J Type Overdrive (TR6), Part I - Theory

Introduction: Last year I wrote a series of notes on the A Type Overdrive. This time it's the J Type Overdrive. The first overdrive I disassembled was a J Type. That was over ten years ago. The OD was installed in my '76 TR6. The gearbox started to make whining noises and I failed to attend to it promptly. Some time later after the noise got really loud the overdrive would no longer engage. Investigation revealed that the rear countershaft bearing had failed and disintegrated. The pieces from the bearing made it into the gears and broke teeth off most gears in the gearbox. Some of the pieces got into the OD pump and destroyed it too. (There's probably a message here someplace.) I took that same OD apart some time later but can't remember why ---I know it wasn't serious ---- maybe it was to fix a leak --- too many ODs and too many years.

I just purchased a gearbox with J Type OD from another '76 TR6. The gearbox was disassembled and the main counter shaft gear (with 1st and reverse) and the reverse idler gears were missing. I was told that the reverse gears had all the teeth chewed off and were sent off to get replacements that never arrived. I was also told that the overdrive had been disassembled and everything was in order.

A cursory inspection revealed that everything seemed to be there (excepting the reverse gears) and none of the gearbox parts showed excessive wear or broken teeth. One prong on the 3rd/4th selector fork was bend to the back so that one prong would have been in the hub slot and the other would have been behind the slot. Not sure how that would have effected operation. Maybe the cover was dropped during disassembly and the fork was bent then. I secured a used '74 gearbox from a friend for spare parts. With all the debris that had been floating around the gearbox and OD, I decided to completely disassemble the unit to make sure nothing was damaged and to clean all the passages --- debris in the hydraulic system is bad news. These notes describe overhaul of that J type overdrive.

After writing the earlier note on the A type it is natural to think of the J type in reference to the A type and describe it in terms of what is different. Some major differences between the A and J types are:

- The rear mounting arrangements are different. The A type uses the same rear mount as the non OD gearbox. Therefore, the A OD can be used any place the regular gearbox fits. The J type rear mount position is further to the rear than the non OD gearbox. A new two position mount (one position for non OD and the other for J Type OD) that uses different mounting brackets welded to the frame was introduced with commission number CF1 in 1973. Others have successfully used the J type OD on earlier frames by fabricating custom mounting fixtures. (I understand that Rimmer Brothers sells an adaptor to mount the J type to the earlier frame. I also have heard reports that it doesn't work. It'd probably a good idea to poll the Triumph or 6PACK email lists for advice on the best way to mount a J Type on an early frame.)

- A second major difference is that the J type OD is much less robust. For example, the gear teeth are smaller and I assume will tolerate less force. The design of the hydraulics is also different in a way that subjects the gears to less force. Many claim that the net effect is that the J type is much less prone to failure. The only area that I find fault with the J type design is the pump plunger assembly discussed later. The less robust design and reduced torque capability limited the J type to overdrive only in 3rd and 4th gears. I don't find that a problem since I never use my A types in 2nd gear unless I'm testing operation in 2nd gear. And --- if it doesn't work in 2nd gear I run down and repair the wiring problem and then never use it in 2nd gear till the next test --- dumb!

- A third major difference (improvement) is that it is much easier to access the hydraulic components of the J type OD without removing it from the car.

- A fourth major difference is that the J type has many less parts, especially thrust and adjustment washers and it is much simpler to dismantle and reassemble since no end float measurements and adjustments or valve adjustments are required. Also, only three easily fabricated special tools are required.

I decided to make this set of notes independent of the other set on the A type. However, I also decided to include a comparison with the A type where appropriate. I followed the same format and sequence as the notes on the A type by cutting and pasting the entire text from the A type notes into these notes and then editing them for the J type. This eliminated all the effort usually required developing an organization and outline

Overview: The J type overdrive (OD) unit described here was manufactured by Laycock-de-Normanville and provided as a factory option on the 1973 through1976 (Commission number CF1 and later) TR6s. (I understand identical units were used on Volvos made in the 70s and early 80s.) The function of the OD is to change the overall reduction ratio between the engine and rear wheels. It operates in two modes, the direct dive mode where there is no change is reduction ratio and the OD engaged mode where overdrive provides a 25% rpm increase in the output over the input rpm (i.e. overdriven). This means that for a given engine rpm, the road speed is 25% greater when the OD is engaged. Another way of saying this is that when the OD is engaged, the engine rpm is reduced by 20% for a given road speed. The OD is operator controlled via an electrical switch on the steering column. The J type OD can be engaged only in 3rd and 4th gears.

Two models of the J type overdrive were fitted to the TR6; model # 25/115838 fitted from commission number CF1 to CF35000 and Model # 25/1158976 from commission number CF35001. Changes associated with the J Type overdrive I've found from reviewing the catalogs are:

- The speedometer driven gear was changed with the model change noted above. This change was coordinated with the introduction of the service counter and different speedometer at commission number 35001. A change was also made in the studs between the OD unit and the OD adaptor housing. These are the only changes I've found between the two models.
- The mainshaft was changed at commission number CF12,500. This was to accommodate changes in the gearbox; the overdrive end of the mainshaft wasn't changed.

