

Chapter 8 Elevator Controls

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8.1 Introduction

Between the control stick, which was assembled in Chapter 7, and the center elevator weldment, which was installed in Chapter 3, there are two fixed assemblies to complete. The first is the elevator torque tube and the second is the elevator idler arm. The elevator torque tube is mounted to the forward face of the bulkhead, coupling the two pushrods along the sides of the fuselage to one pushrod that goes back to the elevator. The elevator idler is necessary to break up the long run from the torque tube to the center elevator weldment.

Before you can complete the last connection, the idler arm/center elevator weldment pushrod to the center elevator weldment, you will need to continue with the construction of your airplane and return to this connection after completing Chapter 18, Chapter 18 *Mounting the Vertical Stabilizer and Rudder*.

Steps to Completion

- Assemble the elevator idler arm.
- Install the elevator idler arm.
- Mount the elevator torque tube
- Make the elevator pushrod enclosure.
- Make and install the forward pushrod.
- Make and install the torque tube/idler arm pushrod.
- Make and install the idler arm/center elevator weldment pushrod.
- Adjust the elevator controls by checking the elevator controls to the aileron travel.

Construction Prep.

A Word about Sanding and Cleaning

The instructions in this chapter refer to preparing a surface or preparing a bonding area. When we recommend preparing a surface or a bonding area, we expect each of the following steps to be completed every time.

1. Sand the area using 40-grit sandpaper.
2. Vacuum all sanded areas.
3. Clean all sanded surfaces with Acetone.

8.2 Parts List

Idler arm assembly

Item	Part Number	QTY	Description
1)	BC4W10	1	Bearing for elevator idler arm
2)	EL-056-02	2	Elevator idler arm
3)	AN470AD4-8	6	Rivets
4)	EL-056-03	2	Spacers
5)	AN4-34A	1	Bolt
6)	AN970-4	4	Washers
7)	AN365-428A	1	Locknut

Elevator torque tube assembly

Item	Part Number	QTY	Description
1)	EL-403-04	1	Elevator torque tube
2)	4450	2	Hinge
3)	AN3-6A	8	Bolts
4)	AN960-10	8	Washers
5)	K1000-3	8	Nutplates
6)	AN4-10A	2	Bolts
7)	AN960-416	4	Washers
8)	AN365-428A	2	Locknuts

Torque tube assemblies

Item	Part Number	QTY	Description
1)	6061T61.000x083	12 ft.	Rigid aluminum tubing
2)	057-01	4	Rod ends
3)	057-02	4	Rod ends
4)	AN3-10A	1	Bolt

Torque tube assemblies (Continued)

Item	Part Number	QTY	Description
5)	AN3-11A	2	Bolts
6)	AN316-5	4	Checknuts
7)	AN316-6	4	Checknuts
8)	AN365-1032A	4	Locknuts
9)	AN365-428A	4	Locknuts
10)	AN3-7A	1	Bolts
11)	AN4-11A	2	Bolts
12)	AN4-25A	2	Bolts
13)	AN470AD4-20	8	Rivets
14)	AN960-10	10	Washers
15)	AN960-416	10	Washers
16)	AN960-416L	2	Washers
17)	MD35-14M	4	Rod end bearings
18)	MD35-16M	4	Rod end bearings

8.3 Construction Procedures

The elevator controls will connect to the control stick (CS401) that you installed in the previous chapter, *Chapter 7 Aileron Controls*.

