# A Type Overdrive, Part IV
# Final Assembly & Testing

Part III ended with a nearly assembled OD.  We pick up here with attaching the OD to the gearbox and finishing the OD assembly.  The OD was then tested and several problems were uncovered and solved.

**Installing the OD Adaptor:** The OD adaptor was bolted to the back of the gearbox using the same holes as the rear extension for a non OD gearbox.   A gasket (same gasket as non OD gearbox) with sealer was placed between the adaptor and the gearbox.   A second check was made on the surfaces that mate with the OD using a straight edge to make sure all were flat.   The bottom received special attention since a bowed or bent adaptor plate in this area will leak.    The plate was then secured with 6 bolts. The earlier gearboxes like this one use safety wire on these bolts while the later versions use lock washers.  The pump cam was then slid onto the mainshaft with the cam part to the rear as shown in the left photo below.

**OD to Adapter Gasket & Leaks:** The joint between the OD and the OD adaptor plate seems to be the most prevalent location for leaks.  In many cases, this joint leaks but the oil flows back and drops off the large drain plug leading folks to think the leak is around the plug.  I've seen reports of people going to great lengths to fix nonexistent leaks around the plug.  (Sometimes the plug really does leak, as discussed later.)  The adaptor plate leak is typically along the bottom where there is a fairly large distance between studs.   A very slight bow in the adaptor plate in this area is usually responsible for the leak. Ronnie Babbitt used epoxy successfully to fill the low spot on his adaptor plate. Others have noted that there are two types of gaskets available, one very thin and another about 1/32 inch thick.  There was one report on the Triumph List of an OD that leaked with the thin gasket but not with the thick gasket in conjunction with the Hylomar sealer.  The Hylomar seems to penetrate the gaskets in a way I've not seen with other sealers.  I've observed that a joint can be tightened a few days after a gasket with sealer has been installed and both sealer and gasket material squeeze out of the joint. If the surfaces don't mate perfectly, this action may result in a better seal.  **Caution: The studs go into aluminum and use fine treads; over tightening the studs can strip the threads in the casting.**

**Getting Ready to Mate:**  The gearbox was engaged in 4th gear, the mainshaft rotated till the pump cam was positioned with minimum height at the bottom and the mainshaft was positioned with a spline pointed up; this position was then marked on the rearmost gear in the gearbox (Whiteout on the tooth at center top).   Next, gasket sealer was applied to both sides of an OD to adaptor gasket and the gasket placed on the OD.  The pump piston was then pushed down and a piece of 20 gauge wire used to hold it depressed.  The wire was run in front of the little wheel at the top of the pump and then around the drain plug. This allowed the pump to  slide past the low point on the cam when the OD was mated to the gearbox.   The eight springs were then slipped over the thrust ring pins.  The four shorter springs go on the pins closest to the center.  Our springs seemed to have a continuum of lengths from about 3.8 to 4 inches.  According to The Service Instruction Manual, the springs should have free lengths of 4 1/4 (short) and 4 1/2  inches (long).   The springs seemed robust and we assumed they were a bit compressed due to old age.  I selected the longest and put them on the outside.  (This came back to bite later).

The dummy mainshaft was then rotated so that the spline was at the top and this position marked by putting a dab of  Whiteout on the rear flange opposite the parting line at the top of the rear casting.  The dummy main shaft was removed and a small amount of oil was poured into the main shaft hole.


**Mating OD to Gearbox:**  The OD was slid over  the gearbox mainshaft and the back end was shored up with blocks as shown in the left photo below.  The OD was then pushed toward the gearbox (or as the manuals say, offered up) while rotating the mainshaft back & forth till the splines on the mainshaft mated with the planet carrier and then the unidirectional clutch. Lock washers and nuts were put on the two long studs and used to draw the OD to the gearbox.  The nuts were tightened alternately a couple turns each while rotating the mainshaft back & forth.  When the mainshaft became hard to turn, both nuts were loosened until the shaft turned freely and then the back of the OD was wiggled --- the other studs seem to bind entering the adaptor plate and wiggling the OD freed them.  A very minimum torque was used on these nuts.  If the nuts are hard to turn, they should be backed off because something is hung up.  Once the OD was closed within an inch or so, a screwdriver was used to push the springs forward and over the nipples on the adaptor plate (center photo below).  The OD was then drawn further toward the gearbox until enough of the short studs were protruding so that lock washers and nuts can be screwed on.  The top nuts must be screwed on before the OD is against the adaptor plate, there will be insufficient gap at that time to slip the nut over the end of the stud --- see right photo below.  The wire holding the pump down  was clipped and removed when there was about a 0.1 inch gap between the OD and the adaptor plate.   The OD was then pulled  to the gearbox by tightening the nuts on the two long studs.    Once the OD was against the adaptor plate, the other four nuts were tightened.  (Tightening the lower two nuts before the the OD is against the gearbox is one way to bend the adaptor plate.)



**Filling with Oil & Installing Top Cover:** I use GL4 gear oil in all my gearboxes and ODs -- see separate note on gearbox lubricants. The drain plugs were checked to make sure they were in place and tight and then 1.75 quarts of oil was added --- poured in the gearbox top over the gears. The gearbox was then tilted back so some oil flowed into the OD unit. The oil should be level with the bottom of the side fill hole on the later gearboxes. The correct fluid level can be checked with the dip stick on the early gearboxes.

Gasket sealer was applied to one side of the top cover gasket and it was then positioned, sealer down, on the top of the gearbox. The cover was then installed, being careful to make sure the shifting forks engaged the shifters properly and then secured with the eight bolts and lock washers. The two longest bolts go in the rear two holes on the cover.

**The Test Motor:** Ronnie Babbitt had been having trouble with the OD leaking in his TR3. After taking it out several times he decided to motorize a test stand so that he could exercise the thing for an extended period to check for leaks. His setup is in the left photo below. He also made an adaptor to secure a pressure gauge. He found his pressure was a little low; we'll talk about that in the next section. The test setup allowed him to find his leak (bent adaptor plate), which he subsequently repaired. I was very envious of Ronnie's setup and decided to copy it..

