Assembly instructions for the remote-controlled model submarine

--- SubMarine ---

You need a translation because you don't speak German?

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On the right side please choose your own language and click the blue button inside the right field.

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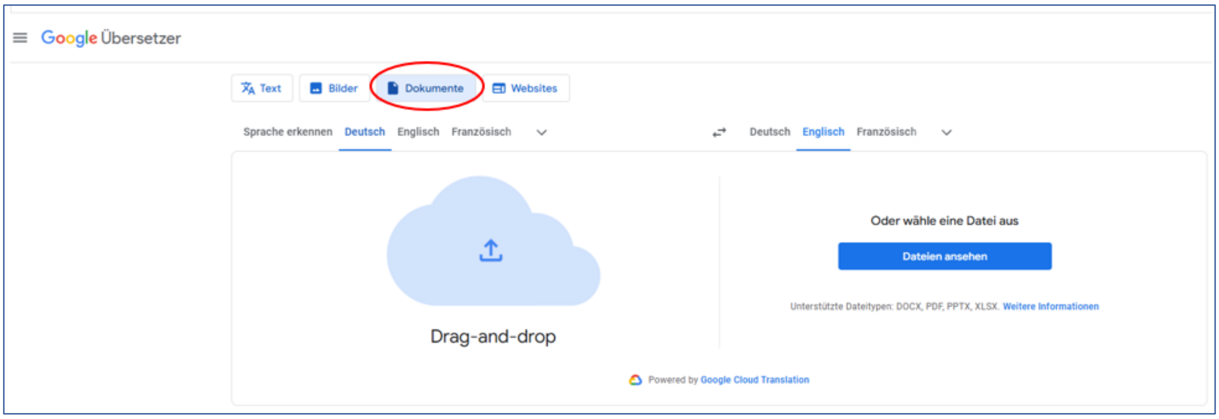

The original language of the following text is in German. The whole translation into English was made with GOOGLE translate (https://translate.google.com) and …. it was not checked. Hence, be a little careful with the information.

<u>Some general tips and advice followed by building instructions. Please read at least the first two and a half pages before you start building! This can save you a lot of time.</u>

The STL and STEP files primarily serve to provide a better understanding of the parts, making them easier to manufacture. They can only be used directly for milling or 3D printing if the construction drawings do not require any custom dimensions. If no CAD program is available to view them, a free online CAD viewer can be used.

The quality of the 10 mm plywood used plays a crucial role in the boat's eventual strength. The prototype was built from poplar plywood. This wood is relatively soft and not very rigid. Therefore, I recommend using high-quality birch plywood (e.g., from model aircraft construction) or beech plywood.

The bonding of the wooden panels of the pressure vessel also influences its eventual strength and should therefore only be done with a long-curing two-component epoxy resin adhesive (e.g., UHU Plus Endfest 300). A long curing time is important to allow sufficient time for alignment and because these adhesives produce the strongest bonds. A small bead of adhesive in the inner corner of the joint is desirable where possible. Wood glue is only an alternative if the panels were machine-cut—meaning they have perfectly right-angled and straight cuts—and are pressed together for bonding.

Later tests in a hyperbaric chamber showed that the prototype, despite the use of poplar plywood, wood glue, and angled cuts (fret saw), could withstand an overpressure of 300 mbar, corresponding to a diving depth of 3 m. Higher pressures were not tested. Private pools rarely exceed 1.5 m in depth, public swimming pools about 2 m – only the diving area can be deeper. The city park lakes I'm familiar with are hardly deeper than 1–2 m, and here one usually stays near the shore and at depths where the boat is still visible. A diving depth of 3 m is therefore sufficient for most situations. Just a little more and radio communication can become problematic (the SubMarine has a shortened antenna!). Incidentally, the hyperbaric tests showed that the diving servo used in the prototype is only powerful enough to extend the diving pistons down to a depth of 1.3 m. Anyone wanting to dive deeper will need a more powerful servo; otherwise, resurfacing, at least statically, will be impossible.

