A Type Overdrive, Part I - Theory

Introduction: Let me introduce myself before getting into the fun stuff. Working on Triumphs is one of my hobbies. I have no financial interest and earn no income from Triumphs. I'm an electrical engineer by training and profession and have retired from a career in R&D and then from teaching college. I've had no formal automotive training (which will become obvious if you read much further), just a lot of physics and mechanics at university that was required of all engineers back then, and over 20 years experience with Triumphs. Many folks have provided input, specifications, neat insights, etc. and I've tried to identify each of these sources. If I've failed to give credit someplace, please let me know and I'll fix it. I've also tried to identify where I didn't have reliable data or specifications and used my judgment, however flawed that might be. Please let me know of any errors you find so that I can fix them too. Finally, this documents my thoughts and experiences and in no way should be interrupted as instructions for anyone else.

Overview: The A type overdrive (OD) unit described here was manufactured by Laycock-de-Normanville and was a factory option on the TR2, TR3, TR4, TR5/250 and TR6 Triumphs through 1972. 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 OD provides a 22% rpm increase in the output over the input rpm (i.e. overdriven). This means that for a given engine rpm, the road speed is 22% greater when the OD is engaged. Another way of saying this is that when the OD is engaged, the engine rpm is reduced by 18% for a given road speed. The OD is operator controlled via an electrical switch on the dash or steering column, depending on the model. The OD could be engaged only in 4th gear in the early TR2 application. The operation was changed after TR2 s/n TS5980 so that it could be engaged in the top three gears.

Five models of the A type overdrive were fitted to the TRs. The following are the model numbers and a brief description of the changes with each model. These data is taken from the Moss Catalogue, input from Randall Young, Triumph Service Bulletins supplied by Fred Thomas and data from a telephone conversation with an employee of Overdrive Repair Services in the UK (staffed by ex Laycock employees). Randall says he thinks the 22 refers to the gear ratio, in this case, 22% increase. He says other models with a larger increase were provided for other applications such as big Healeys. The Moss catalogue lists all these models with a leading 6 (i.e. 22/61275). Randall thinks the 6 was added when the factory rebuilt a unit. He has also seen models with a leading 2 --- maybe the indicates a different manufacturing location.

- #22/1275 TR2 to TS5979

- #22/1374 TR2 from TS5980 to TR4, October 1964. The major change in this unit was to increase the diameter of the operating pistons from 1 1/8 inches to 1 3/8 inches. A Triumph Service Bulletin dated August 1955 states that in response to requests from Triumph owners, OD capability was added for 2nd and 3rd speeds in addition to 4th speed The operating piston diameter was increased to handle the additional torque of the lower gears. Additional changes were required to the gearbox top cover to accommodate the isolator switches for 2nd and 3rd speeds.

- #22/1712 TR4 from October 1964 through TR4A solid rear axel. The only change I'm aware of with this model is the use of operating pistons with rubber O rings rather than steel rings. The pistons are the 1 3/8 inch size and may be substituted for the steel ring pistons in model #22/1374, but not in model #22/1275 that used the smaller pistons.

- #22/1753 TR4A IRS to TR6 3/71. Three changes were made in this model. One change was to use a different filter. A second change was to use a 1/4 inch instead of a 5/16 inch ball in the non-return valve. The most important change was the replacement of the 1 3/4 inch diameter accumulator piston with a smaller 1 1/8 inch diameter piston. An employee of Overdrive Repair Services told me this change was made to to soften the engagement. He said the accumulator of the earlier models had so large a capacity that the pressure dropped very little when the OD engaged. This caused a very hard engagement that sent such a shock to the drive train that it tore up axels in the IRS cars. With the smaller accumulator, the pressure drops during engagement and then builds up quickly. This lower pressure allows a small amount of clutch slipping that softens the engagement. He also told me the pressure for the early large piston accumulator was 350 to 370 psi while the pressure for the later small accumulator models should be about 450 psi. It is my guess the pressure was increased to provide a higher torque capability to match the 6 cylinder engines in the TR5/TR250 & TR6.

- #22/1985 TR6 from 4/71. The only change I found for this model was a different filter.

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 switches in the gearbox cover.