The OD unit is attached to the rear of a regular gearbox in place of the rear extension as shown on the right. The only changes required to the basic gearbox to use an overdrive (OD) are a different mainshaft and the addition of an isolator switch in the gearbox cover. The isolator switch as well as the reverse lamp switch and associated wiring is missing from the gearbox in the photo.

A reproduction of the SERVICE INSTRUCTION MANUAL for the LAYCOCK - DE - NORMANVILLE OVERDRIVE UNIT WITH ELECTRICAL CONTROL purchased from The Roadster Factory (TRF) was used in the preparation of these notes. The original date of publication of this manual on the A type OD is not listed but only the TR2 is referenced so I guess it to be late 1950s. Interestingly, the drawing accompanying the parts list appears to be essentially identical to that shown in a TR250/TR6 Haynes manual and current TRF and Moss catalogs for the A Type OD. The sections of the Haynes Triumph TR5, 250 & 6 Owner's Workshop Manual the Leland TR6 Repair Operations Manual covering the J type OD as well as TRF, Moss and Victoria British catalogs were also used as references.

This part describing how the OD operates is divided into three sections:

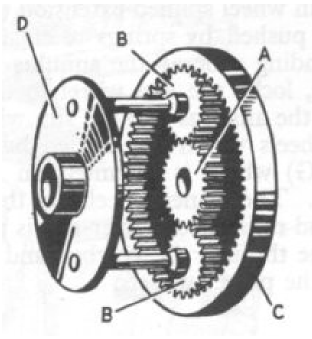
- The mechanical components including the gears and the two clutches
- The hydraulic components that control the shifting.
- The electrical components that control the hydraulics.

Section 1 - Mechanical Components

Epicyclic Gear: The heart of the OD is the epicyclic gear shown in the diagram (taken from the Service Instruction Manual) at the right. The parts are:

- A: Sun gear
- B: Planet gears
- C: Outer ring gear or annulus
- D Planet gear carrier

The word annulus has several meanings, some relating to rings and others to anus. As we see later, the OD annulus is the component at the rear of the OD that both provides output and contains the ring gears, so maybe both meanings apply.



The operation of these gears is not obvious (at least to me) at first glance. The four things to remember when trying to understand the epicyclic gear are:

1. Input rotary power is applied to the planet gear carrier (D).
2. Output rotary power is taken from the annulus (C).

3. For direct drive (no speed change) the sun gear (A) is locked to the annulus (C).
4. For an output that is a higher speed than the input (overdriven) the sun gear (A) is locked stationary.

For this discussion, let's assume all rotation is clockwise, the normal Triumph propeller shaft rotation for forward gears. It should be fairly easy to see that if the sun wheel is locked to the annulus, the planet gears can't rotate on their axis. Therefore, the planet carrier is essentially locked to the annulus and the output will turn at the same speed as the input.

It's a little more complicated to envision what is going on when the sun gear is locked stationary. First, observe that when the planet carrier is rotated clockwise with the sun gear stationary, the planet gears will rotate clockwise on their axis. Next observe that planet gears rotate past exactly the same number of teeth as contained on the sun gear when the planet carrier is rotated one revolution.

Next, observe that if the planet carrier is stationary and the planet gears are rotated clockwise, the annulus will rotate clockwise. In the diagram, it can be seen that the number teeth passed on the sun gear is transferred to the annulus gear by the planet gears. Since the annulus has about 4 times as many teeth as the sun gear, the annulus will rotate about one quarter revolution for each rotation of the sun gear.

Let's now restate the two effects:

When the planet gears don't rotate on their axis, the annulus turns at the same speed as the planet carrier.

When the planet carrier is fixed and the planet gears rotate at the same speed as the input, the annulus rotates at one quarter the input speed.

When the two effects are added, the output speed will be about 125% of the input. The number of teeth on each gear is listed below when we make a precise calculation of the speed.

The left photo below show the annulus with ring gear. The epicyclic gear without the ring gear (annulus) is shown on right below. The sun gear is being withdrawn from the carrier.

The number of the teeth on each of the gears is:

- Sun gear = 20 teeth
- Planet gear = 29 teeth
- Ring gear in annulus = 80 teeth.

When the planet carrier rotates one revolution, the planet gear rotates around the fixed sun gear once and will have passed all 20 teeth on the sun gear. The planet gear will rotate by 20 teeth on it's axis and will in turn drive the sun gear to move 20 teeth relative to the planet gear axis. Since the ring gear has 80 teeth, the 20 tooth movement represents exactly 25% or one quarter rotation. This is added to the one revolution caused by the planet carrier rotating with the planet gears not rotating giving a total of 1.25. This means that when the OD is engaged, the road speed for a given RPM is 1.25 times the direct drive road speed. Another way to say it is that the engine RPM with the OD engaged for given road speed is 1/1.25= .80 times the direct drive RPM. I've been told that the 25 in the model number represents the 25% speed increase. This checks with the A type that have a 22% speed increase and model numbers that begin with 22.



The three photos above show the assembled epicyclic gear. The left photo shows Whiteout marks on the sun gear shaft, on the planet gear carrier, and on the annulus. In the middle photo, the sun gear has been held stationary and the planet gear carrier has been rotated about 45 degrees clockwise. Note that the annulus seems to have rotated a bit further. The right photo shows the situation after the planet carrier has be rotated one full revolution with the sun gear held constant. Note that the annulus has rotated one full revolution plus a further quarter revolution, exactly as computed above.

