# MY EXPERIENCE OF FITTING A TYPE 9 INTO A PLUS 2 ELAN ©

By Richard Axe

Introduction.

I have owned my 1971 S130 for nearly 6 years now and in that time I have rebuilt the big valve engine, refurbished the suspension and brakes, fitted a 3.54 ratio differential as well as restoring some of the original features that had been displaced sometime in its history.

I was fortunate that the paintwork did not require any attention, whoever carried out this refurbishment work around 12 years ago must have known what they were doing.

In my personal view the car really needs a higher top gear for modern traffic conditions. The car feels decidedly under geared particularly on motorways and the engine has the power to pull something much higher. So I decided to bite the bullet and set about fitting a 5 speed box which would give me the higher gearing I was looking for.

Trawling through the lotuselan.net archives I found numerous posts on a gearbox upgrade. The most straight forward would to use the Lotus 5 speed box which had been fitted to later cars or purchase one of the readymade conversion which are on the market or, admittedly involving more work but very satisfying, tackle the conversion oneself. Nothing wrong with any of these solutions they have all been successfully implemented. But I liked the idea of an engineering challenge so I decided to do it myself.

The most popular donor gearbox is the Ford Type 9, it comes in various guises and there is an article called "Taking the Fifth" by Kim Henson/Jon Hill, (www.eddybrown.co.uk/mg/type-9-article) which gives a very good summary of variants available. I opted to use the version fitted to a 2.0l Sierra which had the short input shaft and is available with a mechanical speedo drive which I wanted to retain. Although this version has a lower first gear than the Lotus 4 speed, with the longer diff ratio I was using the combination would prove the be just right for my driving style.

Reviewing the archives more closely identified some of the problems others had encountered going down this route and by far the most difficult was to reposition the gear lever to a more suitable place. But there are, as I discovered, a load of other issues to overcome.

Configuration.

The standard short shaft Type 9 was my choice of gear box, in addition I wanted to retain a cable speedo drive. I obtained a suitable box in v. good condition and it came with a gear lever, a Sierra clutch cover (not used for this project) and the input spline from a Sierra prop shaft.

Determining how best to re-position the gear lever was my first task. In standard form the Type 9 gear lever is some 11" further back than on the Lotus 4 speed and clearly not too convenient. There seems to have been a number of different methods employed to reposition the lever. In my case I opted to re-configure the gear box tail housing and selector rail assembly; not unique is principal but as usual the devil's in the detail. More of this detail later, however I did succeed in moving the lever some 8" further forward. Although this did not achieve the original Lotus position (!!!) You probably know that the Lotus gear lever has an extension that cranks the lever back some 1.5" so the actual difference in position was not great and is perfectly acceptable in use.

In consequence of repositioning the gear lever the apertures in the chassis and tunnel top were both in the wrong place. The chassis would have to be modified but after some deliberation I decided not to try and modify the tunnel top; I elected to make a new one in fibreglass and have it suitably trimmed.

The clutch configuration needed some thought, the Sierra had a cable clutch but looking at this arrangement I decided that the mods needed to fit this would be too extensive. Another possibility would have been to re-engineer the arrangement used on the 4 speed box but others have successfully fitted a concentric hydraulic clutch and to me this seemed the neatest solution. I chose to base the clutch design around a Mondeo slave unit which is readily obtainable from retailers.

The Type 9 has a 1" x 23 spline input shaft as opposed to the 7/8" x 20 spline used on the Lotus 4 Speed so a different clutch plate was required. I fitted a 216mm RS 2000 clutch plate together with the standard Lotus 4 speed clutch cover.

The Type 9 gearbox bell housing will not fit the Twin cam engine; there are special spacer conversion kits advertised which will enable the 4 speed bell housing to match the Type 9 but I chose to fit new aluminium bell housing. The one I selected had provision for mounting the starter on either the LH

or RH side. I did not intend to change the starter position of course but the LH starter position would provide a convenient place to mount the clutch hydraulic pipes.

The Type 9 output shaft had a larger diameter spline than the Lotus 4 speed thus requiring a change to the prop shaft. Additionally the prop shaft needs to be approx. 1.0" longer than the Lotus unit. I chose to modify a spare Lotus unit I had by cutting off the smaller Lotus spline and welding on a Sierra spline in its place.

The gearbox mounting also needed to be re-configured. I retained the Lotus bracket and rubber mount but needed to reverse this bracket and slot its mounting holes approx. ½" to line up with the chassis fixing holes. To maintain a similar prop shaft centre line I added 0.6" spacer blocks between the bracket mounting faces and the chassis to drop the rear of the gearbox.

The speedo drive needed an adaptor and right angle gearbox as the original speedo cable was being retained.

The gear lever started life as a standard Sierra item which I modified and added an extension shaft and new gear knob.

