CONSOLIDATED PBY-5A CATALINA
BY IVAN PETTIGREW
CONSTRUCTION NOTES

Before starting construction of the Catalina model, three decisions need to be made regarding options that are offered. The first is regarding the wing, whether to make it in one piece, or with the outer panels removable. The second option is regarding the tip floats; fixed up, fixed down, or retractable. Then the major decision is whether to make the model as a straight flying boat, or as an amphibian with operating retracts. It could very easily be made with detachable fixed undercarriage, but details of that option are not shown on the plans. The wing pylon is normally left attached to the wing. The pylon fastens to the fuselage with two dowels at the front, and two hold down bolts at the rear. When assembling the wing, it is necessary to connect four pairs of wires that run up through the pylon. The wires carrying current to the motor will be the heaviest. To avoid confusion, it is best to use different kinds of plugs on the remaining three pairs of wires. These are aileron servo, tip float retracts and differential power to the motors. A cover over the nose section (which includes the cockpit area) is removable to allow easy access to the batteries. It also gives access to the retractable nose gear.

Making the wing in one piece results in lighter weight and greater strength. But for ease of transportation, the model may be built with the wing in three sections. The prototype was built this way, but the outer panels seem to be seldom removed. Each outer wing panel is secured with a nylon clip screwed into the lower surface of the main spar. The thing that makes the Catalina wing a little more difficult to build with removable panels is the necessary linkage for the retractable wing tip floats. In the prototype, a small trap door is made in the lower panel of the wing where the control rods meet, and access is thus given to the lock screw in the sleeve that joins the control rods. Assemble the wing upside down so that the nylon clips under the wing, and aileron clevises are easily accessible. If using a typical seven seat mini van, it is best to leave the middle and rear seats upright (without headrests,) and slide a six foot long sheet of thin plywood in from the rear, resting on top of the upright seat backrests. Carrying the wing on this sheet means that it can be transported in one piece, and assembly at the flying site is very fast. The wing struts on the model are just for appearance, and the upper ends are fastened to the wing with Velcro. When the wing is removed, the struts can be swiveled backwards along side the fuselage and held in place with a rubber band. If demonstrating the retracts with the wing removed, be sure to swing the struts forward from the stored position before lowering the gear.

Retractable tip floats make for safer operation while taking off and landing in windy conditions. More about this is mentioned later. But the floats could be fixed in the raised position if the model is only going to fly from land, or fixed in the down position if only flown from water.

The retracts for the Catalina are challenging, and should only be attempted by an experienced scratch builder. On the other hand, they are very rugged. The gear handles rough landing surfaces very well because of the torsion bar type springing. It has been very reliable and completely trouble free.

At the time of revising these construction notes, the original has completed five seasons of flying, most of it being done from water. The water handling of this model is excellent, and operating off water is much more fun than from land. The prototype rarely flies off land, apart from at a few electric fly-ins each year. "Touch and Go's" on water with the Catalina are a delight, and a typical flight often consist of fifteen to twenty (should they be called?) "Splash and Go's." The prototype has probably logged well over a thousand of these. The only incident was early in its history when a tip float broke loose when hitting a wave in rough water operation. When taking off in windy conditions, it is best to apply power very slowly. As soon as aileron control is effective, which is while the model is coming up on the step, the tip floats can be retracted. This reduces the risk of hitting a wave with the tip float, and actually gives more lift, since the floats add wing area and some extra lift. Likewise, when landing in windy conditions, it is best to land with the tip floats retracted. While the model slows down on the step, there is plenty of time with ample aileron control to lower the floats. The retract servo used for the floats in the prototype is very old, and rather on the lazy side. In static tests it struggles to lift the tip floats to the up position, but in the air it lifts them with ease because of the aerodynamics lift of the floats. During flight it struggles more to get the floats to the down and locked position. If a float is reluctant to go down, a touch of rudder to give a momentary yaw in the right direction is a quick fix.

