CHAPTER 15
REVISION LIST

The following list of revisions will allow you to update the Lancair ES construction manual chapter listed above.

Under the "Action" column, "R&R" directs you to remove and replace the pages affect by the revision. "Add" directs you to insert the pages shown and "R" to remove the pages.

Page(s) affected	Current Rev.#	Action	Description
15-1 thru 15-10	0	None	
15-11	B3	R&R	-
15-12 thru 15-18	0	None	
15-19	B3	R&R	-
15-20 thru 15-27	0	None	
15-28	B6	R&R	Added figure 15-9a
15-29 thru 15-31	0	None	

CHAPTER 15:
CONTROL SYSTEMS / RIGGING

REVISIONS

From time to time, revisions to this assembly manual may be deemed necessary. When such revisions are made, you should immediately replace all outdated pages with the revised pages. Discard the out dated pages. Note that on the lower right corner of each page is a "revision date". Initial printings will have the number "0" printed and the printing date. All subsequent revisions will have the revision number followed by the date of that revision. When such revisions are made, a "table of revisions" page will also be issued. This page (or pages) should be inserted in front of the opening page (this page) of each affected chapter. A new "table of revisions" page will accompany any revision made to a chapter.

Arrows

Most drawings will have arrows to show which direction the parts are facing, unless the drawing itself makes that very obvious. **"A/C UP"** refers to the direction that would be up if the part were installed in a plane sitting in the upright position. In most cases the part shown will be oriented in the same position as the part itself will be placed during that particular assembly step. However, time goes on and changes are made, so careful attention should be paid to the orientation arrows. That old cartoon of the guy agonizing over the plans for his canoe, built one end up, one end down, should not happen in real life. Especially to you.

CONTENTS

1. INTRODUCTION

This chapter will address each control system and adjustment.

2. DRAWING LIST

3. EQUIPMENT REQUIRED - SPECIAL PARTS, TOOLS & SUPPLIES

A. Parts

•

B. Tools

- drill motor
- drill bits: 1/2"
  #12
  #30
- hammer
- hack saw
- tape measure
- rotary grinder (Dremel or equiv.)
- 5-10 lb weight bags (2)
- 3/8" socket and ratchet wrench (2)
- flat file
- protractor, degree reading

C. Materials & supplies

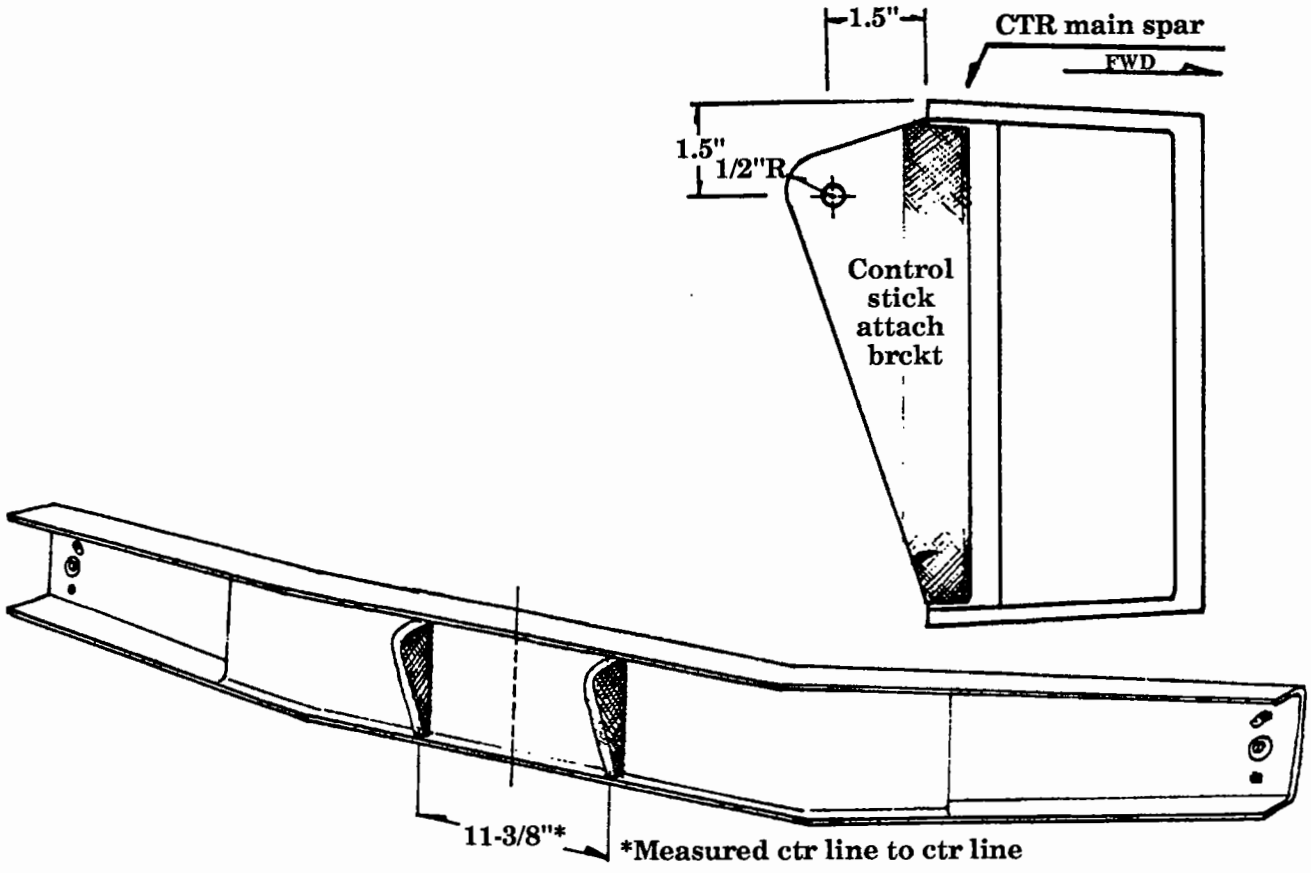
- epoxy
- flox
- BID cloth
- micro
- sandpaper, assorted grit
- Duct tape or release tape
- MC or acetone for cleaning
- zinc chromate paint
- top coat for applying over zinc chromate (on pushrods)

4. PROCEDURE
A. Stick assembly

1. The control stick assembly will attach directly to the main spar web via the two attach brackets fabricated out of phenolic. Refer to figure 15-1. The "Stick Crossover Weldment", figure 15-2, will attach directly to these two phenolic brackets with the AN4-11 bolts using AN310-4 castle nuts and cotter pins. See figure 15-2 for proper orientation onto the attach brackets.