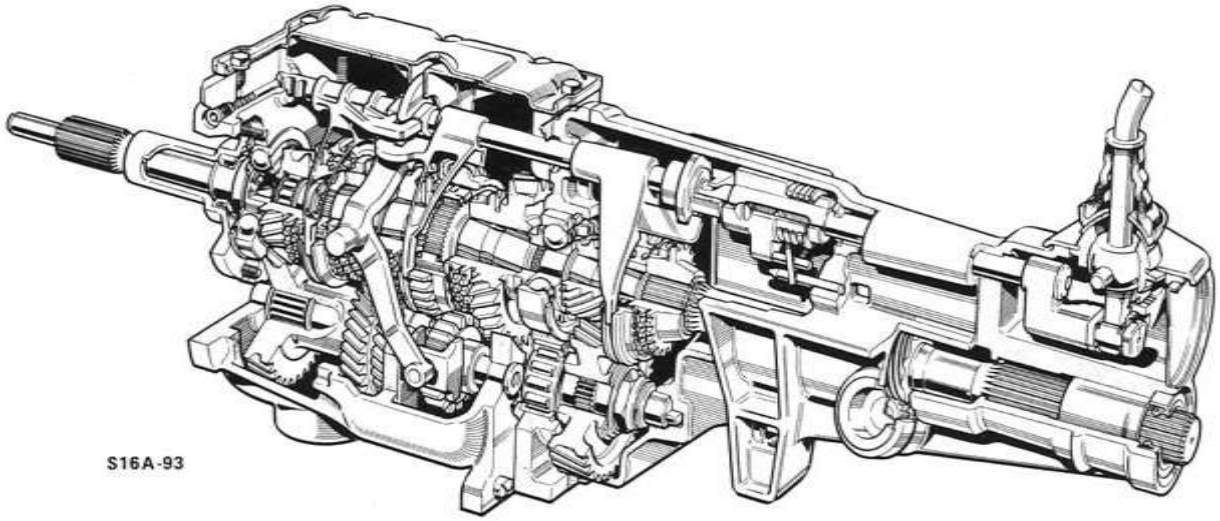
I also had to change the reversing light switch to fit the new tail housing configuration.

These were the major gearbox considerations so taking them in turn this is how I went about the modification.

Repositioning the Gear Lever and modifying the Tail Housing

I obtained a section view of the Type 9 from www.madabout-kitcars.com which showed how the tail section was configured in its standard form.

## Ford Type 9 cross section diagram




As you can see there is scope for re-positioning of the gear lever towards to the 5th gear cluster. Fortunately this is a single rail gear box so there is less to re-configure.

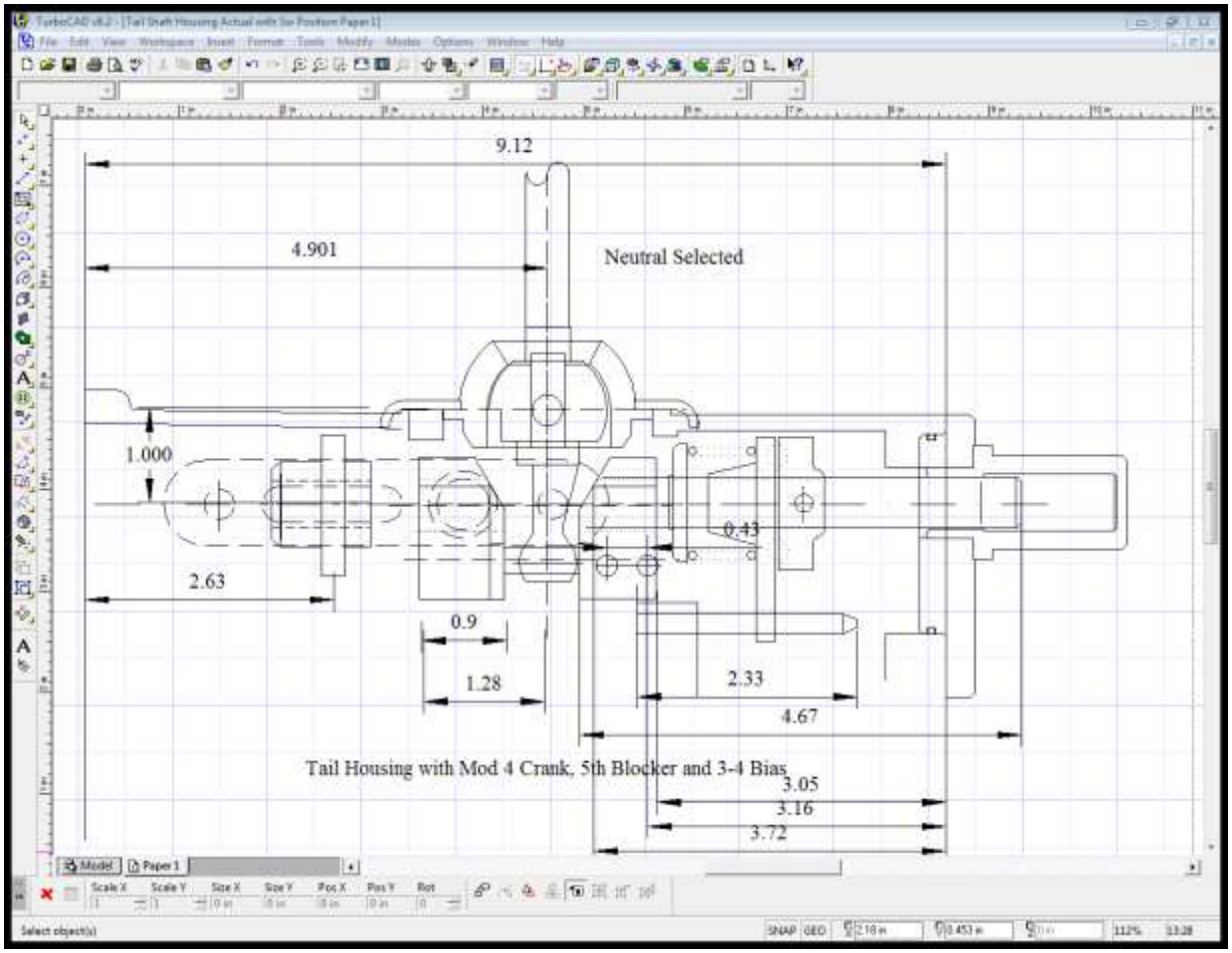
The mechanism between the 5th gear cluster and the gear lever at the rear of the box is the selector bias device. That is the unit that spring loads the gear lever in the lateral direction with 3rd/4th being its neutral position. The selector rail itself is supported at the rear by a bearing in the housing between the bias unit and the gear lever; there is also a shaft seal pressed into the housing in front of this bearing.

