Repair Manual

Keel Assembly and Mounting Structure

Fairey Marine Atalanta, Titania and Fulmar

by Trevor Thompson in 2009

Based on an original document by Maurice Donovan, and created with the assistance of John Ingleby, Murray Reed and Dominic Dobson.

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Introduction

This manual is intended to assist owners of Fairey Marine's Atalanta, Titania and Fulmar to carry out for themselves, or have carried out, a full overhaul and service of the keel assembly and mounting structure.

It details techniques and equipment, that various owners have used and describes the procedures that have been used to safely dismantle, re-condition, protect and re-assemble the various component parts.

Please note that the Association can provide copies of all of the drawings which relate to the components and assembly for the keel system. These drawings will provide the information required for engineering professionals to make replacement components which will fit first time.

We now live in a partly metricated world (in the UK at least) and you do need to be careful in replacing imperial thickness plate with metric thickness plate when making new pressure plates etc. There is very little spare room in the width of the keel box, and a millimetre here and another millimetre there can make the difference between a keel rising smoothly between the pressure plates on re-assembly and the keel refusing to fit. I speak from experience.

Many owners are tempted to modify the design, thinking that they have improved it, only to find that the modifications prevent the keel structure from being reassembled. Think carefully before modifying anything – this is a well designed structure, created by professional engineers, who worked to the highest aviation standards. It has also stood the test of time - so the original designers new what they were doing!

Before we can discuss how to take things apart we really need to look into how this unusual (but superior) keel arrangement works:

How the keel system functions

The keel system is quite unlike the typical lifting keel or centre board found in dinghies or cruising yachts.

Typical centre-plates are supported on a bolt or pin passing through the sides of a casing, and when lowered press against the wooden sides of the casing. These plates are usually free to rise, only held down by gravity and the sideways pressure of the boat sailing to windward. This arrangement transfers all of the forces created when sailing into the wooden centreboard case.

The Atalanta is different.

By the way whenever you see "Atalanta" in this document you can assume that it also means Titania and Fulmar – unless the text specifically states otherwise.

In the Atalanta each keel is supported by, and held firmly against, a metal structural support arrangement. This left hand photo shows the metalwork, from forward looking back, assembled in a boat:

The right hand photo shows it from the aft side of the main bulkhead. This framework passes the stresses from the keels directly through to the main bulkhead, and then distributes it into the structure of the boat.

This photo shows one of these supports.


The three tubes pass through the keel box (we Atalanta owners refer to our “centreboard cases” as “keel boxes” – don’t ask me why – we just do!). The side with the tubes in it is bolted to the inner side of the keel box, and the other side is bolted to the front of the main bulkhead – the bit that you have to keep climbing over. Most of our boats have a thin plate inside the keelbox which takes the heads of the machine screws which hold the main structure to the keel box inner side. Note that A1 to about A12 did not have this thin plate fitted when new. They had washers under the heads of the bolts.

This photo shows the reinforcing plate with the three holes for the tubes to pass through and countersunk holes for the bolts which pass through the side of the keel box.

That part which is bolted to the main bulkhead is bolted through the bulkhead to a thick metal plate on the aft side of the bulkhead. This plate also connects the supports for the port and starboard keels together. This metalwork actually transmits the forces from the keels directly into the main bulkhead. The tubes which pass through the keel box side are long enough to clear the thin plate, and press directly onto the keel system in the keelbox. There is no strain applied directly onto the wooden keel box from the keel.

On each side of the keel there is a pressure plate, and the three keel bolts pass through each of these plates, into the tubes in the support structure. A nut fits on the end of each bolt – and these nuts are tightened when the keel is in the desired position to firmly clamp the keel in position. Only one of these bolts passes through the keel – the lowest aft bolt. This is the one that the keel pivots on. The other bolts pass, one above the keel and one in front of the keel. The pressure plates enable the clamping force from all three bolts to hold the keel rigid. So – the keel is unusual in that it does not move when under way but it is held firmly, side to side, and fore and aft –unless you loosen the nuts! It is also unusual in that the forces are not transmitted to the wooden centre board case – but bypass the wooden structure and are applied directly to the main bulkhead.

This photo shows the inside of the keelbox with the keel removed. You can see the two pressure plates which fit each side of the keel – the gap in the middle is where the keel fits. In the middle of the picture you can see the front bolt – which passes in front of the keel itself. You can just make out the top bolt (at the top of the photo) which goes over the keel. You can certainly see the hole where the keel pivot bolt goes through. You can just make out the thin plate which bolts to the keel support structure inside the boat – it is covered in black sikaflex mastic.

The keel is raised and lowered by turning a removable handle which fits into a keel lifting mechanism located on the aft side of the main bulkhead, one either side, of the passage through the bulkhead.

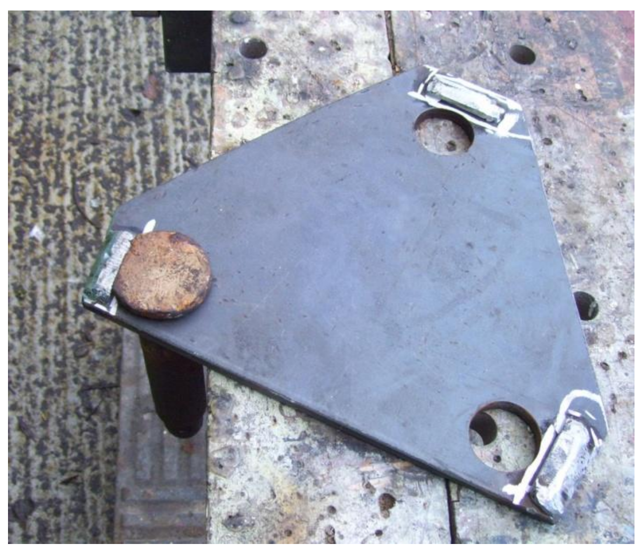
This handle turns a horizontal shaft, and through spur gears rotates a threaded rod which hangs vertically down into the keel box. A nut is threaded onto this shaft and runs up or down the rod as the handle is turned. An inverted “U” shaped stirrup rides on top of this nut, and its lower ends connect to a pin which passes through a lug on the keel itself. The idea is that normally the top of the stirrup sits on top of the nut, but if the keel hits something, and is forced back into the keelbox, then the stirrup rises up away from the nut – allowing the keel to rise without damaging the lifting mechanism. When the obstruction is removed (you have passed over the rock?) then the stirrup drops back down into contact with the nut – probably with a thump. The lifting jack is fixed to the main bulkhead at shoulder height.