- Always thoroughly remove dust from the wooden panels before gluing or any surface sanding. Brush them with a clean brush and, if necessary, blow them off with compressed air from a can. Always apply the adhesive to both sides and spread it evenly and in a sufficient layer thickness on the surfaces to be bonded.

To protect the wood from water, it needs to be varnished. Beforehand, however, sharp edges should be rounded off, panel joints smoothed, and the entire exterior surface sanded until a uniform finish is achieved. Any filling or sanding should be postponed. After thorough dusting, I would recommend marine varnish to protect the boat from water damage. For the subsequent coats, it's best to follow the manufacturer's instructions and use systems that specify a step-by-step process (e.g., primer with high dilution, intermediate coat with medium dilution, and topcoat undiluted). This creates a kind of impregnation of the wood surface. Careful intermediate sanding with 320-grit sandpaper is crucial to remove protruding wood fibers and create a well-adhering base for the subsequent coats.

After the intermediate coat of paint, you can use wood filler to repair imperfections. For larger repairs, a white wood filler can be used. For finer repairs, there are white nitrocellulose or alkyd resin fillers available, which are applied with a painter's spatula or Japanese spatula. Always test the compatibility of all products with each other to avoid unpleasant surprises. Usually, several sanding and filling applications are necessary until the result is satisfactory – however, this also depends heavily on personal preference.

After the filling is complete, the surface should be sanded again with 240-grit sandpaper (manufacturer's instructions naturally take precedence) and the final coat applied. Ideally, this should also be applied a second or even third time after an intermediate sanding. A soft (!) brush or, better yet, a small 50 mm foam roller is suitable for painting (you should have both on hand). Since boat varnish is generally transparent, a colored varnish must be applied as a final step. This can also be sprayed on from a can.

The interior of the boat should also be varnished with the same care to prevent water damage to the wood in case of water ingress.

At each stage of construction, you can consider whether you want to carry out some of the surface treatment at that point, as it might be more difficult later due to confined spaces or interfering attachments (which would make filling, sanding, or working with a foam roller more difficult). The interior of the boat, in particular, is naturally not so easy to paint once it's completely sealed and access is only possible through the end panel. The same applies to the stern section. Painting will still be possible, but anyone who wants to sand between coats will find it quite challenging.

Anyone who, based on these considerations, wishes to surface-treat individual panels or panel assemblies before further assembly should ensure that the areas of the panels to be glued later are left uncovered. This allows the adhesive to bond optimally directly to the wood. From today's perspective, I would only glue the front and both rear side panels to the pressure hull once it has been completely painted. I would only apply the final coat of paint after their assembly. Why? So that if water penetrates the front or rear side panels, it cannot spread into the pressure hull.

As an alternative to wood, polycarbonate (PC), as used for the hatch cover, or rigid PVC could certainly be used for the boat. Acrifix 192 would be a suitable adhesive for PC, for example (read the application instructions!). The advantage: plastic sheets are inherently waterproof and eliminate the tedious painting process with all its intermediate steps. On the SubMarine, after only a few uses, the paintwork on the central section of the pressure hull plates had cracked in many places. This was certainly due in part to my careless workmanship, but also to the choice of unsuitable paints. Therefore, in hindsight, I would use marine varnish next time.

If sheet materials other than those suggested here are to be used, their bondability and flexural strength must be taken into account. The poplar plywood used in the prototype has an average flexural strength of approximately 20 N/mm², and at best 40 N/mm². As already mentioned, this allowed the pressure hull of the SubMarine to withstand 300 mbar of overpressure (corresponding to a water depth of 3 m) in a pressure chamber. This is a very good value. As a precaution, I would consider a flexural strength of 40 N/mm² as the minimum strength for a sheet material.

- To make sawing out the 10 mm and 5 mm boards easier, please see the drawing "01_Saegeschnitte_sparen".

- Construction drawings often specify ABS or PS plastic sheets as the material. ABS is preferable because it is the stronger and more robust material. However, PS can be used if ABS is unavailable.

- Great care must be taken to ensure a tight seal when gluing in all screws and bushings. On the prototype, leaks occurred at two screws and two glued seams that had cracked (white glue was used).