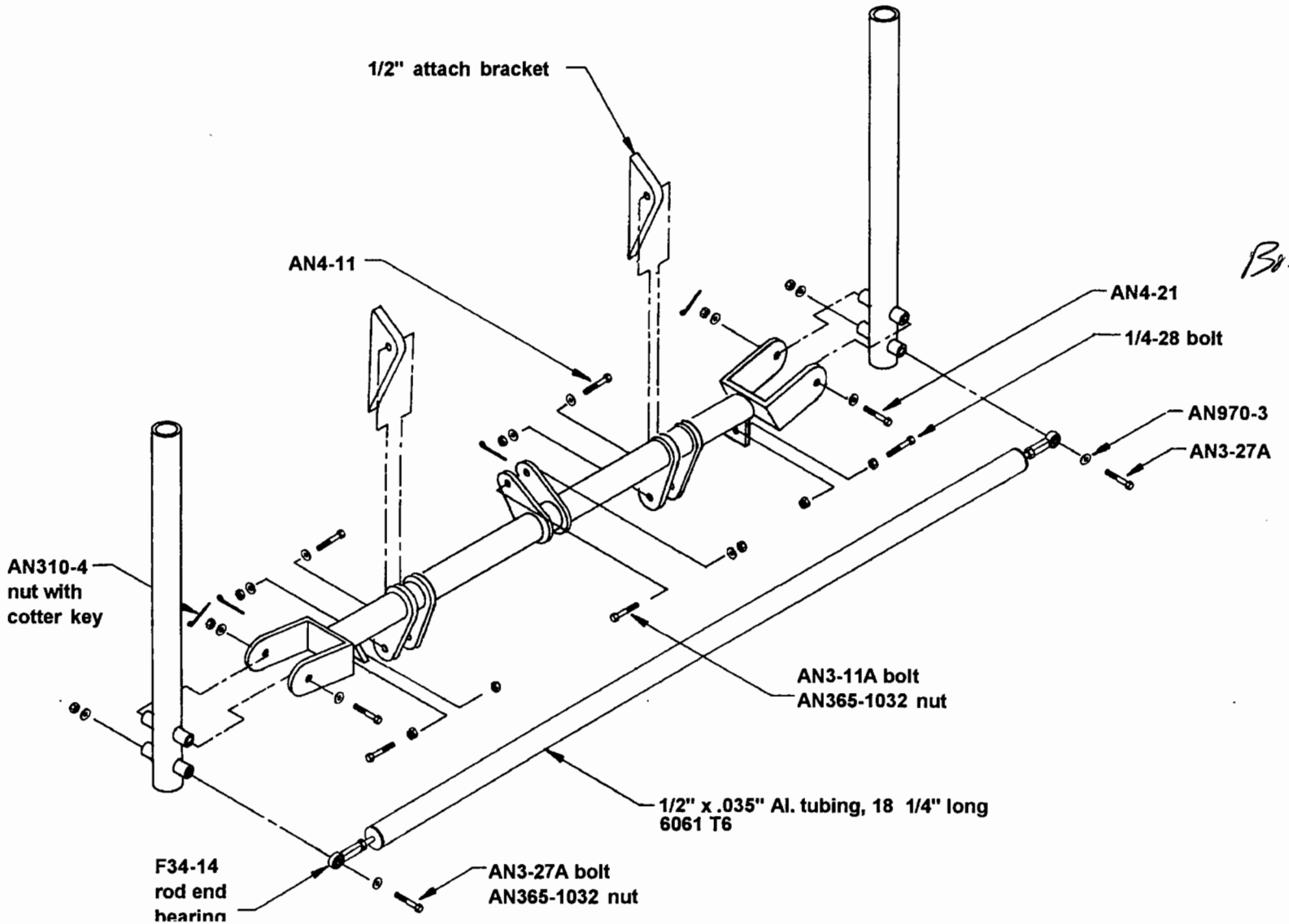
NOTE: You might find it easiest to first assemble the sticks and their linking push rod prior to installing into the fuselage.

Main Spar Web Attach Brackets
Figure 15-1



CROSSOVER WELDMENT INSTALLATION

Figure 15-2



Both The Same

2. Install the two control sticks using the AN4-21 bolts with AN310-4 castle nuts with cotter pins. The sticks should be positioned with the longer portion of the pivot bushing to the fwd side of the stick tube itself. Place a small dab of grease on the bolt prior to inserting into the assembly. Also, the nuts should be set such that there is no "slop" yet the side to side rotation of the stick is smooth and easy.

3. Make a push rod tube (AL-1) that will connect the lower ends of each stick, see figure 15-3. This 1/2" O.D. tube should be cut 18-1/4" long. Insert the rod ends (AN490HT-8P) and secure them with two rivets each. These rivets must be "peened" over with a hammer, do not use a rivet squeezer.

4. Thread the check nuts (AN315-4) and follow with the rod end bearings (F34-14). Adjust these rod ends until, when placed on the lower end of the stick, the sticks are positioned parallel to each other. Set the rod end bearings by tightening the jam nut against them. Temporarily slip this assembly together using the AN3-27A bolts. (These bolts will be too long until the additional aileron push rods are attached, but it will still help hold it together for now.)

NOTE: The control sticks are made to accept a stick handle with a 3/4" I.D. (inside diameter). You may wish to trim the control sticks down but you should have your stick handles first since they will contribute to the overall length of the control stick assembly.

B. Aileron Control System Installations

Also refer to page 10-16, "Aileron Travel Limits". Some of that section will be duplicated here.

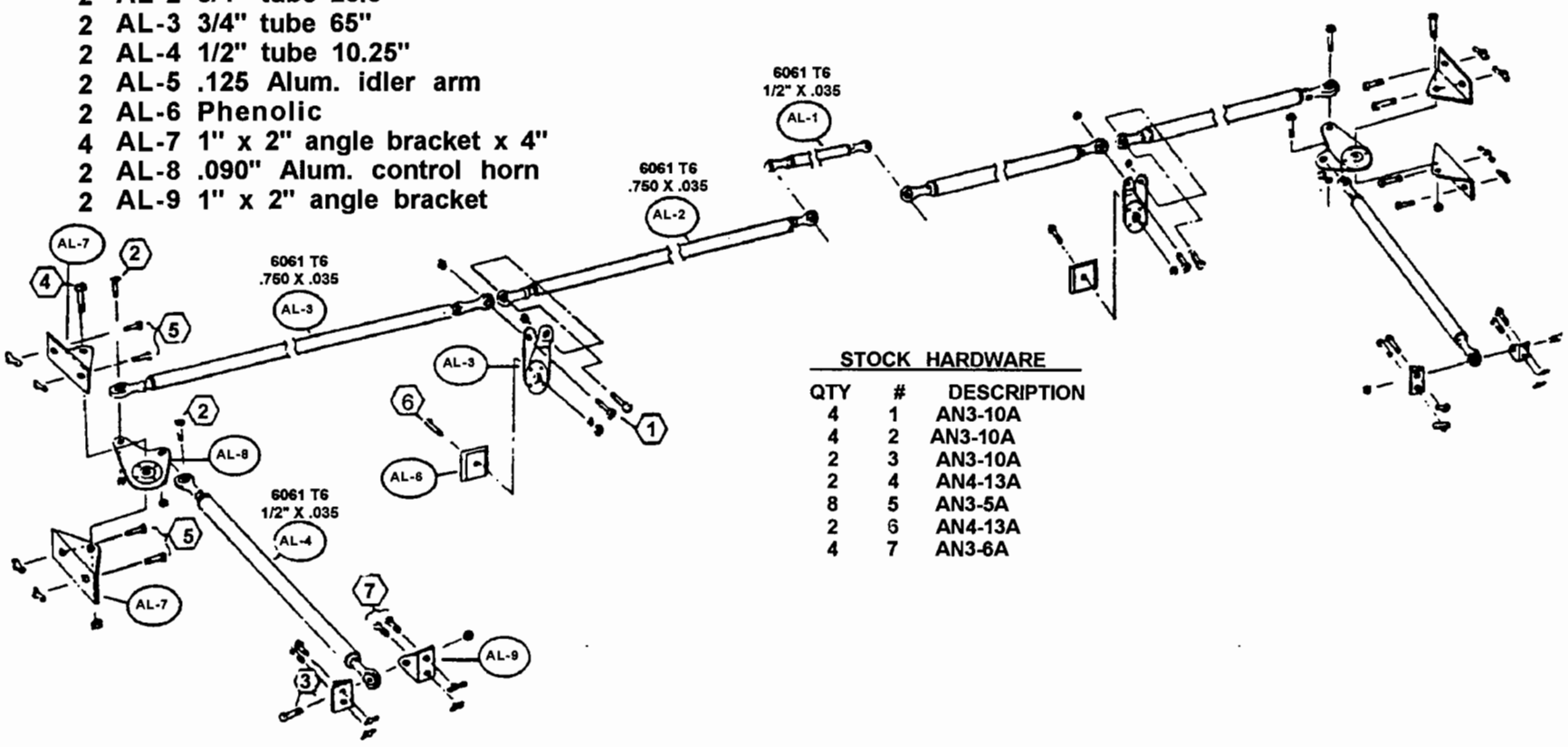
1. See the Aileron breakdown drawing, figure 15-3. The aileron idler arms should be fabricated using the drawings in figure 2-10. It is recommended that the alternate AL-3 attachment location be used, see "NOTE" on figure 2-10.