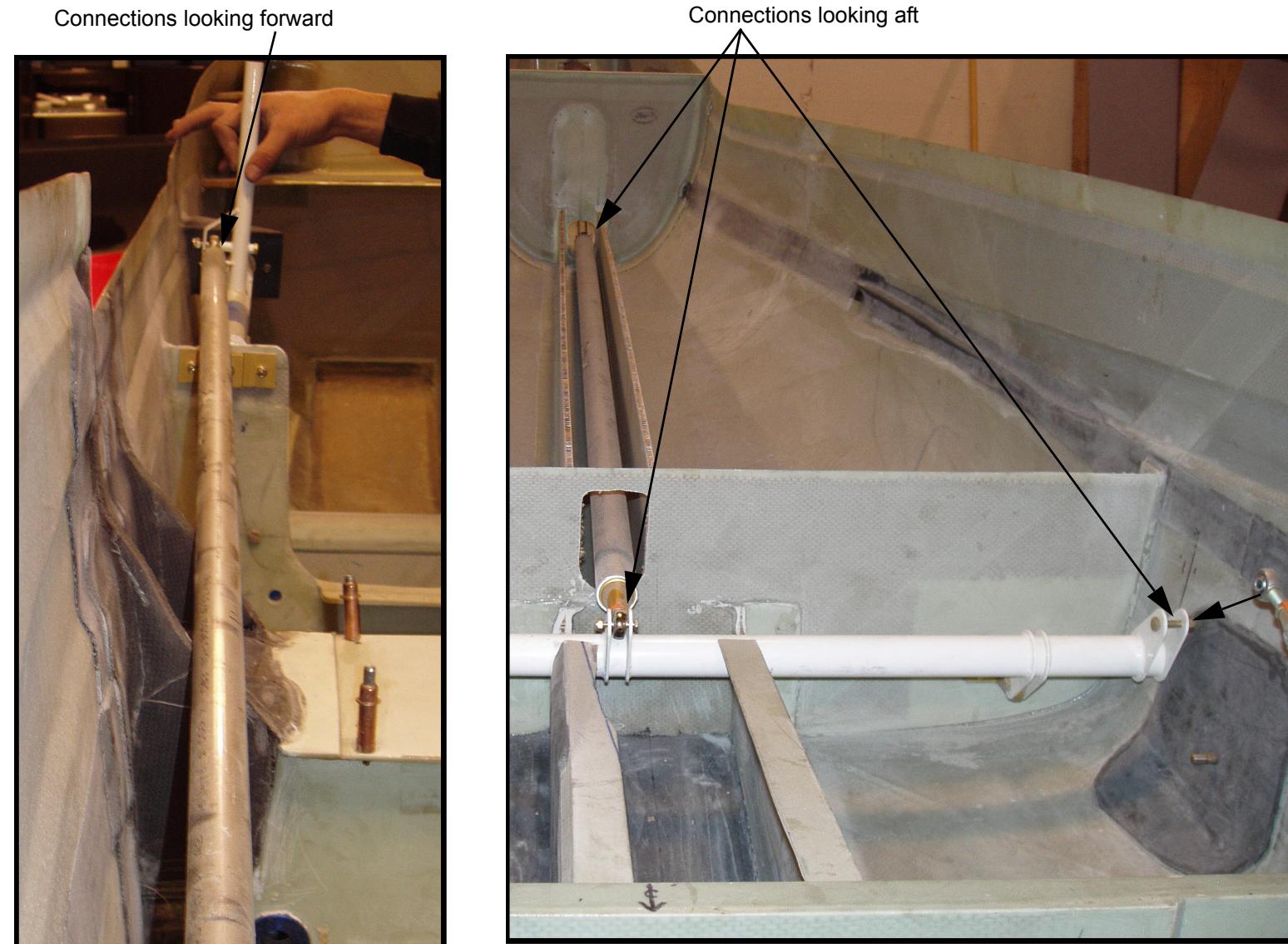
First you will install the idler arm, its housing and the elevator torque tube. Then you will build the pushrod enclosure and make the openings in the bulkheads for the pushrods.

You will make four pushrods from aluminum tubing and assemble the bearing rod ends. The pushrod assemblies are:

- Two forward pushrods that connect to the control sticks and the elevator torque tube.
- One pushrod that runs from the elevator torque tube to the idler arm.
- One pushrod that runs from the idler arm to the center elevator weldment.

When the ailerons and the elevators are fully connected at the end of this chapter, the checknut on the forward pushrods will need to be adjusted as described in 8.3.F *Adjusting the Elevator Controls* on page 8.17.

Figure 8.3.0.1 Elevator connections overview (idler arm to center elevator weldment is not shown in these views)