Case: The case is composed of two parts, the main casting and the rear casting. The main casting contains hydraulic components to switch the OD between the direct drive and overdrive. The rear casting contain the annulus & associated rear shaft bearings and speedometer gears. The photo below shows the main casting on the left, then the thrust ring (with the springs), then the sliding clutch, then the planet carrier with sun gear and planet gears then the rear casting with the annulus installed inside.

Sliding Clutch: The sliding clutch performs the task of locking the sun gear to the annulus in direct drive and locking the sun gear stationary in overdrive. That is, the clutch has two engaged positions. The main part of the clutch is a cone shaped component called the sliding member. The sliding member is fitted over the splines on the sun wheel shaft (refer to subsequent photos) and as the name implies slides between two positions. When in the rear most position, clutch material on the inside of the sliding member is held against the outside of the annulus hence locking the sliding member and the sun gear to the annulus. This is the direct drive position. In the forward most position, clutch material on the outside of the sliding member engages a stationary brake ring attached to the rear of the main casting, locking the sliding member and the sun gear stationary. This is the overdrive position. The surfaces on the sliding member and mating surfaces on the annulus and brake ring are slightly coned shaped.

The photo at the left below shows the the clutch sliding member with the thrust ring (the part with the springs). The clutch material is visible on the cone shaped outer and inner surfaces of the sliding member. There is a bearing (the thrust bearing) between the thrust ring and the sliding member that allows the sliding member to rotate. Note that the thrust ring doesn't rotate. The sliding member rotates with the annulus when in direct drive and doesn't rotate in overdrive.


The thrust ring is pushed back by the four clutch release springs and via the bearing forcing the sliding member onto the cone part of the annulus for direct drive. The right photo above shows how the coned inner surface of the sliding member fits over the coned outer surface of the annulus. The annulus has been removed from the rear casting for this photo. The red plastic thing is the speedometer drive gear. This gear is secured to a sleeve that serves as a spacer between the two annulus bearings. The annulus head bearing is still on the annulus shaft just to the left of the spacer.

The thrust ring is pulled to the front by two hydraulic pistons when in OD. This in turn pulls the cone shaped outside of the sliding member into the cone shaped inside of brake ring at the rear of the main casting. This is shown in the photo on the right. The black ring is the cast steel brake ring. The sun gear is shown engaged with the splines on the inside of the sliding member shaft.

Unidirectional clutch: This clutch fits into a recess in the annulus as shown on the right. The roller cage and one of the rollers has been removed to show how the clutch works. The splines on the inside mate with the gearbox mainshaft. If the inside of this clutch (the mainshaft) tries to rotate faster in the clockwise direction than the annulus, the rollers will go up the little ramps and be forced against the annulus in turn forcing it to stay at the same speed as the mainshaft. Conversely, if the annulus is rotating faster in the clockwise direction that the center part, the rollers are forced down the ramp relieving the force against the annulus hence disengaging the clutch. In summary, for clockwise rotation, the output can rotate no slower than the input, but may rotate faster than the input.

For counterclockwise rotation, the opposite is true. If the annulus is rotating slower than the mainshaft, the rollers go down the ramps and the clutch is released. If the annulus tries to rotate faster than the mainshaft, the rollers go up the ramp and lock the annulus to the mainshaft

Now consider what would happen if the OD were to be engaged in reverse; the annulus will try to rotate 25% faster counterclockwise than the mainshaft. However, as stated previously, the unidirectional clutch prevents the annulus from rotating faster than the mainshaft in the counterclockwise direction. Lets say that again, the epicyclic gear is forcing the output to turn faster than the input while the unidirectional clutch is preventing the output from turning faster than the input. What happens? If we're lucky, the sliding clutch slips and the problem is discovered quickly and fixed. If we're unlucky, something breaks. The message: **THE OVERDRIVE MUST NOT BE ENGAGED IN REVERSE!**

