Moto Guzzi big-block 5-speed gearbox

Gearbox *'clunk'* - the fix

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Introduction

"Why does my gearbox make a noise like someone dropping a brick in a bucket when I change gear?"

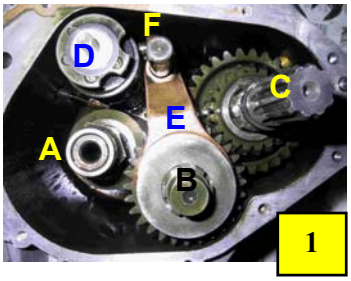
This is a common question asked by Guzzi big block owners and a variety of reasons are usually offered, most of them to do with the bike being shaft drive and most of them being wrong!!!! While there are a number of factors which contribute to Guzzis being clonky, shaft drive, heavy pinions, heavy flywheel etc, etc. The biggest contribution to Brick in Bucket Syndrome is the fact that most Guzzis are in a poor state of tune and most importantly ***the factory never used to put much effort into shimming up the selector drum in the gearbox.***

Now. Mention 'shimming' to most motorcyclist and their eyes glaze over and they start to froth at the mouth. Either that or they run a mile screaming in terror. The thing is it's not as if it's the hardest thing in the world. The only purpose shims have is to alter the length or thickness of something. There's no 'Secret Squirrel/Funny Handshake' stuff here, all a shim does is make another bit bigger. Removing one makes the bit smaller and varying their thickness makes the size vary. It's all very simple.

Now lets get specific with the Guzzi big block five speeder.

Terminology

First of all I'd better get some major parts named. Guzzi's naming of the assorted shafts may not mean an awful lot to people who don't deal a lot with transmissions so I'll use some simpler terms. There are three shafts in the Guzzi box: (*refer also to pics.1 and 2*)



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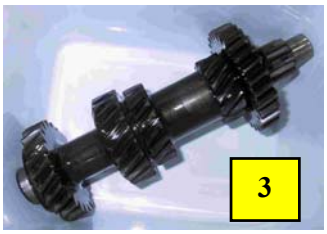
Guzzi's name	My name	Notes
Clutch shaft	**Input shaft**	Where the power comes in (**A**).
Main shaft	**Cluster shaft**	Has four of the five pinions machined onto it as one piece (**B**).
Layshaft	**Output shaft**	Where the power exits the box to the uni-joint and final drive (**C**).

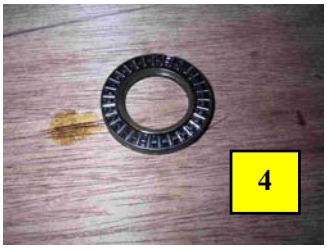
Also in the box there is a selector drum (**D**), three selector forks (**E** *on pic.1 is for 5th gear*) and the shaft (**F**) they slide on and, in the endcase, the selector pawls (**G**) that turn the drum.

Gearbox operation and shimming - general

For the purposes of shimming the shift correctly I'm assuming that all the shafts are fully assembled as units and are ready to be inserted into the gearbox.

There are effectively three shimming operations in the box. The good thing is that unless you are swapping either the cluster shaft, it's thrust bearing or the output shaft, two of them you don't need to worry about. I'll briefly cover these and then you can probably forget them.





Cluster shaft

Because the cluster shaft (*pic. 3*) 'floats' in the box, that is isn't secured at either end, if it isn't the right length it will cause problems. If it's too long between the bearings it will bind and if it's too short, especially with the helically cut boxes, it will bash backwards and forwards as the power goes on and off. Because of the end thrust imparted to the shaft by the helical cut gears there is, at the front of the shaft, a Torrington type 'flat' needle roller (*pic 4*) to take the strain when the motor is delivering power, the thrust on the over-run is coped with by a single ballrace in the endcase which is sufficient as the thrust on the over-run is much less than when under power. To take up the extra space so that the shaft doesn't try to thrash backwards and forwards there is a shim that goes alongside the Torrington bearing. Once the correct shim is in place unless either the shaft or the bearing are changed it shouldn't need to be rechecked. As long as the shaft isn't shimmed up too long so it binds this isn't super-critical but it's worth getting it right.