I had made the decision not to interfere with 5th gear or the selector forks so the gear lever assembly could not be moved any further forward than the 5th gear region and to achieve this meant the bias mechanism would have to be re-sited.

I stripped the tail housing from my gearbox and dimensioned all the relevant parts so I could re-design the arrangement of gear lever and bias mechanism. This defined the maximum forward position I could achieve.

You may have noticed there is a difference around the design of the bias mechanism shown in the above section diagram and the one in the picture below. I have to confess this came as a surprise to me when I stripped down my gearbox and saw a different bias device. I do not know when the design was changed but the same bias unit was also used in my spare gearbox, said to be from a late car, so it's probable a later design. Conveniently this bias unit looks to be more compact but note I have only considered this bias unit design in my project.

The CAD sketch below is a part section through the tail housing showing the position of the gear lever and bias mechanism in the final configuration. The gear lever is shown in the neutral position.



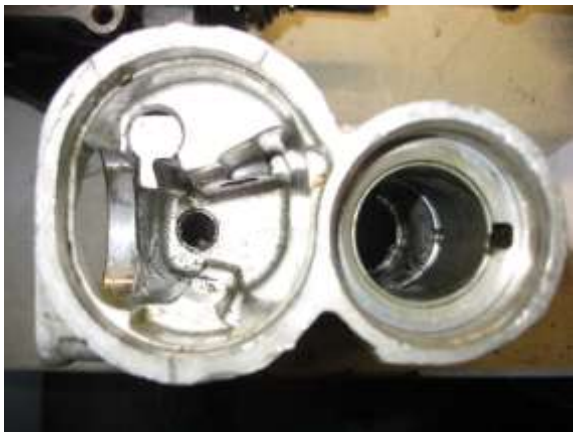
The above sketch shows the position of the gear lever in the modified tail housing. The gear lever pivot mechanism and fork end has not been touched but the crank it fits into is a completely new part. Taking the dimensions from the original crank I was able to design one that fitted into a split selector rail. The bias mechanism is now fitted behind the gear lever position on the rear section of the rail. The rear rail is supported by a plain bearing pressed into the end of a new housing. The front section of the selector rail carries the standard selector forks etc. unchanged, but I did shorten the 5th gear selector disc by 0.45" to allow the new crank to be positioned as far forward as it could.

The redesigned selector rail crank is shown in the photos below. It is a fairly complex item which I had machined in one piece from solid. It is a crucial part of the modification. The gear lever fork end runs in a plastic saddle fitted in the centre of the crank. This is a standard type 9 saddle which I modified slightly by removing its locating tabs which would not fit the new crank.

The crank is a complex part to make and I found I had to hand fettle it slightly when I came to assembly so that the gear lever did not clash with the sloping ramps. It would be joined to the front and rear rail sections with roll pins but I have not shown any roll pin positions as I did not predrill these as you will see later.

Having determined where the gear lever and bias mechanisms would be re-positioned I now had to modify the tail housing to provide a mounting platform and housing.

The platform where the gear lever was originally mounted is a complex item. A photo below shows the internal view and it is lot more than just a hole for the gear lever to sit in. The internal shape is configured with ramps and stops to guide the gear lever in the appropriated way. I had no wish to try and reproduce this so I determined cut lines which would enable me to remove the platform complete with all the essential internal features and this section would be welded in a new position at the forward end of the tail housing. The platform and tail housing joint faces were machined to provide an accurate location and to ensure alignment I also manufactured a jig to hold the platform securely during welding. The next photo shows these parts prior to welding; the machined cut lines can be clearly seen.