Ronnie had used a spare 1.5 HP 1800 (1740) RPM motor. To attach as shown the motor must turn counterclockwise (the gearbox input turns clockwise as viewed facing the front of the gearbox). He said the motor loafed and stayed cool so a smaller motor would be sufficient. My calculations in Part I suggest a 1/2 HP motor would work with plenty of margin. The late TR6 OD specs call for testing at 25 mph (1200 RPM). With these data I went looking for motors. The cheapest I could find locally was about $125. I then checked Harbor Freight and found prices starting at under $60. I ended up getting a 1.5 HP 115/230 volt reversible 3600 (3500) RPM motor for $85; figured I could use it for something else later. This motor has good starting torque and is rated for air compressor duty. (The 2 HP version for $5 more would have been purchased if it had been in stock.)

My setup is shown in the center photo below., An inexpensive 5 inch die cast pulley mated well with the OD output flange. I tried to get a1 3/4 inch pulley for the motor but the smallest size the local stores had was 2 inch. I had a bunch of belts from some previous long forgotten project that were just the right length but too narrow for the pulleys. Used them anyway, worked fine and reduction was 2.7:1 so had ~ 1300 RPM. The board holding the motor is hinged were it attaches to the stand. This was intended to be sort of a clutch ---- lift the motor and let the belt slip to start. Turned out that is was not required since the motor had lots of starting torque, the load was light and the wrong width belt slipped a bit when starting. The motor can be removed when not in use by slipping out the hinge pins.

Ronnie had found a 0 to 800 psi gauge locally (in central Georgia) for less than $10. After a few telephone calls I found that our welding supply store stocked a similar gauge for ~$9. The gauge input is a 1/4 inch male pipe thread. (I understood that a liquid filled gauge would be better because it wouldn't vibrate as much; I planned to try to find one later.) The gauge screwed into the adaptor discussed earlier for injecting compressed air. **Caution, operate and release the operating valve using the lever or solenoid a half dozen times to relieve the pressure before removing the operating valve plug.**



**The Test Spin:** The test spin went fine --- started with the gearbox in neutral and no funny noises. I let it run for a few minutes --- everything stayed cool. No leaks! --- bet it was waiting for the first full moon. The pressure read about 250 psi and no bouncing like Ronnie said he had. Maybe air in system. Operated and released the the lever below the gauge. Could easily hear the OD engage and release (this setup was very quiet). The pressure dropped ~30 psi when the OD engaged but came back practically instantly.

When the motor was shut off the pressure fell to ~200 psi and then held. the operating valve was turned on and off pressure dropped maybe 30 psi each time till it got to less than 100 psi and then faded to zero. As the valve was turned on and off air could be heard escaping --- probably air that was trapped in the passages.

Fired it up again and this time the needle bounced back & forth with a total swing of maybe 30 psi. Must have lost the air cushion. Ronnie reported a larger swing on his needle. He had a later OD unit with a smaller accumulator piston that may experience a greater pressure change per pump stroke (pump volume should be the same). This time after the valve was operated and released a few times there was no longer the clunk of the OD engaging and the pressured didn't drop. The motor was shut off and the valve operated and released --- no change in pressure. Suspected the little hole in the operating valve spindle was plugged and OD was held engaged. To confirm this I tried to turn the output flange counterclockwise --- wouldn't turn ---- the OD was engaged.

Time to go get a snack while the pressure bled off. Came back a little later ---- no change in pressure. I then loosened the adaptor with gauge carefully. The plan was to loosen it enough so that it would leak and bleed off the pressure that way. It worked and not too much oil escaped, there was still a lot of air mixed in --- the oil was frothy. (The oil was observed to be nearly free of air after more operation indicating that most the air worked out of the fluid). The plug, spring & plunger were then removed. The ball was easily picked out with a magnetic pickup tool. The end of a length of ~19 gauge soft steel wire was bent slightly and then pushed into the end of the valve spindle then pulled up --- the spindle come out easily (photo on right). The top of the spindle was cleaned and blown into --- no air passage. --- it was plugged. A suitable drill bit was slid down the inside of the spindle and turned a few times then removed and wiped on a clean paper towel. Didn't see anything in the fluid but it had a lot of air mixed in it and not sure if I would have been able to see anything anyway. This time when the top was blown into, the passage was clear. (This left an after taste nearly as bad as beets.) The spindle was then cleaned thoroughly and reinstalled: everything worked fine then.

So, where did the dirt come from? It was probably in some of the internal passages in the main casting. Recall that this OD had a major internal failure and it is quite possible part of the debris got in the passages during the cleaning process. It appeared that little made it pass the screen, so if it was exercised a bit, hopefully anything else will work itself through the system, and no problems will be encountered in the future.

Another test run and everything worked fine except:

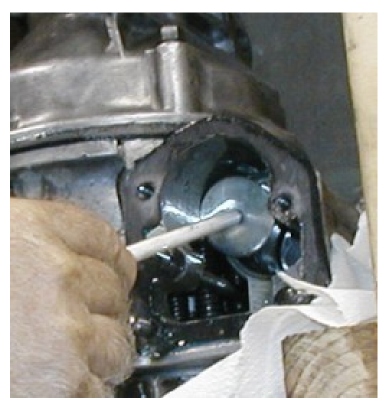
1. once in a while the pressure dropped about 50 psi for a short period and,
2. the pressure was too low, ~310 psi, and it should be over 450 psi (I found out later that the target should be 350 to 370 psi, not 450 psi ---- read on).

**Fixing the Pressure:** Ronnie Babbitt had trouble with low pressure --- about 360 psi. He called an expert and was told to put a 1/16 inch washer behind the accumulator spring, it would raise the pressure 50 psi. (As mentioned previously, there was a washer behind the spring in my late model A type OD.) Ronnie tried it and it worked --- pressure increased ~ 50 psi. He also had access to a calibration lab and found his gauge read about 50 psi low, so the washer got him to about 460 psi ---- great.

One worry I had was whether the pressure was limited by the pressure relief or whether the pump output was just matching the leakage. So, went to the store and got eight 1.5 inch fender washers (1/4 inch hole - 1/16 inch thick), now called packing washers. Also got a 4 inch pulley to speed up the OD. First, tried the bigger pulley on the motor. No significant change in the pressure but the gauge needle really fluctuated --- maybe plus and minus 50 psi. The speed was about 2600 rpm, it vibrated a lot (that pulley fastened to the flange was slightly off center). Found that speed was not the problem so went back to slower speed.