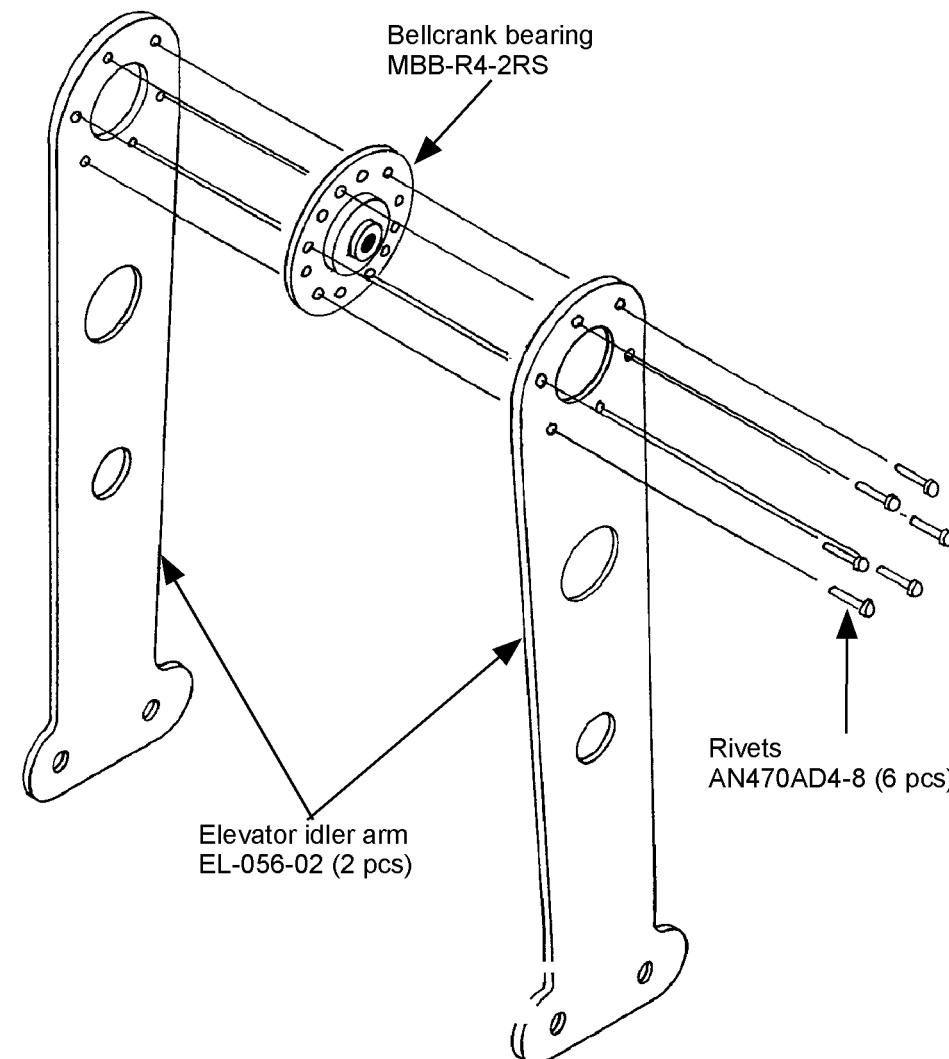
8.3.A Assembling the Elevator Idler Arm

The elevator idler arm is assembled much like the aileron bellcranks, with a bearing riveted between the two aluminum plates, in this case the idler arms.

Steps...

1. Place a bellcrank bearing (part MBB-R4-2RS from the assembly kit BC4W10-A) on one of the elevator idler arms (EL-056-02).
Make sure you have placed the idler arm correctly. The bottom of the idler arm should taper away from the bearing. Also notice that the bearing holes in the idler arm halves are tapered to accommodate the small radius in the bearing.
2. Use every other hole in the bearing as guides to drill 1/8" (3 mm) diameter holes through the elevator idler arm.
This will create six 1/8" (3 mm) diameter holes through the idler half.
3. Remove the bellcrank bearing from the idler half you just drilled.
4. Place the second piece of the elevator idler arm against the one you just drilled.
5. Match drill six 1/8" (3 mm) diameter holes through the second idler half.
Make sure the two idler halves are aligned with each other before drilling.
6. Deburr all the 1/8" (3 mm) diameter holes.
7. Place the bearing between the idler arms and secure it with six AN470AD4-8 rivets. This also secures the two idler halves together.

Figure 8.3.A.1 Elevator idler arm assembly



8.3.B Installing the Idler Arm

The assembled elevator idler is mounted between two sections of prepreg, which are secured to the FS 185 bulkhead and the fuselage bottom.

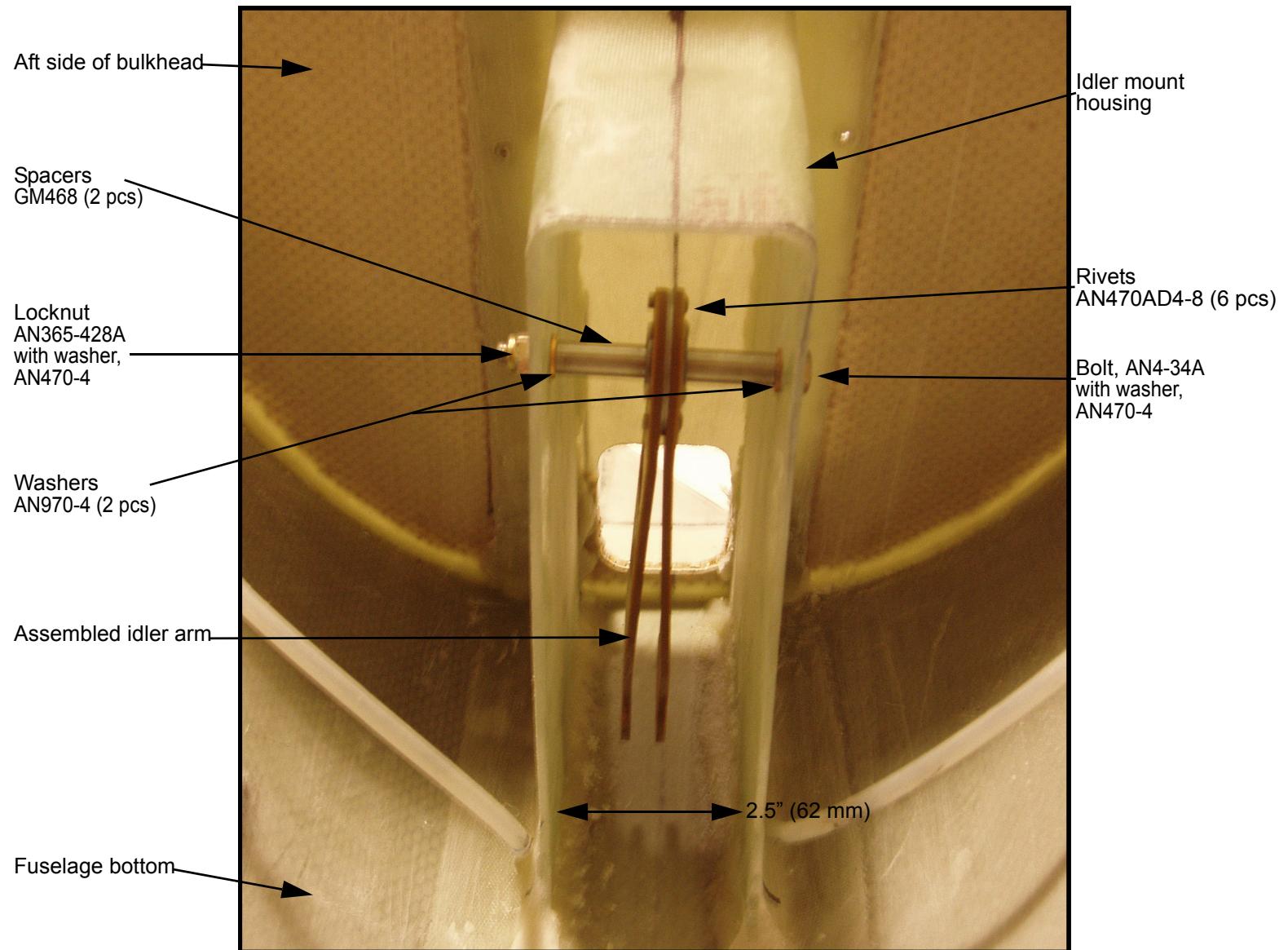
Steps...