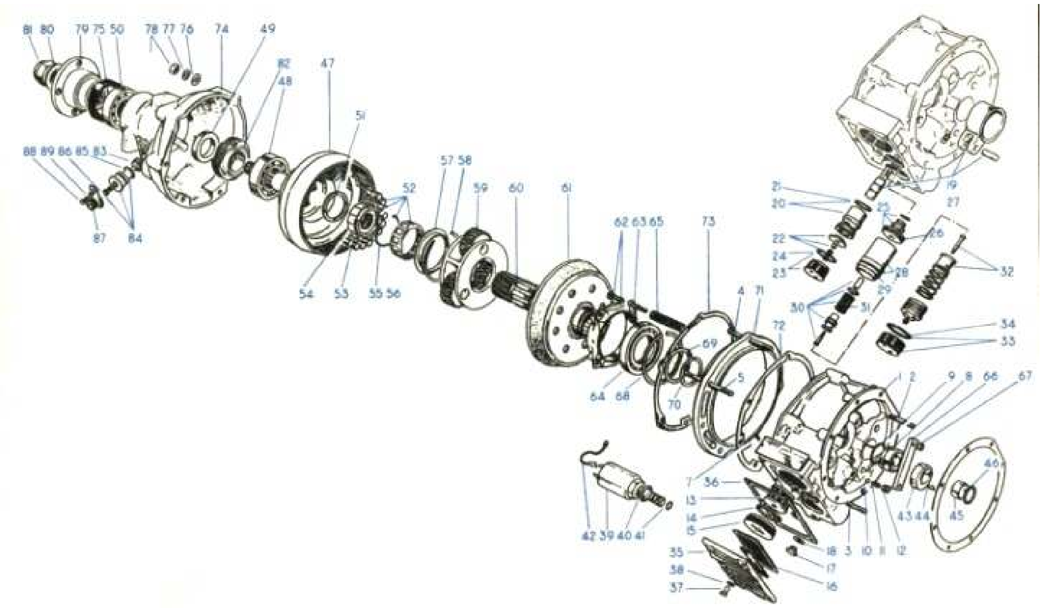
According to the early literature, the design intent was for the unidirectional clutch rather that the sliding clutch to be the primary way power is transferred to the rear wheels in direct drive. This allowed much less force to be applied to the clutch in the rear position by the clutch release springs (1/2 to 1/3, depending on the model) than to the front position even though the torque requirements for direct drive are more than twice that of overdrive because of first gear startups, made only in direct drive.

The unidirectional clutch also serves to keep the engine loaded when shifting the OD in and out. For example, when the OD is switched in, the clutch sliding member must move from the annulus to the brake ring. There will be some time during this transition that the sliding member is not in contact with either, and no power is transferred through the epicyclic gears. If the unidirectional clutch weren't there, the engine rpm would increase significantly and then drop down again when the OD was engaged. The unidirectional clutch essentially keeps the system in the direct drive mode until the clutch sliding member has completed it's travel and the OD is engaged at which point the annulus speed increases relative to the mainshaft and the unidirectional clutch disengages. When switching out of OD, the engine speed will increase as soon as the sliding member disengages from the brake ring but will only increase ~25% till the mainshaft speed equals and then tries to exceed the annulus speed at which time the unidirectional clutch engages.

Now that it is clear that the unidirectional clutch provides the direct drive feature, why is the direct drive position (rear) on the clutch sliding member needed? The answer is engine braking and reverse. During deceleration, the annulus tries to turn faster than the mainshaft, which disengages the unidirectional clutch. The sliding clutch keeps the mainshaft connected to the annulus through the epicyclic gear in this situation so that the engine can brake the motion of the auto. When the shaft is rotated counterclockwise as when the gearbox is in reverse, the unidirectional clutch doesn't function necessitating the use of the sliding clutch.

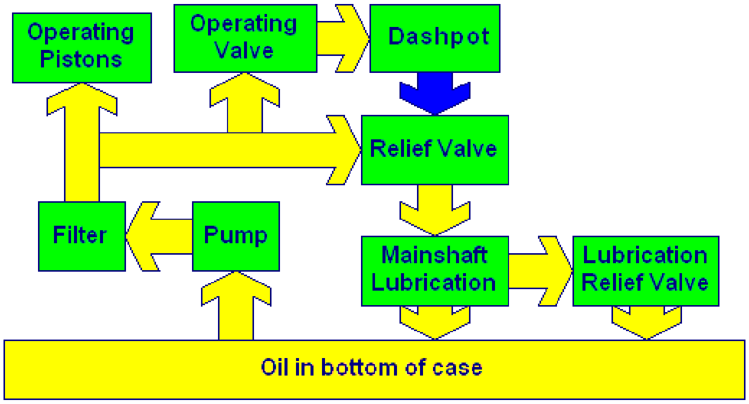
Section 2 - Hydraulic Components

The following exploded view of the OD unit taken from a TRF catalogue should help in understanding how the OD fits together.



The hydraulic components are housed in the main casting and consist of the following:

A hydraulic pump with non return valve (19-23)
A dashpot and relief valve (25-33)
An combined solenoid and operating valve (39)
Two operating pistons (23 & 24)
A high pressure filter (13-15)

