AIRCRAFT ASSEMBLY AND RIGGING

NOTES FROM THE FIELD

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What is rigging?

Rigging is the proper installation of airframe components (wings, ailerons and tail surfaces) designed to do a specific aerodynamic job and contribute to the aircraft's overall performance, stability and safety.

Why is rigging important?

Proper rigging insures that the designer's intent concerning performance, stability and safety are insured. Improperly rigged aircraft can dramatically change flight characteristics and impair the safe control and operation of the aircraft as intended by the designer. All aircraft performance data is based on the aircraft being rigged properly. Rate of climb, stall and slow speed performance are all effected by rigging. The ability of the aircraft to be predictable is based on it's proper rigging and assembly criteria as determined by the designer.

How is proper rigging accomplished? Where to start?

The procedure most often used is as follows

1. Installation of fixed tail surfaces
2. Installation of movable tail surfaces and trim tabs
3. Installation of wing panels
4. Installation of movable surfaces attached to wing panels

For most rigging, the fuselage is leveled in both directions and is blocked and secured. It remains in this configuration until all assembly and rigging is accomplished.

Installation of fixed tail surfaces: horizontal and vertical

When these surfaces are fully cantilevered, little rigging can be accomplished. It is necessary to confirm that they are secured and are level and plumb in relation to the fuselage.

When horizontal and vertical surfaces are either strut or wire braced, more rigging adjustments can be made. These surfaces may or may not have dihedral. This must first be determined from designer's information before proceeding with rigging.

For strut braced surfaces, level both horizontal surfaces with a spirit level by using the strut adjustment. If these surfaces are not intended to be flat a dihedral board will be required. The fabrication of this tool is covered in the discussion on rigging wings.

For wire braced surfaces, after installing the wires, adjust to proper tension as recommended by the designer. When this has been accomplished the fin can then be moved either right or left to the plumb position by lengthening or shortening the top wires only. This is accomplished by counting turns of the wire. For example, 4 turns to loosen (lengthen) the right hand top wire then 4 turns to tighten (shorten) left hand top wire. This will assure that wire tension remains within proper tolerances and allows the fin to be placed in a vertical or plumb position.

Installation of movable tail surfaces and trim tabs

It is generally advantageous to install the elevators first. This is to avoid trying to work around a rudder that extends into your work area when you are trying to mate the two elevators and their related controls and tabs. After this installation has been accomplished, the rigging of elevator stops is done. If the stops are remote, ie. on the stick or torque tube, proper cable length and tension should be checked along with proper direction of travel and distance traveled. Control surface travel of elevators, ailerons and flaps can be easily measured using the bubble protractor. The protractor should be "zeroed" with the control surface in the neutral position. Surface travel is then measured in degrees from the neutral position up and down.

Be sure to check for possible interference of stick movement with objects in the cockpit such as the instrument panel. Remember, if you have a stick in your aircraft, your thumb will probably be on the top of the grip. You want to be sure that you have enough clearance under the panel as not to require first aid due to some control surface movement requirements.

When rigging elevator tabs, remember, travel is of primary importance, not only direction of travel but also distance traveled. Generally the travel tolerance is only 1 to 1 1/2 degrees. In this case, more is not necessarily better. Too much travel on a surface can cause the aircraft to be over stressed or induced into an attitude for which it has not been designed. When dealing with tabs and control surfaces, the trim tab will always move in the opposite direction of the control surface. For example, in a nose up attitude , the tab will be down.

Next, install the rudder. After securing the rudder and its control cables, always check for full travel as specified by the designer. At this point, if toe brakes have been incorporated into the system, be sure that no brake is accidentally applied as you apply full rudder travel. This can be caused by improper geometry or rigging between the brake pedals and the rudder. This is a common problem. Left rudder can apply right brake. What a surprise on roll-out!

If either a fixed or adjustable rudder tab is being used, be sure it is bent or controlled in the proper direction as determined by the propeller rotation. For example, if the prop rotation is righthand, the tab is bent left. The opposite is true for lefthand rotation.