This photo shows the keel lifting mechanism on the port keel. You can see the stirrup at the top of the photo, with the nut underneath it. The threaded rod is clearly visible, and you can see that it connects to a lug which sticks up from the keel. Just above the keel is a shiny tube with a bolt passing through it. This tube holds the legs of the stirrup the correct distance apart, and the bolt holds them together so that they do not slip off the pin in the keel.

Incidentally you can also see that the stirrup has been doubled half way down – this is a standard way of repairing a corroded stirrup which will be described later.

Finally a note about the bolts, nuts and the way they work.

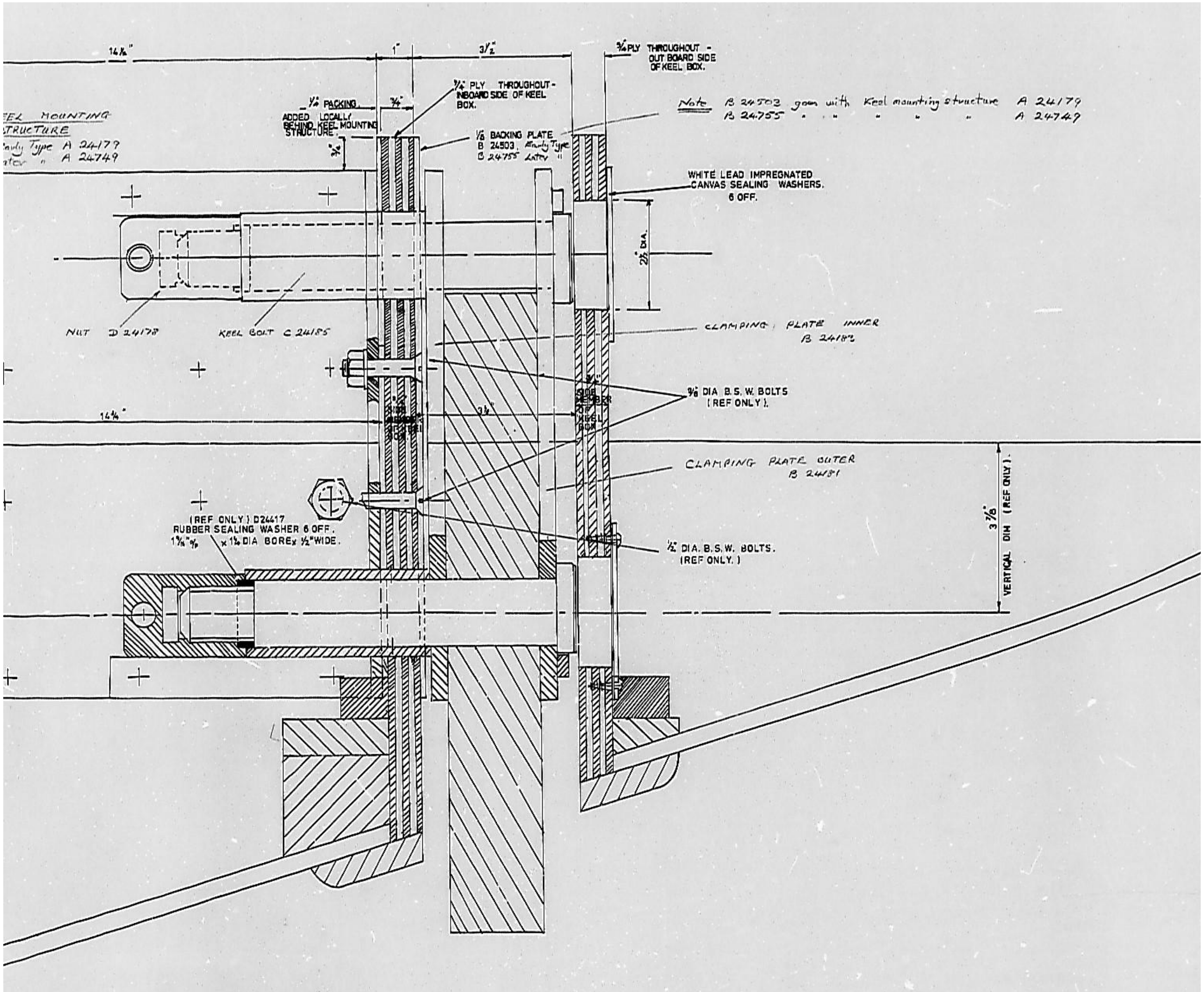
This photo shows a keel bolt and a keel nut. Both are special components. The bolt has a flanged head, with a flat area milled into it. The other end has a Whitworth thread tapped into it, and the special nut fits onto it. The holes in the nut are there to enable a stainless “tommy bar” (slightly bent at each end to clear the support structure) to be inserted and used to turn the nut.



The head of the bolt fits against a doubler welded onto the outer pressure plate as shown here. This doubling piece engages with the flat in the head to prevent the bolt rotating.

One sign of keel problems is when you notice that the nut continues to go round and round without appearing to be more difficult to turn – indicating that the bolt is rotating.

View of the Keel arrangement taken from drawing A24169



Note that this drawing gives the impression that there is plenty of room in there for the various plates to be made thicker – and for everything to still fit in. Be warned there isn't!

Tolerances

This section is about the dimensions of the various components and how much space there is to modify things. It will also provide some actual dimensions that I have measured from my own boat – after the keelboxes have been replaced.