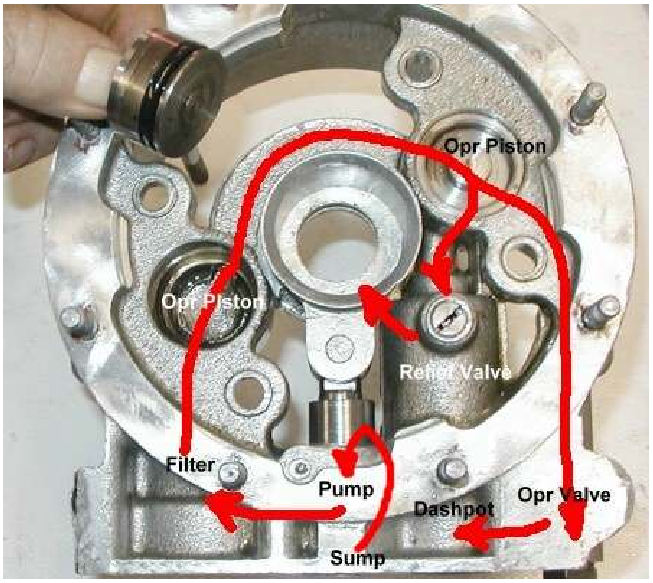


The block diagram above shows the interrelationship of the hydraulic components. The basic operation is as follows: A cam on the mainshaft drives the pump whenever power is transmitted to the rear wheels. The gearbox oil is the hydraulic fluid. The relief valve pressure setting is controlled by a mechanical linkage to the dashpot. If the operating valve is not operated, indicating that the overdrive should be is the direct drive mode, the dashpot is in the relaxed position and the relief valve is set to a very low pressure (~20 psi) via the mechanical linkage (blue arrow). The oil from the pump flows through a filter and then on to the operating pistons, operating valve and through the relief valve to the lubrication channels and then to the bottom of the case. The ~20 psi is insufficient to move the operating pistons. When the operating valve is turned on via the steering column switch and solenoid, oil flows through the operating valve into the dashpot causing the dashpot piston to move off the relaxed position and increase the pressure required to operate the relief valve. As the pressure builds, the dashpot piston continues to move and continues to adjust the relief valve operating pressure until the dashpot piston reaches a stop at which point the relief valve pressure setting is ~ 450 psi. The increased hydraulic pressure is also applied to the operating pistons which will eventually create enough force to overcome the force of the release springs and move the sliding clutch from being engaged with the annulus to being engaged with the brake ring thus shifting the unit into overdrive. When the operating valve is released, the fluid in the dashpot bleeds off slowly causing a gradual lowering of the relief valve setting and in turn, a gradual lowering of the hydraulic pressure and a gradual movement of the sliding clutch back to the annulus for the direct drive mode.

The operation described above is in sharp contrast to the A type OD. In the A type, the pressure relief is fixed at between ~350 psi and ~450 psi, depending on the model. The oil is pumped into an accumulator where it is stored. The stored fluid is used to move the operating pistons very quickly (< .5 second) when the operating valve is turned on. For the J type, after the delay moving the dashpot, additional time is required to actually pump the fluid necessary to move the operating pistons. The J type on my '76 TR6 typically takes about 2 seconds to engage after the switch is operated. The difference in the feeling of the two is very pronounced; the A type slams into OD like when popping the clutch and the J type slides into OD much like an automatic in need of maintenance. There is no question that shocks from the A type engagement can be hard on the OD unit itself as well as the drive train behind the OD. Care when engaging and disengaging the A type can probably minimize any damage.

The A type also has a controlled release from OD engaged. In fact, the late A type on my TR250 seems to release a little softer than J type on my '76.

Hydraulic Channels: The red paths in the photo on the right show the paths the the hydraulic fluid follows inside the main casting. The fluid starts in the sump and then enters the pump input. The fluid then flows from the pump output through the filter and on to the left operating piston cylinder and then above the mainshaft to the right operating piston cylinder. From there the fluid takes two paths. The main path is to the relief valve and then exiting around the mainshaft when some enters an internal mainshaft passage where it travels on to the bearing areas. The second path from the right operating piston cylinder is on to the operating valve and, if it is open, on to the dashpot which controls the relief valve.

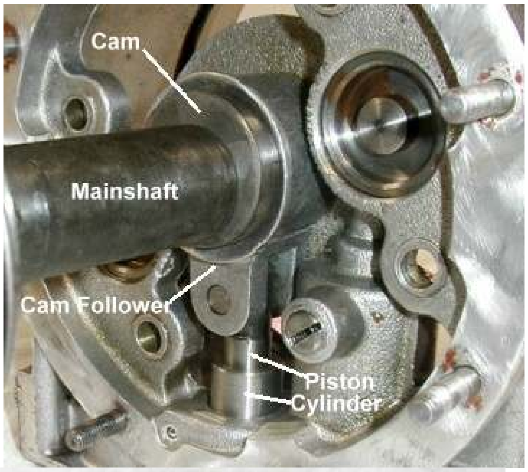


Sump: The bottom of the main casting is shown on the right. The sump cover has been removed with the inside surface face up. The magnetic strip is glued to the inside of the cover. The suction filter is identified. The filter is very thin and rests on the sump cover. The filter output is via a thin tube the fits into a hole in the main casting as shown by the red arrow. The high pressure filter, pump and the dashpot are accessed via the three plugs with small holes.

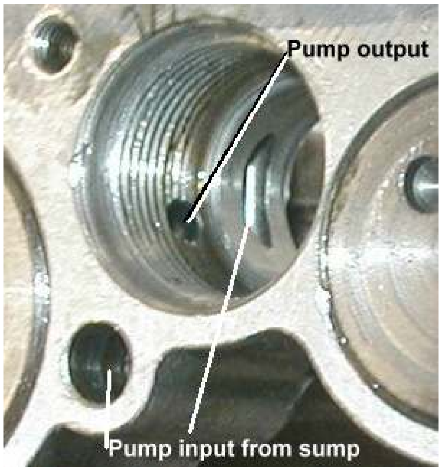
The Pump: The photo on the right shows the front of the main casting. The pump is in the lower part. The pump piston is pulled up and pushed down by the cam follower as the mainshaft and attached cam rotate. The pump piston, pin, cam and cylinder are steel. The Cam follower and the main casting are aluminum.