FUSELAGE

The bulkheads are cut from sheet balsa, bulkheads B to F being made from 1/8" balsa, and the remaining ones from 3/32" balsa. Square holes are cut in bulkheads B to G. These bulkheads are then slid on to a pair of ¼" square balsa rails. If wishing to build the model with retracts, it is first necessary to make the operating-cranks for the main gear retracts and thread bulkheads C2 and D on to these cranks. The radius of the throw of the front arm of these cranks is 7/8". The angle between the arms of the cranks is 135 degrees. Bulkhead C2 is similar to bulkhead D, but only goes up part way. Also notice that a doubler similar to C2 is glued to the front of the lower portion of Bulkhead D to add strength. Where these cranks pass through the bulkhead, it is necessary to attach a 1/8" plywood plate which acts as a bearing for the operating crank. The position of these cranks can be estimated, but it is almost impossible to get the rear ones correct the first time. Hence it is best just to lightly glue these plywood plates to the bulkhead, then come back later and reinforce the joint when it is found that it is in the correct position. When the bulkheads are glued to the ¼" square rails, the bottom keel running along the centre line can be attached to the bulkheads, along with the strips along the upper centre line. At the rear, these strips extend to the location of the rudder post. Next attach the remaining bulkheads to the upper and lower centreline strips, and the longerons to the side of the fuselage where shown. Next the sheeting is applied along the side of the fuselage, but the curved upper surface should be left until later when the control pushrods have been installed and retracts completed. The hull can now be sheeted. The triangular balsa strips added under the outer edge of the planing section of the hull make it a concave contour. These strips really help in reducing spray and getting the model on the step promptly. This model will take off easily with about 75% power. With reduced power, the take off run is longer and much more realistic. However, these triangular strips may be left until later in the construction.

If building retracts, the thick hardwood beams are next installed between bulkheads D and E. The “torsion bar” length of the undercarriage leg that runs along the top of the hardwood beams is held in place by nylon clamps screwed to these beams, and forms the hinge for the retracts. When landing on land, these beams carry the weight of the model. Hence some doublers should be run along the bottom of bulkheads D and E and gussets added between these and the beams. The inboard end of the undercarriage leg has a long “U” shaped slot. With the help of a good sized vice, this slot is formed by bending the wire cold. Since this is the most difficult end of the u/c leg to make, start by making this slot first. The rest is more straightforward. The undercarriage legs can be installed at this time and the position of the rear operating-crank bushing moved a little (if necessary) to get the correct movement. When in the “down and locked” position, the crank is slightly “over centre” in the slot, so there is no fear of a gear collapse. The up position is not so critical. When the gear is operating freely, it will be noticed that quite a bit more force is necessary to raise the gear than to lower it.

To overcome the strain on the retract servo during the retract cycle, a rubber band (or light spring) is attached between the gear legs. Small “S” shaped hooks should be soldered to the gear legs just inboard of the point where they exit the side of the fuselage. A rubber band is attached between the hooks on each gear leg. This has the effect of pulling the legs together as they are raised. The tension on the rubber band should be adjusted until an almost equal force is required to raise or lower the gear. Of course, the wheels should be in place while making this adjustment and it is only meaningful if the fuselage is kept level during tests. When the gear operates freely up and down, the retract servo can be installed and connected to the operating crank. Two independent pushrods can be used from the servo output arm to the two operating cranks, or one master pushrod with a secondary one attached (and hinged) to the servo end of the master rod. The retract servo used in the prototype is an inexpensive Cirrus CS-100 BB withch gives 102 oz-ins torque. If a study is made of the stress on the operating crank when a heavy landing is made, it will be seen that the ends at bulkhead D are forced together. To reduce the possibility of the bearing plates on bulkhead D breaking loose, a piece of 1/8” hardwood ½” wide, and approximately 1 ¾” long should be glued to this bulkhead between the bearing plates. This should be a snug fit.