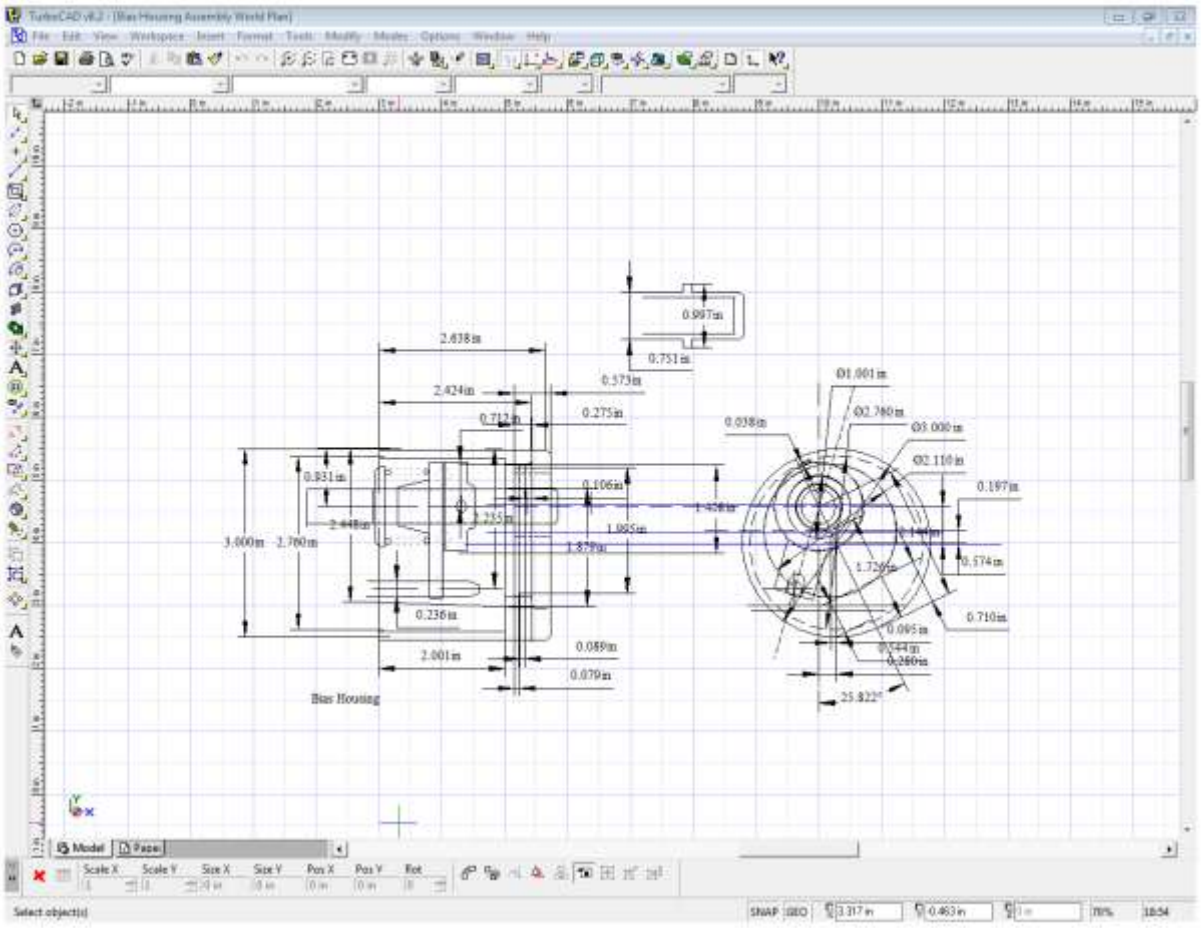


The photograph below shows the tail housing after welding on the gear lever platform.

The position of the platform and its mounting face for the gear lever were accurately maintained during this operation.

The open end at the rear of the platform now had to be extended to contain the bias mechanism and sealed to make it oil tight as well as provide a location for the rear rail support bearing. To achieve this I designed a three part housing, consisting of a cylinder welded to the end of the platform and tail housing, a removable end cap and a plain bearing for the rear rail. The end cap assembly would be bolted into the end wall of the cylindrical housing with cap screws and sealed with an ‘O’ ring.

As you will see in the composite sketch below my design was a bit tricky to make as none of the centres of the diameters or bores of housing parts coincided. These parts were turned out of aluminium on a centre lathe where I had to offset the item to generate the bores and diameters on different centres,




The left hand photo shows the finished cylindrical housing with its wall cut away and the right photo shows the respective cut out made through the wall of the tail housing.

The photo below shows assembled housing details held in their correct position by the slave selector rail prior to welding.

After welding I found the tail housing had distorted. The output shaft bearing was about 0.030" out of line with the output shaft. Fortunately it was only the bearing area that was seriously affected; the speedo drive for example still rotated smoothly.

To recover the situation I cut off the section of tail housing containing the output bearing, manufactured a new bearing housing and machined a location on to the tail housing so it could be welded on in the correct position. In addition I left a machining allowance on both the bearing bore and the shaft seal bore these would be finished to size after welding.

The machining work was done on a vertical jig borer using the main shaft output ball bearing location plate to provide the datum position.

The exercise was a great success restoring the alignment allowing the prop shaft to rotate as it should. As an incidental advantage I decided to move the bearing position 0.5" further back to help offset the requirement for a longer prop shaft.

A few more tasks still needed to be done to finish off the modifications to the tail housing.

I mentioned earlier that the 5$^{th}$ gear selector disc had been shortened to allow the platform to be moved as far forward as possible. In addition the 5$^{th}$ gear locking plate needed to be shortened and its rearmost fixing hole remade further forward as the welded- on platform now clashed with the original hole position.

The holes were tapped for the end cap securing screws and the remains of the original selector rail rear bearing and its housing was cut off the tail housing as it was no longer needed.

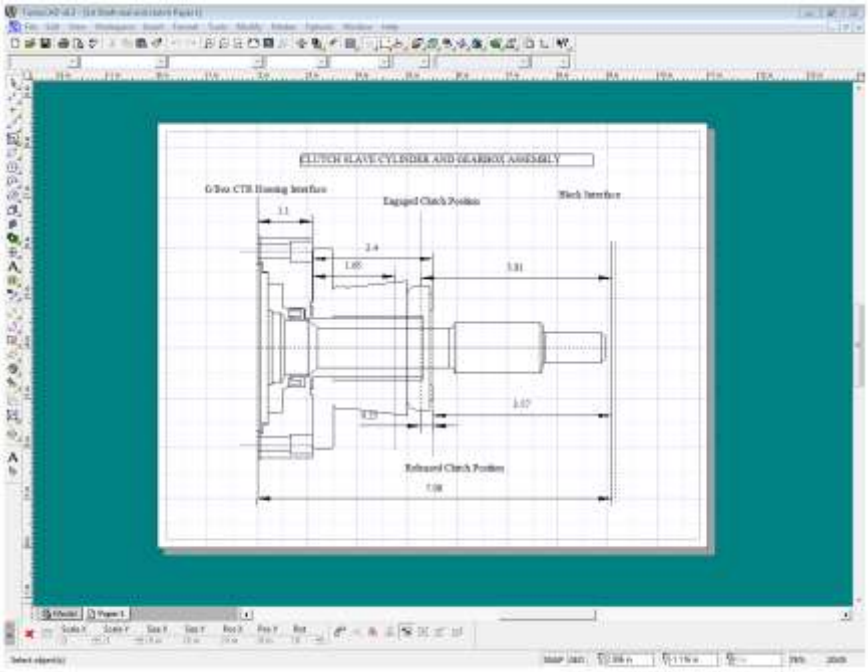
The final activities on the tail housing modification were to weld on the threaded boss for the new reverse light switch and re-fit a shortened bias unit anti-rotation pin in its original hole in the centre of the tail housing.