	External width of keelbox	Internal width of keel box	Keel box side width	Thin plate	Tube extension beyond plate	Inner pressure plate	keel	Outer pressure plate	Space left
Nominal as per drawings	5 inches	3 ½ inches	¾ inches x 2 (1 ½ inches or)	1/8 inch	1/8 inch	3/8 inches	2 inches	3/8 + ¼ inches	¼ inches
Metric equivalent	127mm	88.9mm	38.1mm	3.17mm	3.17mm	9.51mm	50.8mm	9.51+6.34mm	6.34mm
Calista's port keel	127.0mm	86.25mm	20.68mm (40.36mm)	3.17mm	3.17mm	8.8mm	55.68mm	9.5mm+5mm	-1.68mm
Calista's starboard keel	127.0mm	87.36mm	19.82mm (39.64mm)	3.17mm	3.17mm	8.8mm	55.7mm	9.5mm+5mm	+2.0mm

Note

The port keel only fits in because the doublers on the outer pressure plate (which prevent the bolt from rotating) protrude into cut-outs which I formed in the outer keel box side with a rasp. This gained 1.7mm and the keel just fitted into the gap between the pressure plates. My measurements indicated that the gap I was fitting the keel up into was 0.00mm! The starboard keel had plenty of space in comparison.

One problem is that the replacement keel box has thicker sides than designed. That may be because the plywood is thicker, the paint is thicker – or it could be thickness of glue. It is most likely that it is caused by a combination of all three! The second problem is that the epoxy paint and *Coppercoat* on the keels has increased the thickness of each keel.

In theory there should be 6.37mm (1/4 inch) clearance inside the keel box. It is very easy to let that clearance disappear, particularly as our boats are now getting old enough to have had their keel boxes replaced (or be in need of them being replaced).

Removal of Keel Bolts, Keel, Pressure Plates, and Stirrup

Removing keel slot seals

1. It is possible to remove the keel with the boat securely chocked about 800mm to 1m above the ground. These boats need to be carefully chocked since the hulls are comparatively lightly built. Most of the weight should be taken on beams across the boat, one just in front of the keel box, and another just behind the keel box. Most of the weight should be on the central keelson, with the hull supported in line with the keel boxes.
2. Originally the water was prevented from sloshing up into the back of the keel box by a wooden filling piece which was lifted before raising the keel. (This was not, and can not, be fitted to Titanias or Fulmars). On boats fitted with rubber sealing strips– rather like those used on dinghies – it is best to remove the seals (this applies to most boats by 2009). These strips are held on by long rounded steel strips fixed in place by wood screws. The ends are held by larger shaped plates. All of the screws need removing and the rubber strip and metalwork needs to be prised free. The following photos show the rubber seals and the long metal strips holding them in place on the left. On the right you can also see the shaped plates which finish off each end:


3. If you just want to gain access to the keel for antifouling you need not remove the keel box covers as described in this stage. If you intend to examine the inside of the keelbox, then it is probably better to remove them as described. Remove the covers on the tops of the keelboxes in the galley (on an Atalanta). In a Titania and in a Fulmar the lid on the keel box is within the main cabin – and that needs to be removed. In the case of a Titania (and Fulmar) that also means removing the wooden covers which hold the clear Perspex windows first, and (in a Titania) the covers at the back of the keelboxes, where the cockpit drains empty into the keel box. Do not try taking off the keel box cover forward of the bulkhead (applies to all variants) as this passes under the bulkhead and builds into the jack boxes. It is really part of the keel box wooden structure which is preassembled before fitting into the boat – so best left alone unless you have to replace the keel box itself. You will have no way of knowing what type of mastic sealant has been used on these lids, but it is likely that you will have to use a Stanley knife to cut along the joint line. This should avoid damage to the lids. However I have found that it can be impossible to avoid destroying the lid while getting it off – so don't be surprised if this happens.

4. Remove the 3 round cover plates which seal the keel bolt access ports on the outer side of the keel box. They are under the bunks on the forward side of the diagonal bulkhead. These covers are held on with 8 wood screws (or self tapping screws). These need to be removed to allow the keel bolts to be removed. There have been a number of alternatives described by owners over the years – so you may have a slightly different set of circular covers.

Removal of keel bolts

Before discussing how to remove the keel itself we need to discuss how to remove or just move the actual keel bolts. Any one or all of the keel bolts may be firmly rusted into place. If you are lucky they will all move freely – and that will indicate that the keels have been maintained properly.

The following instructions explain how to remove any one keel bolt, but please note that if you are trying to remove the main keel pivot bolt (the lowest one) you will need to support the keel (as described in the section on removing the keels) before you actually remove it.

1. Slacken off the keel nuts about 12mm, tap the end of the nuts smartly (but carefully) with a lump hammer. It might be better to protect the end of the nut with a piece of wood – but it may be difficult to hit the nut squarely with wood in the way. If the bolts move, carry on tapping and unscrewing the nut until the nut comes off, and then drive out the bolt out using a brass or aluminium drift. The bolts should pass out through the ports in the outer keel box side – which you have revealed by removing the circular covers. The rubber bolt seals will normally come out with the bolts.
2. If the bolts will not move as described above then take off the nuts and dig out the rubber bolt seals. Inject or spray penetrating oil into the tube. Leave for several hours or even days. Replace nuts and try again. If still not free, try gently heating with a gas flame or hot air gun. Try tapping again. Note that I have not had to use this technique, but previous experience of similar situations suggests that this technique would require an oxy- acetylene flame to really have a chance of working. This may well involve specialist outside help. Whenever using heat and flames in or near a boat (it is wooden!) be extremely careful, and please have fire extinguishers and hose pipes to hand.
3. An alternative, which may be safer, is to use a screw jack or hydraulic jack on its side. Unscrew two opposing nuts about 12mm. Place a car jack between these opposing nuts and apply load. One bolt should give way - carry on jacking and unscrewing the nut as necessary. Finally, completely remove the bolt by pushing or driving it out with a drift against the end of the bolt. The opposite bolt can then be tackled by setting the jack against the keel bolt hole which has just been emptied. This procedure should be carried out carefully, because even though the two keel mounting structures are bolted together there is a risk of damaging or distorting the keel mounting structure / bulkhead.

The technique above can be used for shifting bolts and releasing pressure plates if keels become jammed, without actually removing cover plates or bolts.

Note that it is possible that the bolts will be so badly corroded that it is not possible to remove them from the tubes. At least one owner has had to dismantle the keel box, and cut through the bolts and tubes, to remove the keel bolts. This involved replacing all of the keel support structure as well as the keelbox itself.