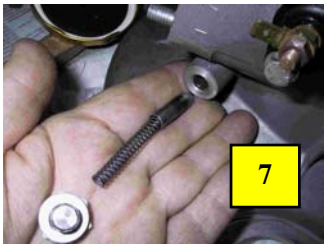
Output shaft

With the output shaft (*pic. 5*) shims are put onto the shaft inboard of the bearing that is on the end of the shaft retained by the queer, left hand thread stakenut. The purpose of these shims is to centre the bearing, which is an unusual two part design, in it's race, which sits in the main gearbox casting. When the big nut on the end of the output shaft at the back of the box is tightened down it pulls the whole shaft up tight against the big, double row, output shaft support bearing. By putting the correct shims under the bearing at the other end of the shaft it ensures that the bearing rollers run in the centre of the race. The good thing is that the race is a goodly bit wider than the bearings which leaves a reasonable margin for error, usually if it's done wrong the worst thing that happens is that the nut on the end of the shaft will rub on the inside of the main gearbox case and will leave a witness mark there that is visible when the shaft is removed. If, however, you are unlucky, this rubbing may cause the nut to un-stake itself and wind off. This firstly causes the nut to burrow through the front of the gearbox casting into the bell housing and if you're really, really lucky the pinions start dropping out of engagement or double-engage. This is expensive and dangerous as it tends to make the back wheel lock and/or gearbox explode, guaranteed to break the ice at parties NOT! Set it up right once and forget about it until you replace the output shaft.

Selector drum

OK, now on to the one that 'really' matters! What will make a terrific difference to your gear change is getting the shift drum (*pic.6*) shimmed up properly. While the factory seems to of been taking a bit more care over

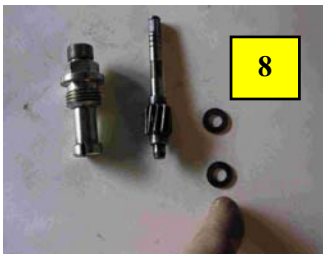
recent years if the cleanliness of changes is anything to go by most of the older, pre '95 bikes seem to be flung together on the bench and as long as they selected all five gears, no matter how poorly, that was deemed good enough.



The selector drum itself has grooves in it and as the drum is turned by the pawls of the selector the selector forks move in these grooves. The other end of the forks run in sliding dog clutches that choose which gear is going to be engaged to deliver power at any one time. There is a positive stop détente (*see pic.7*) system that ensures that when engaged the gear selected remains engaged rather than the box having a mind of it's own and the drum rotating of it's own free will. Like most motorbike boxes the Guzzi box is a constant mesh gearbox meaning all the pinions are engaged all the time. Which one delivers the drive is chosen by the dog clutch that is engaged, not by sliding pinions in and out of engagement as is done on a car gearbox.

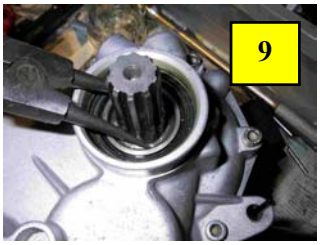
Dismantling

First of all lets take the gearbox apart.

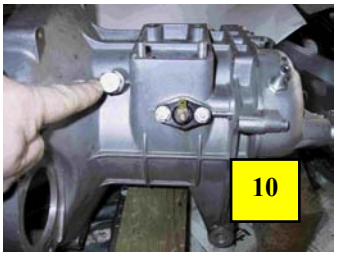


Removing speedo drive, pegnut, stakenut and speedo worm

To start off with remove the speedo drive, being careful to remove the hardened steel washer (*see pic.8*) from ***under*** the drive, ***don't loose this***, you can't buy them separately!



Now biff down the tang on the lockwasher behind the peg nut that holds on the clutch boss and remove the nut and boss. Reverse the box and then remove the 27mm stakenut that retains the speedo worm onto the output shaft, this is best achieved with a rattlegun as it's done up 'Uck'n tite'. The speedo worm can now be removed, along with the drive ball and the collar underneath it by using a pair of external circlip pliers (*see pic.9*) inside the flange on the worm and lifting. ***DON'T grab the edge of the speedo worm with pliers.*** The seal runs on this surface and it is surprisingly soft. Grab it with pliers and it's rooted, you'll have to buy another one.

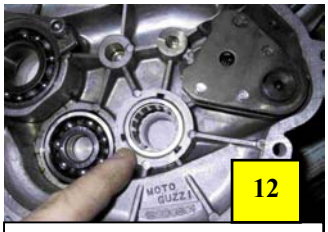


Removing the détente

After this the détente can be removed. First make sure the box is ***in neutral***. On earlier boxes the détente lives underneath the breather just forward and upwards of the neutral light switch. On later boxes the breather is on the endcase but the détente lives under a 17mm blanking plug in the same place (*see pic.10*). Be careful removing it, there is a ***spring underneath*** the breather/plug and when it comes undone it will fly up and biff you or fly off to some dark and inaccessible part of the workshop never to be seen again.