The finished tail housing was thoroughly cleaned and after blanking off all the apertures was powder coated a mid-grey colour.

That pretty well finishes the tail housing modifications.

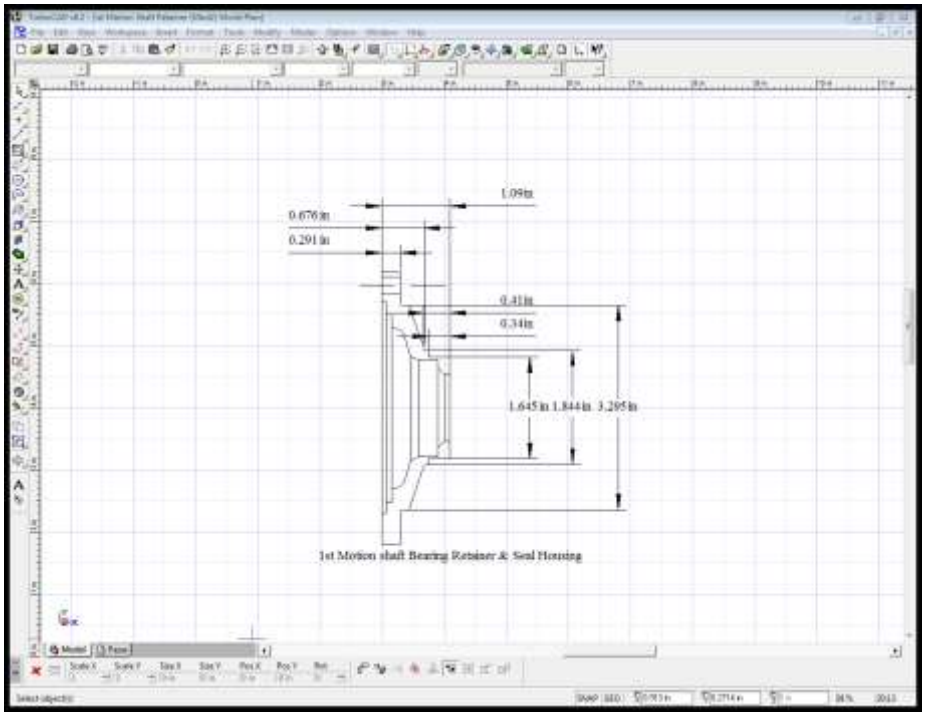
Clutch Modifications

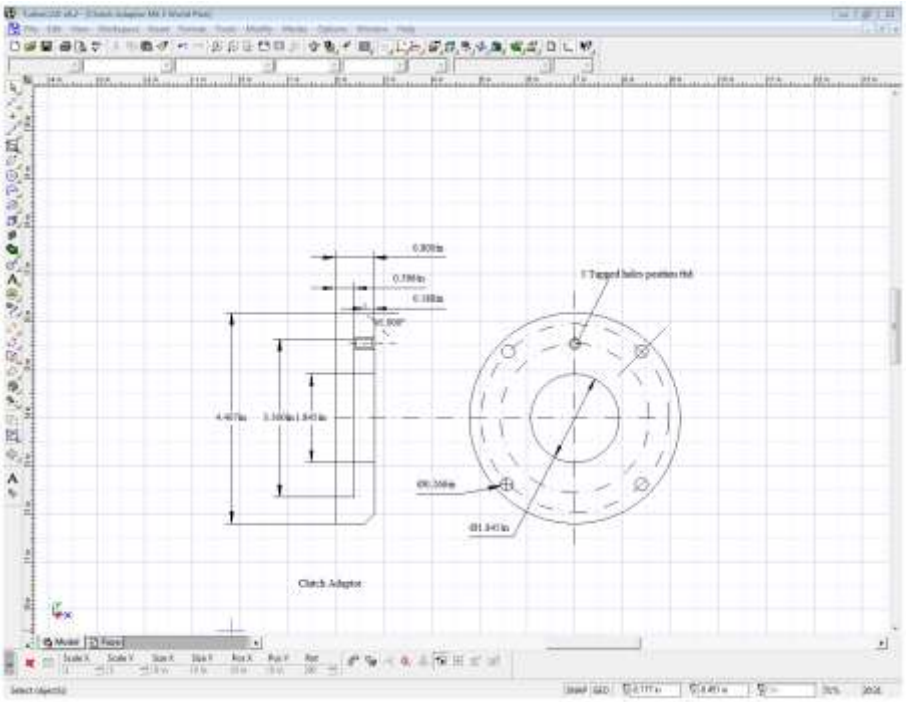
I had made the decision to change to a concentric type clutch so again measurements were needed to create the design. In this case not only were fixed point measurements needed but I also needed to know the release characteristics of the RS 2000 clutch plate in the Lotus cover. So I started with this task and set up a test rig which enabled me to actuate the clutch and measure its release and engage points. I do not have a picture of the rig but used my arbour press to actuate the clutch assembly mounted on the flywheel and with a DTI measured the dimensions I needed. The stroke required was 0.225" between the engaged and release positions. A calculation on the relative strokes of the slave and master showed that the required movement could be achieved without any need to change the master cylinder. With this information and the measured position of the assembled clutch on the engine I could determine where to position the slave cylinder on the gear box. I optimised the position as far forward as I could whilst ensuring a clean release but leaving scope for clutch wear which moves the release/engage position rearwards.