It may be better if you really can't get the keel bolts to move to remove the wooden cover from the top of the keelbox forward of the main bulkhead. Note that this fits under the main bulkhead so this will probably mean destroying it. This will give access for you to get a hack saw blade into the gap between the keel and the keelbox and to cut through the offending keel bolts. It will be a long laborious job, probably easier with a power saw that takes hack saw blades. With the bolts cut the keel will then be lowerable, and the keel support structure can be removed, so that the remnants of the bolts can be removed using heat and hammer on the bench. This might save the damage to the actual keel box sides – which are not easy to replace.

Removal of a Keel

To remove a keel :

1. Lower the keel using the normal keel lifting mechanism until the back of the keel is touching the ground.
2. Now move the lifting handle slightly back and for to try to work out the point at which the keel jack is just taking the weight of the front of the keel. Try moving the bottom keel bolt to see if it is free to move. When the weight is on the jack the bottom bolt should have little force on it and it should be free to gently drift out. If the bolt is badly worn (and you will not know until it is out) then you may have to lift the keel jack to enable the bolt to be removed.
3. The keel can now be lowered using the keel jack until the stop at the end of the threaded rod is reached. At this point it may be necessary to remove the stop which prevents the nut from dropping off the end of the thread – to gain an extra 30mm of travel. This stop is held on by a pin which passes through the stop and the threaded rod. You may well find that there are a number of holes in this – left over from previous dismantling. I have had to drill out the pins to remove them. This may be a suitable position from which to repaint the keel – particularly if you just want to antifoul it.
4. There are a number of ways of supporting the keel, at this point. Some owners use a wooden beam with uprights fixed to it to hold the keel upright. I allow my keel to turn onto its side under control . I place a wooden batten on top of the sides of the keelbox near the front of the keel, and then pass a ratchet strap around the keel, inside the keelbox, and over the piece of wood. These are two of the straps used to hold the boat onto the trailer when on the road. They are rated at 3 tons. I use them to support the keel, and to form a reserve to catch it if it slips – rather than to lift it. By ratcheting up the strap, take the weight off the keel jack. Now remove the stirrup from the keel lifting pin and withdraw it into the keelbox by rotating the handle. Now I pass a piece of thin nylon webbing or cord around the keel lifting pin, up over the bolt which holds the sides of the stirrup together, repeating this to form a lashing. Raising the keel jack takes the strain onto the lashing, allowing the ratchet strap to be slackened, and then the keel is lowered further and further until it is on its side. I repeatedly stop to slacken the ratchet strap,

as it is lowered. I use an engine stand (intended for use in rebuilding a car engine) as a wheeled stand on which to manoeuvre the lowered keel. Take care when handling the keel as it weighs 450lbs or 250kg – in other words about a ¼ ton.

Safety Note Never lie under an unsupported keel – or place hands or legs near it when it is being lowered or raised. Never place a finger into an empty bolt hole when the keel is being removed or refitted.

Removal of Pressure Plates

1. Place carpet or something resilient under the front of the keelbox.
2. Remove the remaining two keel bolts completely. The pressure plates will fall onto the floor (or carpet) under the boat.

Removal of thin reinforcing plate

The thin reinforcing plate is straight forward to remove once the keel has been removed.

1. There are 8 nuts on the face of the support structure around the three tubes inside the cabin – aft of the main bulkhead. Remove all of these nuts. It may be necessary to use a nut splitter if the nuts are badly corroded. This is particularly likely in the case of the one nut which is most inaccessible!
2. Knock all of the bolts out into the keel box using an old bolt as a drift.
3. Use an old chisel as a scrapper to scrape between the thin plate (or what is left of it) and the wooden keel box side.

Removal of keel support structure

You may need to remove the keel mounting structure from the boat, depending on its condition. As long as the bolts fit into the tubes easily, and there is no sign of water leaking into the boat from behind the mounting structure and any rusting can be cleaned up and painted where it is then I would leave it in position. However if it seems rusty, or the keel mountings were leaking when last in the water – then it may be better to remove it and have it re-galvanised before refitting it.

It may be possible to remove it using a crow bar under one of the edges along the centre of the main bulkhead, taking the force on the other mounting structure, but if it is well bedded into position you may have to resolve to more sophisticated methods.

Previous owners have used a special tool for pulling the keel mounting structures off the sides of the plate cases. The tool consists of an 8 inch rigging screw attached to metal rods and a metal disc at each end. In use the discs fit over the ends of two opposing tubes inside the keelboxes, tightening the rigging screw should pull one of the mounting structures free. It may need to be moved and used in each pair of tubes in turn.

Tackle one keel mounting structure at a time using the other as the anchor for the draw-off tools.

1. Remove 12 nuts on the bolts which secure the structure to the keel box.

2. Punch the bolts out into the plate case. Lever off the backing plate gently from inside the keelbox. It may be stuck fairly fast with white lead – or it might have rusted away!
3. Undo and remove the nuts and bolts from the first mounting structure to be removed from the bulkhead.
4. Fit the draw-off tool and slowly tighten the bottle screw with the tommy bar. Drawing too quickly or unevenly can damage the edges of the holes in the keel box.
5. When the first mounting unit is freed away, remove it and clean off the mating faces and holes in the plate case. Replace the structure dry and bolt it back firmly onto the bulkhead only. It is used as the anchor for drawing off the second mounting structure.
6. Repeat operations and, when complete, unbolt the first unit again and remove both from boat.

Note that it is possible that the keel box itself could be in poor condition and might not take the strain of this procedure described above without damage.

Removal of the keel Jack

A nut and bolt hold the two legs of the stirrup together so that they do not splay apart and come off the pin on the keel. Remove the nut and bolt, splay the legs out. Remove the stirrup from the pin in the keel. The wooden cover plate which hinges up to reveal the gears should be propped open, and the four nuts and bolts securing the lifting gear to the bulkhead removed. There is a ply plate which covers the inboard side of the gears – and this may need removing by unscrewing 4 screws. The keel jack and stirrup should now be free to be completely removed for servicing.