Removing the endcase

Once the détente is out the endcase can be removed by taking out all the screws that hold it and then lifting the case up. If the box was in neutral before the détente was removed then the pawls should slip out through the cutaways in the end of the selector drum. Quite often the output shaft will be reluctant to slip through the output shaft bearing, if this is the case I find using a plastic dead-blow hammer to alternately tap the case up and then the output shaft down will free it up. Note: I say 'tap' not belabour with mighty blows and extreme physical violence. You're trying to be a mechanic here not a f*&%ing blacksmith !!!!!



(Watch out for dropping needle rollers!)

When the case comes off turn it over and check that the shim from the end of the selector drum hasn't stuck to the case. Many people think there are two shims at the back of the drum (*see pic.11*). In fact there is only one but there is also a large washer that retains the pins the selector pawls work on. Don't get these confused and don't loose either of them. The other thing you will probably find in the endcase is that the needle roller bearing that the input shaft rotates in (*see pic.12*) will of probably 'walked' out of the case over time. Knock it back down to it's register, (unless you are going to strip and blast the box in which case it can be removed by heating the casting.) and then secure it there by centre punching around the edge in three places. ***DO NOT use a bearing retaining compound***. These bearings do walk until punched into place but it is rare for this to cause major problems, don't fret over it.

Removing the selector drum

Next step is to pull the selector drum away from the forks and lift out the 5th gear selector fork along with it's dog clutch. The shift shaft can then be removed, and the two lower selector forks removed. As you do this examine them both carefully, don't get them mixed up and see if there are any signs of undue wear on either side of the forks where they slip into the dog clutches. This is very important as it will give you a good indication of if the shimming is correct, or, if it's wrong, which way the drum needs to be shimmed.

Having noted the position of the selector forks the selector drum can now be removed. Once it's out check to see if the shim at the front of the drum is still on the drum or if it's stuck at the bottom of the box. Wherever it is, retrieve it and slip it on to the end of the selector drum shaft and put the one from the back of the box on the other end and place the drum to a side for now (*p.13*).

Removing the three shafts

After this the three shafts, input, cluster and output can be lifted whollus-bollus from the box. Once again the input shaft may be a bit sticky in the bearing, no worries, tap it out with a dead blow hammer. Sometimes it's possible to wiggle the shafts out individually once the input shaft has been knocked out a bit but whatever way you do it make sure that when all the shafts are out that:

- You have the ***thrust bearing and shim*** of the end of the ***cluster shaft*** (*pic.14*) and they can be either put aside or put back on the shaft before it's put aside.
- You have picked the ***flinger ring*** off the inside of the ***input shaft bearing*** where it will almost certainly of remained (*pic.15*) when you withdrew the shaft. This looks like a thin shim but it's purpose is to encourage oil into the races of the big double row bearing, it is important so don't loose it!!

Guzziology suggests that the neutral light switch should be taken off, cleaned and put back using a sealant sparingly (Threebond 1211 is an option). It otherwise tends to weep oil, and is normally inaccessible behind the starter when the gearbox is in the bike. (Take note, this is the **only place** Guzziology recommends using such stuff). Your choice! But keep away from the silastic types!!!

Inspecting the box

That should leave you with a bare box with only the neutral light switch remaining. Whether you take this out or not is up to you, I usually do simply because having come so far it seems churlish to leave it in but it's not vital. If you didn't previously remove the détente plunger from the case when you removed the spring you can now poke this out as well and put it aside with the spring and its plug/breather.

Since it's apart you can now check the bearings. Needle rollers shouldn't be loose in their cages and the big, double row, ball races should be checked to make sure that there is no play and most importantly that the cages for the balls are intact. It is not uncommon for, if a UJ fails disastrously, for the shock wave this causes in the box to shatter the cages that hold the balls in these bearings. If this happens the balls all just roll down to the bottom of the races and, needless to say, the bearing is a good deal weaker and less good at it's job than it might be. If you have any doubts, replace them. Some of them aren't cheap but they're cheaper than the damage caused if they fail! The front needle roller may of walked in the case too. Knock it back and punch it in as you did the one in the endcase.

The bearings under the pinions rarely need replacing, even at very high mileages. Unless you have suspicions something is wrong with them and they spin freely I'd leave well enough alone.