The above sketch shows the clutch layout I needed. But it also shows a single piece adaptor sandwiched between the slave cylinder and the front face of the gear box. I did not use this arrangement, in the end I modified the existing gear box input shaft bearing retainer and made a simpler spacer plate to finalise the position of the slave cylinder. I was also able to retain the existing input shaft seal in its original position in the retainer.

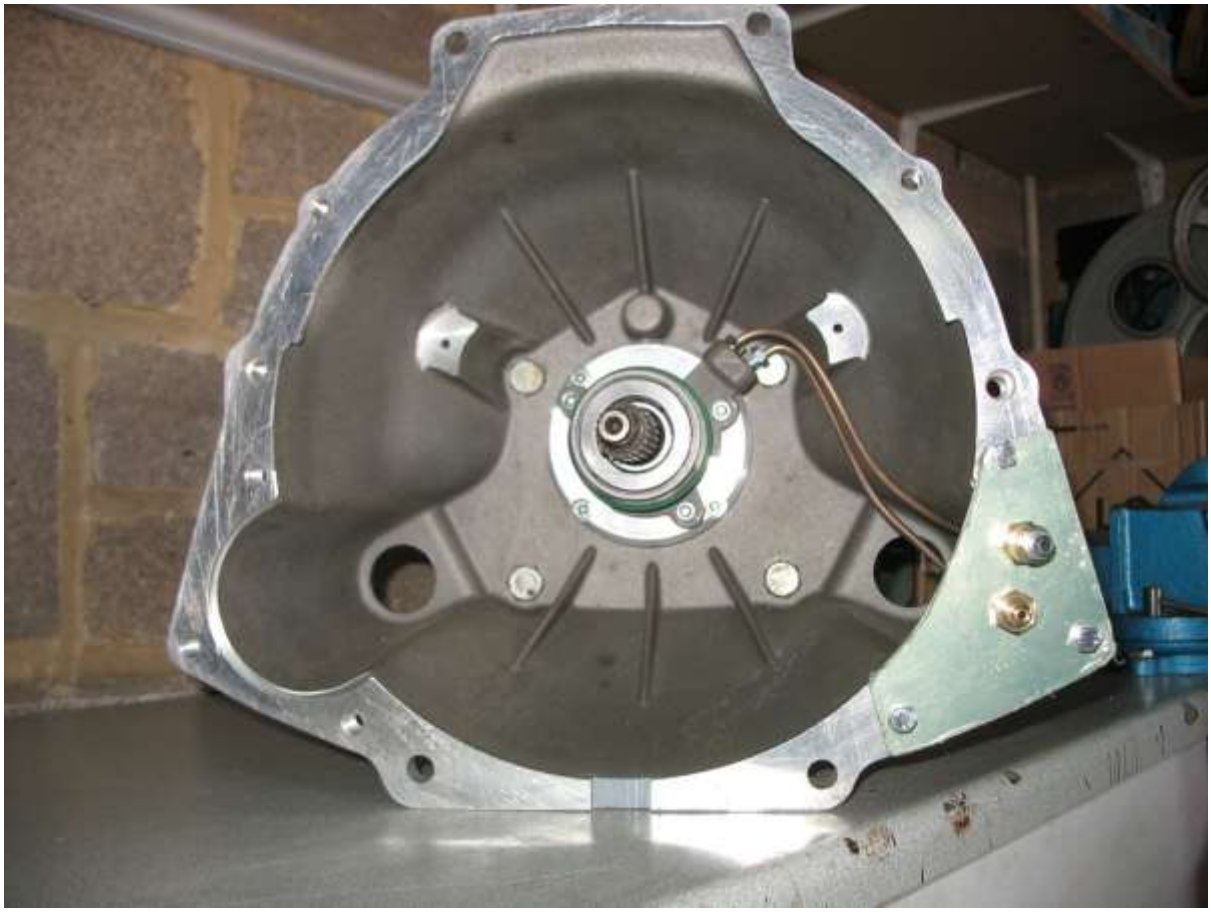
Sketches of the two parts referred to above are shown below.




The clutch pipework was made from brake pipe and I had to use a mixture of fittings as the Mondeo unit had metric threads and I wanted to terminate the pipework in imperial.

I turned the bulkhead pipe fittings from hex brass bar for both the feed and bleed line and these were fixed to a plate mounted on the LH starter holes in the bell housing. This configuration can be clearly seen in the photo below.



Taking note of one of the lotuselan.net contributors frustrating experience, I set up a test rig to ensure that the clutch did operate correctly before installing everything in the car.

For this I mounted a spare master cylinder on a bench and connected the hydraulics up to the assembled engine and gearbox.

Note. Don't attempt to operate the slave cylinder without restraining its movement otherwise it will come apart, don't ask how I know that.

For interest I have included a photo of the test rig below. The laptop in the bottom right was fitted with a snake scope so I could watch the clutch in operation; you can just make out the Mondeo slave cylinder in the picture on the screen.


Bell Housing

There are specially produced bell housings available as well as adaptor plates which will convert the 4 speed bell housing to suit. The adaptor plate looked to be the cheapest solution however it also adds length to the housing which brings other problems.

I decided to use a Type 9 to Twin Cam aluminium housing, this item had alternative mountings for the starter and as I mentioned previously I used the left hand one to mount the clutch pipe work. This proved to be a very neat solution. I had to trim the bell housing in two places, on the lower front flange to miss the exhaust pipes and the back of the right hand starter bulge which clashed with the chassis. The installation is tight, there is not as much room around the housing as with the 4 speed unit but it will fit with careful assembly.

