plate followed by the master cylinder pushrod and both were secured with the retaining clip.

Several folds of a rag were placed between the front half-shell and the holding tool used during disassembly. Nuts on the two studs were then tightened securely.

The photo on the right shows how the unit goes together with the big spring then the diaphragm plate, the rear half shell (not shown) goes on the top. The other holding tool was attached to the rear half shell, using several folds of cloth between to prevent scratching the new paint. The lips of both half shells that retain the outer edge of the diaphragm as well as the mating edge of the diaphragm were all coated with the red rubber grease. As mentioned previously, these lips were not painted to ease reassembly. The grease serves to minimize corrosion of the unpainted surfaces as well as easing the job of turning the shell to lock them into place. The area under my hand in the photo was also coated with the grease that came in the rebuild kit.

There's no picture of the final assembly step, I needed all three hands to do the assembly. I secured the front half-shell in the vise and connected the vacuum pump and turned it on. I then positioned the rear half-shell over the diaphragm plate and pushed down while guiding the master cylinder push rod through the seal in the front half-shell. When everything was positioned correctly and the rear half-shell was pushed down, a partial seal was established and the rear half shell was drawn down into position. At this point I was able to inspect everything and then turn rotate the top piece the half-inch or so to lock it in place. (And to think we used a sledge to get it apart.)

The next step was to connect it make sure it held a depression; the pump was run until the depression pressure stabilized and about 20" of Hg and the valve was then closed. There was a small leak. Rats! I fiddled around with the input push rod and finally rotated it couple turns and the leaking stopped. For some reason the valve between the rear chamber and the atmosphere had been leaking. Next I tested the operation at various pedal positions. It worked fine but there seemed to be a leak when the input was pushed. What I did was push the input about halfway in, waited until the depression stabilized and then closed the valve. The depression bled away in a few seconds. There was clearly a leak between the two chambers. The diaphragm was known to be good so it must be the valve. Well, have to take it apart again. Less than five minutes and had it apart. Decided to try the old valve. Reassembly at this point was a snap.

This time it worked find. After several tests it I found it has a very small leak --- bleeds to half depression in about 5 minutes. I think that is satisfactory. However, still bleeds down pretty quickly when the brakes are applied. If you look at the table below, you see the same for both my '76TR6 and '68TR250. Ryan's seem to hold real well. Maybe I should have switched units with Ryan (without telling him).

Push Rod Adjustment: The end the push rod that drives the master cylinder primary piston is adjustable. I laid a ruler across the front of the servo and measured the gap between the end of the pushrod and the ruler (see red circle on the adjacent photo). The gap on the servo I had just overhauled measured ~0.035". I hadn't changed the adjustment during the overhaul since the adjustment screw was frozen (rusted solid). Another servo I had measured zero gap. The piston in the master cylinder I just overhauled sticks beyond the face of the servo by about 0.040", so this servo will hold the piston slightly off the stop provided by the end of the tipping valve.

While I don't have specifications for the push rod adjustment I can make some guesses. We don't want it too short to avoiding introducing slack into the system. We don't want it too long because it might prevent the primary piston from returning far enough to open the tipping valve. The 0.035" gap that moves the primary piston about 0.005" off the stop seems to be reasonable.

Observations: Before leaving this subject some general observations are in order:

- It is very difficult for the home mechanic to disassemble a servo unit.
- The cost of parts for all but very minor repairs exceeds the cost of having the unit professionally rebuilt.
- Some parts such as the diaphragm are available only to the professionals.
- Virtually any unit that hasn't been smashed (or distorted when taken apart by the owner) can be rebuilt.

While the exercise described above was interesting and entertaining to the participants; the inescapable conclusion of any rational person is to send the servo off to a professional to have it serviced.

Testing Servos: After playing around with the gauge and valve described earlier I decided on the following four tests. Test 1, 2 & 3 can be run using either a vacuum pump or vacuum from the intake manifold. Test 4 requires a source of low-pressure air. The tests can be run with the servo on or off the car.

Test 1: Released Static Test: I connect the gauge and valve between the vacuum source (pump or manifold) with the gauge between the valve and servo. With the valve open one should read a little more than 15 inches of hg with the engine at idle. The reading with a pump depends on the pump. Once the pressure is stable the valve is closed. The measurement is the time required to bleed to have depression. A perfect system will hold the depression forever. I'm guessing if a servo holds above the half depression for a couple minutes, it's usable. (Gary at Partco says he likes to see zero leak down here.) This test verifies:

- the seal around the master cylinder push rod
- the seal around the cylinder at the pedal side of the diaphragm plate,
- the seal of the valve between the pedal side chamber and the atmosphere
- the seal around the check valve
- the seal between the two half -shells
- the seal around the studs

Note that the most likely leak is around the master cylinder pushrod and this seal as well as the one around the check valve can be replaced without removing the unit.

Test 2: Operated Static Test: This is the same as Test 1 above except that the pedal/input pushrod is pressed far enough to move the output against some resistance. The valve is then closed and rate of depression loss observed. I'm guessing, as with Test 1, if a servo holds above the half depression for a couple minutes, it's usable. The test verifies

- all the seals as in Test 1 except the valve to the atmosphere which is open when the pedal is pressed
- the diaphragm seals between the two chambers
- the valve between the two chambers when the pedal is pressed.

If the unit holds depression in Test 1 but not in Test 2, the likely faults are the diaphragm or poppet valve assembly, which require opening the canister to service.

Test 3: Dynamic Test: I push the pedal in slowly while observing the gauge vacuum. The depression should drop as the pedal is pressed because the diaphragm is moving toward the front. However the depression should rebuilt quickly once the pedal motion is stopped. What I look for here is any place where the depression drops in a jump indicating the seal is being lost. I noticed this on several the units I bench tested and attributed it to scabs on the master cylinder pushrod opening the front seal. Gary at Partco said a scratched hub shows up here.

Test 4: Check Valve: For this test I disconnect the vacuum hose and insert low pressure (10 - 15 psi) compressed air into the hose and then close the valve and observe the rate of pressure loss. This requires a pressure gauge. The gauge I was using was a compound gage - both pressure and vacuum so no problem. I'm guessing as with Tests 1 and 2 that if the check valve holds above the half pressure for a couple minutes, it's usable.

Test Results: The following is results of tests I ran on a variety of servos.

Servo Test Data - All times in minutes.								
Servo Unit	Ryan's Spare	My Rebuilt Unit	My '76TR6	My '68TR250				
Test 1: Decay time to half depression	>60 min	4.2 min	~5 min	>10 min*				
Test 2: Decay time to half depression	>60 min	~.5 min	~.9 min	~1 min				
Test 3: Irregular depression observed?	No	No	No	No				
Test 4: Decay	>60 min	>10 min*	>10 min*	>10 min*				

time to half pressure								
Evaluation	Excellent	Not sure	Not sure	Not sure				

*Impatience set in.

Many thanks to Gary at Partco for taking the time to review this note and offering several suggestions as well as examples of typical failures.