A reproduction of the <u>SERVICE INSTRUCTION MANUAL for the LAYCOCK - DE - NORMANVILLE OVERDRIVE UNIT WITH ELECTRICAL CONTROL</u> purchased from The Roadster Factory (TRF) was used in the preparation of these notes. The original date of publication 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.

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

1. The mechanical components including the gears and the two clutches

2. The hydraulic components that control the shifting.

3. 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.
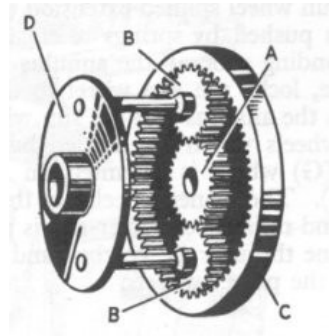
I admit to staring at the diagram for quite a while trying to figure out how it works. Then spent a much longer time trying to come up with an explanation that hopefully is easy to understand. So here goes -----

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.   If the sun gear and planet gears have exactly the same number of teeth, when the planet carrier is rotated one revolution, the planet gears will rotate one full revolution around the sun gear resulting in one full rotation of the planet gears on their axis.

Next, observe that if the planet carrier is stationary and the planet gears are rotated clockwise, the annulus will rotate clockwise. In the diagram, the annulus has about 4 times as many teeth as the planet gear so one revolution of the planet gears will rotate the annulus about one quarter revolution.

Let's now restate the two effects:

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

2. When the planet carrier is fixed and the planet gears rotate at the same speed as the input, the annulus rotates at about 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 gear will be listed later and the precise speedup computed.

The photos below show the annulus. (Unless noted otherwise, all photos are of a TR3 OD unit, model #22/1374.) The output flange slides over the splines on the left side of the left photo. The spirals milled in the center of the shaft drive the speedometer gear. The shaft has two bearings, one over the splines and the other next to the shoulder on the right side of the shaft. The bearing on the shaft is in position to be pressed pass the spirals to the shoulder.   The right photo shows the large end of the annulus with the ring gear. The annulus is still installed in the rear casting here. The rollers in the center are part of the unidirectional clutch discussed later.

The epicyclic gear without the ring gear (annulus) is shown below.   The left photo shows the sun gear in position. The middle photo shows the gears on the mainshaft. The splines on the inside of the planet gear carrier mate with the mainshaft so that input power is always applied via the planet gear carrier. The right photo shows one of the planet gears removed from the carrier. These gears are composed of two gears locked together and have two roller bearing cages pressed inside. The shaft the gears revolve on is pressed into the planet carrier. The washer with the tab is a thrust washer.

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

- Sun gear = 21 teeth

- Larger planet gear = 24 teeth

- Smaller planet gear = 15 teeth

- Ring gear in annulus = 60 teeth.

When the planet carrier rotates one revolution, the larger planet gear rotates around the fixed sun gear once and will have passed all the 21 teeth on the sun gear. Since the planet gear has 24 teeth, it will have rotated 21/24 = .875 revolution. The smaller planet gear meshes with the ring gear. The smaller planet gear also rotates .875 revolution when the planet carrier does one revolution, but since it has only 15 teeth, the total number of teeth meshed with the ring gear per revolution or the planet carrier is .875 X 15 = 13.125 teeth. The amount the 60 tooth ring gear rotates due to the one planet gear rotation is 13.125/60 = .21875 revolution. This is added to the one revolution caused by the planet carrier rotating with the planet gears not rotating giving a total of 1.21875 or rounded to 1.22. This means that when the OD is engaged, the road speed for a given RPM is 1.22 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 1/1.22= .82 times the direct drive RPM. (Randall Young suggested that other applications of these ODs such as the big Healeys use different ratios, some as low as 0.75 to 1.)

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 nearly 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 gear. The photo below shows the main casting on the left, then the sliding clutch, then 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 previous 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 right shows the end of the clutch sliding member. The thrust ring is to the rear. 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 allow the sliding member to rotate. Splines are visible on the inside of

the sliding member. These splines mate with similar splines on the sun gear shaft (see previous photos). 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 eight clutch release springs and via the bearing forces the sliding member onto the cone part of the annulus for direct drive. This is shown in the left photo below where the main casting has been removed. The thrust ring is pulled to the front by two hydraulic pistons when in OD. This in turn pulls the outside of the sliding member into the brake ring at the rear of the main casting. This is shown in the right photo below where the rear casting and annulus has been removed.

