PART ONE

The Fine Old Art Of Rigging A Biplane

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SPORT AVIATION enthusiasts who become involved with biplane projects discover something when they inquire at airports about a certain subject — the skill of rigging biplanes is nearly a lost art among present-day aircraft mechanics!

Yet, because more and more amateur-built and antique biplanes are being put into the air as a result of the burgeoning popularity of hobby aviation, the need to know about this subject becomes more urgent. This article therefore has been prepared from a selection of the best in old-time aviation texts. Rigging a typical biplane is much like erecting a tent. Alter the length or tension of one wire or rope, and it will surely affect some other portion of the assembly. A wrong angle at one place will put some other things out of alignment. If an early step in the task is done incorrectly, all things done after that will also be incorrect and the only solution is to start all over again. And to start right, it is essential to have a firm grasp of what the task is all about.

Biplanes differ from other types in that their upper wings are held aloft by several struts, completely separate from the fuselage. The reason why biplanes are so fascinating to see at a fly-in may well be that they seem to be offering their upper wings to the sky, as if eager to grasp the air and climb to the heights. Those top wings are so obviously planes meant to cleave through the air, not mere appendages to a fuselage! But they can most certainly bedevil the rigger, for unless all the struts and wires are correctly adjusted, they are simply not held up so as properly to do their work. Now a great many biplane designs have been built, and it is essential to remember that different designers thought out different approaches to the problem of adjusting two wings just so, with a minimum of complication combined with enough leeway of adjustment to permit of making small changes to get each aircraft to fly hands off. One cannot make any statement about biplane rigging without somebody pointing to some design to which it can't be applied. When specific assembly and rigging instructions are not available, one has to study the craft and deduce how its designer meant that top wing to be held in place fair and square.

Speaking of the kinds of biplanes most likely to be worked upon today, the roots of the lower wings connect to the lower longerons of the fuselage through mating fittings which, with rare exceptions, are non-adjustable. Thus when the lower wings are bolted onto the fuselage, their root ends are held at the angle of incidence the designer intended. When rigging instructions for a biplane are lacking, this often provides a sound foundation upon which to work. It is easy enough to adjust the biplanes such as the Fleet (28 foot span) have one-piece upper wings but more commonly there are two panels, joined in the middle, such as the Swallow biplane, and the Waco 9. When inverted vee cabane struts are employed as on the latter, rigging the top wing is facilitated as stagger is the only variable.

The center section, when used, must be put in place with real care. If stagger is off, there will be trouble making the wing wires and outboard struts fit. If it is not centered directly over the fuselage as seen from above, the whole top wing will be off center. If it is askew when seen from overhead, the top wing won't be parallel to the lower one. And more. Many planes have leveling

points - pads or knobs of one kind or another - welded onto the basic fuselage frame and identified either by placards or notes in the service manual.

If nothing looking like them can be found it is quite probable that the fuselage top longerons can be used for leveling, especially when the engine thrust line appears to be parallel to them when seen from the side. A tall saw horse or step ladder is put under the tail of the fuselage and wheels blocked up off the ground by the axles to eliminate tire flexing. Level the fuselage (and hence the airplane) both fore and aft and laterally. Lift the center section into place and rig its wires only tight enough to hold it rigid under the handling of rigging operations. From identical points, such as holes in the fittings, suspend plumb lines from both ends of the center section. If plumb bobs on long lines keep swaying, immerse them in pails of water to steady them. Turn wires until distances X and Y are identical to within a small fraction of an inch such as 1/32 in. or 1/16 in.

Always slack off one wire before tightening its opposite number when rigging.

Put bolts into the lower wing root fittings to serve as accurate reference points for measuring X and Y. If stagger does not allow them to be used for this, then make sure you use some accurate, reliable points on each side of the fuselage.

On most biplanes there is only one set of center section wires, running from fuselage frame up to the front spar. In a few there is also a set for the rear struts and spar, in which case it is necessary to use suitable care and plumb lines to make sure both sets are set up so as to hold the center section true, seen from above. Remember also that many center sections contain a pair of crossed wires that are part of the top wing's drag truss; these must be adjusted before any covering is applied, or before the gas tank is installed, and trammeled to make sure the center section is squared up. Some biplanes, such as the cleanlooking old 1927 Swallow have crossed wires between the cabane struts instead of the diagonal of "N" struts. These are called stagger wires. Whether there is an adjustable diagonal strut or stagger wires, it's essential to get them adjusted exactly alike on both sides, otherwise they will hold each end of the center section at a different amount of stagger, and either things won't fit together or will have to be forced and will result in the section being askew, as seen from above.