The photo below shows the pump parts in more detail. From left to right:

- Cam
- Cam follower & piston
- Cylinder
- Cylinder bottom with non return valve seat
- Non return valve ball
- Non return valve sparing
- Pump plug



The pump is show assembled in photo above. The oil enters the cylinder via the slot in the side and is then pushed down by the piston and out through the hole in the bottom. The spring loaded non return valve ball seals the hole in the bottom of the cylinder but when the pressure in the cylinder exceeds the pressure on the other side of the ball, the ball is pushed away and the oil is pushed out of the cylinder. When the piston starts to rise, the pressure inside the cylinder drops and the ball seals the hole in the cylinder bottom preventing the oil from flowing back into the piston.



The photo on the right shows the area of the main casting that houses the pump. The pump cylinder slides in from the bottom and is sealed by an O-Rring. The lower part of the cylinder has a shoulder that rests against a shoulder in the casting. The cylinder bottom, non-return valve ball and spring are then positioned and everything is secured by the pump plug that also has an o ring seal.

The pump runs all the time that the mainshaft is rotating. However, if the OD is sent for direct drive, the pressure relief is set to a very low pressure (~20 psi) and the pump has the very easy task of pumping oil to the mainshaft for lubrication. I've had some discussions in the past about how much power is consumed in the various types of ODs by the hydraulic pump. Since the pressure is very low when the OD is not engaged, the power consumed by the pump is negligible. However, when the OD is engaged, the pressure relief is set to about 450 psi. When the OD was apart the following measurements were taken so the pump power could be computed.

Piston diameter = 0.50 inches.
Piston travel under pressure ~ 0.15 inches (travel below the input slit).

This combined with the 450 psi pressure is all that is needed to apply high school physics to compute the work per stroke and then input power for a given shaft rpm.

The force of the hydraulic pressure is the area of the piston is multiplied by the pressure:

Hydraulic force = π $(0.5 \text{ inches}/2)^2$ 450 psi = 88 pounds

Work is the product of force and distance, in this case the 88 pounds times the 0.18 inch piston travel:.

Work per stroke = (0.15 inches)(88 pounds) = 13.2 inch pounds = 1.1 foot pounds.

Power is work per unit time. At 1000 RPM the pump will be consuming (1000 RPM)(1.1 foot pounds) = 1100 foot pounds/minute.

Since one horsepower (HP) equals 33000 foot pounds per minute, the power consumed at 1000 RPM in HP is

1100/33000 = 0.033 HP

At normal driving engine speed of 3000 RPM, 3 X .033 or about 0.1 HP (about 75 watts) will be consumed. The OD might get a little warm but certainly will not get hot due to the pump energy. Note that this is not a precise calculation but probably has an error less than 25%, so it shows that the power consumed by the pump is negligible. There are other sources of power loss (heat) such as friction in all the bearings, bushings and thrust washers so the OD likely gets pretty warm if operated for an extended period.

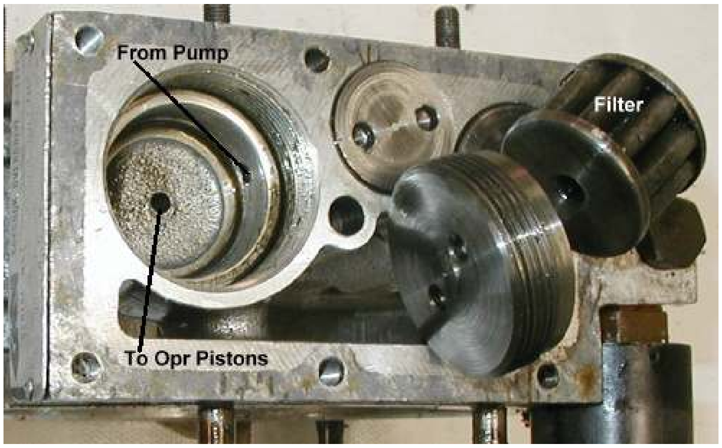
The pump output per stroke is the area multiplied by the stoke length:

π $(0.5 \text{ inches}/2)^2$ 0.15 inches = .029 cubic inches.

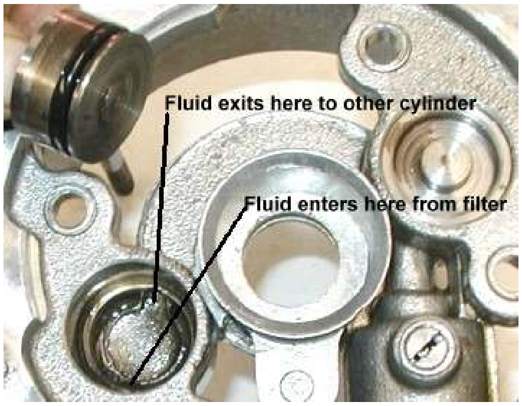
The output at 1000 RPM = 29 cubic inches per minute or 0.5 cubic inches per second.

Note that the above calculations are rough estimates to provide a feel for the operation. Errors of 25% or more are possible.

