

Disassembly of a Raymarine ST4000 Tiller Auto-pilot - Andrew Garrett

Half way across the Gulf of Carpentaria my Raymarine ST4000 tiller auto-pilot failed and I had to hand steer in 35kt winds for 2 ½ days. Whilst anchored off the Gove yacht club some cruising friends “helped” me pull it apart. After one particularly violent tug vital bits flew off in every direction. How many balls should there be and what was the orientation of that part?

I rang and e-mailed Raymarine throughout Australia and the UK seeking answers to:

- 1) How many balls should there be (we could find 41 - we had only lost 3);
- 2) What lubricants are preferred (it was as dry as the proverbial bottom of a parrots cage); and
- 3) Is there a drawing of its assembly?

The answers were consistent “there are no serviceable parts inside - return it to us for repair”. A bit hard from Gove so I reassembled it as best I could and very reluctantly purchased a new one (not happy) and waited for it to be flown in to Darwin from the UK. To continue sailing alone around Australia without a replacement would be unwise. There is a newer model but I understand that the only difference is that metal gears have replaced the plastic (and un-worn) ones on mine.

Now that the warranty on the new one has elapsed I have pulled it apart - a bit more carefully. I found 43 balls. I have subsequently been advised that there should be 44 balls! The following notes are not intended as a manual nor as an inducement for you to exceed your capabilities.

But, they may help someone in a similar situation.

TOOLS REQUIRED:

- rubber gloves to grip and unscrew shaft elements;
- a vice, locking pliers (or the proper tool), tweezers and insulation tape;
- a piece of card cut to say 30mm wide and long enough to roll around a 15mm shaft once;
- round toothpick/cocktail skewers; and
- paper towel, kerosene, light grease and light oil.

As you disassemble it place items on a long paper towel in the correct orientation and sequence.

- At A, unscrew and loosen the cable clamp securing the cable to the back of the unit (failure to do this may twist and damage the cables).
- At B unscrew the tiller pivot receptacle.
- At C unscrew the plastic end piece bearing from the shaft element.
- At D unscrew the two shaft elements.
- This is revealed at D. Note the O rings either side of the centre rim. Check they are OK.
- The arrowed pin E, secures the screw shaft to the gear race (located inside the black plastic to the left of G) the pin can break (I now carry a spare). It is a “C” shape, a press fit in (I’ve used a shortened split pin previously but it can foul F).
- F is a buffer to reduce impact.
- G is a plastic disk that protects the gear race (to the left of G).
- This is the gear race expanded. The 4 small gears have a shoulder positioned to the right as shown, ie touching the metal assembly. Their left face is flush and contacts a plastic shim inside the assembly.
- Check for wear.



Fig 1

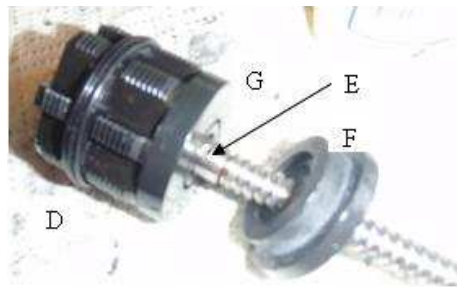


Fig 2



Fig 3

- This is the motor section, to the left of D. Marked "RS-555SH, Made in China, TD057303". The central gear engages into the four small gears in the gear race.
- There appears to be only one screw (arrowed) but this is vital as it slots into either of two round receptacles in the plastic gear race mounting to stop it rotating. Fig 4.
- Carefully unscrew the left end of the shaft element (ie with the auto-pilot pivot pin) and check the cable (mine was frayed) - be careful to not over twist it.
- The 19mm dia stainless steel push/pull shaft is attached at its left end to a brass assembly ~30mm long by ~20mm dia. There is a slotted plastic guard pointing to the left held in place by the shaft. Fig 5
- To unscrew the push/pull shaft from the brass assembly grip the shaft with rubber gloves and the very left end (NOT the centre) of the brass with a vice or pliers (or use the intended tool) - don't scratch either. Remove the shaft and plastic guard.
- At the very right hand end of the central screw is a star shaped centraliser (pointing left). It is held in place by a cir-clip - it can be removed. Fig 6.
- The next bit is very tricky! Ensure that you have paper towel, a container etc in place to catch feral balls! There are/were 44.
- The brass assembly has a brass collar around it. The collar needs some (gentle) force to slide it off. In Fig 7 the collar has been removed.
- Inside the assembly are 44 2.0mm dia steel balls that reticulate through a small steel channel tube that is in two halves (8 balls can be seen in Fig 8).
- Catch all balls! Slide off the channel retaining collar, using tweezers remove the 2 half channels. There will still be feral balls - unscrew/slide the brass assembly off the end of the main screw.
- Count and clean the balls eg in kerosene.
- Clean everything as required, buff BUT DONOT SCRATCH the push/pull shaft.