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 22% 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 ~22% 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.
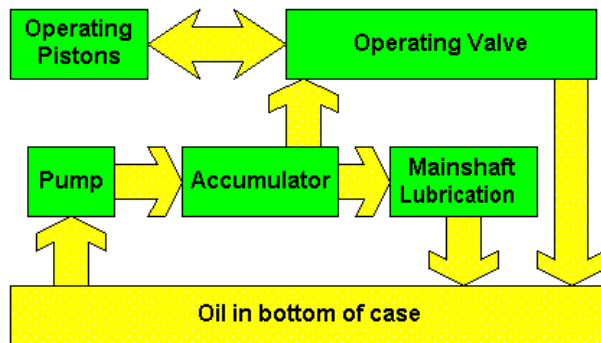
Section 2 - Hydraulic Components

The following exploded view of the OD unit taken from a Moss catalogue should help in understanding how the OD fits together.
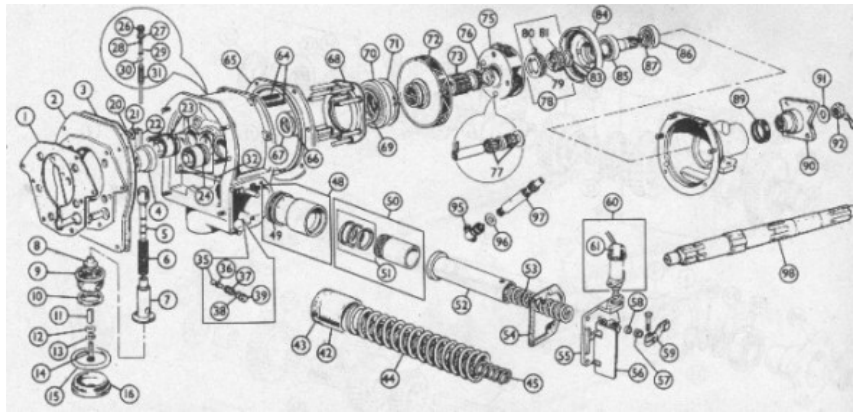
The hydraulic components are housed in the main casting and consist of the following:

- A hydraulic pump (4-8 & 35-39)

- An accumulator (42-45 early or 48-53, later)

- An operating valve (26-31)

- Two operating pistons (23 & 24)

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 accumulator is a spring-loaded piston/cylinder chamber where the fluid is pumped for storage. The accumulator has an internal pressure relief valve set to about 360 psi (early) or 450 psi (later); oil from the pressure relief goes through internal passages in the main casting to the gap between the large mainshaft bushings. The oil then enters radial holes in the mainshaft and travels through an axial drilling in the mainshaft and exits through radials holes under the sun gear providing lubrication to the sun gear, planter carrier and thrust washers before returning back to the bottom of the case.   The control valve, operated by an external electrical solenoid, controls the flow of hydraulic fluid from the accumulator to the operating pistons. When the control valve is operated, the fluid will push the operating pistons forward pulling the clutch sliding member into the brake ring.   When the valve is released, the clutch release springs push the pistons back into their cylinders and the clutch sliding member back into the annulus. As the pistons go into their cylinders the oil is pushed back through the released operating valve and then on to the bottom of the gearbox.

The Pump: The top photo on the right shows the front of the main casting. The vertical rod with the spring around it is the pump piston. The top of the piston is fitted with a roller to ride on a cam on the mainshaft.   The heavy rod protruding from the cam is a dummy mainshaft. The round objects on each side the cam are the operating pistons discussed later. The large horizontal spring on the lower right of the photo is the outside accumulator spring, also discussed later.


The second photo shows the pump components. The pump body is top left with spring and then piston below it. The pump body is pressed into the main casting and secured with the two screws.   The spring is used to force the piston up --- the mainshaft cam forces it down.   The lower end of the cylinder is sealed with the large threaded pump body plug in the upper middle. The screened cup is a filter secured to the plug by the screw in the lower right.

The diagram, taken from the Service Instruction Manual, shows the pump cross section. The piston is shown in the full down position, nearly touching the pump body plug. Oil is supplied from the screen filter at the bottom up through a milled flat section on the outside of the pump body and into the cylinder through a slit. The slit and flat section can be seen in the photo of the pump components.