I made a new dirt shield to close the bell housing having discovered that the original would not fit as the starter position is slightly lower than on the 4 speed. You can see this item and the cut out for the exhaust pipes in the photo below.

As mentioned above the starter position is slightly different than on the 4 speed, in effect the starter has been rotated around the bell housing to a lower position but it is on the same p.c.d. and I did checked that the starter would engage correctly. The new position positions the starter a bit closer to the sump.  I have a high torque starter which as far as I can tell is a Brise unit this will fit- just but the electrical connector block has to be lowermost. There could be an installation issue with larger diameter starter motors.

As with the tail housing this bell housing was thoroughly cleaned and powder coated mid-grey when I had finished the work on it.

Prop Shaft Modifications

The Type 9 gearbox output shaft has a larger spline than the 4 speed so the Lotus prop shaft will not fit. In addition the Type 9 gear box is slightly shorter than the 4 speed necessitating a longer prop shaft. Having acquired a Sierra spline with the gearbox I modified my spare Lotus prop shaft by fitting this spline to it. The original spline on the prop shaft yoke was machined off to leave a location spigot and the Sierra spline machined to suit. The two were welded together then cleaned and powder coated with the rest of the items before assembling with a new set of U/J's and balancing. A photo of the modified part of the prop shaft is shown below.

I have mentioned that the prop shaft needed to be a bit longer with the Type 9 installation, I had pinched a bit of length by repositioning the bearing in the tail housing but in case this was not enough I had made a short spacer which, if needed, would be sandwiched between the flanges at the diff end of the prop shaft. In practice I did not need to use this spacer, the prop shaft fitted fine without it.

Mounting Bracket

I used a spare 4 speed mounting bracket together with the standard rubber mount. This fitted to the Type 9 without a problem but I needed to reverse the bracket to get it anywhere near the chassis fixing holes. In addition the rear of the gearbox was too high. I needed to slot the bracket mounting holes by approx. 0.5" to match the chassis holes and I put 0.6" spacers between the bracket and chassis to lower the gear box into its correct position. I did have a concern that the lower position of the mounting bracket might interfere with the exhaust pipe but in practice there was plenty of clearance.

The photo of the installed gear box below shows the mounting bracket and the spacers. The sharp eyed of you will notice a boss sticking up from the exhaust just in front of the bracket, this is a provision for a Lambda sensor if I ever get round to using one.

Speedo Drive

The Type 9 box I used had a mechanical drive which pokes out the right hand side of the tail housing. There was no room to directly connect a cable and to run it forward to the instrument panel. The bend needed would be much too tight so, as with the 4 speed, a right angle gearbox was needed. To fit one a thin flanged adaptor that plugs into the gearbox was needed, this was held in place by a circlip, and the speedo gearbox fitted onto the threaded end of the adaptor. I used an adaptor from a Mini which had the correct thread and machined the body to create the thin flange. When I trial installed the gearbox the right angle gearbox fouled the front flange on the chassis so I reduced the length of the threaded adaptor by about 0.25" and dressed off part of the chassis flange which then provided sufficient clearance. I also clamped the speedo cable to the gearbox housing using a 'P' clip to prevent the assembly moving and relieve the load on the adaptor fixing. The circlip retention was not the most secure of arrangements and I managed to spring the circlip out of its groove when first installing the gearbox. Clamping the cable made the installation a bit more secure.

I don't have a picture showing the clamped cable but the one below shows the speedo drive gearbox in place, the cable was clamped to the rib you can see in the centre of the centre section of the gearbox.

Gear Lever

I started with the lower part of a Sierra gear lever, and threaded on an extension piece to bring the gear knob up to the height I wanted. The gear lever is spring loaded in the upward direction by a rubber bellows compressed between a shaft circlip and the pivot platform. I arranged the split in the gear lever assembly so that I could trap a large washer in the same position as the circlip thus compressing the rubber bellows in the same manner. The gear knob I selected was a leather covered device complete with the Lotus logo in the centre, this item is mounted to the shaft through a rubber sleeve and fixed in position with three grub screws. Looks good and feels very comfortable to use. The photo below shows the modified gear lever with the rubber bellows in position on the gearbox.

Reverse Light Switch.

You may notice that the selector rail crank had a generous area of flat on its rear RH side; this was designed to be used to actuate the reverse light switch. A totally new position was needed for it and the original was not long enough to fit so a new longer switch was obtained and a suitable boss welded on the right hand side. The switch had spade type terminals; however as access to them is nearly impossible with the gearbox installed I elected to permanently solder lead out wires to the switch and clamp these wires back to the switch body. The exposed connections were coated for protection and the lead out wires terminated with bullet connectors. The switch and lead out wires can be seen just below the gear lever position in the photo below.

Tunnel Top

The tunnel top I am using I made from scratch in fibreglass. The original top provided the dimensions for a mould and I made this from MDF. I used a wet layup with two layers of 520 grade glass cloth and reinforced all the edges with a layer of 175 grade tape. Incidentally I just used a layer of cling film as the release agent, worked a treat and as I nicked it from the kitchen it did not cost me a penny. It was not quite finished when the photos below were taken; I have tidied it up since.