2. The aileron bellcranks should be fabricated and installed (see pages 9-16 through 9-24), and the aileron control horns should also be installed (page 10-11, figure 10-5). You are now ready to install the remaining pushrods, see figure 15-3.

QTY	#	Description
1	AL-1	1/2" tubing, 18 1/4"
2	AL-2	3/4" tube 20.0"
2	AL-3	3/4" tube 65"
2	AL-4	1/2" tube 10.25"
2	AL-5	.125 Alum. idler arm
2	AL-6	Phenolic
4	AL-7	1" x 2" angle bracket x 4"
2	AL-8	.090" Alum. control horn
2	AL-9	1" x 2" angle bracket

AILERON CONTROL SYSTEM

FIGURE 15-3



STOCK HARDWARE

QTY	#	DESCRIPTION
4	1	AN3-10A
4	2	AN3-10A
2	3	AN3-10A
2	4	AN4-13A
8	5	AN3-5A
2	6	AN4-13A
4	7	AN3-6A

C. Control stick assembly to aileron idler arm

1. The AL-2 push rods (3/4" diameter) will attach between the control sticks and the aileron idler in the stub wing. They will therefore be transitioning through the cockpit closeout ribs. See page 4-20, figure 4-12 for the approximate clearance hole required.

   WARNING: This AL-2 push rod clearance hole in the close out rib must be kept small to maintain structural integrity. The hole must not be more than 10% larger than indicated in figure 4-12 on page 4-20.

2. Measure for the proper required length of the AL-2 push rods.

   NOTE: For adjustment of the AL-2 push rods, hold the stick assembly in the vertical position and place the idler arms such that the two push rod attachment holes at its top are equidistant (measured left to right) from an imaginary line projected straight up from the lower 1/4" BC4 bearing attachment of the idler. It is very important that both left and right idler arms are in identical positions. If they are not, the ailerons will not operate with the proper travel ranges relative to one another.

3. Use a tape measure to check for the push rod length while the control stick is vertical and the aileron idler arm is also vertical (see above note). Be sure to deduct 4" from the overall length required when cutting the push rod tube. This is to allow for the rod end installations at each end of the push rod tube (you may want to first check the length again with the rod ends merely slipped and taped into position on the push rod tubes. After the length is verified, attach the rod ends with the AN470AD-4-16 rivets. Some kits may have been supplied with longer rivets (-22's), these should be trimmed to 1-1/8" in length. Thread the bearings onto the rod ends.

   Attach the AL-2 push rod and check for clearance at the cockpit close out rib. The left to right action can be simulated accurately by moving the control stick full left and right until it hits the stops on the stick cross over weldment. The fwd to aft movement can not be adequately determined until the elevator linkage is attached, therefore this will be checked later.

4. When attaching AL-2 the pushrod bearings onto the stick and idler arms, check to verify that the bearing housing does not hit the stick or idler arm. If it does, a bind will result. Since the travel requirements of the system are substantial, a small washer used as a spacer is often required to shim the bearing out just a little from its attachment surface. This provides additional rotational room for the bearing housing.

D. Aileron idler arm to outbd bellcrank

1. Attach the AL-3 pushrods. Set the outbd aileron bellcrank neutral position such that 1-1/4" of travel is available in a direction outward toward the wing rib that it is attached to. This will leave a little clearance when the 1-1/8" of travel is made, see figure 9-8, page 9-17.

2. Measure for and attach these AL-3 push rods in a similar manner as used with the measure and fabrication of the AL-2 push rods. Check that there is clearance from the aluminum tube inserted through the fuel tank. There must be no contact throughout the full aileron travel range. Again, check that the bearing housings clear their attachments. Set the checkouts tightly against the bearings.

E. Aileron bellcrank to control horn on aileron

1. Next fabricate and install the AL-4 push rods which connect from the outboard aileron bellcrank to the aileron control horn. This is a 1/2" diameter push rod and uses AN490HT-8P rod ends. With the control stick still in the neutral position, attach the AL-4 push rod and set the aileron at the neutral (in-plane) position.

2. Router the access hole through the aft spar web using a drill bit first and follow up with a rotary tool to enlarge as required for adequate clearances through all ranges of aileron travel. Again, keep this hole as small as possible.

F. Aileron control adjustments & limit stops

With all the push rods connected, it is time to adjust the system and verify the proper travel ranges and limit stop.

1. See figure 15-4 for aileron travel ranges. You'll need an assistant to help perform an accurate check. Have him push the control stick to the maximum left position. Then check the upward travel of the left aileron and the downward travel of the right aileron (± 1/8" is acceptable). Do the same with the control stick in the maximum right position.

2. It can often take a lot of back and forth adjusting of the aileron push rods until acceptable travel ranges are established. This can be frustrating if you have the symmetry off since that will adversely affect the aileron differential.

> **NOTE:** As a helpful tip during rigging: If you find that the differential is not working out the same for one side vs. the other side, it is most likely the aileron bellcrank that is slightly out of rig, i.e., those two bellcranks are probably not aligned the same relative to the "square" of the airframe.

G. Aileron adjustment corrections

Select the aileron that does not produce as much UP travel as the other. Have someone hold the control stick in the direction of that aileron. Disconnect the AL-4 pushrod and extend it so as to produce more up aileron. Re-attach and check against the other aileron. With this adjustment, the downward travel will be minimally affected. Rigging corrections may be required elsewhere but this is a good location to first inspect and adjust.