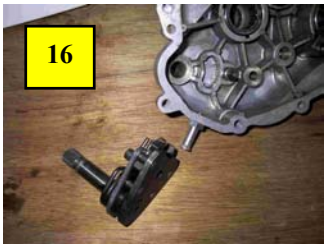
Shimming the selector drum

OK, this is the bit you've been wanting to read. How do you shim up the selector drum for a better change?

Firstly lets just establish how the gears sit on the shafts. Counting from the back of the box you come to 5th, 1st, 2nd, 3rd, 4th.

- 5th is the only gear controlled by it's own selector fork.
- 1st and 2nd share one selector fork.
- 3rd and 4th share one selector fork.

You can do pretty much anything you like with the shimming and you can be pretty sure of being able to get 5th. The gears you need to concentrate on are the others but the changes most likely to be a bit cranky are 2nd to 3rd and 1st to 2nd. 2nd to 3rd because you have to move two selector forks to achieve this and 1st to 2nd because you need to traverse neutral and the spacing of the ratios is greater meaning the amount parts have to accelerate and decelerate in these changes is greater.



Take the pawls out of the endcase (*pic.16*) and remove the old gasket. Now install the selector drum into box and bolt the endcase back on. ***Just the drum with it's shims and the washer to retain the pegs, nothing else***. Now, by sticking your finger in through the input shaft bearing and reaching 'up' you should be able to feel the drum and be able to try and slide it forward and aft on it's spindle. NOT rotate it, it will certainly do that, what you are trying to do is gauge the end float in the drum. 99 times out of a hundred you'll find that there is play in the drum, bloody heaps of it!!! between 10 to 20 thou is NOT uncommon, that's up to ½ a mm. Now the whole point is that as the drum turns and the selector forks follow the grooves in it they will push the sliding dog clutches into engagement with whatever pinion is going to be delivering the drive. Thing is that as we know, every action has an equal and opposite reaction so as the fork tries to push the dogs into engagement the other end of the fork will be trying to push the selector drum in the opposite direction. Add too much slop into the equation and what happens? The dogs won't engage fully and will try and fling themselves out of engagement or you'll find a false neutral. *Beginning to sound familiar??*

If, as well, you add in the fact that the drum may have incorrect thicknesses of shims in proportion to each other at either end and you may well find that when a gear or pair of gears are engaged, (1st and 3rd or 2nd and 4th.) the drum may locate the selector fork so it's pressing hard against one side of it's guide in the sliding dog. This is where you need to look carefully at the selector forks for the four lower gears and see if there are severe wear marks on one side or the other. If there are then it's a sign that there is insufficient shim on the end of the drum that the wear is obvious on the selector fork flank. Usually you'll find that if the1st/2nd fork is worn on the 'back' flank the 3rd/4th one will be too, maybe not as badly but it will be visible. A correctly shimmed for depth of engagement drum should exhibit little or no wear to either face of the selector forks.

The way I tackle this is:

1. Measure the thickness of the shims you start out with, the one at the front and the one at the back of the selector drum, that the factory put in. Note them down.
2. Make sure the large washer under the rear shim is in place.
3. First of all to start adding shim to the selector drum until I've eradicated all end float but the drum will still spin freely. It doesn't matter where this shim goes for now, what I'm trying to do is find out how much more it needs to take the end float out. Just swap shims until all the end float is gone.
4. Subtract the thickness of the original shims from the ones that have eradicated the end float and you'll know how much extra thickness you're going to need.

Having got that you have to work out at which end or in which proportions on either end you are going to add it. To do this you look at the selector forks and see if there is wear. Usually you'll find that there are wear marks on the rearward facing flank of the 1st/2nd fork and 'maybe' on the same face of the 3rd/4th. This isn't guaranteed but it's the 'commonest' factory cock-up! In this case you need to move the drum towards the front of the box by adding shim to the back. Try adding the next size up shim to the back of the drum and then adding enough shim to the front of the drum to get the thickness required to eliminate the end float.

Assembling

Now you have to put the whole box back together !!!!!

1. Slip the three shafts into the box together, you can stick the thrust bearing and it's shim onto the cluster shaft and the flinger ring onto the input shaft with ***grease*** so they don't fall off, then slip them in.
2. Then the selector drum and its shims can be put in.
3. Then the selector forks for the lower gears. These can be a pain, you have to wiggle them up with a bit of bent coat hanger, (or a very expensive Guzzi special bent coat-hanger) to pull them into engagement with the drum. When they are in the shaft they slide on can be re-installed and the 5th gear fork and dog slipped on by pulling the drum to one side.