Assembly

Most of the gearbox assembly is straight forward; however particular attention had to be paid to the selector rail components. You will recall that the modified arrangement put the selector crank between the two selector rail sections. So there are two angular constraints as well as an axial restraint to consider. In order to ensure that I had positioned the crank correctly I first drilled and tapped both ends for grub screws to temporarily lock the shafts and crank together. With the both selector rails in place but without the bias device I made adjustments to the position of the crank to ensure all the gears could be selected. It's worth taking some time on this as the positioning of this crank is critical for clean selection. It was during this exercise that I found that there was insufficient clearance between the ramps on the crank and the gear lever fork end. A bit of hand fettling was needed to overcome this problem. Once the crank was locked in position on the selector rail this assembly was removed from the gearbox and a hole drilled through the crank and rail assembly for a roll pin. The roll pin was not fitted at this stage.

The front selector rail and crank were kept locked together in the correct position and then re-installed into the tail housing ready for the next stage. The next task was to position the bias mechanism onto the rear selector shaft. The forward end of bias sub-assembly buts against a circlip fitted on the rail and the other end compressed against its spring and locked to the selector rail with a roll pin. This assembly was then inserted through the rear of the new housing and pushed into the end of the crank ensuring that the fork end of the bias mechanism was located on the anti-rotation pin. With the crank in the $3^{rd}/4^{th}$ gear lateral position i.e. the neutral position for the bias mechanism the assembly was locked to the crank with the rear grub screw. Rechecking that all gears could be selected cleanly and the biasing was correct, the front grub screw was loosened and the bias sub-assembly was removed and a roll pin hole drilled through the crank and rear selector rail.

Care needs to be taken on the positioning of both the grub screws and the roll pins so that they are accessible during setting up and on final assembly. In my case after locking the selector assembly together with the roll pins I also locked the grub screws in place with a drop of Loctite.

The gear lever assembly now sits over the oiled part of the gear box so I made a sealing gasket for its joint with the housing and fitted 'O' rings to seal the reverse switch and the end cap.

Four cap head screws hold clutch slave cylinder adaptor and modified gearbox input shaft bearing retainer to the gearbox. The slave cylinder is fixed to the adaptor with three cap screws and the hydraulic pipes bent into position on assembly. The pipes terminate in bulkhead fittings mounted on a plate fixed to the bell housing, the bleed nipple screws directly into one of the bulkhead fittings.

As a general observation, the synchro hubs and their blockers and springs will always part company just as you think you succeeded in putting them together and the countershaft needle rollers always drop out at the critical moment.

Installation

I have already recorded some aspects of the installation; however there are some other issues to complete the picture.

The mounting has already been dealt with and the revised position of the gear lever noted. In order to accommodate this new position I had to relieve part of the chassis top to create the gear lever aperture. The photo below shows the 3" diameter hole I made for the gear lever taken from underneath the car, the hole sits just in front of the chassis bulkhead as can be seen. The bulkhead mentioned above had to be relieved to give clearance for the top of the new housing on the tail section. As already mentioned the side of this bulkhead had to be relieved to clear the speedo drive and I also relieved a section of the lip on the bottom of the chassis just in front of the above bulkhead to clear the mounting.

I closed off the old chassis aperture with a 0.070”thick reinforcing plate as shown in the photo below. This plate is bolted in place so it can be removed, particularly if I need to access the gear lever platform. This whole area will be insulated before the tunnel top is fitted.

The photo below shows where the gear lever will sit in its new position. It puts the lever more or less in the centre of the platform on the tunnel top whereas the original 4 speed has the gear lever quite well forward, very close to the dashboard.


INT
FAN
WINDOW
HAZARD
WINDOW
PARK
DRIVING
OFF
ON
LAMPS

The tunnel top had been trimmed in matching black vinyl and basket wave with a new leather gaiter. The gaiter I used was an aftermarket item meant for a VW Passat. I turned up a black plastic ferrule to terminate the gaiter at the top of the gear lever.

A new section of rigid pipe was manufactured to connect the clutch original flexible pipe section to the bulkhead fitting on the bell housing; this pipe was routed behind the exhaust pipes and runs just in front of the bell housing closure plate. I may need to re-consider this routing if temperature is an issue.

Conclusions.

It has taken me the best part of a year to get to this stage and cost just under £1000 in parts, material and other peoples labour. The crucial question is of course how does it drive? I have only driven around 150 miles so far but I am very pleased with the results, the gearbox is quiet and the gear change action is good, not the same as the 4 speed but nevertheless it is smooth and positive.

I had calculated that my speedo would read 3.5 mph fast at 70 mph with this configuration. When I calibrated it against my sat-nav and it read 1mph fast at 30 mph and 6mph fast at 70 mph, slightly higher than calculated but perfectly acceptable.

The tacho/sat-nav indicated 26mph/1000rpm, I am not sure I believe this as the calculations show the speed should be more like 22mph per 1000rpm. However this is not the end of the world and is not going to bother me.

More importantly this modification gives me a car that is much better suited to modern road conditions than before and makes it even more enjoyable to drive.

I think the modification has been well worth the effort so anyone entertaining the same idea will, I am sure, not be disappointed with the results. So don't hesitate just go for it.

This article is intended to record my personal experience on this project; therefore any views expressed are my own. If I have strayed into other peoples design territory it has been by accident and I apologise now.

The drawings, sketches and data reproduced here should not be taken as definitive design documentation bearing in mind that they have, in the main, been derived from measurements taken from my hardware only. They are an indication to those interested in the project on how I resolved the issues. Since none of the drawings etc. had been produced with publication in mind a lot of data is missing e.g. I have not included any tolerances or material specs. So if you do use the data included in this article you do so at your own risk.

I must not finish without expressing my thanks to those enthusiasts from lotuselan.net that have shown an interest in my project and provided helpful comments and suggestions from their own experience, a big thank you to you all.

25th May 2012