Removal of the Stirrup

When the keel jack assembly is free from the boat it is easy to remove the stirrup from the threaded shaft. At the bottom of the threaded shaft there is a stainless collar (with an internal thread) which is screwed onto the shaft. A pin passes through the collar and shaft to prevent it coming undone in service. You may be able to drift this pin out. I have however found it necessary to drill the pin out. The collar can then be unscrewed and removed from the shaft. This allows the bronze nut which travels up and down the shaft (to raise and lower the keel) to be completely unscrewed until it is clear of the shaft. The stirrup can now be slid down the shaft and completely removed.

Removal and replacement of the keel box

The wooden keel boxes on our boats are now approaching 40 or 50 years of age – and as they are difficult to maintain properly are likely to need replacing on some of our boats.

This is a major task which has been completed professionally on my own boat, and carried out by at least two members on their own boats. Note that both of these members have considerable boat building skills – and one is a professional boat builder.

The following is based on Murray Reed's experience, and his photographs:

The plywood is cut and chiselled away piece by piece, one side at a time until both sides are totally removed. You can see the blocks which form the front of the keel box in this picture. Ensure that they are in good condition.

Here you can see that the keel box has been partly removed. That part nearest the hull is clean and ready for its replacement, but the top area has yet to be removed.

New keel box sides were prepared from 18mm thick plywood, in two pieces, with a scarf joint vertically down each side. Note that once the boat has been built it is not possible to fit a keelbox without removing lots of internal woodwork – including bulkheads – unless you put it in as two pieces as Murray has.


On the left you can see Murray inserting the first section of a new keelbox side. On the right you can see that half keelbox side, with a scarf joint prepared for jointing when in the boat

The keel box sides in my boat were replaced as one piece – but that involved removing half of the bulkhead between the cockpit and main cabin.


These photos show the new keelbox being assembled , and finished.

Checking components for condition

Keel

The keels seem to have survived the passage of time well. There is only one recorded case of a keel breaking, and needing replacement. There is also at least one case of the lug which holds the lifting stirrup failing. Apart from that they seem to have been manufactured from a grade of cast iron which has resisted corrosion well. You should just need to remove the surface rust and repaint them.

Thin plate

In almost all cases where you are likely to have to replace this.

Pressure plates

In most cases the pressure plates seem to be reusable. However the signs to look out for are that the holes are so oversize that they allow the bolt heads to rotate, and/or that the doubling lugs which catch the flat on the bolt head are worn and allow the bolts to rotate. If the plates are less than 6 mm thick after the rust has been removed then it would be worth replacing them as a matter of course.

Keel bolts

If there is evidence of much wear or corrosion then new keel bolts will be needed. It is possible to repair the thread on a worn keel bolt using the die nut which can be hired from the Hon. Sec. (for a small fee plus carriage). Please note that this die nut is only of use for repairing existing threads – it is not suitable for (or capable of) cutting a thread in new material. Cutting the thread in a new keel bolt requires either a lathe, or a proper adjustable die and die holder (neither of which the association has). The following photo of an old bolt and a replacement make an interesting comparison:

Nuts

In most cases the nuts seem to be in good condition – so you are unlikely to have to replace these. However they may need to be re-galvanised. This will then need to be followed by drilling out the holes for the tommy bars (or the tommy bar will not fit into all of the holes), and re-tapping the thread inside the nut. The association has a tap which is available for this purpose. The tap can be hired from the Hon. Sec. of the AOA (for a small fee plus carriage).

Repair and replacement of worn and damaged parts

In this section we need to look into corrosion of steel underwater, and suitable materials from which to make replacement parts. We need to look into mastics and protecting against rot and corrosion. We will also look into some modifications and their pros and cons.

The nature of corrosion in steel and stainless steel

The following is taken from the online encyclopedia "Wikipedia":

"Iron ore, like most metals, can be usually found in the Earth's crust only in combination with oxygen or sulfur.[2] Typical iron-containing minerals include Fe_2O_3—the form of iron oxide found as the mineral hematite, and FeS_2—pyrite (fool's gold).[3] Iron is extracted from ore by removing oxygen and combining the ore with a preferred chemical partner such as carbon. This process, known as smelting, was first applied to metals with lower melting points, such as tin, which melts at approximately 250 °C (482 °F) and copper, which melts at approximately 1,000 °C (1,830 °F). In comparison, cast iron melts at approximately 1,370 °C (2,500 °F)."

The chemical formula for iron ore "Fe_2O_3" shows that in its natural state (which is stable) Iron (Fe) is combined with oxygen (O). When smelted the oxygen is removed from the iron – and the resulting material is basically unstable. It is likely to revert to its stable state when it is able – such as when exposed to oxygen in either air or water. This is why, steels corrode or rust, they are reverting to their stable state.

Low Carbon Steel (mild steel)

Again from wikipedia:

"Modern steels are made with varying combinations of alloy metals to fulfill many purposes.[5] Carbon steel, composed simply of iron and carbon, accounts for 90% of steel production.[1] High strength low alloy steel has small additions (usually < 2% by weight) of other elements, typically 1.5% manganese, to provide additional strength for a modest price increase.[55] Low alloy steel is alloyed with other elements, usually molybdenum, manganese, chromium, or nickel, in amounts of up to 10% by weight to improve the hardenability of thick sections.[1] Stainless steels and surgical stainless steels contain a minimum of 11% chromium, often combined with nickel, to resist corrosion (rust). Some stainless steels are magnetic, while others are nonmagnetic."[56]

Most components used on the Atalanta keel system are made from some form of steel (bolts and plates) or iron (the keels themselves). These will all corrode if not protected.

Stainless steelsAgain from Wikipedia:

*"In metallurgy, **stainless steel**, also known as **inox steel** or **inox**, is defined as a steel alloy with a minimum of 11% chromium content by mass.[1] Stainless steel does not stain, corrode, or rust as easily as ordinary steel (it stains less, but it is not stain-proof).[2] It is also called **corrosion-resistant steel** or **CRES** when the alloy type and grade are not detailed, particularly in the aviation industry. There are different grades and surface finishes of stainless steel to suit the environment to which the material will be subjected in its lifetime. Common uses of stainless steel are cutlery and watch cases and bands.*

Stainless steel differs from carbon steel by the amount of chromium present. Carbon steel rusts when exposed to air and moisture. This iron oxide film (the rust) is active and accelerates corrosion by forming more iron oxide. Stainless steels have sufficient amounts of chromium present so that a passive film of chromium oxide forms which prevents further surface corrosion and blocks corrosion from spreading into the metal's internal structure.