The pressure continued to be irregular, dropping significantly for short periods. That sounded like a valve problem. Both the operating and non-return valves were pulled and the balls and seats inspected again. The seats looked good but one of the balls had some very fine scratch marks. Don't know which valve it came from since the parts had been mixed. Went to the bearing store for replacements; had to buy a box of 65 balls for $6. When the operating valve was installed, the lever on the outside was turned too far and the valve spindle dropped to the bottom of the case. Used that bent wire to retrieve it and pull it up. The new balls cured the sudden change in pressure --- hard to believe. Next time I'll replace the balls to begin with since I have 63 spares.

Another concern was whether the gauge was correct. I don't have a way to calibrate it but did connect it to the airline and compared to two other gauges on the line ---the gauge read about 20 psi higher than the other two gauges at 120 psi and was at about 20 psi when no pressure was applied. The gauges had been compared earlier and they had read the same at that time.



The pressure was at about 310 psi and needed to get to be 450psi, so needed an increase of 140psi. Decided to try two washers behind the spring. Turned the gearbox on the front to let oil drain out of the OD (this is a test that needed to be run anyway to see if front seal leaked -- it didn't - yet). The cover plate was removed (nuts on studs first, then the bolts beside the spring, slackened together). **Caution, operate and release the operating valve using the lever or solenoid a half dozen times to relieve the pressure before removing the cover plate.** Then put in two washers (photo on right), put it back together and fired it up. Pressure went to about 360 --- about 25 psi increase per washer. The washers were 1/16 inch thick just like the one Ronnie used, but this is a different type accumulator and spring.

Next tried 6 washers and got a pressure of above 550 psi, an increase of over 240 psi, or a little over 40 psi per washer.

Next, removed one washer, leaving five. Tried it again. It started with no pressure and took a few minutes before any pressure build up. Probably no oil in the OD. This time pressure went to over 550 psi again, then fell back and went back & forth a couple times then headed to over 600 psi. What was going on? Maybe a valve sealed better, maybe there was some air someplace --- a mystery! Getting about 50 psi increase per washer with five washers.

Tried again with four washers, pressure was a little over 400 psi.

Tried again with three washers, pressure about 390 psi. Something happens with more than four washers ------ finally figured it out ---- with more than four washers, the spring must be fully compressed before the piston can move far enough to expose the pressure relief holes. Duh!

**Measuring the Accumulator Springs:** It was time to take some accumulator spring measurements:

**Accumulator Spring Measurements (inches)**

| Description | OD | ID | Free Length | Compressed Length |
|---|---|---|---|---|
| Early Accumulator Outer Spring | 1.48 | .88 | 6.37 | ~4.9 |
| Early Accumulator Inner Spring | .78 | .48 | 5.46 | ~4.1 |
| Late Accumulator Spring | .86 | .42 | 6.3 | ~4.4 |

The distance from the bottom of the inside of piston to the underside of the cover plate is about 6 inches. The piston moves about 0.8 inches to get to the relief holes. That left about 5.2 inches between the bottom of the piston to the cover plate when the piston has reached the pressure relief holes. These measurements could each be off 0.1 inch, so they are only a rough indicator, not precision data. These rough data however indicates that the maximum size of spacer that can be used without cutting off the pressure relief is about 0.3 inch or about five of those packing washers, which is consistent with our experimental data that the maximum size is .25 inches or four washers.

From the chart it was noted that the spring from the later unit would fit inside the big spring (it was snug). This spring was longer and much stiffer than the original inner spring. This late spring was substituted for the inner spring and the unit reassembled with no adjustment washers. Read about 470 psi! We had a solution!

The reason I was screwing around trying to use the old spring is that the major suppliers listed these early accumulator springs as NA. Victoria British suggested one convert to the later accumulator (piston housing, piston, tube & spring) for about $180. They did stock the later spring for $25.

I preferred to not substitute an incorrect spring if a correct replacement could be found. The Triumph email list was asked for help. Fred Thomas called and suggested Moss UK (011 44 208 867 2020); he had good luck getting parts from them that are NA here. (Several other suggestions of parts sources were also received and are listed at the end of Part II.) Gave Moss UK a call --- they had it (25 pounds plus ~4 pounds shipping, about $42). It was ordered on Friday afternoon UK time; they said to expect delivery in about a week. They shipped it airmail (Royal Mail - then USPS) on Monday and it arrived Thursday. Not bad, and the shipping charges were 4 pounds or about $6. A new spring for the later accumulator was also ordered from Victoria British.

The dimensions for the new springs are listed with the originals below. The free length of the new outer spring was about 0.2 inches longer which should get the pressure up to near normal. Note that the late spring was a little different. The TRF catalog indicated that a change was made in this spring in mid '69. They list the earlier spring as NA. Both Moss (US) and Victoria British, who supplied the spring, listed only one spring that I guessed was the later spring. Substituting that late spring for the original inner spring in an early accumulator might be a good solution for low pressure, this spring had about the same OD as the original early spring so there should be no concern of it binding. The cross-sectional area of the early accumulator piston is about 2.4 times that of the late one but the early piston moves about 0.8 inches and newer about 0.5 inches. When these two effects were combined it was calculated that the late spring should give about 2/3 the maximum pressure on an early accumulator as on a late one. That would be 2/3 of 450 psi or about 300 psi increase, which would be too much of a boost. It was clear that I was going to take more pressure measurements. The dimensions of all the springs are shown in the next table.

**Accumulator Spring Measurements (inches)**

| Description | OD | ID | Free Length | Compressed Length |
|---|---|---|---|---|
| Early Outer Spring (original) | 1.48 | .88 | 6.37 | ~4.9 |
| Early Outer Spring (new) | 1.48 | .84 | 6.57 | ? |
| Early Inner Spring (original) | .78 | .48 | 5.46 | ~4.1 |
| Late Spring (original) | .86 | .42 | 6.3 | ~4.4 |
| Late Spring (new) | .77 | .36 | 6.4 | ? |

**New Gauge:** Unfortunately, the cheap gauge had become erratic, the no pressure reading had increased to about 40 psi; hours of 50 psi fluctuations 1300 times per minute must have been too hard on it. A liquid (glycerin) filled gauge was found at McMaster Carr via the internet (www.mcmaster.com/). It was ordered at midnight and they sent an email the next morning saying they had shipped it UPS from Cleveland --- less than 200miles away. It arrived the following day. The gauge was what they call Grade A that is calibrated to within 1% around the middle of the scale. A 2 1/2 inch dial, 0 to 1000 psi gauge, part number 49053K79 had been selected. The cost was $21.34 plus 1.28 sales tax plus $3.15 shipping, $25.77 total. This outfit doesn't seem to pad the shipping like some of the others and will get more of my business.