The construction of the nose gear is more straightforward and is operated by a nylon pushrod from the same retract servo as used for the mains. The take off point is at 90 degrees to that used for the other pushrods. There is no steering for the nose wheel, but with the differential power of the motors, steering is not a problem on the ground.

When the model is in the water, it is not possible to keep water out of the wheel wells. It comes in up to the level of the water line. There is no door for the nose wheel-well, but this is not a problem, and water does not come into the fuselage if the top of the wheel well is covered to prevent water splashing inside.

The area of the fuselage where the main wheels retract takes in some water up to a depth of an inch or so where the water line is. It is not up to the position of the bearings used for the operating cranks, so no waterproofing is necessary for these. It is of course necessary to waterproof bulkheads “D” and “E” immediately in front of, and behind the wheel wells. This is to prevent water in this “wet” section going through to other parts of the fuselage. To reduce the amount of water in the main wheel well, blocks of foam may be fastened where they don’t interfere with gear operation. On take off, most of the water drains out the gear leg slots on the side of the fuselage, but the small remaining amount drains out through holes made through the bottom of the rear bulkhead “E” to the area under the step. To stop water in the wheel wells from splashing over into the adjacent bays, a cover can be placed between bulkheads D and E. above the level of the retract mechanism. In the prototype, a piece of clear Mylar film is pinned in place. This allows visual inspection of the main gear.

When the gear is operating, and the control rods are installed, the remaining sheeting is applied to the upper surfaces of the fuselage. Next the cover over the nose section, including the cockpit area, is built, and then the wing pylon. These are built in place, using very thin plastic like cling (saran) wrap to keep the sections from being glued to the fuselage.

Single engine floatplanes use water rudders to control direction while taxiing, but multi engine flying boats do this with differential power to the engines. Without either of these methods of steering on the water, a model is difficult to control on the water in any kind of wind. Some builders may wish to go with a water rudder at the point of the second step, but differential power to the electric motors is much more effective. With series wiring of the motors, it is very easy to hook up differential power. When full rudder is applied during taxiing, the end of the output arm on the rudder servo closes the contacts on a micro switch and drops a resistance across the inboard motor. This cuts down the speed of the inboard motors to a realistic idle, and the outboard one speeds up a little. The system will work without the resistors by just using wire to make a direct short across the motor, but this will work like a brake and stop the motor completely. It does not look very realistic. With differential power it is easy to taxi cross wind in considerably windy conditions and turn downwind at the completion of the landing run. At low taxing speed, turns of small radius can be made in the water. The value of the resistor needs to be about one third of an ohm, but it absorbs quite a bit of current. Hence it will get very hot if it is not large enough to dissipate the heat. It is best to use three “one ohm” resistors in parallel, but these should be 10 watt resistors in order to absorb the heat. Full rudder deflection is not normally made in normal flight, so there is little fear of differential power being activated while in the air. Experiments with stall turns have been very impressive. Loops and barrel rolls are not exactly scale manoeuvres for a Catalina, but they have been done as part of the flight testing program. No weak spots have shown up so far!

TAIL SECTIONS

These are of conventional construction. The use of a symmetrical airfoil with a deep spar means that there is greater strength than there is with a flat surface. Hence it can be built lighter, and is less prone to warping. Keep the tail light. For accuracy in joining the control surfaces, it is best to shape the spars first and hinge them together before starting construction. The rearward position of the elevator horn is important. This is because of the angle of the pushrod. Both sides of the fin should be sheeted with 1/16” sheet balsa from the top of the fuselage up to the elevator platform, since there is considerable stress in this area. Light flexible pushrods should be used for the tail surfaces, but they should be supported at various places along the fuselage in order to avoid bowing when pressure is applied to the rods.