The Bible verses interspersed throughout the drawings speak for themselves. They are taken from various Bible translations, depending on which I found most understandable. If they resonate with you, simply pray about them.

<u>A rough assembly sequence, listing only the most important steps and parts to be assembled</u> :

1) Fabricate **a diving servo mount** .

2) Prepare **the base plate (drawings 1 + 2)** . Use the diving servo mount only for marking; do not glue it in place yet. The 6 mm screws and spacers can be mounted later if you wish to perform a complete or partial surface treatment beforehand (e.g., impregnation, filling, sanding, painting).

3) Fabricate **the rudder servo mount** including the servo.

4) Fabricate **the rear bulkhead** and glue it to the **base plate (drawings 1 and 2)** . The attachment of the add-on parts can also be done after the subsequent surface treatment.

5) Prepare both **side plates (2 drawings)** . The openings for the immersion cells should also be provided at this stage.

Next come the screw holes. For this, you first drill the mounting holes in the handles of the immersion cell housings (see " **Immersion Cells** " – dimension Sa) and then use these as templates for drilling the holes in the side plates and the **immersion cell sealing plates** . Theoretically, you could also stack everything on top of each other and drill it all at once.

Then the side panels can be attached to the base panel. and glued to the stern bulkhead. The diving cells and screws can also be mounted later, after the surfaces have been treated as desired.

6) Fabricate **the elevator servo mount** including the servo.

7) Fabrication of the **bow bulkhead,** including the holes for the **diving plane servo mount** and the linkage guide. It is then glued to the bottom plate and the side plates. **The T-nut** and **sealing washer ,** as well as the **plastic tube** for the linkage guide, can also be glued in place after the boat's surface treatment. The T-nut is then simply pressed into the existing indentations, using a clamp if necessary, but not hammered in, as this could, in the worst case, loosen the glue holding the plywood panels together.

8) Fabricate **the front plate** and glue it to the boat hull. The threaded rod can be left in place until the surface treatment is complete. The **diving plane bearings** will be installed later, along with the **diving plane itself** .

9) Surface treatment of the boat, either completely or at least in the interior and in the area of the diving system, both inside and out. The stern area is still missing here because the closure plate has to be glued in later, and the two stern side panels would be in the way.

The area of the base plate where the orientation lines for gluing the diving servo mount were drawn, and slightly beyond, should not yet be surface-treated to ensure optimal adhesion.

Overall, care should be taken to ensure that areas subjected to relatively high loads and where gluing will later take place are not yet surface-treated. This applies in particular to the areas where the cover plate will be glued, but also to the holes for the screws.
The area of the diving cell sealing plates, however, can be completely finished, as can the rear bulkhead, both inside and out (except for the top edge). For the area where the T-nut is located, the surface treatment will be postponed, or the T-nut will be glued in place before the surface treatment.

10) Now, in principle, the complete **diving system,** including **the diving servo mount** and servo, can be installed. See also all other **diving… drawings** . The diving servo mount must be watertight after being glued to the base plate. A test should be carried out (after subsequent surface treatment) by filling the mount with water.

As indicated in the drawing " **Diving system assembly** ", the screws are guided from bottom to top through the holes of the diving levers, so that the stop nuts are on top, which is more practical for later disassembly/assembly.

Before attaching the **servo horn , the servo drive must be in its neutral position. This can be achieved using the remote control system by manually setting the corresponding encoder (potentiometer) to the neutral position. A simpler method is to connect a servo tester and set it to neutral.**

11) When the boat's interior is complete (diving system is installed, surface treatment has progressed as far as desired, but the electronics are not yet integrated except for the diving servo), then the **closure plate can be** built and finally glued into the boat hull.

The outer surface of the closure plate, especially in the area where the sealing cord will be glued, should be filled and sanded for surface preparation, as thin superglue, which is known to have poor gap-filling properties, will be used here later. Before gluing, the **sealing cord (see drawings Sealing Cord 1 + 2)** , the **rod retainer** (see "Closing Plate"), and the screws must be attached. For the gluing technique, see also "Base Plate 2". The **deck bracket** can also be glued on at this stage; alternatively, you can wait until the deck is finished so that any necessary adjustments can be made more easily.