1. Slide a washer (AN970-4) over the bolt (AN4-34A) and insert the bolt through the hole in the right idler mount.
2. Slide the following parts over the bolt:
 - washer (AN970-4)
 - spacer (EL-056-03)
 - assembled elevator idler
 - spacer (EL-056-03)
 - washer (AN970-4)
3. Slide the bolt through the hole in the left idler mount.
4. Secure the elevator idler arm using one more washer (AN970-4) and a locknut (AN365-428A).
5. Tighten the locknut until the spacers area tight against the bearing and washers.

If the locknut bottoms out on the shoulder of the bolt before the spacers are tight, use more washers under the locknut until you can tighten it.

Note: If your idler housing does not have an access hole on each side, cut an access hole in the housing so you can reach the bolts that will be inserted on the bottom of the idler arm. The exact locations and sizes of the holes are not critical, just so you have enough room to tighten and remove the pushrod bolts that will be in the idler.

Figure 8.3.B.1 Securing the assembled idler between the left and right mounts



8.3.C Mounting the Elevator Torque Tube

The elevator torque tube mounts to the forward face of the bulkhead just aft of the rear seat. The hinges that the torque tube rotates on are of the same design as the horizontal stabilizer hinges, with pre-installed bearings for easy operation. The torque tube translates the pitch inputs of the two control sticks into one pushrod that goes back to the elevator.

Steps...

1. Secure the two hinges (4450) to the bottom attachment points of the elevator torque tube (EL-403-04) using a bolt (AN4-10A), two washers (AN960-416) and a locknut (AN365-428A).
2. Mark a center line on the torque tube and align it with the fuselage center line.

This will provide equal spacing (or close to equal) between the ends of the torque tube and the sides of the fuselage. This distance needs to be a minimum of 1/4" (5 mm). The torque tube is 37" long.