WING CONSTRUCTION

The full depth sheet balsa spar is continuous throughout the wing. If building the wing with removable outer panels, all of the spars should be made first, along with the hardwood tongues and boxes where the panels join. Bass is considered to be the best wood for the tongues. The ribs are cut and butted to the front and rear surfaces of the spar. Construction notes are written on the plan. The wiring for the motors runs along between the leading edge and main spar, but it is important that it is installed before adding the sheet covering to the upper surface. The wire should be at least #14 gauge, and twisted in order to reduce the risk of radio interference. It will be noted that before the sheeting is applied to the upper surface, the wing is still not torsionally strong, meaning that it can easily be twisted quite easily. After the sheeting is applied to the upper surface of the same area, the wing will be very rigid and difficult to twist. Hence it is very important when applying the sheeting to the upper surface, to weight that section of the wing down on a surface that is perfectly flat. This ensures that there is no twist in the wing out to the point where the taper starts. The washout starts from this point and extends to the tips. There is no dihedral in the Catalina wing. The upper surface should be straight, but because of the taper of the outer panels and thinner ribs towards the tips, there is a certain amount of dihedral to the lower surface. It will be noticed that the airfoil section changes where the ailerons start. The NASA type leading edge cuff with blunter leading edge is used on the outboard panels. This reduces the risk of tip stall considerably. The break in the leading edge can be disguised somewhat by putting a fence made from 1/32” ply at this position.

The tip floats are built up from sheet balsa. The retract mechanism is similar to that used for the nose gear. A retract servo is used for operating the tip floats.

The construction of the nacelles and cowlings is fairly basic. The nose ring of the cowling starts like a doughnut, and can be of one piece of thick balsa, or laminations.

CONTROL THROWS

These are shown on the plan. Importance must be given to the differential in the ailerons, and it will be achieved if the control arm on the aileron servo is made as shown. At the start of the take off run in a flying boat, one of the tip floats will be in the water. It is necessary to lift this float out of the water using ailerons, or the model will want to turn in the direction of this float that is dragging in the water. Poor aileron design aggravates this problem in many models because of the adverse yaw that is inherent at larger angles of attack, such as while getting on the step. Two things are done in the design of the Catalina to overcome this problem. Frise ailerons are used, and a substantial amount of differential is used in the aileron linkage. At the start of the take off run, while holding up elevator to get on the step, advance the throttle just a small amount at first until the wings are leveled, with both tip floats out of the water. When this is under control, advance the throttle further and relax on the up elevator as the model accelerates on the step. With practice this becomes one smooth continuous movement. A very slight amount of up elevator may be necessary at the point of lift off, especially if operating from glassy water.

In the prototype, Mabuchi 550 motors were used at first. These are the basic Speed 600 type can motors that have been around for years. They are not the best of motors, but were used in this model at first because there were two surplus motors with Master Airscrew gearboxes on hand from the days of powered gliders. This model does not need a lot of power, and because of the series wiring of the two motors, each motor is running at the equivalent of eight cells on 19 amps. At this loading, these motors are reasonably efficient. For builders who are buying new motors for this model, I would recommend getting the Kyosho Magnetic Mayhem 22 turn car motors. These are more efficient than the older can motors, and the same gear ratios and prop size can be used. Magnetic Mayhems will give more performance and longer flights. When buying the Magnetic Mayhem motors, it is important to get the ones that have reverse timing if they are to be used with the simple gear drives that reverse the direction of the output. With these motors, it would be reasonable to expect flights in excess of 10 minutes, using regular RC-1700 nicads. The model is usually flown on 16 cells, but will fly quite adequately on 14 cells. If operating the model from an airstrip where the grass is on the heavy side, eighteen cells may be used, but 16 is adequate for water operations. Eighteen cells would not be recommended for the older Speed 600 type motors, but the Magnetic Mayhems will handle the extra voltage and still remain very cool.