High Pressure Filter: The photo of the bottom of the main casting on the right shows the filter and the filter plug. The filter is made of very fine metal mesh. The filter slides into the open cylinder on the left. The fluid enters the filter chamber from the pump through the hole part way up the cylinder wall. After going through the filter, the fluid exits to the operating pistons through the hole in the end of the cylinder.



Operating Pistons: The operating pistons are located in the main casting as shown in the photo on right. The left piston has been removed. Note the rubber O-Ring used to seal the piston. The fluid entry and exit holes for the left cylinder are indicated on the photo.



Bridge Pieces: The two bars fastened to the thrust ring pins by nuts are called bridge pieces. When the OD is switched to the engaged position, fluid enters the rear of the operating piston cylinders and pushes the operating pistons forward into the bridge pieces and then pushes the bridge pieces and connected thrust ring and clutch forward until the front cone clutch mates with the brake ring.

When the unit is switched to direct drive, the fluid is allowed to slowly leave the operating piston cylinders. When this happens, the springs push the bridge pieces, the pistons, the thrust ring and the clutch toward the rear until the rear cone clutch engages the mating surface on the annulus.

The operating piston diameter is 1.25 inches. The force exerted at 450 psi hydraulic pressure is:

$\pi\ (1.25 \text{ inches}/2)^2\ (450 \text{ psi})$ = 550 pounds per piston for a total force of 1100 pounds for both pistons.

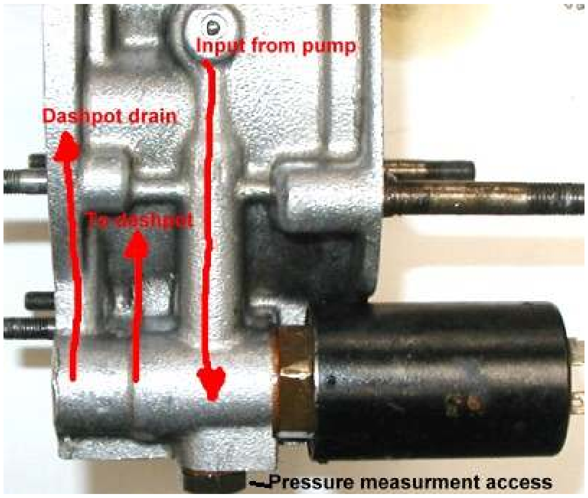
The pistons move about a tenth of an inch between the two clutch positions, so the total fluid required to operate the pistons is about:

$2\ \pi\ (1.25 \text{ inches}/2)^2\ (0.1 \text{ inch}) = .25$ cubic inches.

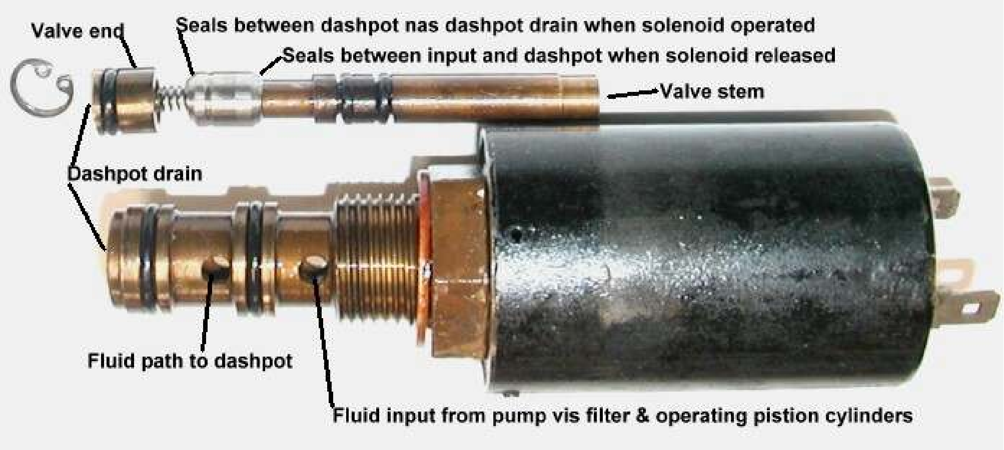
Additional fluid about equal to that of one piston is required to operate the dashpot so the total fluid volume require to switch the OD from direct drive to overdrive is about 0.4 cubic inches. At a pump output of .5 cubic inches per second at 1000 RPM, the pump can supply enough fluid to operate the pistons in a little less than a second at 1000 RPM and a little less than a quarter second at 4000 RPM. (Note: this doesn't take into account the restriction of fluid to the dashpot through the control orifice discussed later that slows the engagement some.)

Operating Valve: The photo at right shows where the internal channels that connect to the operating valve run in the main casting. When the valve is off (direct drive) the input from the pump is blocked and the path between the dashpot and dashpot drain is open allowing the dash pot to bleed down. When the valve is operated (overdrive), the path between the input and the dashpot is connected and the dashpot drain is closed. The plug in the bottom under the valve provides access to screw in a pressure gauge.

The solenoid and valve components are shown below. The solenoid screws into the main casting and the two holes in the side and the one in the end match up with the three channels in photo on right.