The new gauge is pictured on right. Notice the liquid level. The needle was steady on this one, what a difference!

**An Alternative Gauge:** Some months after writing this note I noticed the following on one of the Triumph email list: *I have those gauges already made up as a tool, incorporating an original operating valve plug and a glycerin filled 600 psi gauge ready to fit on the overdrive in place of the operating valve plug. I sell them for $55.50 including shipping in the US. They are invaluable for not only testing the overdrive on a test stand but, more importantly, one can test the overdrive for proper pressure while still in the car! Most of the time the problem with a non-working overdrive is related to insufficient pressure. Bill Bolton, Bolt-On Healeys, Oregon. We sell parts for Healeys of all types.* A subsequent email pointed out: *We do not produce a catalog nor price listing as it becomes obsolete too soon and is so expensive. Simply tell your members that if they cannot find the part to email to Tricarb@aol.com, call on 541-895-5576 or fax to 541-895-4091 and ask. It helps if they have the BMC or Moss part number.* This seems to be a very good price for gauge and adapter.

**More Accumulator Pressure Measurements:** With a new gauge and a stack of accumulator springs, I first tried that new outer spring with the original inner spring and found the pressure to be 360 psi. That was still a little low, but 450 psi looked reachable with a couple packing washers. I had a bunch of questions about what if "this spring" was used or "that spring combination" so I made out a list of things to test and set about the task. I got pretty efficient changing the springs ---- about three minutes by tilting the unit up part way on it's side so the oil wouldn't leak out as shown in photo on right. The dust shield and the nut on the top stud were left off. The solenoid and actuating lever were not used during these tests.

Rather than adding the packing washers immediately, the old outer spring and then that spring with the two available late OD springs used as the inner spring were measured first. Part of the reason to do this was to get good comparisons with a gauge that is easy to read and thought to be relatively precise. These are the first three measurements listed below. (The reading with the new gauge were 20 to 40 pounds lower that with the old gauge.) Note that the used late spring adds 205 psi and the new one adds 265 psi (I calculated earlier that this one would add 300 --- close). Also, the decision to not buy a late spring to be used as a replacement for the original inner spring looks good since this combinations gave 515 psi (test 3), a little high.

The new outer spring was then tried with and without the original inner spring, tests 4 & 5. That inner spring seemed to have very little effect on the pressure ---- it was worthless!. In hindsight, a new one of those should have been purchased too. The 0.9 inch plug spacer was then added to give a total 65 psi contribution from the inner spring (test 6 vs. test 4).

Next, tests 7 through 10 were made using the .060 thick 1.5 inch diameter packing washers purchased earlier. For example, 2 washers gave about 465 psi. Some other tests were made and then that pressure was checked again --- down to 450 psi. What is going on? Time for bed. Plugged it in again the next morning ----- 465 psi. Got it, the oil got warm and the pressure went down. Rats, another variable.

Later that day tests 4 through 10 were repeated very quickly when the oil was cool. The results of those tests are recorded below.

At this point the setup of test 9, the 0.9 inch plug and the 3 washers looked like the best choice. It did seem a shame to have this thing all fixed up like new and use that many washers. An attempt was made to secure a replacement inner spring. Called Moss UK, they didn't have any and none were on order. Then called Overdrive Repair Services (011 114 248 2632) to see if they had one. The guy who answered the phone asked "why do you want one of those?" I explained that I had low pressure and since I had a new outer spring, figured we should get a new inner spring to increase the pressure. He said that the inner spring has little effect on the pressure (I noticed that), it is there to to support the outer spring --- help keep it straight. I said that the pressure was only about 350 psi. He said that was what it's supposed to be, 350 to 370 psi. He then explained the 350 psi and the big accumulator provided near instant engagement that tore up the axels in the later IRS cars so easily that the design was changed to the smaller accumulator on the later units to make the OD engagement softer. That made sense since Ronnie Babbitt's data showed that the pressure drops when engaged much more in the later units, and then built up in a second or so. Further, the later J type has no accumulator and has a much softer engagement. After the call I got to thinking ----- what pressure should the later A type unit be? Called the guy back and he said about 450 psi for the later units with the smaller accumulator pistons. The smaller accumulator makes for slower engagement but the higher pressure holds it in OD harder and should allow for higher torque without slipping. The later engines were 6 cylinders that had greater power and torque so it all fits together.

After considerable thought and consultation with a fortune teller, I flipped a coin and decided to make a small plug for the inner spring to compensate for any loss of strength due to old age. I also thought it would give a little margin. This combination is test 11 in the following chart and shown in the photo after the chart.

I decided to include the data on the other tests, even though most produce a pressure much higher than required. The effects of the various number of washers may be useful in the future should it be necessary to fix a unit with a weak spring or I want to operate the unit at a high pressure. Some weeks after these tests were run I had a conversation with Brian Schlorff of Power British at the 2001 TRF Summer Party. He said he always shimmed both the early and late accumulators to give 450 psi. I asked him about the higher pressure in the early accumulator increasing the shock to the drive train due to the rapid engagement. He said he handled that by tuning the operating valve ---- see discussion of operating valve.

**Accumulator Pressure Tests (1300 rpm with cool oil)**

| Test | Spring Configuration | Pressure (psi) |
|---|---|---|
| 1 | Early Accumulator Outer Spring (original) | 250 |
| 2 | Early Accumulator Outer Spring (original) + Late accumulator spring (used) | 455 |
| 3 | Early Accumulator Outer Spring (original) + Late accumulator spring (new) | 515 |
| 4 | Early Accumulator Outer Spring (new) | 350 |
| 5 | Early Accumulator Outer Spring (new) + Early Accumulator Inner Spring (original) | 360 |
| 6 | Early Accumulator Outer Spring (new) + Early Accumulator Inner Spring (original) + 0.9 inch Plug | 415 |
| 7 | Early Accumulator Outer Spring (new) + Early Accumulator Inner Spring (original) + 0.9 inch Plug + 1 Washer | 440 |
| 8 | Early Accumulator Outer Spring (new) + Early Accumulator Inner Spring (original) + 0.9 inch Plug + 2 Washers | 465 |
| 9 | Early Accumulator Outer Spring (new) + Early Accumulator | 485 |

| | | |
|---|---|---|
| | Inner Spring (original) + 0.9 inch Plug + 3 Washers | |
| 10 | Early Accumulator Outer Spring (new) + Early Accumulator Inner Spring (original) + 0.9 inch Plug + 4 Washers | 510 |
| 11 | Early Accumulator Outer Spring (new) + Early Accumulator Inner Spring (original) + 0.5 inch Plug | 380 |

The pressure was measured again at both 1300 and 2600 rpm after the oil cooled over night. The unit was then run for about 30 minutes at which point the case was pretty warm (maybe 140 degrees F) and then the pressure again at the two speeds again as shown below.