In multi motor electric models, there is an increased risk of problems with radio interference from motor brush noise. It is always recommended to put a diode across the terminals of each motor in addition to the usual capacitors. The best diode to use is a Schotky, but a small 2N4001 is often sufficient on a lower powered model such as this. The radio and servos should be kept as far as possible from the speed control, motors and motor wiring. This is taken care of with the layout shown in the plans, the speed control being located beside the retract servo. Servo leads must be kept short. Do **not** use outboard servos for the ailerons. These would require long leads running along the wing parallel to the motor wiring, and they would be very prone to picking up interference. At the low airspeed of this model, one standard servo is ample to operate the ailerons.

COVERING AND FINISHING

It has been found over the years that film does not stand up to repeated use in water, so the hull and tip floats are best covered with light tissue (silkspan) applied with nitrate dope. The silkspan should be applied to the entire fuselage. Be sure to prime the fuselage and tip floats by applying two coats of clear nitrate dope before covering. When applying the tissue, first spray it lightly with water and rub it on to the surface while damp. Then brush a coat of dope on to the tissue. It will bleed through and cement itself to the primed surface below. After it has dried, apply at least one more coat of clear dope. The fuselage should be sanded after each coat of dope is applied, and when a smooth surface has been obtained, the colour should be applied. Krylon spray paint is known to be one of the lightest and most suitable for models of this type, but any lacquer spray paint should be suitable. Check for compatibility with the nitrate dope. The wings and tail surfaces are best covered with low temperature film. Mica film used for the lower surface of the wing saves weight and adds strength. It doesn't look as good as film, but under the wing is not so noticeable. Some high temperature films are very strong and shrink considerably. These should be avoided on the lightweight tail surfaces. Water seepage into the tail surfaces can be a problem with models flown a lot from water. Water will get into a tail surface through the slightest opening, but if the surface is covered with film, the lack of breathing results in water damage to the structure. The horizontal tail surfaces are the most prone to this problem. The builder has found it best to use a covering like litespan on the lower surface of the stab and elevator. It seems to breathe, and avoids the problem of condensation.

EMERGENCY FLOTATION

With an electric powered model, because of the weight of the batteries and motors, there is not enough flotation to keep the plane on the surface of the water in the event of a crash, or the hull being punctured. Hence it is recommended that blocks of foam board be placed in the fuselage, or even some of the wing bays. The small air sacks used as packing are another option. When asked why the model of the Catalina is so light, the writer often points out the little air sacks in the fuselage and says that they are filled with helium. In the case of several multi motor flying boats that I have flown for several years now, I have fortunately never had to put these flotation devices to the test. But in earlier years I lost a single motor pylon type flying boat following a crash due to radio failure. When I got to the crash scene, all that was floating was the wing and tail section that had torn loose. The fuselage, complete with radio gear, motor and battery, was at the bottom of the lake, and had it been a multi motor flying boat, the wing would have probably gone down as well because of the weight of the motors. Flotation is like insurance. You will only need it if you don't have it.

Enjoy building and flying your Catalina. There is not much I can say about the flying that does not apply to other flying boats. Full power is necessary to get the model on the step, but the power should be applied slowly with elevator full up, at the same time using ailerons to keep the wings level. As soon the model is on the step it will accelerate and back pressure on the stick should be reduced until the elevator is only slightly up. As soon as the model becomes airborne, reduce the amount of up elevator so that a safe climbing speed is attained. The last part of the landing approach is best done with a small amount of power which is left on right through the landing. If it skips on touch down, it is because the landing speed is too high. The final part of the approach should be with a small amount of power which is kept on right through the flare. Back pressure should be applied on the elevator until speed is diminished and a slightly nose high attitude is attained. The tip of the second step should almost touch the water as the main step makes contact. If landed in this attitude, the Catalina will not skip, even if the touch down is quite hard. After touch down, the elevator should be kept up, as in a three point landing with a tail dragger. The landing run after touch down is most impressive if extended by leaving on the small amount of power used for the approach. It is not usually possible to taxi the Catalina out of the water with the undercarriage down. It might be possible with a hard surface ramp at a shallow angle, but at the typical beach, there is too much weight on the nose wheel and it bogs down in the sand. This is brought about by the high thrust line of the motors. On the contrary, it is very easy to taxi down off the beach into the water and retract the gear once floating.