Figure 8.3.C.1 Connecting hinges to the elevator torque tube

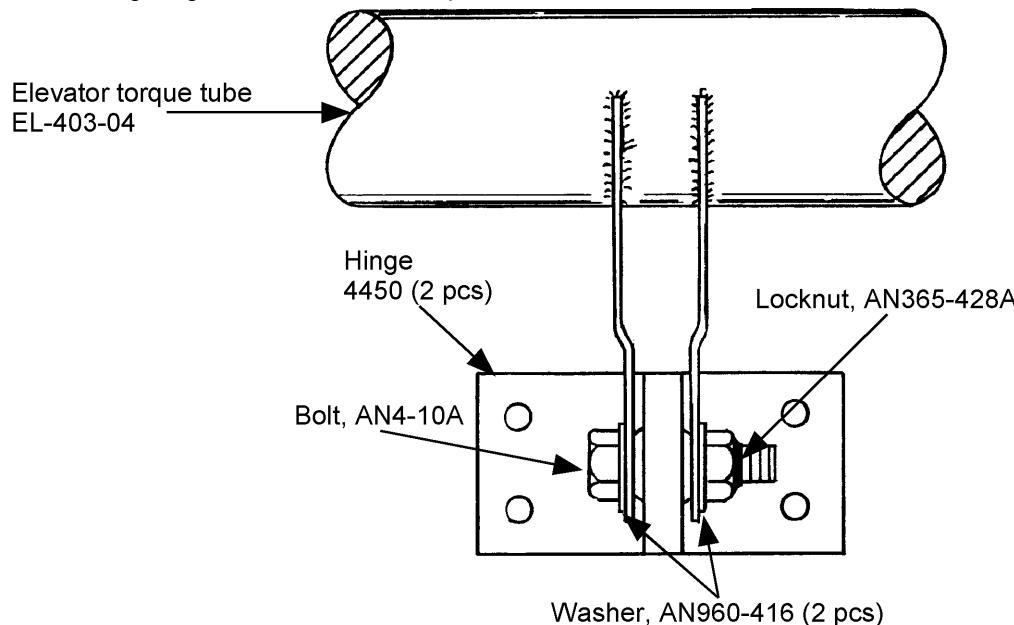
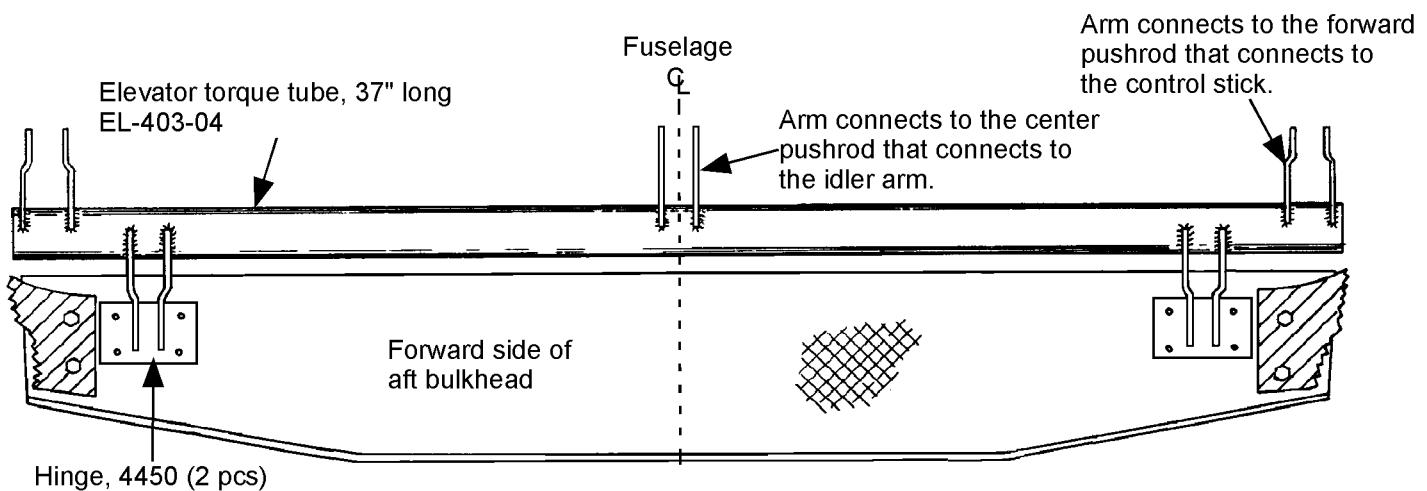
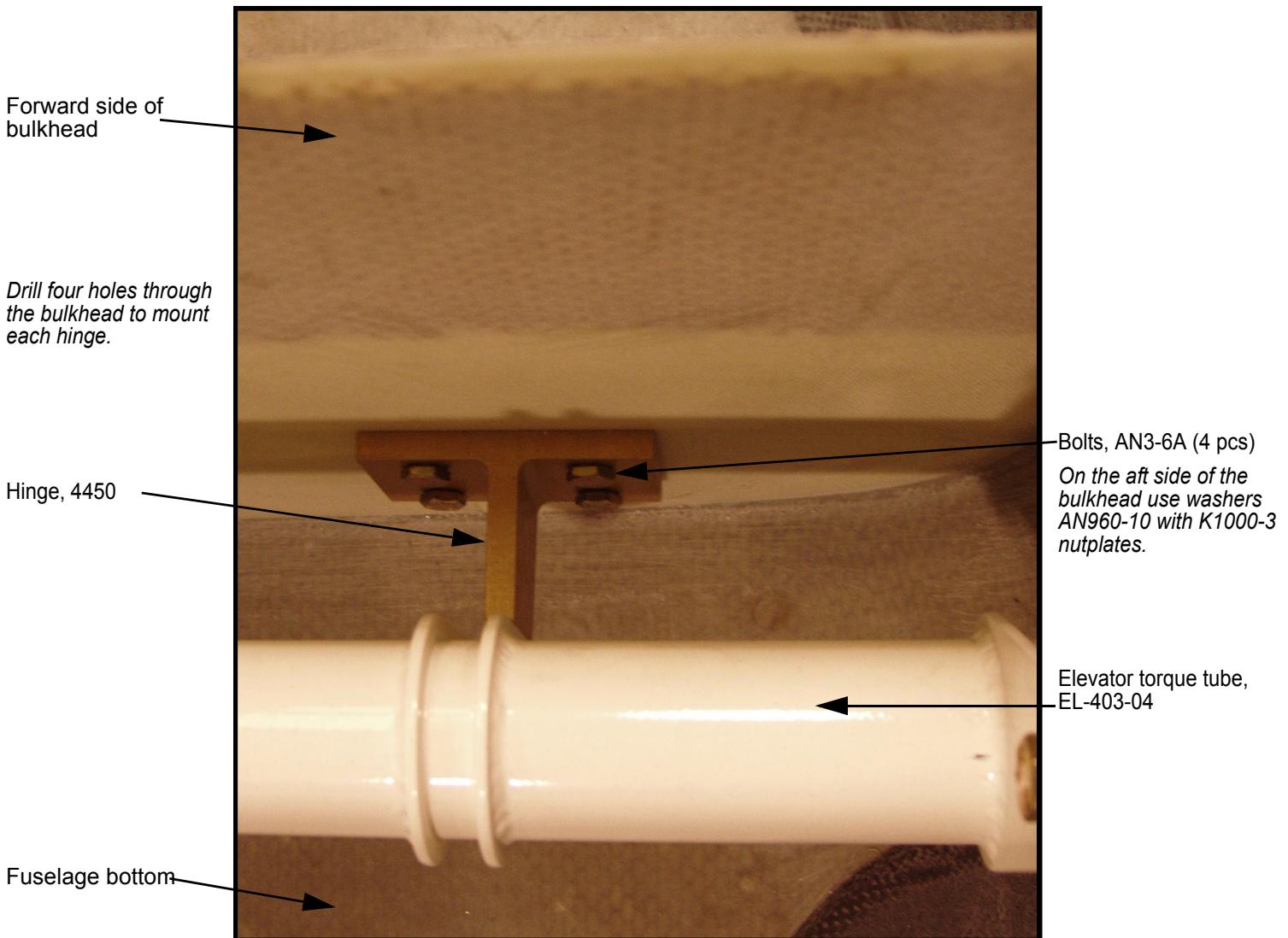