1. The limit stops can usually be set by the maximum allowable travel within the stick assembly itself. That is, the sticks will only rotate outboard until they contact the crossover weldment (at lower portion of stick). You'll also notice that the cross over weldment also has provisions for an adjustment screw stop on each side. This can be used if desired but the natural stops are usually correct. If you choose to use the screw stops, use a 1/4" bolt with check nuts on each side of the drilled tab under the cross over weldment. Adjust as necessary on each side and lock in position with the two check nuts - one on each side of the tab.

2. When all is adjusted correctly, there should be absolutely no binding of controls and no interference fits or rubs. If when all assembled, you find a peculiar bind of any type, it may be easiest to disconnect various sections and independently check them for the bind. Otherwise, it can be difficult to determine exactly where the bind is being generated.

CAUTION: All rod end bearings must have an area washer used if the bearing is being attached in a single shear mode, i.e., if it is being bolted up to the side of a tab or controlling arm. The washer must be on the opposite side of the controlling arm attachment. This is to prevent the bearing from slipping off the bolt if it were to work loose from the rod end bearing housing into which it is installed. Use AN970-3 type washers.

Elevators

The elevator and control horn should be already installed per instructions in chapter 7, see figure 7-7.

The elevator push rods will travel from the stick crossover weldment, over the aft spar and through the baggage bulkhead where the idler arm will be located. From there the second pushrod will route directly to the elevator control horns.

H. Elevator idler arm

1. The standard elevator idler arm on the Lancair 320 also incorporates a bob-weight system. The weighted system will introduce dynamic feedback into the elevator controls. See figure 15-5. The idler arm is required for several reasons. The primary reason is for system rigidity and also to help keep the controls low over the fuselage bottom.

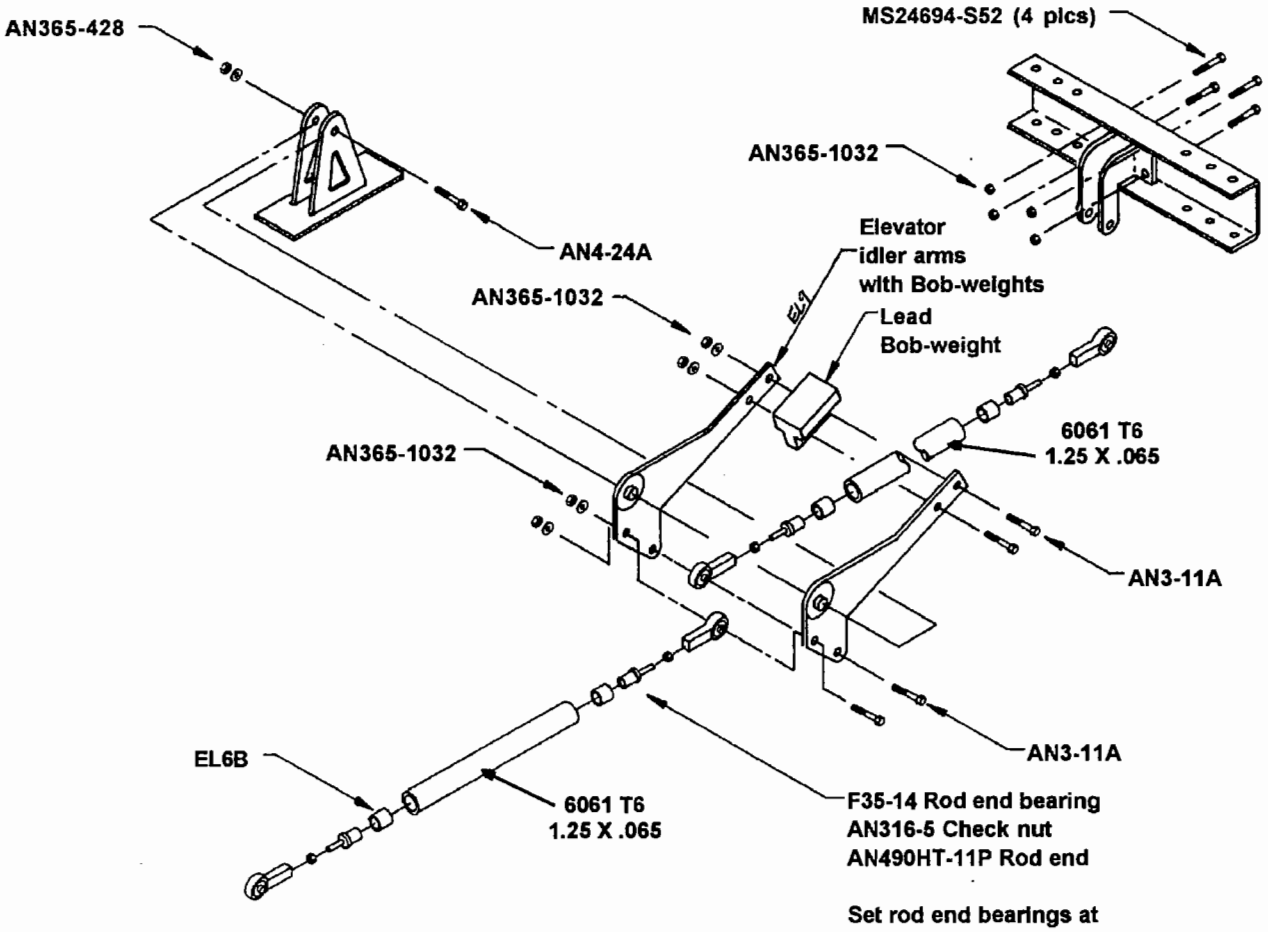
2. Select the two, pre-cut idler/bob-weight arms and the two BC4 bellcrank bearings. Per figure 15-5, attach the bellcrank bearings to the idler arms using six (6) rivets AN470AD-4-6) per bearing. (You can of course install all twelve rivet locations per bearing but six is sufficient and is the minimum allowable). Note that when you place both idler arms together, the bearings will mount to the same side of each arm, they are not mounted in a mirror image fashion. In this manner, one bearing flange will be located between the two idler arms and the other bearing flange will be to the outside of the assembled idler arm system.

   Check that the chamfer made in the idler arms is sufficient to accept the fillet on the bearing. The bearing flange must sit FLAT against the idler arm. File if necessary.

   You may use a rivet squeezer if desired to properly set the AN470AD-4-6 rivets or peen them by hand. Use a #30 drill bit for these rivets.

Elevator Idler Arm/ Bob-Weight

Figure 15-5



I. Elevator idler arm attach bracket

1. Next build the Elevator Idler Arm Attach Bracket, see figure 15-6.
   This attach bracket is made of 1/4" plywood (excess from the firewall plywood section). Cut the two side panels and the base plate per figure 15-6. Go ahead and drill the 1/4" bolt hole in the tops and the oval slot in the middle of the side pieces. If you stack the two side pieces together during this drilling, then the holes will be well aligned.
   To cut the oval slot, use a 3/4" drill bit at each end (drill centers spaced 1-1/4" apart) and complete the oval using a sabre saw (with a fine cut blade) for the side cuts.