**Accumulator Pressure - Speed & Temperature Sensitivity**
Early Accumulator Outer Spring ( new) + Early Accumulator
Inner Spring (original) + 0.5 inch Plug

| | **Cool** | **Warm** |
|---|---|---|
| **1300 RPM** | 380 | 360 |
| **2600 RPM** | 390 | 375 |

Earlier, using the first gauge, the shaft was turned by hand after the pressure had built up using the motor. The pressure was steady and then pulsed up 20 psi or so when the pump pushed more oil in. The new liquid filled gauge indicates the average of the steady value and the pulses. As the shaft speed increases, a slight increase in the pressure reading was expected because there would be more of the pulses ---- exactly as observed. If the pressure had increased significantly, a pump or valve problem would have been suspected.

The first though was that the temperature affected the hydraulic pressure in the same way that a hot engine has lower oil pressure; the warm engine oil is thinner and slides by the surfaces being lubricated easier. If this were the case, different results would be likely using different lubricants in the OD. These tests were conducted using 80W90 GL4 gear oil from TRF. In the engine, the pressure builds back up if the RPM is increased. With the OD, doubling the speed produced only a minor pressure change, that likely due to more of the short pump pulses. It was then concluded that the pressure change between hot and cold was due to the accumulator springs exerting less force when warm --- the pressure relief occurs at a little lower pressure.

At this point the accumulator topic had been beat to death and it was time to move on.........

**New Problem:** The next thing was to make a number of test observations. The first step was to verify that the OD was shifting. The motor was turned on and the pressure ran up and the shifting verified by operating and releasing the lever below the operating valve and listening to the piston move. The motor was then stopped and the valve operated to verify it was really in OD (there was still ~ 300 psi hydraulic pressure). The piston could be heard to move, but it wasn't locked in OD because the shaft could be turned counterclockwise. Checked and rechecked several times. While turning clockwise there seemed to be a little increase in output over input but not a solid consistent 20%. It was concluded that the OD wasn't engaging. Rats! Tear it apart again.

The plan had been to replace the oil anyway in an effort to remove any possible dirt that may have been in the internal passages. Once the OD was removed, the shifting was tested with compressed air --- worked great. Put it back on, leaving the cam off to make job quicker ---- failed on compressed air. Slackened the nuts so that it pushed back ~ 1/8 inch from adaptor --- worked! It was then clear that something was stopping the sliding member from going all the way forward. Pulled OD off and measured all the clearances --- seemed like there was plenty of room, no way could it interfere. Next, pulled the rear casting off and just put on the main casting and tried to shine a flashlight through from the back to see if the rods or nuts on the thrust ring were hitting anything. Couldn't tell for sure so tried again without the eight clutch release springs --- worked fine. Must be something with those springs.

After the previous bout with the springs it was decided to investigate the clutch release springs more carefully. There were clearly two different types, four had a smaller spring wire diameter. Both the free length and compressed length of all eight were measured. That old thrust ring was used to hold the spring straight in the hydraulic press to measure the compressed length. The four in each group were very similar. The average measurement for the springs in each group is in the table below. It became clear that the short springs on the center 4 rods couldn't be compressed as much as the longer four springs on the outer four rods.

Original Release Spring Measurements (inches)

| Group | Free Length | Compressed Length |
|---|---|---|
| Smaller Wire | 4.0 | 2.6 |
| Bigger Wire | 3.8 | 3.0 |

The longer springs (smaller wire) had the shorter compressed length and probably originally had the shorter length. The springs were put back in, this time with the springs made from the smaller wire on the inner rods. (The base for the outer rods is about 1/4 inch toward the rear than the base for the inner rods, hence the outer rods can accommodate a longer compressed length spring). While attaching the OD to the gearbox the springs seemed pretty weak. (The OD had been taken off and on so many times at this point that wing nuts were under consideration.) The OD engaged perfectly but the springs in this position were too weak, it was very slow to release from OD and finally stuck in OD. Time to order new clutch release spring!. TRF & Victoria British wanted $40 for a set and Moss (US) wanted $70. TRF was out and no idea when they would get any. Victoria British had them in stock and got the order. They arrived two days later via Priority Mail.

The new springs were carefully measured and compared with the original springs. The original springs with the thinner material were clearly the short springs that go on the inner rods. The summary data is shown in the following chart.

**Clutch Release Spring Properties (all dimensions in inches)**

| Spring | Free length | Compressed Length | OD | ID | Wire OD | Turns |
|---|---|---|---|---|---|---|
| Short (new) | 4.48 | 2.57 | .51 | .35 | .084 | 31.5 |
| Short (original) | ~4.0 | ~2.6 | .54 | .37 | .083 | 31.5 |
| Long (new) | 4.54 | 2.96 | .53 | .34 | .094 | 31.5 |
| Long (original) | ~3.8 | ~3.0 | .53 | .34 | .094 | 31.5 |


The photo above shows the original and new springs together. The ends of the new springs are painted, red on the short ones and yellow on the long ones. All the springs had about 31.5 turns. Note that the new short springs were wound in the opposite direction from the others --- doubt that the winding direction was part of the original specification. The right 3/4 inch or so of the original springs were clearly collapsed. All of them were that way and they were pretty uniform, so much so that I thought they were manufactured that way. Recall that the release bearing had failed on this unit and these springs pressed the thrust ring into the rotating clutch sliding member. The thrust ring and sliding member got very hot. It was then concluded that the ends of these springs also got very hot, hot enough to remove the temper and allow the springs to collapse. And here I was thinking the PO had substituted the wrong springs. Shame!