Figure 8.3.C.2 Installing the elevator torque tube



- Find the vertical position for the torque tube by running a string line from the control stick to the elevator torque tube. Set the torque tube to give a minimum of 1/2" (10 mm) of clearance between the pushrod and the bulkhead.
- The torque tube needs to be high enough for the control stick/torque tube pushrod to clear the shear box.
- Rotate the assembly through the full motion of the stick to simulate the movement of the pushrod.
- Trim the seat supports to allow room to install the torque tube.
- Position the elevator torque tube so the two hinges rest flat against the forward face of the bulkhead.
- When you are satisfied with the position of the torque tube, use instant glue to temporarily secure the hinges to the aft face of the gear box.
- Remove the elevator torque tube from the hinges.
- Using the four pilot holes in each hinge as guides, mark the four locations and drill 3/16" (4.5 mm) diameter holes through the bulkhead.
- As usual, you should start with a small drill, then increase the drill size until you reach 3/16".
- Position the hinge on the forward side of the bulkhead and insert four bolts (AN3-6A) through each hinge and bulkhead.
- Secure the hinges with washers (AN960-10) and K1000-3 nutplates.
- Remount the elevator torque tube to the hinges and verify that the torque tube moves freely.

Figure 8.3.C.3 Position the elevator torque tube hinge



8.3.D Making the Elevator Pushrod Enclosure

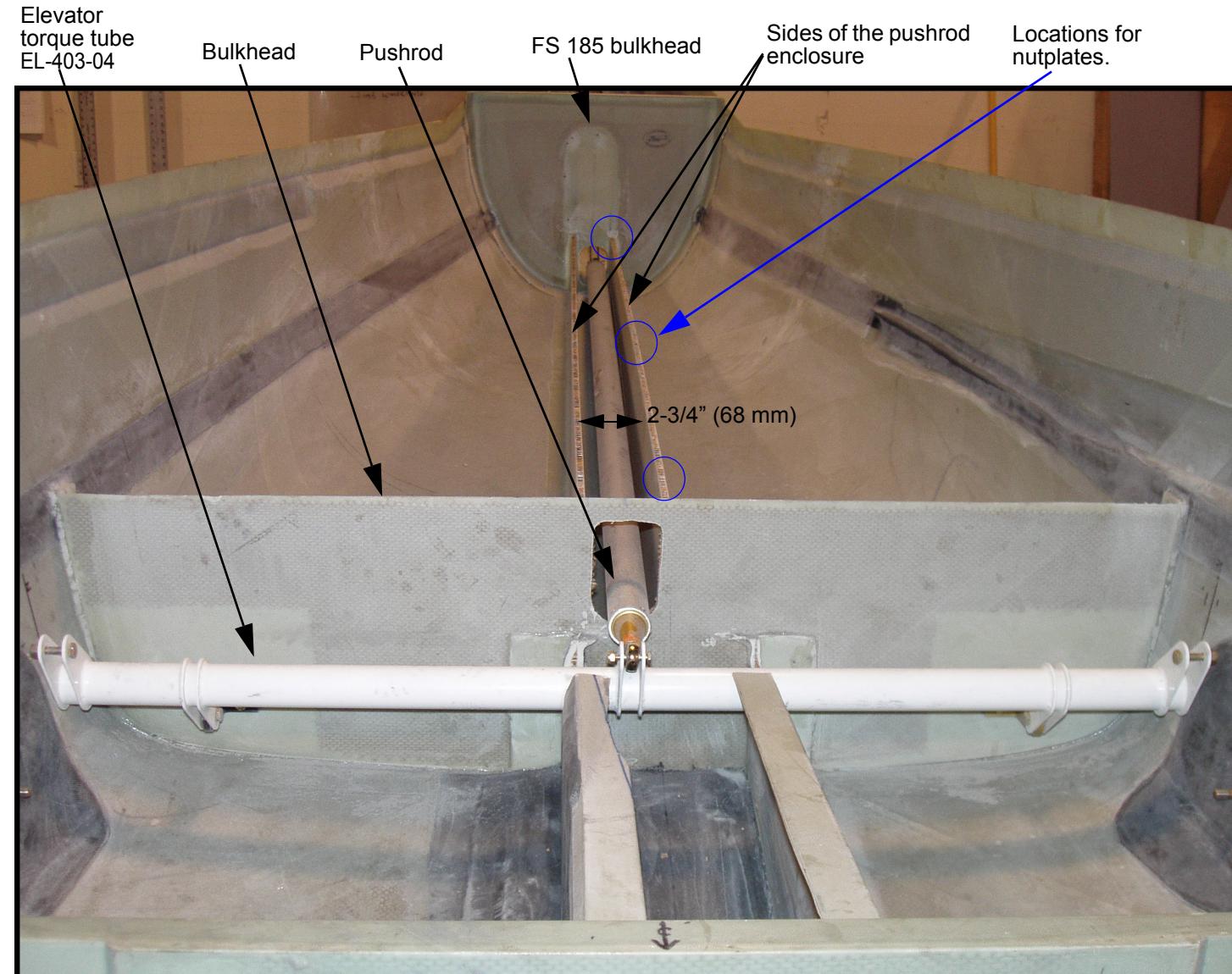
The elevator pushrod enclosure will cover the torque tube/idler arm pushrod in the baggage area. The sides of the pushrod enclosure are permanently bonded in place. The cover is removable for access to the pushrod.