Stick a gasket on now and re-install the endcase. The box must be ***in or close to neutral*** to do this because the selector pawls need to fit through the cutaways in the end of the drum. Wiggling and tapping usually does the trick.

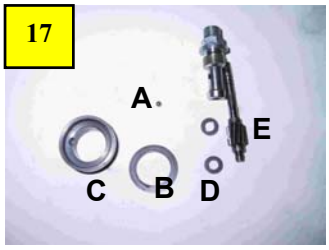
It is then VITAL that the clutch boss be fitted and tightened down and the nut on the output shaft likewise. They have to come off again so don't worry about the seals or o-rings but they have to be tightened down to pull the shafts up against their respective bearings. Then install the détente, if you don't it won't select properly.

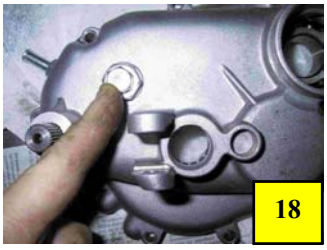
Checking the gear shift - final shimming

Now you can turn the clutch boss by hand while selecting gears with a pair of grips of some sort on the gear lever which you've put on the splines. If you've got it right it will engage all five gears up and down the box with no binding or reluctance to enter a gear.

- Binding in 1st or 3rd indicates that you need to add more shim to the rear of the drum and remove it from the front.
- If it binds in 2nd and 4th then it needs adding to the front and removing from the rear.

At all times the ***total thickness of shim should be kept the same*** to eliminate end float in the drum. Sufficient end float is allowed for by the fitting of the gasket. Once the shafts are back in the box swapping shims is comparatively easy. You need to undo and remove the nut from the output shaft to remove the endcase and ***the détente should be removed before the drum is taken out to*** swap shims to prevent the spring pushing it into the box but the shafts can stay put. A bit of swapping of shims will eventually leave you with a gearbox that will select all gears sweetly, it is sometimes necessary to use two shims (thin ones), at the front of the drum to erradicate the end float when the shimming is correct at the rear. Although this shouldn't be so it sometimes is, don't worry, it is '*normal'*, or as normal as anything made by Guzzi is !





Final assembly

Finally the clutch boss and speedo drive can be removed again to allow the fitting of new seals and o-rings to the input and output shafts and the final re-assembly undertaken. Don't forget (*pic.17*) the speedo drive ball (**A**), the collar (**B**) under the speedo drive worm (**C**) or the hardened washer (**D**) under the speedo drive (**E**) itself.

Back in the bike

Once it's back in the bike minor adjustments may be necessary to the pawls by way of the external adjuster (*pic.18*) on the back of the box but if you've got it right you'll wonder why you lived with it being horrid for so long!!!!!

Final words

Lightening the flywheel and sourcing a straight cut gearbox are the best ways of minimising 'clunk' and you'll never make a Guzzi change like an RGV but you can make them a whole lot nicer and almost completely erradicate false neutrals if you spend a couple of hours getting it right. Whew ! A bit of an epic that but I hope it helps people.

Anything I've missed or any questions, fire away...

Pete Roper

Appendix: Tools required

The Guzzi workshop manual lists a number of special tools that you may or may not get your hands on before the job starts. For higher quality tools than the original 'special tools', you should get in touch with Rolf Halvorsens for purchase of his toolkit (rolf.i.halvorsen@nammo.com). Assuming you get access to these items, the tools will make the job far easier than if you are limited to only the spanners, sockets and odds&ends that are found in most toolboxes.

Peg-nut socket

This is the trickiest nut to deal with in the whole operation. It is difficult to chisel it off/on by crude methods due to the location inside the clutch boss and there is a risk of damaging the boss. See *pic.19*, part of Rolf Halvorsens toolkit.

Deep socket 27 mm

This extra long socket - needed for the nut on the output shaft. The surface of this nut is small - easy to damage - and the seal is in the way for a good grab with most sockets. A modified socket that reaches properly to the bottom of the nut is recommended, part of Rolf Halvorsens toolkit, see *pic.19*.

External circlip pliers

These pliers have a round, pointy, end and (*see pic.20*) are made for holding external circlips open, so they work ***outwards*** when grabbed in the normal way. The tool is needed for pulling out the speedo worm without damaging it, but is also useful to keep in the toolbox for when you are actually facing a circlip one day.