Before the new springs were installed the pressure required to operate the clutch using the original springs installed in the correct positions was measured; it took 80 to 85psi. This measurement was repeated using the new springs found to be 140 to 160 psi. This time the OD couldn't be pushed onto the gearbox far enough for the mainshaft splines to engage the planet carrier splines as with the original springs; the nuts on the long studs had to be used to draw it to that position. The mainshaft was rotated back and forth a few degrees each side of the center mark as the OD was drawn onto the gearbox and no difficulty was encountered and a minimal force was required on the long studs. The OD engaged without difficulty and released quickly with the new springs.

One last thought on the release spring subject ---- why did it work and then stop? At some point the nuts on the studs between the gearbox and the OD were tightened. A leak between the adaptor plate and the OD was suspected --- turned out it was oil from around the adaptor screwed into the operating valve for the gauge --- it wasn't tight enough. The Hylomar stays soft and actually penetrates the gaskets. When the nuts were tightened later, some Hylomar squeezed out and the gasket seemed to flatten and some of the gasket squeezed out too. Apparently the OD was right on the edge of engaging so tightening it must have been enough to make it fail. Lucky it was found before putting it in the car.

**Valve Springs:** With all the shrunken and limp springs it was decided to verify the condition of the non-return valve and operating valve springs. Both valves seemed to work great, but I wanted to avoid any future problem. A new spring was ordered with some of the other parts and the spring was also pulled from the later OD that that had been opened to remove the accumulator. The measured free lengths are shown below. It was difficult measure the free length reliably because the springs are pretty weak so there is likely some error in the measurements. I didn't know which spring went in which valve in the early OD. The spring from the later OD came from the non-return valve. It was decided to put the new spring in the non-return valve and secure another new spring and put it in the operating valve which is accessed from outside the case.

**Valve spring free lengths (inches)**

| Early OD | Early OD | Late OD | New |
|---|---|---|---|
| .67 | .73 | .73 | .775 |

Del Border, in that article on Healy ODs (http://www.team.net/www/healey/tech/big_hly/od/finespanner.html) had a problem with low hydraulic pressure he cured by modifying the non-return valve plunger. He fabricated a new plunger with the thickness of the end increased from 0.125 inches to 0.219 inches. This preloaded the spring. He felt that this was better than getting a new spring that might in time become weaker. I have a lathe in the workshop and could turn out a new plunger in a few minutes. However, I'm very reluctant to put non standard parts in the OD. I'd much prefer to shim the plunger so that when taken apart later, it would be obvious to both me and anyone else what had been done. A shim could be machined the exact size required to met Del's 0.094 inch increase in thickness. Checking around the workshop I found that split lock washers for #6 screws have about the right ID and OD and are a little over 0.040 inches thick. A couple pair of pliers were used to bend two washers at the split so that the washers were flat. The washers are shown on the plunger in photo to right. The combined thickness of the washers and the end of the plunger is 0.215 inches. It was decided to not to shim the plunger in this unit.

**Solenoid Test:** The solenoid current drain was measured before installing it. The solenoid should draw 15 to

20 amperes with the plunger removed (do this for only a few seconds, the solenoid is not designed to carry this current continuously). The current drain should be about 1 ampere with the plunger in place. I used an inexpensive multimeter for this test. One of these is also a good tool to help solve Lucas mysteries. They cost $10 or less, not a precision instrument, but won't make you cry if you step on it or drive over it.

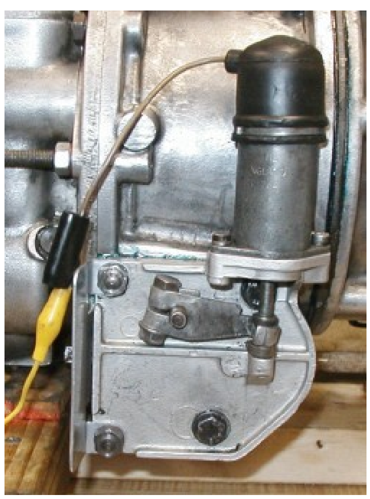
My able assistant (an Electrical Engineer) allowed herself to be photographed if I agreed to make no sexist or blonde comments. I agreed (but I lied). This young woman was a terror in a '73 TR6 at Engineering College more years ago than she's willing to admit. (She has a neat mom that I've been flirting with for years.)

The engineer set the multimeter to the 20 ampere current range and connected the negative (black) probe to the solenoid lead using the yellow clip lead. The positive (red) probe was held against positive battery terminal and the solenoid case was touched against the negative battery terminal. The first test was made with the plunger removed. We read 16 amperes on one and 17 amperes on a second solenoid. Next, she measured the current with a plunger in the solenoid. When the current was applied this time, the plunger snapped into the solenoid and the current read about one ampere, just as it should. She explained that with the plunger in the solenoid, the initial current is about 17 amperes until the plunger reaches the back of the recess and operates a switch to remove the high current pull-in coil and leave only the low current holding coil in the circuit. She must have checked out the schematic at the end of Part I.

**Installing the Solenoid:** Installing the solenoid was straightforward. The operating shaft collar was slipped onto the end of the shaft followed by the actuating lever (also called solenoid lever). The plunger boot was rotted away, so the plunger was pulled from the solenoid and slipped into the hook on the end of the solenoid lever. If the boot were still there, the solenoid with plunger would have been fed through the hole in the bracket and over the hook. Originally there was a thin gasket between the solenoid and the bracket. The gasket may have been to minimize corrosion between the dissimilar metals. No one seems to stock the gasket now. One was cut from thin gasket paper. The two screws were then tightened.

**Adjusting the Operating Valve:** The manuals talk about putting a 3/16 drill through the hole in the lever on the outside of the case below the operating valve and in a matching hole in the main casting. This is supposed to position the operating valve open the correct amount. The solenoid is then operated, the actuating lever pushed down against the bottom lip of the plunger and the pinch bolt then tightened. This may have worked when new, but not on these old worn units. In most cases I've seen, the valve is still closed in the position with the drill in the holes.

It was decided to use a dial indicator to adjust the valve as shown in the right photo below. The plug and spring were removed and a length of 5/32 inch OD - 1/8 inch ID brass tube (hobby store) was placed over the end of the plunger and the combination then placed between the ball and the dial indicator. The solenoid was not operated without something over the ball --- didn't want to be dodging steel balls --- the solenoid is a very effective ball launcher (bit of experience speaking here). While messing around the lever was turned too far and the end of operating valve spindle (the long thin shaft) dropped past the lever to the bottom of case --- used that bent wire again to retrieve it.