If this fault is present even in small degree, the difference will be very noticeable as between the left and right tip of the top wing; there could be two, three or more inches difference in stagger!

So it is recommended that the span wise alignment of the center section be carefully checked.

(Continued ….Same Hatz Time… Same Hatz Channel)

From the Prez' picture files…. Bartlesville…

(Picture by Pres Chuck)

Billy, Lorin, Bill Rusk and Mark Marino present the forum at BVO.

Rigging a Biplane, Part II…

When the center section is all done and the lower wings are hanging by the landing wires, it is time to install the upper panels. Depending on the ship's size, it can be easy or a struggle. Lay a plank across two step ladders at convenient working height just outboard of the wing tip so that two men can lift the tip to proper height while a couple others raise the root end, using the lower wing's walkway and the landing wheel for steps. Have handy spikes, awls, drift pins, Phillips screwdrivers, etc., to shove into strut, root and wire fittings quickly and take the strain off the men. Then one by one put the correct bolts in place. Set the bubble protractor at the specified degrees of wing dihedral. Place the straightedge on the top of a lower wing as in Fig. 7 and by turning up the landing wire bring in correct dihedral.

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Sometimes it's necessary to bring the bubble a little past the line to take into account wire slackness; when the flying wires are tightened later, dihedral will be pulled down to the correct amount. Once the protractor has been set, do not change it until dihedral rigging is done, because one's hands and eyes are not sensitive enough to get exactly the same setting two or three times in a row. Put pencil marks on the wing to show where the straightedge was laid, so it can be replaced exactly if need be for a later check. If there are two landing wires on each side, use only the front one to rig in dihedral at this stage.

At this point, careful center section adjustment and carefully made wing root fittings will be holding upper and lower wing panels at the correct angle of incidence at the roots. Next step is to rig that angle into the panels all the way to their tips. Place the incidence board under the lower wings at or just outboard of the interplane struts. If the ship has two landing wires, use the rear one to raise or lower the trailing edge. Or perhaps the rear interplane strut has a threaded fitting. Then rig incidence into the top wings with whatever strut or wire adjustments are obvious. Then things can be tightened up, turning each of the several wires about half or one turn at a time in orderly fashion. Never use pliers or common wrenches on them! Saw and file a half-streamline shaped notch into the end of a brass or aluminum rod or bar, to fit the wire section nicely, and use that for turning them without causing dangerous scratches. Don't pull wires up agonizingly tight, for that will strain fittings and warp wooden structural members.

Fair tension is ample. If a wire flutters on the test hop, it can be tightened a little . . . though you may find that has slacked off another one, which will then start wiggling! That's why they use "javelin struts" where the flying and landing wires pass each other as on the Waco 9. These are of wood, taped on. There is a difference of opinion in old texts on the question of rigging some wash-in or wash-out into biplane wings, to counter propeller torque's tendency to roll a plane in the opposite direction. One school of thought points to the corkscrew path of the prop slipstream. Obviously it makes the relative wind blow up on one wing root more, and blow somewhat down on the other one, resulting in an automatic difference in lift, changing with engine speed to counteract torque. Others say to use wash in and wash-out, one old text recommending an inch of wash-in on biplanes powered by 100 hp engines! Some say to use

wash-in only, others to divide the required corrective force between opposite lower wings with wash in and wash-out. It seems that the validity of the slipstream theory would depend on the relation of wing span to propeller diameter. The eight and nine-foot propellers on slow turning 100 to 250 hp radial engines obviously puts prop wash over a considerable proportion of the wing area in biplanes of 28 to 30 foot span. But most texts describe the washin, wash-out method. Unless specific rigging data is available it might be best to test hop a biplane with no wash-in or wash-out, note wing heaviness, and adjust accordingly. If an undue amount of wash-in (higher angle of incidence) is needed to correct torque, it can lead to premature stalling of the wing tip concerned so it would be well to divide corrective measures between some wash-in on one wing and wash-out on the other side.