The drawing " **Closure plate assembly** " is used for mounting the closure plate.

12) Fabricate both **tail side plates . Only glue the spacer** (see "Tail Side Plates 1" and "Rudder Linkage 1 + 2") in place once the **rudder linkage 1 + 2** is mounted. The tail side plates should only be glued to the pressure hull once the **tail bulkhead has been completed** with the desired surface treatment and all attachments (" **pressure gauge,** " etc.; see " **Tail Bulkhead** "), except for the rudder servo mount, which is not needed here.

The plastic tube for the pushrod guide can be glued into the **tail bulkhead , but it doesn't have to be yet; see " Rudder Pushrod 1** ". It might be better to wait a little longer to allow for adjustments if necessary. It's important to use a suitable plastic primer with materials like PE, PP, and PA to ensure this opening is also watertight.

13) Fabricate **engine housings 1, 2, and 3** and **the engine mount** . Once the **stern side plates** are glued to the pressure hull, the engine mounts can also be glued in place. The **engine wiring** should only be routed into the pressure hull at the very end, when the boat is almost finished. This way, the engine can remain completely outside the boat if needed.

14) Fabricate **the rudder bearings** and **the rudder** . The completed rudder is also needed to mount the lower rudder bearing. The rudder is held in place solely by the clamping action of the two rudder bearings. If necessary, a long M2 screw or a threaded rod can be inserted completely through the tube and the bearings. In this case, the bearings must be drilled through.

15) Once the boat's exterior has been completely painted, all previously uninstalled components can be fitted. These include , among other things, the **rudder linkage (1 + 2)** and the **diving plane linkage** , as well as the **engine . Optionally, the diving cell protection screens** can also be manufactured and fitted.

The electronics, including the **servo mounts** for the rudder and elevator and the two servos themselves, should not be installed yet. This should only be done after the leak test.

16) Assembly of the complete upper and **lower deck sections** (see all **deck drawings**) with **turret** and **turret end plate** . Masking work can be saved during painting if the upper deck section with the side rails, the lower deck section, and the turret with the turret end plate are painted separately and then glued together.
The turret opening in the upper deck section must accommodate the turret with a minimal oversize (the thickness of the paint). This must be checked before painting.
Attaching the window to the tower is easier as long as the tower base is still flat and has not been shaped into a tower.
Due to the small volume of the diving system (approx. 45 ml), only a small amount of adhesive – preferably thin superglue – should be used for all bonding operations on the upper deck and the conning tower. Only the trailing edge of the conning tower, particularly in the upper area where the antenna rests when extended vertically, should be reinforced with an additional adhesive, such as a polymer adhesive. Otherwise, the bond seam could tear.

Incidentally, the large cutouts in the upper deck and the conning tower are primarily designed to minimize water accumulation. When surfaced, any puddles that form become a weight that the diving system must overcome. Without the central opening, approximately 3.5 grams of water would collect on the conning tower roof alone.

The openings also have the advantage of allowing a partial view into the boat's interior. For example, the prototype has a LiPo battery monitor installed, which can be read through the hatch cover without removing the deck.

17) Manufacturing of the **hatch cover** including all attachments.

18) Production of the **ballast plate** . The hammerheads and additional ballast will be mounted later.

19) Completely manufacture **the diving plane , insert the diving plane bearings** into the control axis and attach the whole assembly to the front plate – see also " **Diving Plane Assembly** ".

leak tests are carried out initially , by completely submerging the boat in the bathtub. With the exception of the diving servo, which would be quite difficult to remove later, the electronic components are not yet installed to protect them from water ingress. The water temperature should be equal to or slightly higher than the ambient temperature to prevent the boat's interior from cooling down and creating a vacuum that could draw water in.

The sealing **cord** for the hatch cover is coated with glycerin (>95% for the prototype) (or a glycerin-dish soap mixture, see "Sealing Cord 1") using a soft brush, unless a silicone foam cord is used. This is because the pores of the sealing cord material are not completely closed, and it can therefore be somewhat permeable to water. Silicone cord is said to be 100% pore-proof, but we have no personal experience with this.