Components labeled A through F form the non-return valve.   The photo following the diagram shows these components. The hole from the right side of the pump body near point A leads to the accumulator (discussed next). Part A is a valve seat machined in the side of the pump body opposite the input slit. The hole is sealed by ball B and held by plunger C and spring D. The copper washer E and plug F seal the valve chamber. Two sizes of balls were used in the non-return valve, the earlier valves used 5/16 ball and the later ones used1/4 inch balls.   The ball size must be matched to the seat on the pump body.

When the piston is in the upper most position, the bottom of the piston is about even with the top of the input slit allowing oil to flow into the pump body. When the piston starts to move down oil is forced back out the input slit until the bottom of the piston passes the bottom of the slit sealing off the input. Further downward movement of the piston will force the non-return valve ball away from the seat allowing the fluid to exit to the accumulator. Once the piston reaches the bottom of it's travel, the pressure on both sides of the ball equalize and the valve spring forces the ball into the seat closing the valve. The spring at the top of the piston holds the roller against the cam and forces the piston back up as the cam rotates to the low spot.
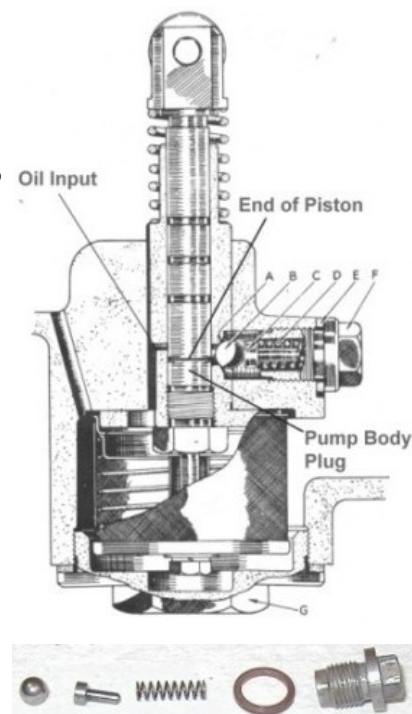
The pump runs all the time that the mainshaft is rotating. The pump is pushing against the pressure in the accumulator, limited by the pressure relief valve to about 360 psi (early accumulator) or 450 psi (later accumulator). The late TR6s used the J Type Overdrive. In a recent comparison between the A and J types on the Triumph email list it was pointed out that the J type OD pump doesn't consume power in the direct drive mode since the pump output is opened to the main case so that the pump pushes against zero pressure. It was further claimed that the A type OD pump consumed about 25 HP at high speeds. I pointed out that the OD would melt in a few minutes if it had to dissipate that much power (25 hp ~ 18kw). When the OD was apart the following measurements were taken so the pump power could be computed.

Piston diameter = .53 inches.
Piston travel = .15 inches, ~ .1 inches below input slit.
Spring force ~ 10 pounds (it can easily be pushed with a thumb)
Nominal relief valve pressure ~ 450 psi (for later accumulator).

This 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.

For each cycle of the piston, it moves down .05 inches pushing against only the spring and then after the input slit is sealed, an additional .1 inches pushing against both the spring and the force due to the 450 psi accumulator fluid pressure.

Lets first compute the force of the hydraulic pressure --- the area of the piston is multiplied by the pressure:

Hydraulic force = π (.53 inches/2)^2 450 psi = 99 pounds

Work is the product of force and distance. The per stoke work is the sum of the work over the first .05 inch of travel and the work over the last .01 inch of travel.

Work per stroke = (.05 inches)(10 pounds) + (.1 inches)(10 pounds + 99 pounds)
            = 11.4 inch pounds = .95 foot pounds.

Power is work per unit time. At 1000 RPM the pump will be consuming (1000 RPM)(.95 foot pounds) = 950 foot pounds/minute.

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

    950/33000 = .0288 HP or about .03 HP

At normal driving engine speed of 3000 RPM, 3 X .03 or about 0.1 HP (about 50 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.

Accumulator: The early accumulator consists of a cylinder in the main casting fitted with a piston and held by a pair of springs. The top photo on the right shows the piston being extracted from the cylinder. The next photo shows the piston and the two heavy springs. The smaller spring fits inside the larger one.