Installation of wing panels

If your aircraft has cantilevered wings, little rigging can be done after installation. The additional installation of a fixed tab on the aileron or drooping one flap slightly is about all that you can do if there is a construction flaw which causes one wing to be heavy.

If the wings are wire or strut braced, rigging is more easily dealt with.

After the wings are installed, you must first set the dihedral. Dihedral is the angle at which the wing panel is mounted to the aircraft on its lateral axis and the tip is higher than the root. In order to set or check the dihedral, you need a dihedral board. Construct a dihedral board as follows. Obtain a straight piece of 2x4 approx. 62" long. Determine the number of degrees of dihedral required for your wings. Make a wooden block the same width in inches as the degrees of dihedral. Place a mark at 60" on the 2x4 and secure the wooden block at the mark. Dihedral boards are useful in rigging wing dihedral, rigging wing twist and rigging dihedral in horizontal stabilizers.

Why place your block of wood at the 60" mark on your 2x4? Think back to your training in navigation. We have been taught that if you are one degree off course you will be one mile off course in 60 miles, so one degree is one mile in 60 miles. It is also one inch in 60 inches. Here's an example. Let's say your wings have a dihedral of 1 1/2 degrees. You would place a 1 1/2" block at 60" on the 2x4. Place the board on the wing with the block toward the fuselage. Adjust your wings until the board is level. You now have 1 1/2 degrees of dihedral. The same procedure is followed on horizontal stabilizers with dihedral and in rigging wing twist.

Let's talk more about wing twist and how to rig twist. Most aircraft designers use some method to insure a progressive stall characteristic. This allows the wing to start the stall at the root and progress to the tip. Seldom does the entire surface stall. The amount of twist varies with airfoil design and is pronounced on some aircraft. The next time you encounter a Piper Cherokee, particularly an older model, stand directly centered on the nose and look at the wing tips. The illusion is that the tips are thicker than the root. This illusion is caused by the amount of top surface exposed to view due to the twist in the wing. This is the reason the airplane has such a gentle stall.

Rigging twist into wings on strut braced aircraft can be accomplished as follows. If the aircraft has one lift strut, such as a Cessna 172, you will find an eccentric located at the rear wing attach fitting. This will change the angle of incidence to allow for the correction of a wing heavy condition.

If the aircraft has two lift struts, such as a J3, you will find an adjustment on the rear lift strut on either the upper or lower end. This allows you to twist the wing. If one wing is heavy, it is generally desirable to reduce lift on the light wing. This can be accomplished by lengthening the rear strut. This reduces twist in the outer panel therefore reducing lift in that area. During the test flight, if you notice rigging problems, chances are they are due to improper wing twist.

Installation of movable surfaces attached to wing panels

Aileron installation is similar to other control installations except that they normally have differential movement. Most ailerons will have differential travel to equalize resistance in both directions of travel and between left and right surfaces. If differential travel exists, the aileron will travel further up than down because it is more efficient in the down position.

In some aircraft, the design requires that the ailerons droop 1/8" to 1/4" when rigged properly. In cruise flight, these ailerons will normally then rise to the streamlined position.

After installing the ailerons, the rigging of the aileron stops is accomplished. Check cable length, tension and travel using the bubble protractor.

FLIGHT TEST TO CHECK RIGGING

All rigging checks should be accomplished in calm air and at cruise power and airspeed.

Most aircraft will require slight down elevator in straight and level flight. If this condition exists, it is normal. In addition, slight rudder deflection is also normal due to the "P" factor. Direction of this deflection is based on the direction of engine rotation.

Most fixed tabs on rudders are adjusted to prevent the nose from turning at cruise power and airspeed. To check rudder tab rigging, go to cruise power and airspeed. Take your feet off the rudder pedals. The ball should be centered and the aircraft should continue flying straight . If the aircraft yaws, note the direction and bend the tab in the same direction as the yaw.

To check rigging of wings and ailerons, go to cruise power and airspeed. Align the trailing edges of the ailerons with the wing trailing edges. Holding the ailerons flush, note if you have a wing heavy condition.