Initially , attempts were made to use only petroleum jelly, which was readily absorbed into the rubber cord. Since petroleum jelly is a petroleum derivative and could potentially damage an EPDM sealing cord, its use was discontinued fairly quickly. Since then, only a glycerin-dish soap mixture (the "glycerin-dish soap mixture") has been applied before each dive. This mixture is now only applied to the top of the sealing cord; it is no longer necessary on the sides. It's possible that the petroleum jelly provided a long-term seal. The EPDM sealing cord has not been affected by this treatment (petroleum jelly and the glycerin-dish soap mixture) so far. It is possible, therefore, that the glycerin-dish soap mixture alone will not be sufficient, and that petroleum jelly will need to be applied several times around the entire cord.

Inside the boat, the floor is lined with paper tissues, which can sometimes indicate where water has entered. The hatch cover is used to check for leaks. The water detects even the smallest leaks. The task is simple: locate them and seal them.

Water can penetrate behind the diving cell sealing plates, as well as behind the diving cell O-rings. The control linkages for the rudder and diving planes can also leak, as can the plastic tubes and the two sealing washers at their respective bonded connections to the bow and stern bulkheads. The pistons of the diving system can, of course, also leak. The pressure gauge, stern cable entry, ventilation, and antenna are further points to check. The glued seams of the pressure hull can leak, as can all screws that pass through the pressure hull.

If overpressure is created in the boat during leak tests, leaks may be detected even more easily. Furthermore, those without a sufficiently large tank can also perform dry tests by spraying or applying a leak detection spray (e.g., Würth Leak Detector) without corrosion protection, or alternatively a soap bubble solution, to all potential leak points and observing for bubble formation.

To create a defined overpressure in the boat, the pistons are extended manually (to the point where they stop). Then the vent is opened and the hatch cover closed. A syringe filled with 45 ml of air is connected to the vent. This air is then pumped into the pressure hull. The pressure increase can be seen and felt on the pressure gauge. It is practically the same as if the pistons had been retracted. Now all areas that might be leaking can be sprayed with leak detection spray.

If the boat is leaking, this will also be indicated on the pressure gauge. The pressure may drop so quickly that air has to be pumped in repeatedly to locate the leak. However, no additional air should be injected, as this could increase the pressure unacceptably. Instead, the syringe must be removed each time, allowing the pressure in the boat to drop to normal, and then reattached before pumping in the 45 ml of air. Larger volumes of air could, for example, cause the glued seams to tear.

If the boat is watertight, assembly can continue.

21) Mounting of the **elevator and rudder servo mounts** including servos and connection to the **elevator and rudder (1 + 2) linkages** , which are also fully assembled.

22) Installation of the electronics (see **"Electronics Installation Proposal"**). Mount a 40 MHz receiver (alternatively 27 MHz, but not recommended due to insufficient interference immunity; 868 MHz is also possible – however, the author has no experience with this) and speed controller using Velcro. Test-mount the battery using Velcro (store the battery outside the boat in a fireproof location afterwards). The antenna length is shortened to approximately 55 cm. 20 cm of this remains on the receiver, and 35 cm is attached to the hatch cover via a separate contact. The original antenna length of the prototype was approximately 90 cm. However, even with the reduced antenna length, a good radio connection is still ensured.

23) Complete **remaining assembly** except for the ballast plate

24) **Electrical setup** and adjustment of all electronic components. It is important that no servos are blocked or that control surfaces are not engaged/blocked (use servo travel adjustment on the transmitter). The diving servo must not engage at the piston stop (see diagram "Diving Cell Assembly 1"). Furthermore, this function should be assigned to a rotary encoder – also to prevent excessively rapid reciprocating of the pistons, as this could overload the diving servo mount. The servo horn should not rotate more than 2 x 45° – see "Diving System Assembly".
Slightly deviating center positions of the servos can also be corrected via the transmitter (center point adjustment via general trim or e.g. "subtrim" function).
If the propeller is running in the wrong direction, the transmitter channel can be reversed or the motor cables can be swapped. Never reverse/swap the power supply cables on the speed controller!