Steps...

1. Create a cardboard pattern for the pushrod enclosure sides that meets the following requirements:
 - Extends from the bulkhead aft of the elevator torque tube to the FS 185 bulkhead.
 - Aft end should be 4" high.
 - Calculate the height of the forward end by measuring from the fuselage floor to 1" (25 mm) above the torque tube.
 2. Using the cardboard pattern, cut the sides of the elevator pushrod enclosure from 2 PPS 1/4" thick prepreg.
 3. Remove three 2" x 2" (50 mm x 50 mm) sections of the inboard laminate and core in the very front, the middle and the back of each side piece. Refer to the three circles in Figure 8.3.D.1.
- These three areas are on the inside of the enclosure. The left side of the enclosure is a mirror image of the right side. Later you will install nutplates in these areas to secure the enclosure cover.
4. Reinforce each area with 3-BID extended 1" (25 mm) onto the side.
 5. Remove 1/8" to 1/4" (3 mm to 6 mm) of core around the perimeter of the enclosure sides and bottom.
 6. Prepare the bulkhead and fuselage bonding surfaces. Plan to bond with the sides spaced 2 3/4" (68 mm) apart with the pushrod centered.
 7. Pot the enclosure sides in place with a thick epoxy/micro mixture.
 8. Reinforce the sides to the fuselage and bulkhead with 2" wide strips of 2-BID.

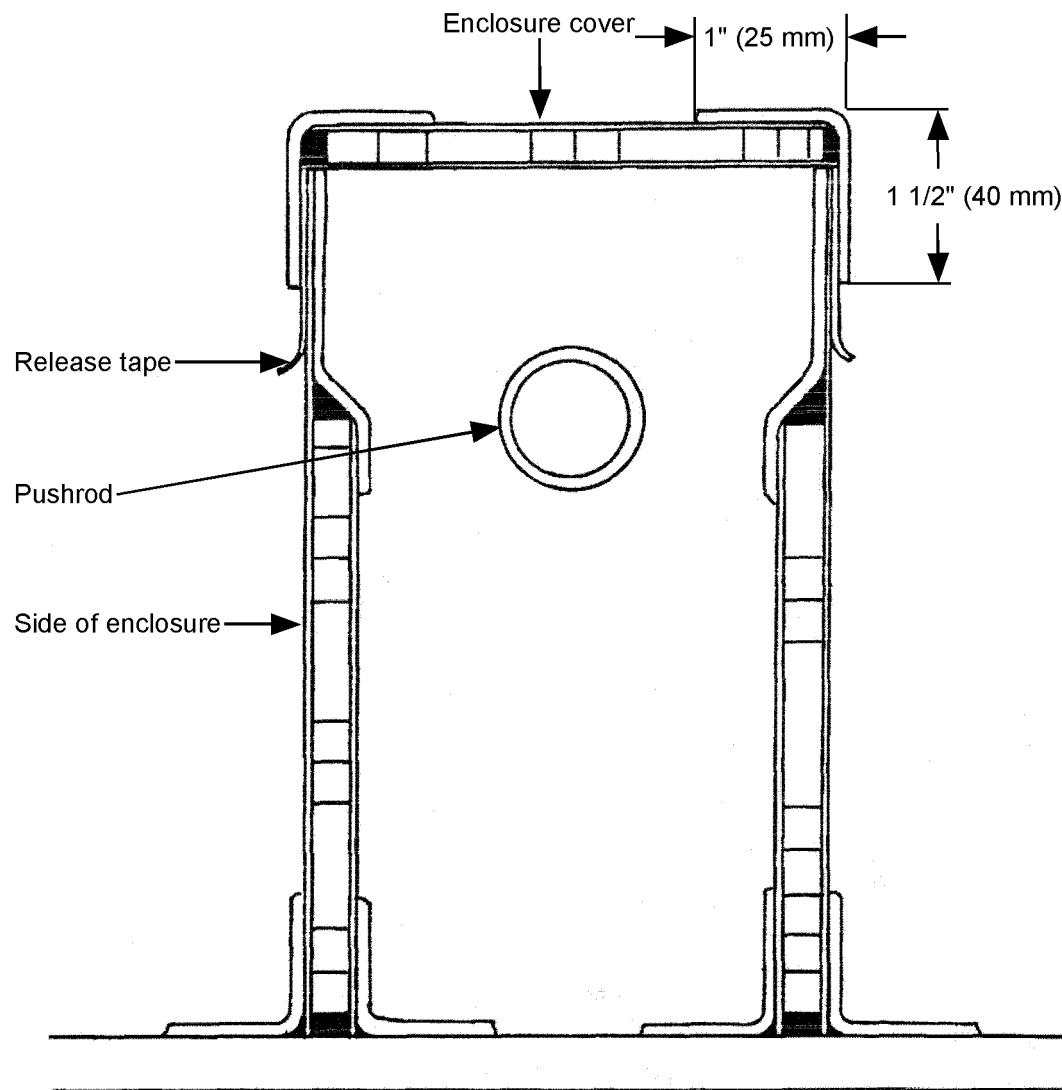
Note: The rear seat supports are designed to be off center.