2. Use epoxy/flox to attach the side panels to the base plate, be sure to establish the necessary spacing per figure 15-6. It is perhaps easiest to now allow this to cure.
   Then add the 2 BID layup to the inside first and follow with the 2 BID on the outside. Allow to cure. This 2 BID on each side MUST cover the entire faces of the side plates. Place a small epoxy/flox fillet in the inside corners where the inside 2 BID will wrap around. This may be a little difficult to get in and stipple the BID but care must be used to achieve a good job on the part.

   WARNING: There must be no air voids along this inside joint line. The presence of air voids could cause part failure and loss of elevator controls.

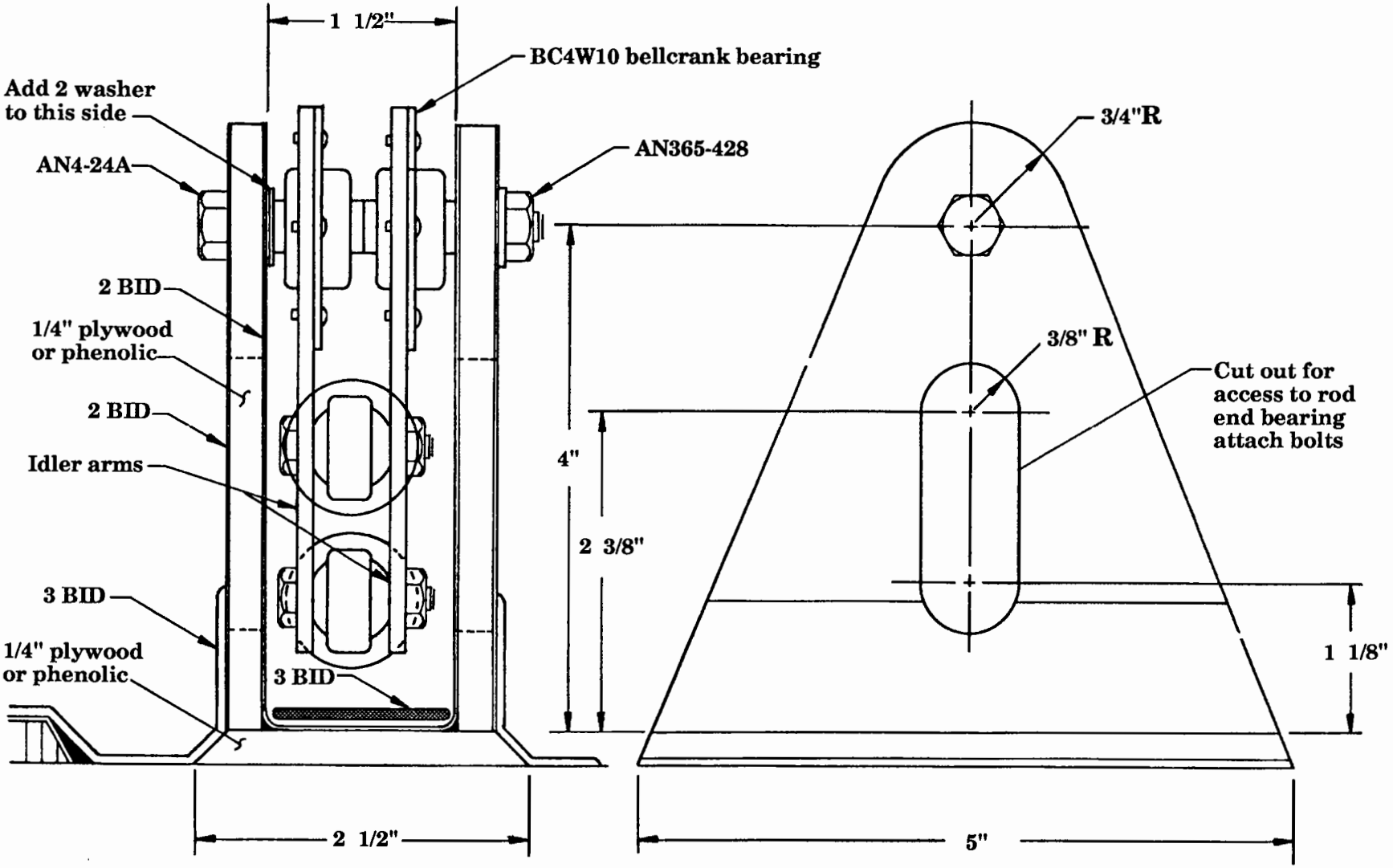
3. After the assembly has cured, use an X-acto knife to carefully trim the glass away from the oval cutout in the center of the side panels. Use a heat gun to soften the glass which will first allow for easy trimming and also provide a secondary post cure as it cools back down. Carefully trim the BID away from the 1/4" bolt hole as well.

4. The finished assembly will install onto the fuselage floor, along centerline. Locate the bracket assembly at FS-94 which is just aft of the baggage bulkhead.

   NOTE: Earlier Lancair 320 plans called for the baggage bulkhead at FS-96. While this is perfectly acceptable, the idler arm bracket assembly should then be placed 1" aft of the baggage bulkhead.

5. Clean and prepare the area on the fslg floor (lower joggle seam at centerline) where the attach bracket assembly will be installed.

6. Using a generous amount of epoxy/flox under the bracket assembly, pot the assembly onto the floor in the correct location. Check that it is parallel to the centerline of the fslg and on centerline as well. Apply weights (5-10 lbs of lead shot or equiv.) during cure. Clean away any squeeze out of flox and allow to cure.



ELEVATOR IDLER ARM ASSEMBLY
FIGURE 15-6

7. Next add 3 BID tapes to both sides of the assembly and also through the center section of the bracket assembly. Contact at least 2 inches all around the assembly. The attachment BID tapes will ride up onto the honeycomb core material, use a light epoxy/flox fillet where necessary to assure a smooth, air bubble free, application of these BID tapes. See figure 15-6.

8. Next install the lead bob-weight into the two idler arms. Place a bolt temporarily through the bearings, also set one bolt through one set of the lower push rod attach bolt holes (AN3 bolt needed). These two bolt holes will hold the two idler arms in proper alignment during installation of the lead weight. See figure 15-5. Position the lead weight and use a #12 drill bit to drill through for the installation of the two AN3 attach bolts and AN365-1032 stop nuts. The lead MUST be positioned such that it extends above the idler arms, not below.

9. Next install the idler arms into the attach bracket in the fslg using the AN4-22A bolt. They will install such that the lead weight is to the aft side. Note that there are two AN960-416 washers placed between the inner side of the plate and the idler arm that has the bearing mounted to the INSIDE (nearest fslg centerline) of it. The idler arm with the bearing mounted to the OUTBD side will not require a washer. These two washers are to provide adequate clearance room for the bolt heads that will later attach the two elevator push rod bearings.
See figure 15-6. Set the 1/4" pivot bolt with the AN365-428 stop nut.

10. The elevator idler arm assembly should be fully installed at this time. The two push rods will be later attached to them. Access to the bolts that hold the push rods will be made available through the two oval cut outs in the side plates. A standard 3/8" socket will fit through these ovals.