The ultimate fun with the Catalina is doing the circular take off, and the 360 degree touch and go. These are exercises that can only be done in planes with retractable tip floats. They should only be tried under light wind conditions when you have the pond to yourself.

The circular take off starts parallel to the shoreline. When the model is on the step, power should be reduced and the tip floats retracted. At the same time, a turn is commenced away from the shoreline. The high speed banked step-taxi should be continued with the retracted tip float almost touching the water. There is no problem if it does touch momentarily. As the model completes a full circle of the pond and comes by the start point, power is increased and lift off achieved. But be warned that the Catalina always wants to fly, and if too much power is left on, it can become airborne unintentionally at any point around the circle. It invariably happens at the three quarters mark while heading for the beach. If this happens, be sure to continue the turn so as not to fly into the trees along the shoreline.

The 360 degree touch and go starts by doing a slow descending turn over the water with a small amount of power. Continue this circular approach, trying to make the touch down at the closest point of the circle parallel to the beach. This is done with tip floats retracted, and the bank angle should be controlled so that the tip float is almost touching the water at the point of touch down. The turn should be continued and power increased a little so that the model continues in a high speed step-taxi. With coordination of rudder and aileron, the model should continue this step-turn until the complete circle is completed, then lift off is achieved as the model passes the point of touch down. Have fun, and let me know of your new inventions for Catalina exercises.

Ivan Pettigrew

SPECS:
PBY-5A Catalina. (1999) 1/12 scale Span 100 ins. Wing area 1350 sq ins
Airfoil is Eppler 195 with NACA leading edge cuff outboard. Length 63 ins. Weight with sixteen RC-1700 cells is 147 ozs giving wing loading 15.7 oz / sq. ft. Motors are Master 540 can motors, (similar to Speed 600) with Master Airscrew 3:1 gearbox driving Master Airscrew 11 x 8 three blade props. Motors wired in series with differential power for water steering. Props turn 5,200 RPM static at 19 amps giving 46 ozs thrust. Six channels provide for retractable landing gear (scratch design) and retractable tip floats. Excellent performer off water as well as land. Hull is 1/32" ply and
fuselage sides 1/16 balsa covered, with silkspan and nitrate dope for water resistance.
Flies at 33 watts / pound.

<u>Motor revision:</u> In April 2001 the motors were changed to Magnetic Mayhem with 2.5:1 gearboxes, drivng the same 11 x 8 three blade props. Performance is much better, with 6,000 RPM at 22 amps static giving 60 oz thrust. This equates to 40 watts / pound.

For further details on flying boats, read the page about "Flying Boat Design' on www.ivansplans.com Some valuable tips are given on water take offs and landings

April 2005. Alternate fuselage construction.

The fuselage construction is not difficult once underway, but the challenging part is getting things together at the beginning. It would be nice to be able to hang the bulkheads in space while the longerons are attached. One way to handle this is to build the fuselage upside down on the building board, over the top of the plan view of the fuselage. The top longeron that runs the length of the fuselage should be tacked to the building board, leaving it in one piece at this stage, and cutting out the part where the pylon fits later on. Next the bulkheads are glued to the longeron at the indicated stations. Now the bottom longeron, or keel, can be glued to the bulkheads and also the side longerons. The structure can now be removed from the building board and the sheeting started. Pick up in the original instructions in the middle of the first paragraph about the fuselage where it says, "The sheeting is next applied along the lower part of the side of the fuselage."

Another way of starting the fuselage construction upside down, is to use a flat piece of foam board. Cut a groove to hold the top longeron, and cross grooves for the bulkheads. With the longeron and bulkheads thus held in place, the remaining longerons can be added to the point where the framework is strong enough to remove from the foam board.