25) For the subsequent **hovering adjustment,** the boat must be fully equipped, including the battery and the ballast plate, which is attached in the center of the three elongated holes.

The following procedure should be followed not only here, but also on subsequent dives, to prepare the boat for diving:

1. After switching on the transmitter, connect the battery in the boat. You can now check all functions again.
2. Now glycerin or a glycerin rinse mixture can be applied to the top of the sealing cord.
3. Connect the antenna.

4. Open the ventilation to prevent overpressure in the boat when tightening the lid in the next step, as the lid acts like the piston of an air pump when tightened.
5. Close the boat with the hatch cover (tighten the screws crosswise).
6. Extend the piston to its maximum extent.
7. Close the ventilation. The boat will therefore be started at normal ambient pressure.
8. Assemble the deck.

Point 6 is important because later, when the pistons are retracted for diving, a slight overpressure is created in the boat, which is desirable to this degree (in contrast to the pressure increase caused by tightening the lid).

If the ventilation were closed (7.) while the pistons are retracted, a negative pressure would be created in the boat when it surfaces (pistons extend), which would put additional stress on the pressure hull. Furthermore, water could also be drawn into the interior.

Once the deck is installed, the boat is ready for use and can be launched. If our test basin is not deep enough to completely submerge the antenna, it can be bent back 90° before the deck is fitted.

The pistons are now retracted almost completely for the following adjustments - to within a few millimeters.

First, the air bubbles in the boat must be removed. These are located in the outer areas of the diving cells, between the bottom and ballast plates, under the deck, etc. To do this, the boat is tilted sideways and lengthwise several times at an angle of approximately 30° to 45° and moved back and forth to allow the air to escape. This procedure is also necessary before all subsequent dives. This method will not remove all air bubbles, but that is not necessary.

The goal is for the fully equipped boat, with its diving pistons almost completely retracted and any additional weights added, to hover horizontally in the water – neither rising nor sinking. This is never 100% achievable, but we're trying our best.

First, attach the two hammerheads to the ballast plate as shown in the "Ballast Plate" diagram. However, this is not necessarily their final position. Therefore, they should initially be secured only with two 20 x 20 mm dots of double-sided foam adhesive tape each. Later, they can be adhered along their entire length with this tape. If necessary, cleaning fluid or lighter fluid can be used to remove the adhesive. The ballast plate should remain in its neutral position as much as possible throughout the entire adjustment process.

Additional weights (e.g., 5g car wheel weights) are placed on the deck and arranged until the vessel achieves horizontal balance. A slight rise is safer than a slight sink.

To keep the volume of the weights small, the adhesive foam can be removed; however, this was not done on the prototype for practical reasons.

Now these weights need to be attached to the inside or outside of the boat. When attaching them to the ballast plate, just as with the hammerheads, only a small amount of adhesive tape should be used initially, as several adjustments will be necessary before the desired result is achieved. To do this, remove only a portion of the protective film at a time, instead of using the entire adhesive surface.

Another option is to attach the weights vertically to the sides of the hammerheads, rather than to the ballast plate. However, this is just one idea.

Mounting inside the boat is also possible. In this case, the area around the diving servo mount is recommended. This allows for good compensation of adjustments to the boat's heel, especially if it lists to starboard or port. The prototype has 550g of ballast stored there (partly attached to the base plate with Velcro and partly to the side of the diving servo mount). Approximately 290g of this would be eliminated if heavier woods like birch or beech were used instead of poplar plywood. The total ballast in the prototype is approximately 1800g (550g internal ballast + 2 x 500g hammerheads + 250g balancing weights and a plastic plate). In principle, hammerheads up to 2 x 800g could also be used. In an upgrade, 2 x 700g hammerheads were used, with the remainder mounted as balancing weights on the ballast plate. There is no ballast inside the boat. However, this latest configuration has not yet been tested on the lake. It is possible that the handling characteristics may be negatively affected.

If a different panel material is used, e.g., polycarbonate (note: in this case, the cover plate could be left clear for even better visibility, and portholes could easily be created by masking the desired areas during painting), the required ballast weight will likely change. It can be easily calculated: The boat's total displacement is approximately 3260 g. Subtracting this from the current weight, measured on a scale, gives the remaining ballast required, because displacement and weight must be equal for the boat to float.