- *Type 304—the most common grade; the classic 18/8 stainless steel. Also referred to as "A2" in accordance with ISO 3506.[13]*
- *Type 316—the second most common grade (after 304); for food and surgical stainless steel uses; alloy addition of molybdenum prevents specific forms of corrosion. It is also known as marine grade stainless steel due to its increased resistance to chloride corrosion compared to type 304. 316 is often used for building nuclear reprocessing plants.[13]*
- *Type 316L—extra low carbon grade of 316, generally used in stainless steel watches and marine applications due to its high resistance to corrosion. Also referred to as "A4" in accordance with ISO 3506."*

So to summarise:

The most common grade of stainless steel is known as "A2 grade" and also as "grade 304" stainless steel. It typically contains 18% chromium, and 10% nickel. It is commonly available in chandlers in the form of nuts and bolts etc. It does not corrode when exposed to air because it forms a non corroding surface layer – which prevents further corrosion. It is not suitable for use under water on a boat since it is subject to rapid "crevice corrosion". This occurs in areas where there is no oxygen present so that the protective layer cannot form – and therefore corrosion can take place. It is likely to happen below the head of a bolt - which is under water– so the head eventually falls off.

Less common is the "A4" grade which is also known as grade "316L". This is often referred to as marine stainless steel. It is available in some chandlers, but more readily from fastening suppliers. It is more expensive, but has better corrosion resistance. This grade typically has 18% chromium, 10% nickel and 3% molybdenum. It also has extra low carbon content.

The accepted wisdom within the marine design and survey professions is that no stainless steel grade is suitable for use underwater in a boat in a salt water environment. However, certain organisations do use it underwater in various ways. In fact it is now in universal use for propeller shafts. Some of us owners are using it for various keel structure components, and fastenings.

There are many grades of steel, bronze, and stainless steel – and there are certainly special grades which will be very suitable for these components. It is up to you if you decide to use stainless steel for keel bolts and the like. However as a representative of the association I have to recommend that you stick to the original specifications for the materials specified for the components. As mentioned elsewhere in this document – it works as designed – so be careful if you change things – it might not work!

I have already mentioned how steels are in an unstable state and tend to revert to the stable state, by rusting. This rusting process is also caused (or increased) by the action of electrical currents. Any two different metals in salt water will form a battery. The salt water is the electrolyte, and the metals the two poles one positive and one negative. If the metals are aluminium and brass – then the current will be large – because there is a big voltage in this particular battery – and the corrosion spectacular. The aluminium will be damaged quickly. To protect steel components underwater it is common practice to fit protective anodes. These ate electrically connected to the steel they are to protect. The anode forms one of the poles of the battery, the steel the other. The material of the anode is chosen so that it corrodes (like the aluminium) and protects the steel (like the brass).

Hot dip Galvanising and zinc spraying

Galvanising is a process where a thin film of an anode material (zinc) is bonded to the surface of the steel component. The process involves cleaning all of the surface contamination and corrosion products off the surface of the steel, and then immersing it into a bath of molten zinc. It is a dangerous and expensive process, because the component has to be heated to at least the temperature of molten zinc, but it provides a thick coat of zinc which is bonded well into the surface of the steel it protects. It does not last for ever – but it does protect the steel.

Zinc spraying is a cheaper alternative where “blobs” of hot zinc are blasted through a flame onto the surface of the metal, where they flatten and bond (to some extent) to the surface of the previously cleaned steel. It is a bit like someone spitting at a sheet of paper! So the surface is not uniform and even – but consists of tiny flattened blobs with miniature gaps between them. It provides good protection – but not as good as hot dip galvanising. It is used on large items such as keels which might crack if they were heated up for galvanising. No galvaniser will galvanise a keel – they will not want to risk it cracking while they are doing it – and you don’t want a cracked keel in your boat. Specialist contractors will zinc spray (or flame spray) keels. You will have to find a suitable contractor through the yellow pages, and you may have difficulty finding one – and that might make it prohibitively expensive.

Earlier editions of this paper mentioned aluminium spraying as a method of protection. Forget that as a method – you will not be able to find anyone to do it, the popularity of that technique seems to have been short-lived. Aluminium is used by the way to protect car exhausts, so it isn’t the technique which is the problem, it is a lack of availability for the sort of small non production job which we are interested in.

Epoxy Paint

Epoxy paints have revolutionised protective coatings for use in a marine environment. They allow thick protective coatings to be applied quickly and efficiently. They provide a tough and oxygen tight coating which adheres well to many substrates. They provide excellent coatings for keels, as well as the inside of keelboxes. However they are expensive.

Antifouling materials

The effectiveness of modern antifouling paint seems to have reduced over the years as all of the nasty chemicals (which provided the anti-fouling properties) have been removed. It has always been necessary to keep copper based anti-fouling paint away from the alloy rudder assembly. Atalanta rudders have always had to be painted with the sort of antifouling which was designed for use on power boat stern drives (which are also made from aluminium alloy). However my experience of these antifoulings has been that they are little better than gloss paint at preventing fouling on the rudder blade!

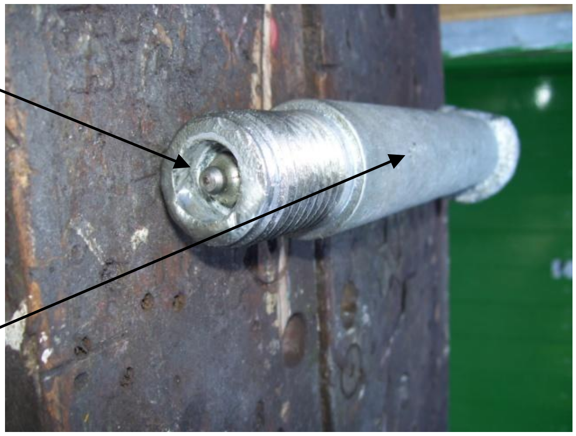
A number of owners (including me) use “Coppercoat”, or one of the competing brands of copper rich epoxy based multi season anti-fouling paints. I recommend this form of antifouling. It is not cheaper – it costs 10 years worth of antifouling, but it does reduce the labour of applying antifouling every year. I find its performance **at least** as good as antifouling paint. It can safely be used on and near Atalanta rudders.