J. Elevator push rod installation

1. Two push rods will be installed. These are 1-1/4" x .065" 6061-T6 tubes. EL6B plugs will be installed into each end which will accept the AN490HT-11P rod ends. The rod end bearings used are F35-14 which have a 5/16" female threaded socket and an AN3 bolt hole in the bearing.

2. First set all the controls to the neutral position. The control sticks should be initially in the vertical position. The idler arm should be positioned so that the forward push rod attach hole is directly below the 1/4" pivot bolt above.

3. Use a measuring tape to accurately measure the required total length of each push rod assembly. From that measurement, deduct 4" in overall length which will account for the space taken by the two bearing assembly ends.

4. Next saw the 1-1/4" tubing to length. Use a hacksaw. Make sure the saw cuts are straight across the tube (perpendicular). File the ends flat with a flat file. Insert the EL6B machined aluminum plugs and then the rod ends (AN490HT-11P). Before you secure them with the two rivets, thread the bearings on and check the assembly for proper length by installing the push rods temporarily into the fslg (use a wrap of tape to temporarily hold the rod ends into the ends of the 1-1/4" tubes).

K. Elevator control access panels

1. The elevator push rod will require two access panels so that you can reach and attach the bolt that secures the aft push rod into the elevator control horn assembly. See figure 15-7. This will require an access hole on the right side that is large enough to allow you to reach in with your fingers, set the bearing and insert the AN3 bolt. An additional small round hole must be drilled into the left side to allow access of a 3/8" socket. With this hole, you can slip the AN365-1032 stop nut into the socket and slip that into the hole and onto the AN3 bolt. Tighten up using another 3/8" socket from the other side. A 3/4" hole is sufficient on the left side which will allow for a simple installation of a 3/4" circular panel cover that simply snaps into position.

   Make a panel to close out the right side access hole from a piece of .025" aluminum or similar. Simply make it so that it fits the hole with about 1/4" overlap on the fwd, aft and bottom sides. The top will fit to the 13° DN elevator travel limit (the down limit stop will be established on the left side, see step L3, below). This larger access panel can simply be attached with silicone. Apply a good bead all around with the overlap surfaces and press the panel into position. Allow to cure with pressure against it.

2. With the push rod lengths verified, permanently install the rod ends into the 1-1/4" tubes. See figure 15-8. Use two AN470AD-4-24 rivets. These rivets must be "peened", do not use a rivet squeezer.

   WARNING: When checking and adjusting the push rod lengths, the rod end bearings MUST be threaded onto the rod ends by at least the equivalent length of the rod end diameter. Also, the rivets that set the rod ends into the push rod must be peened. Do not use a rivet squeezer. Failure to establish these criteria could result in push rod failure and resultant control surface failure.

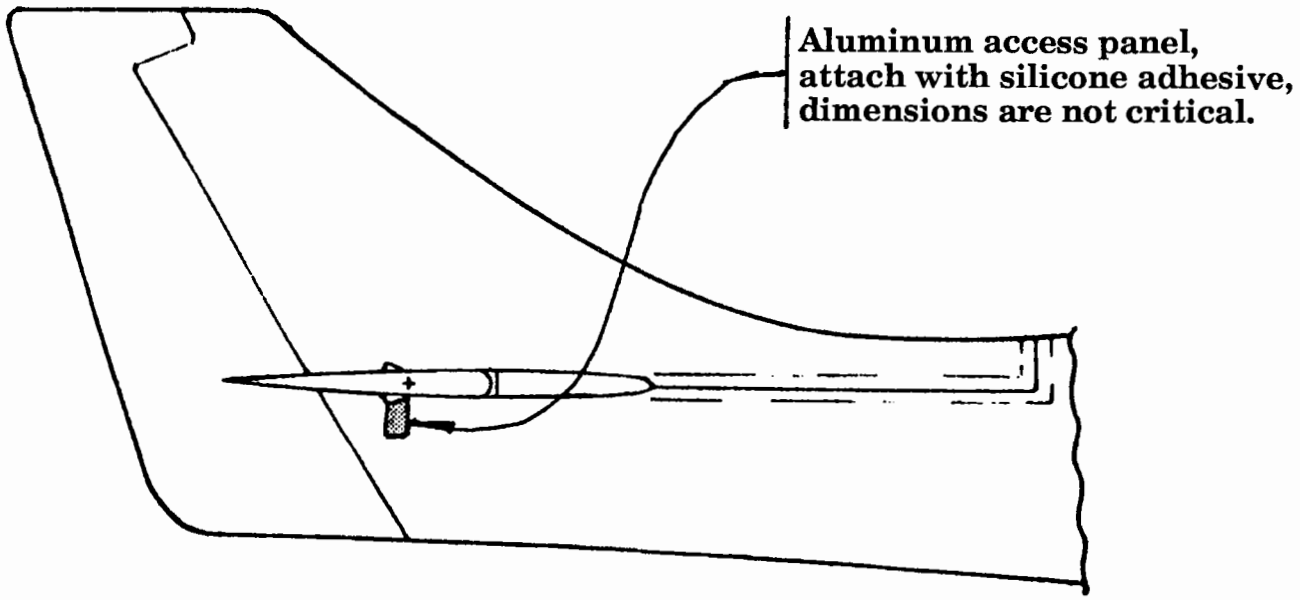
3. Set the rod end bearings with check nuts (AN316-5) tightened against the rod end bearing body.

4. With the push rods now completed, mask off the rod end portions of them and paint the tubes with zinc chromate. You may also wish to follow that up with a "finished" enamel, acrylic or urethane top coat paint (hardware store "rattle can" paints will work just fine).

   NOTE: It is generally best to select a light colored top coat since that will allow for improved visibility of the surfaces during inspections.

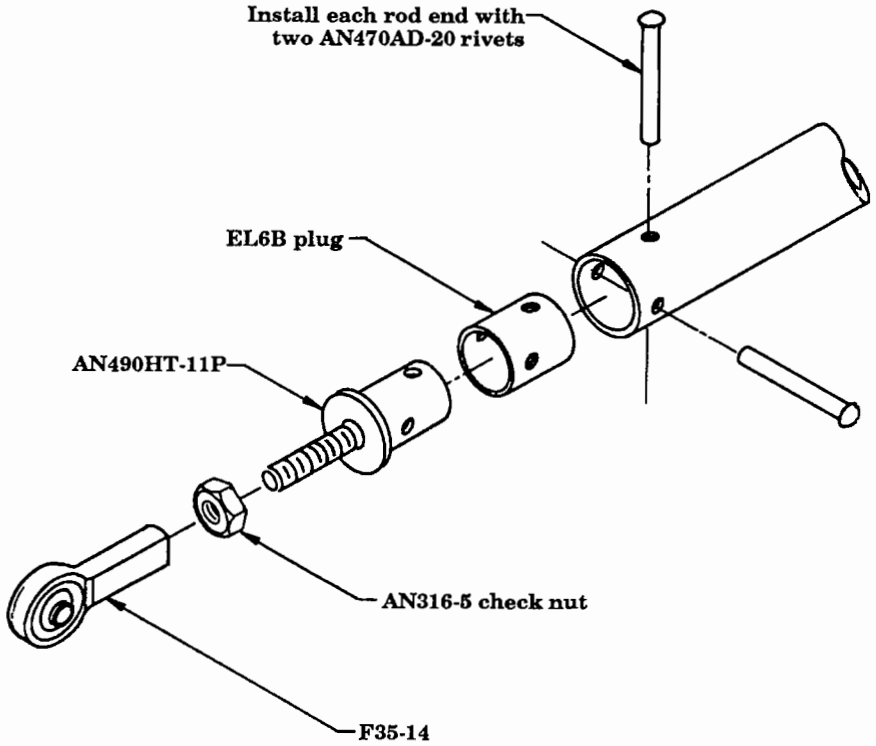
Access panel, elevator control horn

Figure 15-7



Push rod assembly

Figure 15-8



L. Elevator control adjustments & limit stops

With the push rods completed you'll need to establish proper adjustment of the system.