If wing heaviness exists, check the following:

1. Is the ball centered?
2. Does the wing drop before or after the airplane starts to turn?
3. Can the turn be stopped with rudder and ball centered?

With the ailerons flush and the ball centered, if the airplane drops a wing, the wing needs adjustment.

If you can stop the turn with the rudder and the ball is still centered, rudder tab adjustment is in order.

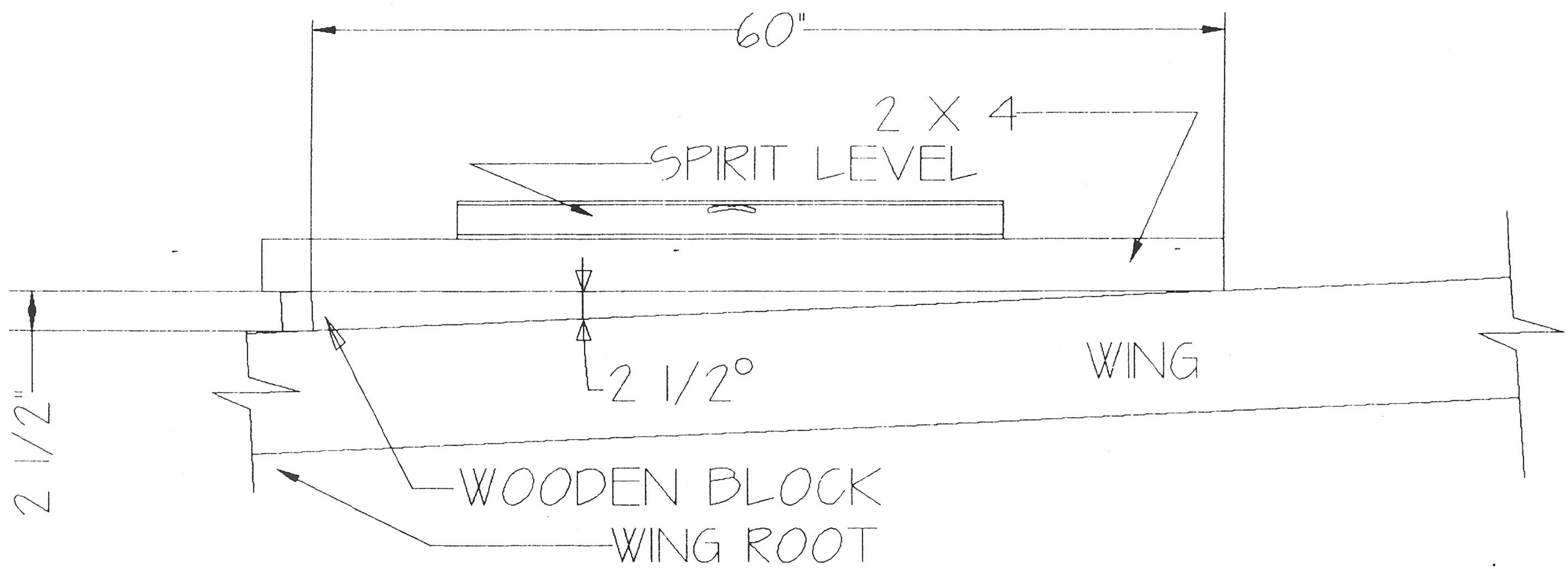
If you release all controls and the ailerons deflect, you have a control balance problem to be corrected with spades or an aileron tab.

NOTES:

The statement "It flies hands off." DOES NOT indicate proper rigging but only that you may have many factors counteracting each other. Hands off, ball centered, controls centered and proper cruise performance are indications of a well rigged aircraft.