Oil from the pump goes through a passage in the main casting into the bottom of the accumulator cylinder. As oil is pumped in, the piston is pushed out of the cylinder compressing the two springs. The pressure builds as the springs are compressed.

There are a series of holes along the cylinder wall that connect to a passage to a chamber around the mainshaft for lubrication. The holes are exposed when accumulator is pushed past these holes, allowing fluid to escape from the accumulator. These holes are the pressure relief mechanism. The nominal pressure required to push the piston to the holes is 360 psi.

The later ODs (models #22/1753 & #22/1985) use a different accumulator as shown in photo on right. An "accumulator housing" (top left in the photo) slides into the cylinder in the casting in place of the piston in the early accumulator. A smaller piston (top right) fits in the housing. A spacing tube (middle of photo) holds the accumulator housing in position (otherwise, when fluid is pumped into the cylinder in the casting, the accumulator housing would be pushed out just like the piston in the earlier design). Pressure relief holes are located in the recess just to the right of the O ring, one of which is visible in the photo. A somewhat smaller spring is required to hold the force exerted by the smaller piston, even at the higher nominal pressure of 450 psi.

It is possible to replace the earlier accumulator with the later accumulator (the housing, piston, spacing tune and spring are all required). The Victoria British Catalog suggests this option if replacement springs, piston or rings are required for the early accumulator.

Before leaving the accumulator, a comparison of some of the properties is appropriate. The early accumulator uses a 1.75 inch diameter piston that moves about 0.8 inches to uncover the relief holes. The later accumulator uses a 1.125 inch radius piston that moves about 0.5 inches to uncover the relief holes. The force on the piston is the product of the piston cross sectional area times the hydraulic pressure.

For the early piston at a 360 psi pressure, the spring force is:

$\pi\,(1.75\text{ inches}/2)^2\,(360\text{ psi}) = 866$ pounds (yes, that's nearly half a ton)

For the later piston, at 450 psi pressure, the spring force is:

$\pi\,(1.125\text{ inches}/2)^2\,450\text{ psi} = 447$ pounds, about half the early style.

The approximate volume of the early accumulator is:

$\pi\,(1.75\text{ inches}/2)^2\,0.8\text{ inch movement} = 1.9$ cubic inches.

The approximate volume of the later accumulator is:

$\pi\,(1.125\text{ inches}/2)^2\,0.5\text{ inch movement} = 0.5$ cubic inches.

An article at www.team.net/healy/tech/big_hly/of/finespanner.html tells Healy owners how to remove the later accumulator and replace it with the "big piston and spring" Triumph parts. The apparent motivation is to get a faster shifting and lay a strip of rubber (or suffer whiplash). He says that one can achieve an accumulator pressure of nearly 600 psi using the large piston early accumulator. This contradicts both the information from the ORS employee cited earlier and my experience discussed in part IV. The large piston early unit operates at about 360 psi. I tried to contact the author Del Border, but the email address listed is no longer in service. I suspect that he replaced the short, weak inner spring in the early accumulator with the stiffer spring from a later accumulator. The combination of the outer spring from an early unit with the spring from a later unit used as the inner spring will give the nearly 600 psi pressure he mentioned.

Operating Pistons: The operating pistons are located in the main casting as shown in the photo on right. The right piston has been removed and the left piston is being lifted out.

The piston shown is the earlier design with steel rings. The later design uses a rubber O ring. Both type of pistons are shown in the middle photo. Replacement steel rings are no longer available but the new design piston with O ring can be used in the earlier #22/1374 model but not the #22/1275 because it used smaller operating pistons.

The bottom photo shows the main casting with the clutch thrust ring assembly in position. The eight springs press against the adaptor plate at the front of the main casting and push the thrust ring

to the rear position engaging the cone clutch into the annulus --- the direct drive position as discussed earlier.

The two bars are held 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.

The nominal 360 (early) or 450 (later) psi fluid pressure is maintained on the pistons as long as the unit is in overdrive.