Grease nipples

Grease nipples to lubricate the keel bolts must be one of the most successful modifications that owners have added. Even a neglected and abandoned Atalanta which had been fitted with grease nipples for the keelbolts had a keel system in remarkably good shape. Being able to grease the keelbolts during the season does ensure that difficult to remove keel bolts are a thing of the past.

There are two ways of fitting grease nipples into the keel structure.

The first and simplest involves drilling down through the side of the tubes where the keel bolts pass into the boat. The grease nipple is in the centre of the adjacent photo. These holes are tapped, and grease nipples fitted into the threaded holes. Grease nipples often have tapered threads to a special tap is required, and care to ensure that the nipple is tight in the thread while its inner end does not intrude into the way of the bolt. It has the advantage that it is straight forward to do, but the disadvantage that the tube is comparatively thin and there is little room for error.



The second way is to fit the nipple into the end of the keel bolt, so that it is flush with the end of the bolt, and feeds grease down a hole drilled along the centre of the bolt, and out through a cross drilling to the surface inside the tube.

You can see in this photo that the grease nipple is visible in the end of the bolt and a slight black mark half way along the side of the bolt where a 1.5mm diameter hole emerges.

The advantage of this is that there is more material to secure the nipple into, and that for the main keel bolts the central drilling can be extended into the bolt and a second cross drilling made within the area where the keel itself fits. This therefore lubricates the keel moving on the bolt. As long as the holes are small the loss of strength will be small. The bolts seem to survive even when well worn – and significant strength has therefore been lost, so I am not concerned about the loss of strength in drilling these holes. This is my preferred solution, and has been in use on Calista for 4 seasons so far. One disadvantage has been that when greasing the bolts the nuts had to be removed for the grease gun to be inserted – which tended to push the rubber seals out, and limit the amount of grease inserted. The latest modification has been to drill down through the end of the nuts so that the grease gun can be attached while the nuts are tight.

Non standard reinforcing plates, and thicker pressure plates

Various people have suggested modifications to the pressure plates, such as making them thinner so that a plastic shim can be added to take the wear. The lack of space has already been discussed – so be careful if you intend to alter the materials or the thicknesses of the plates. I have tried to fit thicker pressure plates – thicker because metrification has altered the standard thicknesses of steel plate available. It caused major problems – and I would have been better off making another set of reinforcing plates rather than reducing the thickness of the plates I had just made.

Reassembling the keels into the boat

Refitting the keel mounting structure

Before assembling the components inside the boat make sure that the support frames and the thin reinforcing plates go together properly. The three large holes in the thin plate should pass over the three tubes protruding from the keel mounting structure. Then working from inside the boat fit one keel mounting structure at a time. Coat the outer surfaces, which will mate with the keel box side and the bulkhead with mastic before fitting. Sikaflex is a suitable modern mastic. Make sure that the area around each tube is particularly well coated with mastic. Offer the frame up and pass bolts through the various bolt holes from inside and aft, so that the nuts are fitted from inside the keelbox, and from the forward cabin. However do not fit the inner row of bolts – these are longer and are used to fix the frameworks to each other with a doubling plate. Fit the nuts onto the bolts in the main bulkhead. Cover the inside of the thin plate with mastic. Fit the thin pressure plate onto the three tubes and over the bolts. Fit the remaining nuts. Loosely tighten the nuts and bolts until the mastic extrudes from under the thin pressure plate.

Repeat the above on the second framework.

Fit the joining plate with the longer bolts which pass through the joining plate and the inner holes in each framework. Again fit the nuts, but leave tightening them until after the mastic has set.

When the mastic is properly cured (it takes about a week) tighten all of the nuts and bolts.

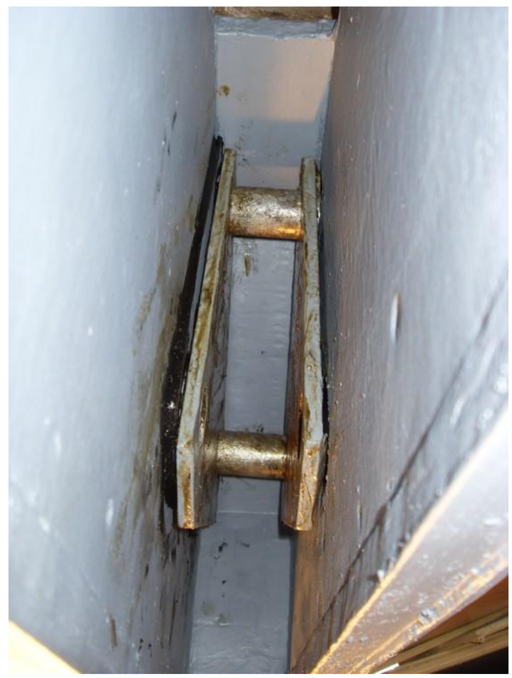
Refitting the keel jack

The keel jack is fitted onto the main bulkhead by passing 4 bolts through the bulkhead from forward to aft, and then lifting the assembled jack and stirrup onto the bolts. Nuts are then fitted and tightened. The stirrup can be pre-assembled onto the jack before fitting into the boat, or it can be fitted when in the boat. The stirrup is fed over the threaded rod, and the bronze keel nut fitted under the stirrup, and onto the thread by turning the lifting handle. A collar is fitted below the nut and secured with a pin. I have secured mine by tapping the hole through the threaded rod and fitting a piece of studding (M 4). One end of the studding has a screw driver slot in it made by sawing across the end of the rod with a hack saw (use 2 blades in the saw side by side to make a wider cut.

Fitting the Keels

Assuming that you have the boat chocked up – as you would have if you had removed the keels – and that the keel mounting structure is still in place, as a starting point:

Firstly fit the keel up stops into the back of the keel boxes..