The lift adjustment is made as follows:

1. Loosen pinch bolt
2. Position the plunger with brass rod in the center of the ball and record the dial indicator reading.
3. Push the solenoid plunger up as far as it will go and then operate the solenoid (don't operate the solenoid with valve released --- shock is not good for the indicator).
4. Move the lever on the operating shaft (below operating valve) to the position where the dial indicator reading is different from the reading in Step 2 by the desired lift.

5. While holding the lever in this position, push the actuating lever down against the bottom of the solenoid plunger and tighten the pinch bolt (this takes three hands).

6. Release the solenoid, push the brass rod down and verify the reading is the same as Step 2.

7. Take the operated and released readings several times to verify the lift is set as desired. (Remember to lift the solenoid plunger before operating the solenoid.) If the setting is not as desired, readjust as required.

Note that this adjustment can be made in the same way with the OD installed in the car.

I couldn't find a specification for the amount the ball should be lifted when the valve is opened; a fairly small lift should give nearly instant operation. Del Border (http://www.team.net/www/healey/tech/big_hly/od/finespanner.html) says the Healy spec is for 1/32 to 1/16 inch --- .031 to .062. That sounded a bit large. Ronnie Babbitt was told the proper setting is .015 to .017 inch. I had a long conversation with Brian Schlorff of Power British at the 2001 TRF Summer Party and he said he started with an adjustment of .010 and then tuned it in the car if necessary to get the correct feel. (Power British has a reputation for high quality work so Brian's advice should not be taken lightly.) After returning from the summer party I made measurements at several different lift settings as recorded the below.

**Operating valve characteristics as a function of valve lift (on test stand)**

| Valve Lift (in) | Time to Shift (sec) | Pressure Drop (psi) | Time to min press (sec) |
|---|---|---|---|
| .006 | Won't Shift | - | |
| .008 | ~2.5 | No Change | |
| .010 | ~1 | ~30 | ~2 |
| .013 | <1/2 | ~35 | ~1/2 |
| .016 | <1/4 | ~40 | <1/2 |
| >.016 | <1/4 | ~40 | <1/4 |

The above measurements were taken after the OD was run enough to become hot. The OD didn't shift at all when the lift was set at .006 inches. There must be enough flex in the mechanical linkage so that the valve couldn't open against the hydraulic pressure when the no pressure lift is .006 inches. At a lift of .008 inches, the unit shifted in 2.5 seconds and the pressure held constant. The shift was detected by the change in the pitch of the gearbox noise. When the lift was increased to .010 inches, it shifted in about 1 second and the pressure dropped gradually to a 30 psi reduction after about 2 seconds and then recovered as the pump supplied fluid. Note that the pressure continued to drop after the unit shifted. It is my guess that the radial play in the clutch sliding member allows it to drag on the brake ring before it is seated. There may also be some air in the system that causes the pressure to build after the sliding member has seated. Both of these would cause the unit to shift early under no load but to slip under load until the pressure builds in the operating pistons.

As the lift was increased further, the unit shifted faster and reached minimum pressure faster. For lifts of 016 inches or greater, the unit shifted and reached minimum pressure in less than 1/4 second -- essentially instantly. For these larger lifts, the OD probably has a very firm shift that sends a shock through the drive train.

A second measurement was taken with a lift of .010 inch after the OD had cooled. The results were nearly identical to the results for a .008 inch lift on the hot OD.

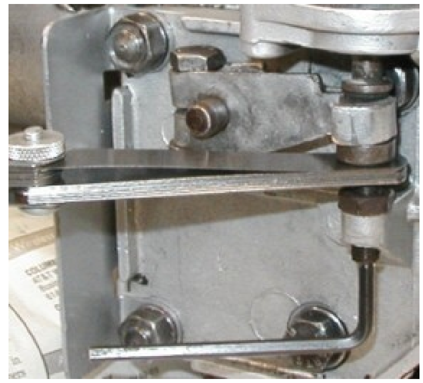
So -- what is the correct lift setting? I don't believe that the designers intended that the operating valve lift adjustment be used to control the firmness of the clutch engagement. This is in part supported by the fact that subsequent changes were made to the accumulator design to soften the engagement. If the designers had intended to control the engagement by the valve, it would have been a simple matter to control the flow by altering the clearance between the diameter of the upper portion of the operating valve spindle and the diameter of the cylinder it slides in. This is probably what limits the speed of fluid flow for a valve lift equal to or greater than .016 inches. I believe that the factory adjustment was large enough to make sure that the operation would be independent of temperature, oil viscosity and reasonable change in pressure and wear. That suggests that a lift adjustment of .016 inches or slightly more is what the factory originally did.

If one wants to use a smaller lift to create a softer engagement, go to it. It will probably reduce the wear and tear on the entire drive train. This is especially important if one increases the pressure on the early large piston accumulators. The only drawbacks I can see is that periodic readjustment may be required and the engagement speed may change as the gearbox heats up.

I think I'll use the .016 lift and rely on the spindle dimensions to limit the fluid flow.

After fooling with this adjustment, I took a test drive in my TR250 that has the later style accumulator and is set for a fairly large operating valve lift. The switch in and out of OD was about the same, about a half second each way and it didn't seem too hard. I then tested my '76 TR6 with J type OD. The first thing I noticed was that it shifted out of OD much quicker, in like a quarter second. The shift into OD took nearly two seconds at 30 mph and about one second at 60 mph. The firmness of the shift, once it happened, seemed about the same as the TR250. If accelerating, you get a jerk with both when they switch in. The switch from OD to direct drive actually seemed a little harsher in the J Type, especially if accelerating. I've never driven a car with the early large piston accumulator so I can't compare. I'll add something here as soon as this one is in and running.