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.
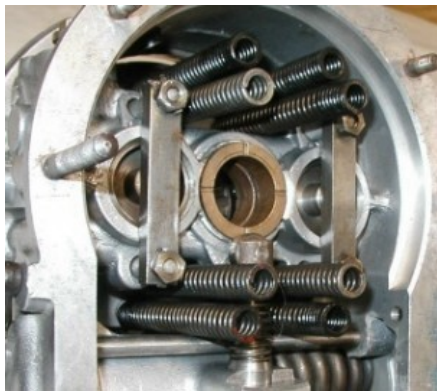
Excepting the earliest model that I've chosen to ignore, the operating piston diameter is 1.375 inches. The force exerted at 360 psi hydraulic pressure is:

π (1.375 inches/2)^2 (360psi) = 538 pounds per piston for a total force of 1076 for both pistons.   The later version with a 450 psi nominal pressure produces a total force of   1346 pounds

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

2 π (1.375 inches/2)^2 (0.1 inch) = .3 cubic inches

With accumulator volumes of 1.9 (older) and 0.5 (newer) cubic inches, there is more than adequate fluid in the accumulator to operate the clutch essentially instantly. As discussed earlier, there will be a larger initial pressure drop in the newer unit with the smaller accumulator, which will allow some slippage and smoothing of the engagement..

Operating Valve: A diagram of the operating valve (taken from the Service Instruction Manual) is on the right. A photo of the components is below.   The valve is on the right side of the main casting with the plug (A) on the outside near the top of the casting. Passage E connects to the accumulator that normally contains oil at a pressure of about 360 psi (early) or 450 psi (later).   Passage L connects to the operating pistons. Parts A, B, C & D are identical to components (same part numbers) of the non-return valve discussed previously. All operating valves use the 5/16 ball whereas the later non-return valves use a 1/4 inch ball. When the valve is released as shown, the spring and plunger press the ball against the seal (F) machined into the main casting preventing the fluid from flowing to the operating pistons.

When the external solenoid operates, lever K pushes the operating valve spindle J up which in turn pushes the ball away from the seal.   Oil then flows from the accumulator around the narrow end of the spindle and out passage L to the operating pistons, which in turn moves the clutch to the OD engaged position.   The fluid initially comes from the accumulator and the pressure drops when the valve operates but quickly recovers as the pump re-supplies the accumulator.   There is also a passage through the machined seal G at the top of the hollow spindle to a small hole at H. When the OD is engaged, the spindle is pushed up so that the ball seals the top of the passage.
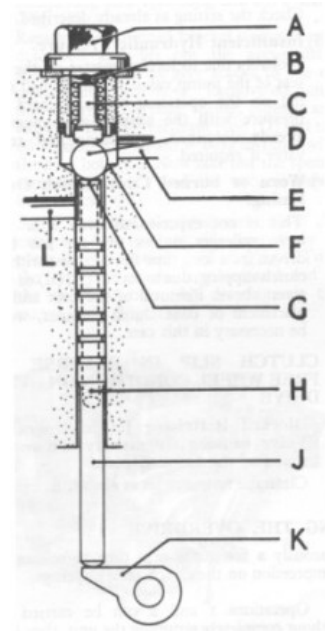
When the solenoid is switched off, indicating the OD should switch back to the direct drive mode, lever K and operating valve spindle J drop to the lower position. The ball seals the passage from the accumulator. The spindle drops far enough so that the top is no longer sealed against the ball allowing the fluid from the operating pistons to escape down though the hollow spindle and out hole H and into the bottom of the main casting. The hole is very small so it takes about a half second for the springs to push the clutch back to the direct drive position.

The lever (K above) is connected to a shaft that extends beyond the main casting on both sides. (See photo below where a finger is pointing to lever K with the operating valve J setting on the lever.) The solenoid rotates this shaft via a lever on the left side of the main casting (right side of the photo below).