Then offer up the two pressure plates and get an assistant to pass the upper and forward keel bolts through the circular cut-outs forward of the main bulkhead, and fit the nuts loosely onto these bolts. I coat both sides of the pressure plates liberally with grease before fitting them, but be careful not to drop them – you will have your head in the way if they slip out of your hands. Now press each plate outwards so that the gap for the keel to fit into is as big as it can be. The last bolt which the keel pivots on has to be left out at this stage.

Now start to lift the keel in. I slide the keel under the boat on the base of an engine stand, on its side. I use two of the straps which I use to tie the boat down onto the trailer, each passing around the keel, and up into the keel slot and over a block of wood inside the boat. The ratchet itself is inside on the block.

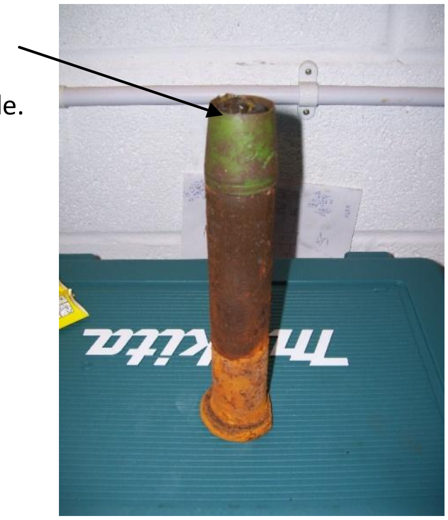
The black webbing is a lashing attaching the pivot pin in the keel to the bottom of the stirrup. This allows me to use the boats own keel lifting mechanism to lift the front of the keel and in doing so to spin the keel upright.

The ratchet straps are tightened as well – and they are really there just in case something slips – they will make sure it can't fall very far.

The keel is now upright and level. The weight is on the straps, and the lashing connecting the lifting pin to the stirrup has been undone ready to fit the stirrup onto the pin. I have found it easier to fit these while the keel is just outside the boat. Note that the stirrup can be removed from the keel while the keel is in the boat in its raised position. It is easy to fit the stirrup the wrong way around – in that the bolt which holds the two sides together (and stops them splaying and falling off the pin) is easily fitted from the outboard side but not from the other, inner side.

When the keel is high enough I use a jack under the back end and the keel lifting gear to raise it into the slot. When it is in position I check that the holes are lining up by passing a pencil into the keel bolt hole. Don't be tempted to use your finger – if anything slips you will lose it!

I have a special bush which fits over the end of the main keel bolt to cover the thread, and to act as a taper on the end of the bolt. This aligns the keel as it is pushed (gently hammered) into the hole.



The last keel nut can then be fitted and the whole system left clamped in the raised position.

Refitting the circular covers

It is possible to fit the circular covers onto foam rubber gaskets, but I feel more secure when I have bonded them on with sikaflex, as well as using screws to hold them in place. Each plate is held on with 8 wood screws or self tapping screws. Refit the cabin furniture.

Refitting the sealing strips

Firstly the metal strips were held up under the boat in their final position and holes for screws drilled into the keel cappings. The rubber strips were placed on the bench and the metal strip were laid on top with the edge of the rubber lined up with the edge of the strip, and the rubber overhanging each end equally. Holes were then drilled through the rubber via those already in the capping strips. Two screws were fitted to temporarily hold the rubber to the capping strip. Mastic was applied to the rubber where it was to be fixed to the wood. The rubber and capping were held in place (assistance needed) while the first screws were inserted. The second strip was fitted in the same way, and then the ends of the rubber were trimmed to fit under the end caps. The end caps were then fitted, holding each one carefully in position while holes were drilled and screws inserted.

Refitting the keel box covers

The internal covers inside the boat which close the top of the keelbox, and the covers on the ends – like those which contain the window to see the keel stirrup need to be fitted carefully. They must seal well or water will enter when sailing.

The keel box top was coated in Sikaflex and then the cover fitted into place. All of the screws were fitted, but not tightened down.

The cover, at the front and at the rear were fitted in the same way. Note that these photos show a Titania, so they are slightly different from an Atalanta.

Notes:

Fairey Marine sealed the keel mounting structures to the inner faces of the keel boxes with a thin felt washer, approximately 1/16 inch thick, impregnated with white lead on the side facing the keel mounting structure. White lead was also used to seal around the keel bolt tubes as well as the interface between the backing plate and the keel box. In addition, a chord of caulking cotton about 1/8 inch diameter and impregnated with white lead, was placed around and behind the rim of the backing plate, seemingly to act as a spacer to help contain the white lead behind the plate. Caulking cotton was also wound round the countersunk heads of the 5/8 inch BSW bolts used to clamp the backing plate to the keel mounting structure. Again, more white lead was plastered round these bolts to provide a seal where they passed through the keel box. White lead eventually sets hard and the mounting structure becomes stuck to the felt. As the felt does not have white lead between it and the keel box, the seal can supposedly be parted at this interface, however, experience has shown that this seal cannot be broken so easily. The section covering removal of the keel mounting structure shows one way to cope with this problem. Even though the seal may prove difficult to part it can, nevertheless, slowly break down in service by working, and thus allow seepage of sea-water in behind the metal parts where extensive rusting will eventually occur and possibly serious leakage develop.

You should find that by 2009 most boats will have had their keel structures refurbished at least once – so the above notes on the original method of fitting the structure may no longer apply to your particular boat.

You should use a modern marine sealant suitable for underwater use. “Sikaflex” is one such sealant which I use around the keelboxes. It is very good, but difficult to get off your hands - so gloves are a good idea.

Fairey Marine initially protected the mild steel parts by galvanising but latterly they adopted a metal sprayed Zinc scheme for this purpose. New or refurbished components should be galvanised. Zinc spraying is usually confined to use on the keel itself. Galvanisers will not re-galvanise the cast iron keels because of the risk of them cracking.

It is also worth recording that in the early boats the sides of the keel boxes were made of solid timber, but this was found to be subject to cracking and was superseded by 3/4 inch marine ply. Up to at least A12 they used solid timber.