It's practical to have a certain amount of ballast (e.g., 40 g) that isn't permanently installed but rather placed loosely, for example, in the deck area. Depending on the season or body of water, the buoyancy will vary, which can then be adjusted by removing or adding weight, allowing the boat to be quickly and easily brought back into optimal buoyancy. Any subsequent adjustments to the horizontal position can then be made simply by moving the ballast plate.

If the additional weights are 5g automotive wheel balancing weights, they can be placed, for example, between the hatch cover and the front plate. Each of the two compartments can hold 30g stacked weights (3 layers of 2 x 5g). Weights can also be placed on the locking plate at the other end of the hatch cover. However, a Velcro fastener would be needed for this.

Weights should not be attached anywhere they would protrude into the deck area, specifically the section that should be above water when surfacing (the upper deck with the conning tower). Anything placed in this area requires additional buoyancy chamber volume. Conversely, this would reduce the boat's ability to surface as far.

The hammerheads should always be "doubly secured" so that they don't fall on your feet.

A crucial aspect of this entire operation is ensuring the boat is suspended horizontally (or slowly rising) in the water with the pistons almost fully retracted. If in doubt, it's better to have the boat slightly bow-heavy, as it tends to surface under speed. This basic setting can also be decisive for the optimal effectiveness of the diving plane. It hasn't yet been mentioned that the ballast distribution also influences the boat's maneuverability. The deeper it sits, the more stable it is in the water, but the more sluggishly it reacts to diving plane movements. Therefore, there are also some ways to influence this.

<u>The first deployment</u>

The first test run should take place in the shallow waters of a calm freshwater body. Saltwater is unsuitable due to the insufficient penetration depth of the radio waves. For safety, the boat can be operated while tethered. To achieve this, thread a lengthwise pierced section of sealing line (approximately 8 mm long) onto the first 50 cm of a fishing line (for example, 8 m long) every 4 cm, so that it floats and cannot get caught in the propeller. Braided line inherently has positive buoyancy compared to monofilament line. It can be attached to the rear deck opening.

As previously described, the sequence for starting a diving trip is as follows:

1. Switch on the transmitter and connect the battery. Check all functions. If necessary, perform a range test on land according to the manufacturer's instructions.
2. Apply glycerin or the glycerin rinse mixture to the top of the sealing cord.
3. Connect the antenna.
4. Open the ventilation.
5. Close the hatch.
6. Extend the piston to its maximum extent.
7. Close the ventilation.
8. Assemble the deck.
9. Remove air bubbles.

If the boat is warmer than the surrounding air, it will contract and the internal pressure will drop. This happens very quickly, especially in autumn and winter. Therefore, it's a good idea to check the pressure gauge regularly during use, or even without checking it, to open the vent every 10 minutes, extend the pistons, and then close the vent again. This procedure can be avoided, or at least the check interval extended, by waiting until the boat has reached ambient temperature before using it.

Have fun building and diving with the SubMarine!

Stephan Post

- Reconstruction and operation of the boat are undertaken at your own risk and responsibility. The author assumes no liability whatsoever for incorrect information or for the malfunction of the submarine or any parts thereof.
No liability is assumed for consequential damages arising from construction or operation.
Replicating this model is only recommended for experienced model builders who are familiar with the machines, tools, paints, and adhesives used and can assess the associated hazards. The manufacturers' safety data sheets must be observed.
The instructions provided here and in the drawings are intended only as non-binding aids to assist the model builder with construction suggestions. These instructions do not relieve the model builder of the responsibility to assess their suitability and, if necessary, choose more appropriate methods.
The mention of brand names should not be interpreted as meaning that these are the only products that can be used in a given application. Many other equally suitable products may exist. Only those products used in the prototype or with which the author has prior experience are listed here, in the drawings, and in the parts list.
- The drawings used the two fonts Droid Serif by Steve Matteson and Swansea by Roger White https://web.archive.org/web/20120416090521/https://www.rogersfonts.org.uk/ .