The valve stem moves inside the solenoid. The beveled edges on the aluminum cylinder on the left end of the valve stem are the sealing surfaces. When the stem is inside the solenoid, the aluminum part is positioned between the two O rings on the Solenoid. The aluminum cylinder diameter is smaller than the inside of the brass part of the solenoid around it. The valve end goes in the end of the brass part of the solenoid and is retained by the little circlip. When the solenoid is released, the little spring between the end cap and valve stem pushes the valve stem to the right until the right bevel on the aluminum part of the stem seals against a matching bevel machined in the brass part of the solenoid --- under the right O ring. This seals the passage between the entry hole from the pump and exit hole to the dashpot. There is an open path from the dashpot thorough a hole in the valve end. When the solenoid operates, the valve stem moves to the left and seals the hole in the valve end (the dashpot drain) and opens the path from the pump to the dashpot. This is a nice design because no adjustments or particularity close tolerances subject to wear are involved. Inexpensive O rings are used to seal the passages. The two O rings on the valve stem are to keep the oil out of the solenoid core and winding. It's amazing that O-Rings costing a few cents seal the 450 psi. One can certainly appreciate the simplicity of this design after adjusting the valve opening on the A type OD.



Relief Valve & Dashpot: The photo at right shows the dashpot and part of the relief valve being removed from the main casting. The plug was removed first and laid face up on the casting.

These components are shown in more detain in left photo below. The dashpot sleeve and plug are on the left with the dashpot piston, relief valve and relief valve body on the right side.

The center photo shows the assembled piston, valve and valve body.

The right photo below shows a close up view of the valve and valve body. The hole in the valve body shows that the valve is about half open.

The piston unit consists of the aluminum piston with the four slots around it and the thin walled steel thimble held separated by a spring around the thimble. There is a small internal bolt that keeps the thimble and piston together. The thimble can be pressed into the hollow end of the piston, compressing the spring around the thimble in the process. When the unit is completely assembled, the top of the thimble is a short distance from the valve body. The relief valve is held closed by the little spring called the residual pressure spring at the bottom of valve in the left photo. In this case, fluid enters through a hole in the top center of the valve body and pushes the valve down against the residual pressure spring (about 20 psi is required). The fluid exits through the hole in the side of the valve body shown on the right and goes on to the lubrication system.

When the solenoid operates, fluid enters the bottom of the dashpot cylinder and pushes the dashpot piston up, compressing the thimble spring in the process. The upward motion of the piston is stopped when the bottom of the hole in the piston rests against the bottom of the thimble. In this position, the valve can't push the thimble down. The heavy spring in the middle of the valve in the left photo must be compressed to open the valve in this case. About 450 psi is require to compress that spring.

Control Orifice: The control orifice is located in the angle drilling between the operating valve and the bottom of the relief valve cylinder (photo on right). The orifice is very small to restrict the fluid going to and from the dashpot cylinder. This restriction of the fluid flow limits the speed at which the dashpot piston moves up to increase the relief valve pressure setting when the OD engages and also limits the speed the the piston moves down to decrease the relief valve pressure setting when the OD disengages. This is how the dashpot (a device to cushion mechanical movement to avoid shock) softens the OD engagement and disengagement.

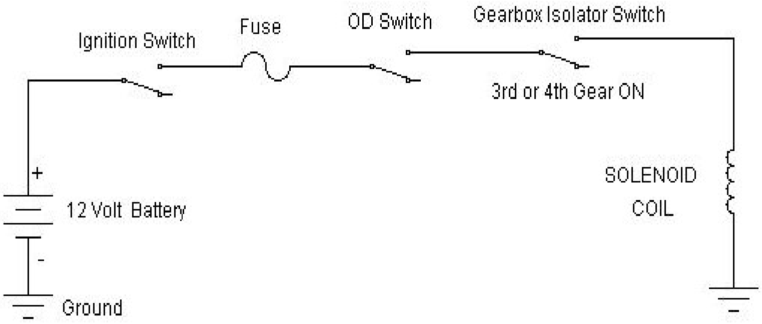
Lubrication Relief Valve: This valve is located in the side of the casting that houses the relief valve and consists of a plug, spring and ball as shown in the adjacent photos. The purpose of this valve is to provide an escape path for excess oil that can't be accepted by the lubrication system --- typically when running at high output RPM.

Section 3 - Electrical Components

Solenoid: The solenoid is a big electromagnet. The valve stem slides inside the magnet. When current flows through the solenoid, the valve stem pushes out of the solenoid operating the valve as described above.

Electrical Circuit: The schematic of the electrical circuit is shown below. The circuit is very simple, the solenoid will operate when the Ignition Switch and OD Switches are on and the isolator switch is also on indicating the gearbox is in 3rd or 4th gear. After once operated, the solenoid stays operated until the ignition is turned off, the OD switch is turned off, or the gearbox is shifted out of one the permitted gears, any of which cause the solenoid to release.

The solenoid draws about 2 amperes so the relay circuitry used to power the high current start winding of the A type OD is not required. However, the steady current drain of ~ 2 amperes for the J OD is about twice the 1 ampere holding current of the A OD. Therefore, the J Type solenoid gets a bit hotter than the solenoid in the A type OD.



This completes the Part I - Theory. Subsequent parts discuss OD overhaul, adjustment and troubleshooting.