1. Connect the push rods (it is best to simply slip the rod end bearing attach bolts and omit the nuts for now since you'll likely be making several small adjustments of the bearings which will require frequent removals and you'll get real tired of installing and removing the stop nuts. Also the stop nuts will get worn out and would require replacement since they should not be used more than three times).

   With the stick in the vertical position, the elevator should also be in the neutral position.

2. Place a degree reading protractor on the elevator and if it's adjustable, set it to zero. If it is not adjustable, then simply note the angle it is reading.

   IMPORTANT: The correct elevator travel range is 27° UP and 13° DOWN.

3. The travel stops for the elevator must be established back where the elevator crosses through the tail cone. The clearance cut must be set to establish these control limits. If adjustment is required either clearance more for additional travel range or if less is required, cut a small phenolic block and insert it into the clearance hole, align and bond to the inside of the skin with structural adhesive. See figure 15-9.

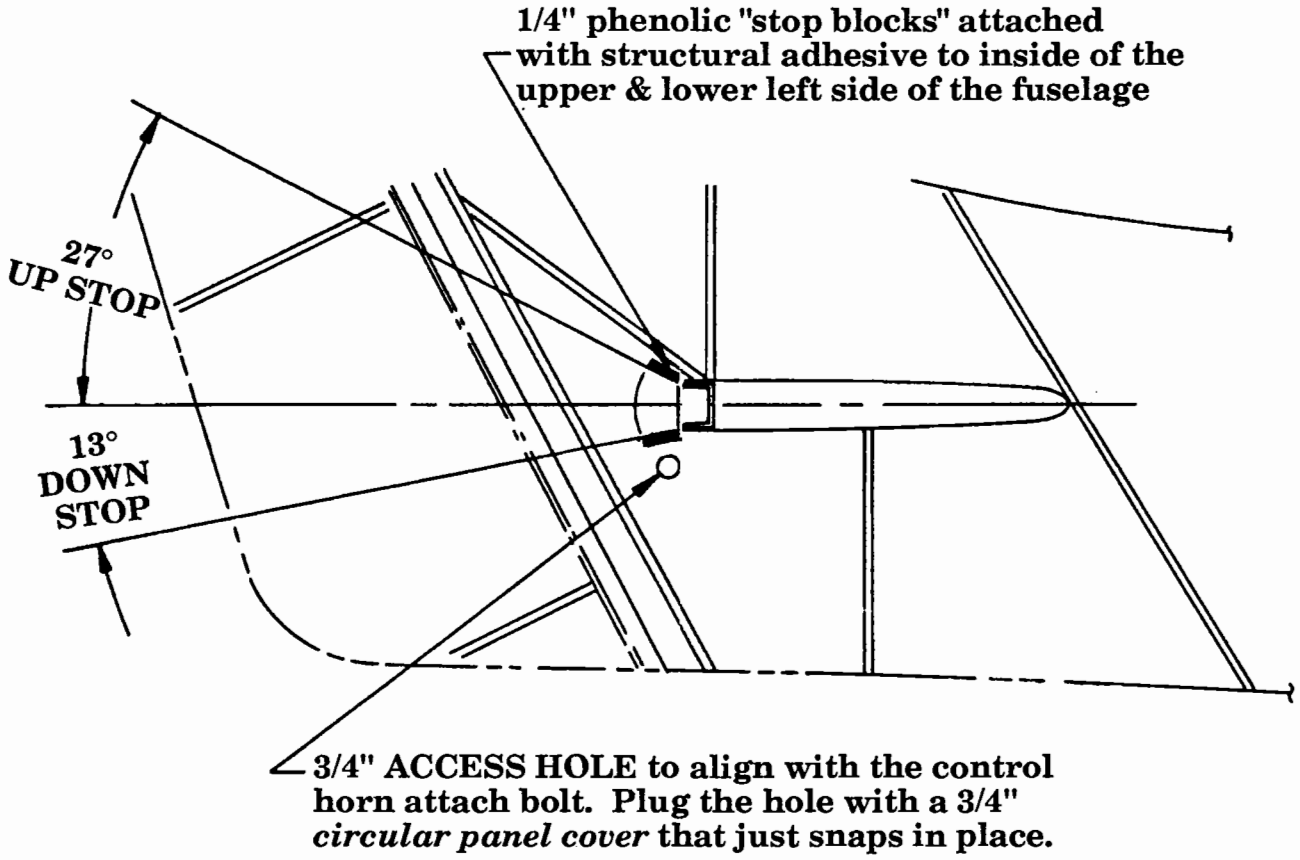
4. Raise the elevator until the degree reading protractor reads 27° up. Set the clearance hole to allow only that amount of upward travel.

5. Lower the elevator to establish the 13° down travel limit.

6. Now sit in the cockpit and verify that in your normal seated position, you will actually be able to reach the control limit stops by moving the control stick. If necessary, adjust the control stick forward or aft to achieve full available travel from the cockpit. This can be accomplished by adjusting the rod end bearings on the push rods.

   EXAMPLE: if you are unable to pull the stick back far enough to achieve full up elevator then you'll have to establish the neutral position of the stick farther forward. To do this, lengthen the forward push rod slightly.

Elevator travel stops
Figure 15-9



7. There are three additional KEY checks that must be made and will affect available travel.

   a. The most forward position that the stick assembly can be set at is established by the required clearances needed between the forward most push rod bearing and its clearance from the top of the stick crossover weldment. If a more forward control stick position were needed, then you would have to modify the control stick itself to lean forward.

   b. The bob-weight must have positive clearance from the aft push rod when the elevator is positioned into the most DOWN position. If the lead weight contacts the aft push rod in the 13° DOWN position, then the aft push rod will have to be shortened. And to keep the control stick in the same position, the forward push rod will have to be lengthened by approximately the same amount. This will then have the net effect of raising the bob-weight assembly for the same elevator position and control stick orientation.

c. The elevator idler arm attach bracket side plates must have sufficient clearance away from the two AN3 bearing attach bolts that fit through the bottom of the idler arms. Swing the system back and forth to verify positive clearances. If your dimensions are correct though, this should not be a concern.