Fig 4



Fig 5



Fig 6



Fig 7

The threaded brass section to the right of centre is where the push/pull shaft was attached. The two 3mm dia holes and groove between is where the steel channel tube goes. (more about the red card shortly). The centraliser's cir-clip slot is far right.



Fig 8

The 2 halves of the steel channel tube with 8 balls loaded (in light grease). The ends of the channel go in the 3mm holes described above (see Fig 7). A tiny finger protrudes from each end and directs balls through the channel tube rather than around the screw. These fingers must not be worn or damaged or balls will escape.

TO RE-ASSEMBLE:

- Ensure you have 44 balls (one or two missing may not be a disaster but aim for 44 - purchase spares in advance?). Place them in a container so that you can pick them up with tweezers and so that you know when you have 8 left.

There are two options:

Option 1:

It is essential to stop balls falling out the right end until the channel tube is in place - this is achieved by pushing a cylinder of rolled card (red in the picture) around the screw and inside the brass right up to the top right ball hole. You need to be able to see the left end of the card but still get a ball into the screw through the hole. A second, thinner, card disk to the left of the assembly may help but I have found this unnecessary with practice.



Fig 9

Option 2 (my preference):

- Locate the red card as in Fig 9 but locate the brass assembly to its right and so that the end of the central screw coincides with the step in the brass. This is so that **when** balls accidentally go to the right they can be collected and reinserted without pulling the whole thing apart. The card should go up almost as far as the left hand hole if possible.

Common to both options:

- Ensure the screw is aligned so that a 2mm ball will fit in the brass holes.
- Squirt just a little light oil in the top right hole. In Fig 9 a ball can be seen in the top right hole.
- Load balls in the top right hole one at a time and gently push them into the screw (with something soft, about 2mm dia - eg a round toothpick/cocktail skewer). Push the balls down and to the left - don't let them go to the right. Hold the assembly so that gravity assists.
- Do not rotate the screw as this may force balls too far to the left (a LITTLE rocking back and forth may help). If using Option 2 you can observe and retrieve feral balls from the right hand end as you go.
- After you have loaded 36 balls, of if you see a ball at the bottom left hole, STOP.
- Put a little grease in the two channel halves and load it with the remaining 8 balls (as shown in Fig 8 above) then combine the two halves to form a tube and press the two ends of the tube in place in the two 3mm dia holes. Push in and hold it right down.

YOU ARE NOT SAFE YET

- DO NOT let go of the tube (it will fall if inverted). Gently remove the card and check for feral balls. There are LIKELY to be a few that have gone too far to the left or right. Collect them, reinsert the card cylinder and gently remove the tube.
- Add the feral balls to the tube or load into the top right hole, without forcing balls too far to the left or right, and replace AND HOLD the channel. Look for more feral balls. Repeat as necessary.

Eventually you will correctly locate all the balls. (I found it impossible to keep count of how many balls were inserted but each time I pull it apart I find 44).

YOU ARE STILL NOT SAFE YET

- 1) DO NOT let go of the channel/tube - you will lose balls.
- 2) DO NOT unscrew the assembly off the right hand end (a serious risk with Option 2) - you will lose balls.
- 3) DO NOT carry the assembly without supporting the gear assembly – it will drop off.

(I have done all three – but only once!)

- Once you have all 44 balls inside, slide the channel/tube retaining collar into place to completely cover the channel (there is actually a groove in the assembly and a matching indent in the collar which is asymmetric) - now you are safer but see 2) above. Turn the screw gently and again check for feral balls.
- Replace the star shaped centraliser, stars facing to the left on the right hand end of the screw and replace the cir-clip. You should now be safe.

Lubricate as required:

- Lightly grease the four gears and motor gear. Do not allow grease into the motor.
- Light grease the screw - make sure you have displaced any oil used to load the balls.
- Run the brass assembly up and down the screw several times to even out the lubricant. Check that the brass assembly spins freely (eg under its own weight) if not you may have too much lubricant.

Re-assemble in this order:

- Replace the slotted plastic guard pointing to the left over the threaded part of the brass assembly and then screw on and tighten the push/pull shaft. This needs to be reasonably tight.
- Working from the left screw the aluminium shaft elements together ensuring there is an O ring at the end of each. Take care inserting the motor gear into the 4 gears in the gear race and ensure that the screw on the motor engages into a hole in the gear assembly.
- Assemble C to A in sequence making sure that A is last and that you don't twist the wires. Tighten the cable entry clamp at A.
- Check that it works by applying 12V to the two pins beside the plastic separator in the plug - do not drive the push/pull shaft beyond its limits.
- I have found that over tightening the shaft elements effects its freedom of movement - check that it is tight enough to be sound and watertight but able to move freely.
- Screw in the tiller pivot receptacle, at least "firmly", as I have had it loosen in rough conditions.
- Clean up and look again for feral balls.

My original unit, which has had a lot of hard use over 7 years, is showing little or no wear and apart from checking the "C" pin and lubricating the unit every couple of years it should outlast me. I now carry my "new" unit as a spare.

Good luck

Andrew Garrett