Old biplanes with plain ailerons and unwarped wings can lose aileron control quickly and completely in a stall. Read pages 163-175 of "Stick and Rudder" by Wolfgang Langewiesche before flying an old biplane! Still talking of torque correction, remember that when the wings are warped to counter it, any particular adjustment will work only for one air speed. Usually things are set to make the plane fly level at cruising speed — but that can vary with load though the engine rpm is held constant. Torque effect shows up more in big propellered, shortspanned biplanes than in today's small propellered, large-span monoplanes. Odd things in an old biplane's flying characteristics often are based on the nuances of torque and those big propellers. For example, if the engine is throttled back fully when gliding in to land, the big prop will windmill and slow down the flow of air through it. This retarded air stream passes over a sizeable proportion of the wing area and it makes the ship come down a lot faster than the average monoplane. Carrying a small amount of power in the approach lets wind flow through the prop without retardation and the approach is less bricklike! The same applies to today's midget biplanes, whose propellers are large in diameter relative to the span. One cannot change the length of a strut or wire without changing others in its group to allow for the altered length. If a terminal is screwed out too far, too few threads do the holding job and there's danger of their stripping. When starting to assemble the plane, run end fittings on as far as common sense says they can or should go. Frequently there is a tiny hole in the side of terminal barrels, so that a wire can be poked in to see if threads have gone in at least that far from the end. If, after rigging, you cannot feel the rod threads, safety demands that rigging be changed to allow that minimum number of threads to be engaged. New streamline tie rods are expensive but can still be ordered to fit through supply houses such as Air Associates or from a manufacturer such as the Macwhyte Company of Kenosha, Wis. Match up left and right wires and struts to have them of equal length before starting. Tie rods have left-hand threads on one end and right-hand on the opposite end. It is standard practice to have the right-hand thread ends at the lowermost, innermost and forward most points, so mechanics won't become confused as to which way the various lock nuts should be turned. Lightly grease threads before installing terminals. Do not jam lock nuts up very tight, for that puts a concentrated pull on the wire at that point; added to the normal flight stresses it could make a tie rod part. Ailerons normally carry an up-load, and depending on the stretch characteristics of the control cable system, will or will not be affected in flight. Sometimes they are rigged so their trailing edges are even with the wing trailing edges on the ground. In other ships, they are rigged with their trailing edges from *V** in. to *Vz* in. low so that air loads in flight will hold them even with the wings. Less frequently, they are rigged to ride slightly above the wing trailing edges when in flight, perhaps an eighth of an inch, on the theory that this reduces overall airfoil incidence at the tips and causes that area to stall later than the rest of the wing so as to retain aileron control longer. If rigging data is lacking, rig them even with the wings and make test flights to decide if changes would help aileron effectiveness. Some biplanes have no dihedral in the upper wing, and in these it is often the practice to set the top wing in place, rig it straight, and use it as a reference point to get the proper dihedral into the lower ones. The Fleet biplane is an example. Partly to illustrate typical, actual factory rigging instructions of the 1920's and 1930's and partly to make the information available to antique enthusiasts, herewith are erection and rigging instructions for the Fleet and Waco F airplanes.

FLEET:

1. Place upper panel upright on leading edge, with padding on the floor.
2. Attach all interplane struts.
3. Raise panel above fuselage and attach center section struts to fuselage.
4. Attach center section wires and tighten to fair