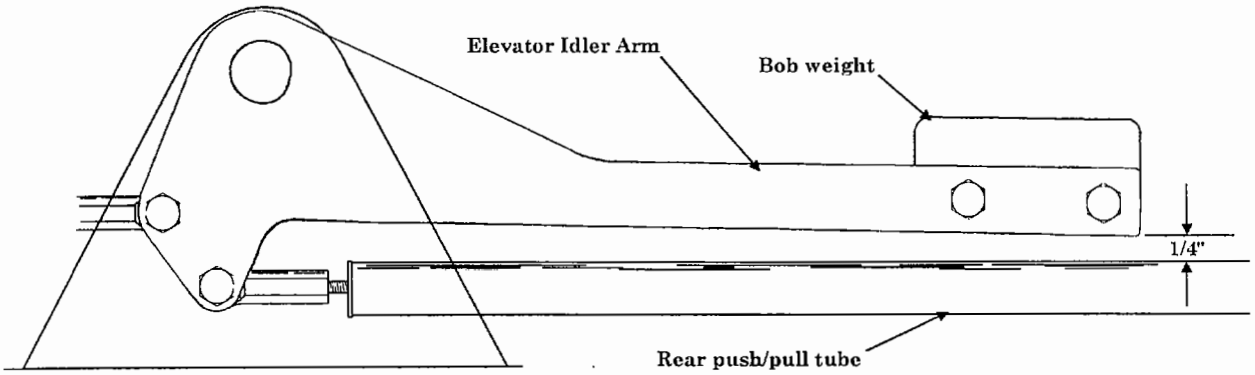
8. With all the control checks made and all limit stops established, the elevator control system is complete.

9. Since you will likely have the system apart again, (probably during airframe painting, etc.), be certain that when you finally do install the pushrods back into the airframe, you use stop nuts to secure all the bearings.

10. Finally, with the elevator controls fully installed, check that the aileron AL-2 push rod will still have positive clearance from the cockpit closeout rib throughout the full elevator travel ranges (as the control stick is moved fwd to aft, the aileron AL-2 push rod will also swing fwd to aft and thus affect the clearance needed in the cockpit closeout rib).

Set the Elevator Rigging

Figure 15-9a



With the control stick all the way forward, the elevator should be on the down stop and the bob weight should be 1/4" off the rear push pull tube. This will set the proper rigging for the elevator.

M. Rudder

This will complete installation of the rudder pedal assembly and the rudder must be installed (it need not be locked into position, merely dropped onto its pivot pin bushings on the vertical tail post).
Refer to figure 15-10 for travel range measurements.

1. The rudder control stops should already be set per chapter 8, section G titled "Rudder travel stops" on page 8-33.

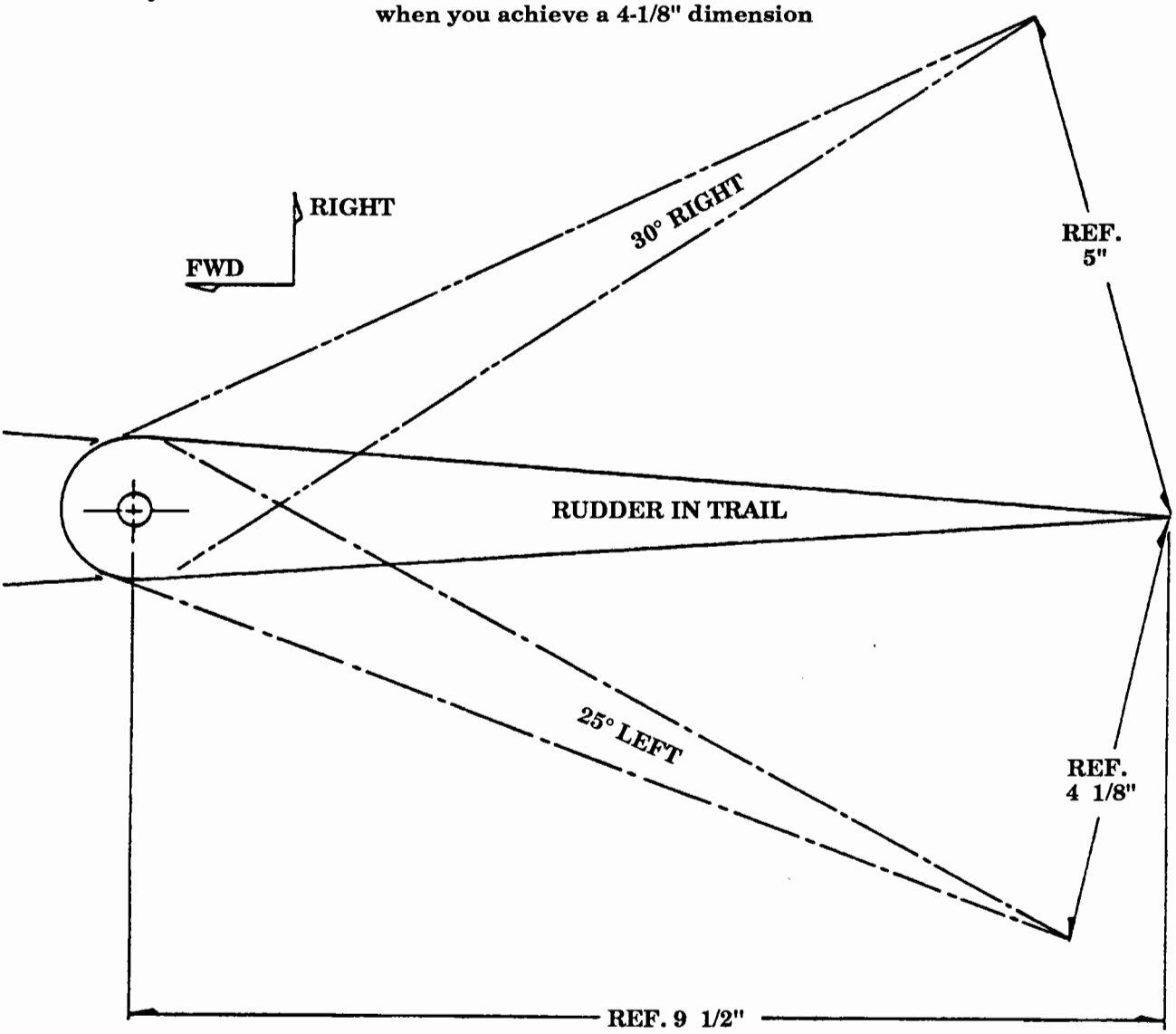
2. While seated in the cockpit, push the rudder pedals and have someone at the tail to verify that you are in fact, reaching the limit stops positioned into the vertical fin area down at the rudder control horn. Control movement should be smooth and the limit stops should be attainable.

Establishing Rudder Travel

Figure 15-10

30° Right Rudder, 25° Left Rudder

To check and establish the rudder travel limits, find a section on the rudder where the chord is 9-1.2" and use it simply as a reference point (the top of the rudder just below the counterbalance section is adequate). At this point, standing behind the rudder, you"ll have 30°'s right rudder when you achieve a 5" dimension as shown below. 25°s left rudder will be established when you achieve a 4-1/8" dimension



N. Flaps

1. The adjustment of the flap linkage is covered beginning on chapter 10, page 10-30 "Flap pushrod installations and adjustments".

2. The flaps are actuated via the electric linear actuator and the accompanying custom micro switch unit that installs onto the actuator. The micro switch adjustments will be covered in chapter 18 "Electrical Installations".

This concludes this chapter