**Actuating Lever Stop:** I noticed that there was no adjustment screw in the stop below the solenoid plunger like on the later A type ODs on my TR250 and TR6. The hole in the stop was not threaded either. One of the catalogues indicated that a rubber stop (NA) was used on the early models. The plunger was pushed down as far as it would go and then the solenoid was powered ---- it wouldn't operate. This must not be allowed to happen The OD will fail to engage and worse, the high operating current will quickly burn up the solenoid winding (~$100). The hole was drilled and tapped 1/4-28 to match the later models and the 3/4 long set screw and jam nut from a later unit was installed since the hardware store wasn't open at that time of the night. The Haynes TR250-TR6 manual says the gap between the top of the screw and the bottom of the operated plunger should be 0.150 - 0.155 inch, see photo on right. The solenoid then operated reliability. Note that too small a gap may cause the OD to not disengage when the solenoid releases. Fred Thomas said an insufficient gap caused him to remove the interior of his TR3 eight times this past spring. Fortunately, his OD was not damaged.



The Haynes manual also specifies an end float on the operating shaft of approximately .008 inch. The end float was checked with the dial indicator and found to be within the approximate .008 inch specification that was interrupted rather broadly.

**More Test Observations:** The test observations were started again, this time with new release and accumulator springs. Unless otherwise noted, the motor was turning the output shaft at about 1300 RPM and the new pressure gauge was in place.

These tests could also be run with the OD in the car. If I were doing that, I would unbolt the the drive shaft at the back of the gearbox rather than running the car for an extended period with the back blocked up and the wheels powered. It would probably takes me less time to disconnect the drive shaft then to block it up anyway.

When starting from zero pressure, the pressure built to about 180 psi very quickly, in a second or so and then built linearly (as best I could tell) to maximum pressure in about 10 seconds. This suggested that the accumulator springs exerted a force corresponding to about 180 psi when the accumulator was empty (accumulator piston all the way in). This also suggested that the total change in pressure caused by the accumulator piston moving was from 180 psi to ~ 380 psi, about 200 psi.

When the solenoid was operated, the pressure dropped about 40 psi and then recovered in a little over 2 seconds. The 40 psi change was about 1/5 of the pressure change for the full accumulator piston movement suggesting that the fluid required to operate the clutch was 1/5 the capacity of the accumulator. In Part I, I calculated that it would take about 1/6 the accumulator capacity to operate the clutch. This difference is a reasonable margin of error of my ballpark estimate and rough measurement of transient pressures.

When the power was shut off, the pressure dropped quickly at first then at a slower rate, reaching 300 psi in 10 seconds and then 200 psi after 10 minutes. The pressure was 180 psi 12 hours later.

The gearbox and OD was then scrubbed thoroughly and fresh newspaper was placed under it and it was run for four one-hour stretches with a 10 to 12 hour break in between to let it cool. This heating/cooling was an attempt to detect any possible leaks. The tests were run with the gearbox in 2nd gear most the time to stir up things a bit in the front. There were no drips and no oil on the outside of the case; it shouldn't leak for at least a month.

While running these tests some of the previous pressure measurements were taken again. Differences of 3% to 4% were noted in some cases probably due to temperature effects and errors in reading the gauge. The gauge is marked every 20 pounds, which is 4% at 500 psi. I tried to record pressure readings in 5 psi increments but in reality that is probably beyond my capability; in hindsight I'd been better off to record the pressure readings in 10 psi increments. Excepting those slight pressure differences, there were no other changes in the observed operation.

**J Type OD:** The J type OD from my '76TR6 was put in the test stand to find a small leak. Before firing it up, a small leak from the countershaft cover plate in the front was noted, but it hadn't yet made it to the drain hole; the cover plate was bowed so it was reversed. The rear seal was replaced (again) because there was a one drop drip on the bottom. The motor was then run for an hour. There was a stream of oil from one of the studs near the top that hold the front and rear casting on each side of the brake ring. There is a copper washer then lock washer and then nut on the stud. The lock washer had distorted the copper washer,. The fix was to replace the copper washers on the two top studs and then add a flat washer between copper washer and lock washer. Joint sealer was also used around the stud.

While the unit was on the bench the hydraulic pressure was measured. The gauge was attached to a hole just to the front of the solenoid. The plug for the hole is setting beside the hose in the photo. The hole threads are 3/8-16. An old rear brake hose from a TR6 was used to connect the gauge. One end was threaded 3/8-24. A 3/8-16 die was run right over the old threads -- worked great. The other end had an inch of so length of

1/2 inch cylinder and then the smaller part threaded 3/8-24. The threaded part was cut off and the larger section was then turned down to 3/8 inch and threaded 1/8 inch pipe threads which then screwed into the reducer on the end of the gauge. (While doing this it was observed that the 1/8 inch pipe thread is nearly identical to the 3/8-24 piece cut off, except the pipe thread is slightly tapered. In hindsight, the 3/8-24 will probably mate with the 1/8 inch pipe thread in the reducer if a couple layers of Teflon joint tape are used.) The pressure was 450 psi at 1300 rpm and 460 psi at 2600 rpm. (The solenoid must be operated to record any pressure; this system has no accumulator.) The specs call for 460 psi to 490 psi. The pressure relief spring was probably a little weak due to age, but this was close enough.

**Temperature Measurements:** It was also observed that the J OD got very hot so a comparison temperature test with the early A type was conducted. Both units were run in high gear at 2600 RPM output (~54 mph) with OD engaged. Near the end of the run the front was elevated for two minutes at a 12 degree angle, then the same to the back and then let run level for a few minutes. This was to mix the oil from the front and back in an attempt to equalize the temperature of the oil. The temperature of the oil in the gearbox was then measured and recorded in chart below. The J type solenoid also seemed hotter than the A type so the power for each was computed and included in chart below.

The fact that the temperature in both gearboxes reached the same final temperature is a coincidence. The ambient temperature was a few degrees warmer when the A Type was tested because the widow was open to disperse fumes from curing a powder coated exhaust manifold. There were probably a half dozen other parameters that affected the results so all that can be said is that the temperature rise is similar, a little over 1 degree F per mph. There are all kinds of other effects when the gearbox is in an auto carrying a load. For example, the surrounding temperature is much higher because of engine & exhaust heat. There is much better ventilation when one is going down the road at 80 mph, the bearing load is higher when transferring power through the gearbox/OD, etc.

**OD temperature & solenoid power after one hour operation at 2600 RPM output in high gear with OD engaged**

| Type | Oil Temperature | Solenoid Power |
|---|---|---|
| A Type | 138 degrees F | 12 watts |
| J Type | 138 degrees F | 21 watts |

After this last test the A type OD was pronounced healthy and ready to be installed. The TR3 in which it goes is months away from as test drive. I'll update this with road test results when that data is available.

**Some troubleshooting hints are presented in Part V.**