Items such as a lack of wing fairings can contribute to a false rigging problem. This can lead to difficult handling characteristics if the gaps between the wing root ribs and the fuselage are

not equal on both sides. Air flowing through these gaps causes the airplane to drift, particularly on flair, leaving you wondering where that crosswind came from.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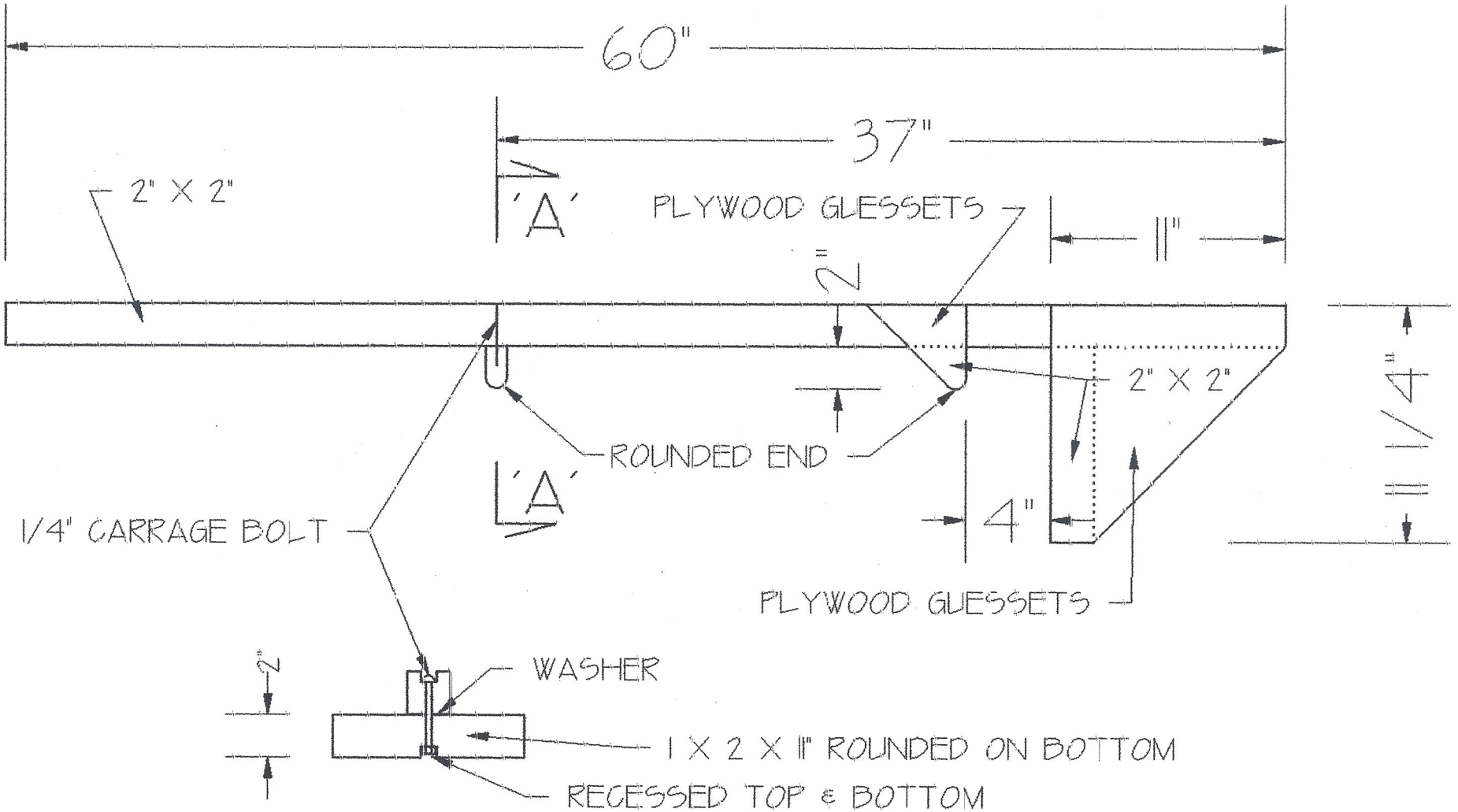

SECTION 'A'-'A'

RIGGING BOARD

3 REQ'D - DIFFERENT COLORS

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