Section 3 - Electrical Components

Solenoid: The solenoid is the cylinder with the wire coming out the top in the photo on the right. The rod extending from the bottom of the solenoid is called the plunger. The shaft end to the left of the plunger is the same shaft in the previous photo that controls the operating valve. The lever clamped to this shaft is called the actuating lever. When 12 volt power is applied to the solenoid (via the dangling wire) the plunger moves up, pulling the end of the actuating lever with it. This causes the shaft to rotate and via lever K pictured above, the operating valve to lift in turn engaging overdrive. When power is removed, the solenoid plunger drops allowing the operating valve to close and the unit to shift to direct drive.
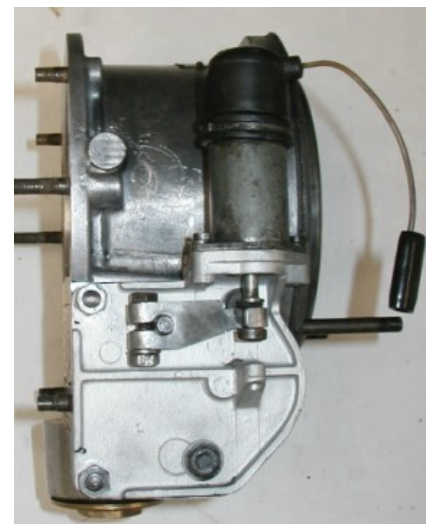
Electrical Circuit: The schematic of the electrical circuit is shown below.
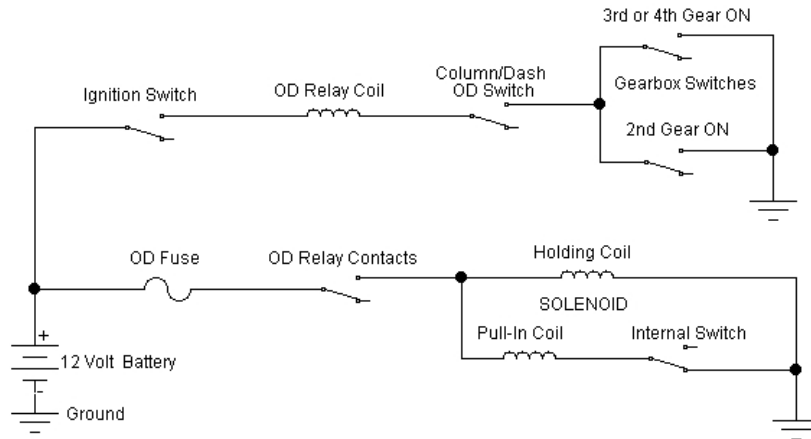
The upper part of the circuit controls the OD relay. The relay operates when there is 12 volts on the left end of the relay coil and ground on the right end of the relay coil. 12 volt power is supplied to the left side via the Ignition Switch (turned ON). Ground is supplied to the right side via the OD Switch on the dash or steering column and one of the Gearbox Switches. The Gearbox Switches are ON when the gearbox is in the indicated gear. All Triumph applications except the first model used on the TR2 have two switches, one switch for 3rd & 4th gear and another one for 2nd gear. In summary, for the relay to operate:

- the Ignition Switch must be on,

- the OD Switch on, and

- the gearbox in a forward gear for which OD operation is permitted

The relay circuit is relatively low current, drawing much less than one ampere. The solenoid draws a much higher current. That is why the relay is used --- the switches are not capable of carrying the higher current reliably whereas the relay contact is. The fuse shown in the solenoid circuit is not original equipment. I prefer to use the spare fuse box position on TR250s and TR6s to fuse this circuit. A 10 amp fuse is satisfactory. The main reason I use the fuse is to protect the wiring should one of the wires become grounded or to protect both the wiring and the solenoid should the solenoid internal switch fail to open.

The Service Instruction Manual states that the relay coil and contacts are not connected through any fuse for the following reason: *Should the fuse blow when the engine is driven at peak revs. in overdrive second gear, the overdrive unit would immediately return to normal second gear. The car running at high speed would then turn the engine at speeds for which it was not designed, with consequent risk of damage to connecting rods, valve gear, etc.* My first comment on this is that there is nothing unique about the engine speedup when leaving OD in second gear, it is a 22% speed up in third and fourth gear also. My second comment is that if the fuse blows, there is likely a short circuit that will cause the insulation to melt on the unfused circuit followed by the wire melting and releasing the solenoid with the same speed up noted above except that the wiring harness will have been destroyed. My third comment is that the fuses are about the only electrical things that have never failed on my TR fleet. The switches and connectors are much more likely to fail.

The solenoid case contains two coils, a pull-in coil that draws 15 to 20 amperes and a holding coil that draws about one ampere. When the relay contacts close, current is supplied to both coils and the plunger moves up very rapidly, taking a tenth of a second or less. When the plunger reaches it's upper most position it operates a switch inside the top of the solenoid that opens the current path to the pull-in coil. Once operated, the holding coil supplies sufficient magnetic force to hold the plunger in the operated position.

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 relay to release followed by the solenoid.

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