tension.
5. Attach lower panels to fuselage; tighten and
cotter nuts. Lower wing-to-fuselage attaching
bolts should be a snug fit without play; use 1/64
in. or 1/32 in. oversize bolts in reamed holes if
there is play. Should
be a light drive fit.
6. Attach landing and flying wires; left-hand
thread at upper ends.
7. Level fuselage. Top longerons and cross tubes
in both cockpits may be used or both bottom
longerons and cross tubes between front and rear
lower wing spars.
8. Drop plumb lines D, Fig. 4, from leading edge
of upper panel at points in line with center
section strut attaching points. Measure distances
X and Y from bottom
longeron to plumb lines and adjust wires A and
B until X and Y are equal and center section is
level.
9. Drop a plumb line from leading edge of upper
panel at outer strut attach points; measure
distance from leading edge of lower panel to
plumb line for stagger. This should measure 23
in., both sides symmetrical
within *l/»* in. and can be equalized by adjusting
center section adjustable struts.
10. Dihedral of lower panel is 4 degrees. Upper
wing has no dihedral. Center section of upper
wing has been leveled as in (8). Level remainder
of upper wing by
adjusting landing wires L so that upper wing is
straight, taking care that flying wires F are slack
enough to allow this. Then tighten up flying
wires F. Lower dihedral may be checked if
desired.
11. Using incidence board, Fig. 6, adjust lower
outer panel incidence to zero degrees via the
adjustment on the rear interplane struts.
12. All streamline wires are lined -up with the air
stream and lock nuts tightened.
13. Insert bakelite spacers at all streamline wire
crossings and tape. Use two of them at center
section wire crossing and four on each side at
flying and landing wire crossing.
14. Grease hinges on wings and ailerons, and
inside of operating arm on inner end of
ailerons.
15. Approach wing with aileron from rear,
sliding aileron operating lever, on aileron,
through opening in rear spar over operating lever
tube in wing.
16. Push aileron forward until hinges mate.
17. Insert greased hinge rod through hole in wing
tip bow. Secure with two drilled head fillister
machine screws at outer end and safety wire.
18. Support ailerons with ¥4 in. droop on each.
Support stick in neutral and adjust fork ends on
inner ends of operating tubes to match holes in
operating lever in cockpit, locking fork at proper
adjustment with

lock nut. Connect operating tubes to operating levers with bolts and bushings. If droop of ailerons on ground is such that trailing edges do not line up in flight, adjust to correct.

19. If in hands-off flight one aileron droops and the other rides high, the ailerons are unsymmetrical in contour, the high degree of balance of these ailerons making them sensitive to changes in contour. This produces an apparent wing heaviness that is corrected with the ailerons rather than on the wing rigging. On the under surface of the aileron near the outer end two ribs are provided with a variable camber device. Cover is cut to reach them. Two screws are turned to change camber, backing them off until the aileron rides evenly in flight on the one which rides high. Test fly until satisfactory.

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WACO F:

1. Remove streamline wire-end terminals and screw them back on five complete turns to insure an equal amount of adjustment on each threaded end.
2. Bolt center-section struts to center-section.
3. Mount center section on fuselage.
4. Fasten center section wires.
5. Adjust c e n t e r section wires so that the distances between pin centers are the same on both wires.
6. Fasten front and diagonal interplane struts on upper wing with adjustment ends at bottom. Fig. 9a.
7. Mount lower wing on wing fittings on fuselage, and insert % in. bolts, long one front, short one rear. Wing tip must be propped up in position until upper wing is mounted and landing wires are fastened and tightened.
8. Fasten long interplane strut to rear of diagonal strut. Fig. 9a.
9. Mount upper wings on center section, using 5/16 in. bolts with taper bushings.
10. Bolt interplane strut on lower wing.
11. Put on landing and flying wires, with lefthand thread to the top. Don't tighten.
12. Draw up front landing wire to 94Vs in. between terminal ends, Fig. 9d.
13. Tighten rear landing wire until tension on both wires is equal.
14. Tighten flying wires.
15. Wings are rigged with no warp, as no allowance for propeller torque is needed.
16. Adjust interplane struts.
17. Cotter all fastenings.
18. Connect aileron push tubes under fuselage so that both lower ailerons are even with the wing trailing edge when control stick is in neutral.
19. Adjust aileron struts so that upper and lower ailerons are even with wing.

Herewith is a table of rigging specifications for several biplanes, reprinted from CAA Aviation Safety Release No. 317, April 7, 1949. The gap figures given for the Great Lakes biplane do not make sense to the writer but they are printed

as
given in that official release.

Sky Gypsy is on the move again….

Howdy,

Please remove the ad for Sky Gypsy from the newsletter and web page as it has sold to a gentleman up in the Minneapolis area. Likely the airplane will spend the winter in Texas and he will fly it up to Minnesota when the spring weather permits.

Thanks for your help,

Kevin Ross

Thanks for the update Kevin. Did you give the new owner our address?

The Editor in central Indiana on a fall afternoon….