Figure 8.3.D.1 Elevator pushrod enclosure



9. Cut a 2 3/4" wide, by the same length as the sides, cover for the enclosure using 2 PPS 1/4" thick prepreg.
10. Remove 1/8-1/4" (3 -6 mm) of core around the perimeter of the cover.
11. Fill the perimeter with a thick epoxy/micro mixture. When the micro dries, round the corners on the cover.
12. Release tape the top 2" of the sides of the enclosure.
13. Prep the cover.
14. Set the cover on top of the sides of the enclosure.
15. Apply a 4-BID to the enclosure cover, extending the BID down 1-1/2" (37 mm) onto the sides of the enclosure.
16. Drill 3/16" (5 mm) diameter holes through the cover and the sides of the enclosure at the six locations where you installed the additional BID. Refer to the three circles in Figure 8.3.D.1.
17. Install the nutplates (K1000-03) using two rivets (AN426A3-5) per nutplate.
18. Secure the cover using six screws (AN525-10R8).

Figure 8.3.D.2 Cover for the pushrod enclosure



8.3.E Installing the Elevator Pushrods

Four pushrods are required to connect the control sticks to the elevator.

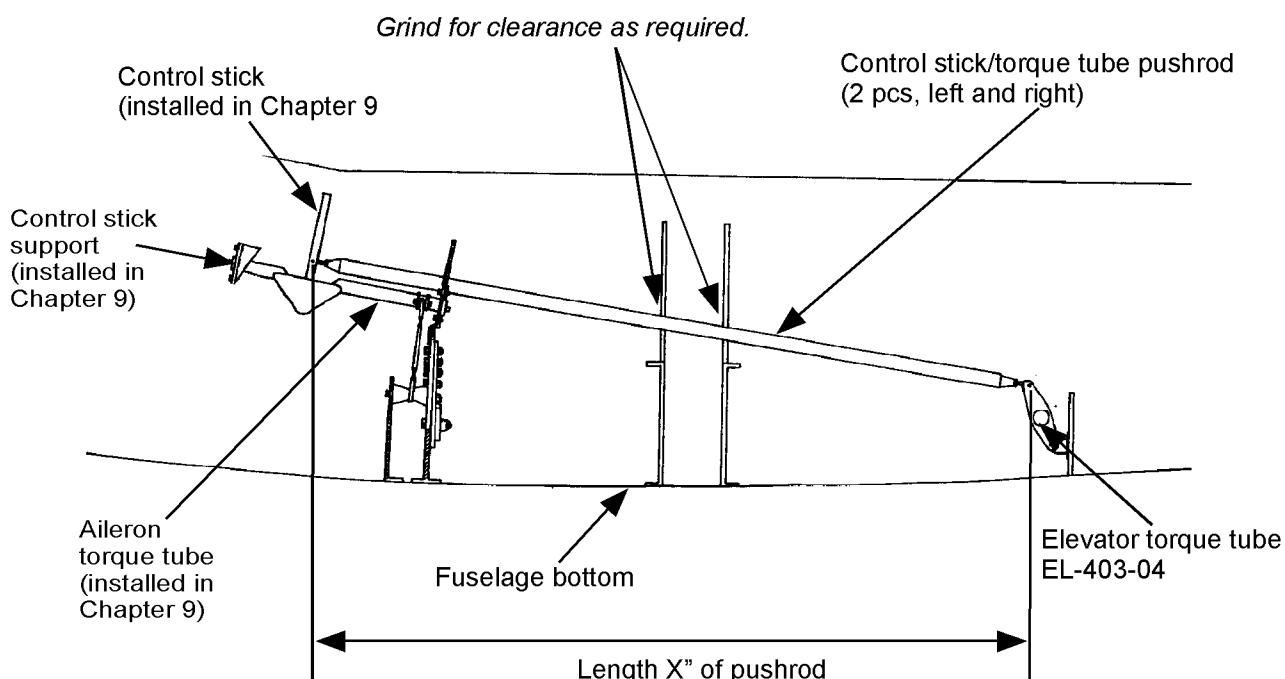
- Control stick/torque tube pushrods – These two pushrods connect each control stick to the elevator torque tube. This pushrod is also known as the forward pushrod.
- Torque tube/idler arm pushrod – This pushrod connects the torque tube to the idler arm. This is the center pushrod.
- Idler arm/elevator weldment pushrod – This pushrod connects the idler arm to the center elevator weldment. This is the aft pushrod.

Making the Forward Pushrod

Steps...

1. Find the length of the forward two pushrods by placing the control sticks in a vertical position (fore/aft). Position the elevator torque tube angled forward of vertical 3/4" (20 mm) at the upper bolt holes.
2. Measure the distance between the bolt hole on the control stick to the bolt hole on the elevator torque tube. Subtract 4-3/8" (110 mm) from the measurement.
$$\text{Length} = X - 4 \frac{3}{8}'' (X - 110 \text{ mm})$$
The result is the length you need to cut both pushrods.
3. Cut two pushrods from 6061-T6 aluminum tubing (1.000" (25 mm) diameter, .083" (2 mm) thick) to the length you calculated in the previous step.

Figure 8.3.E.1 Forward pushrod to control stick and elevator torque tube

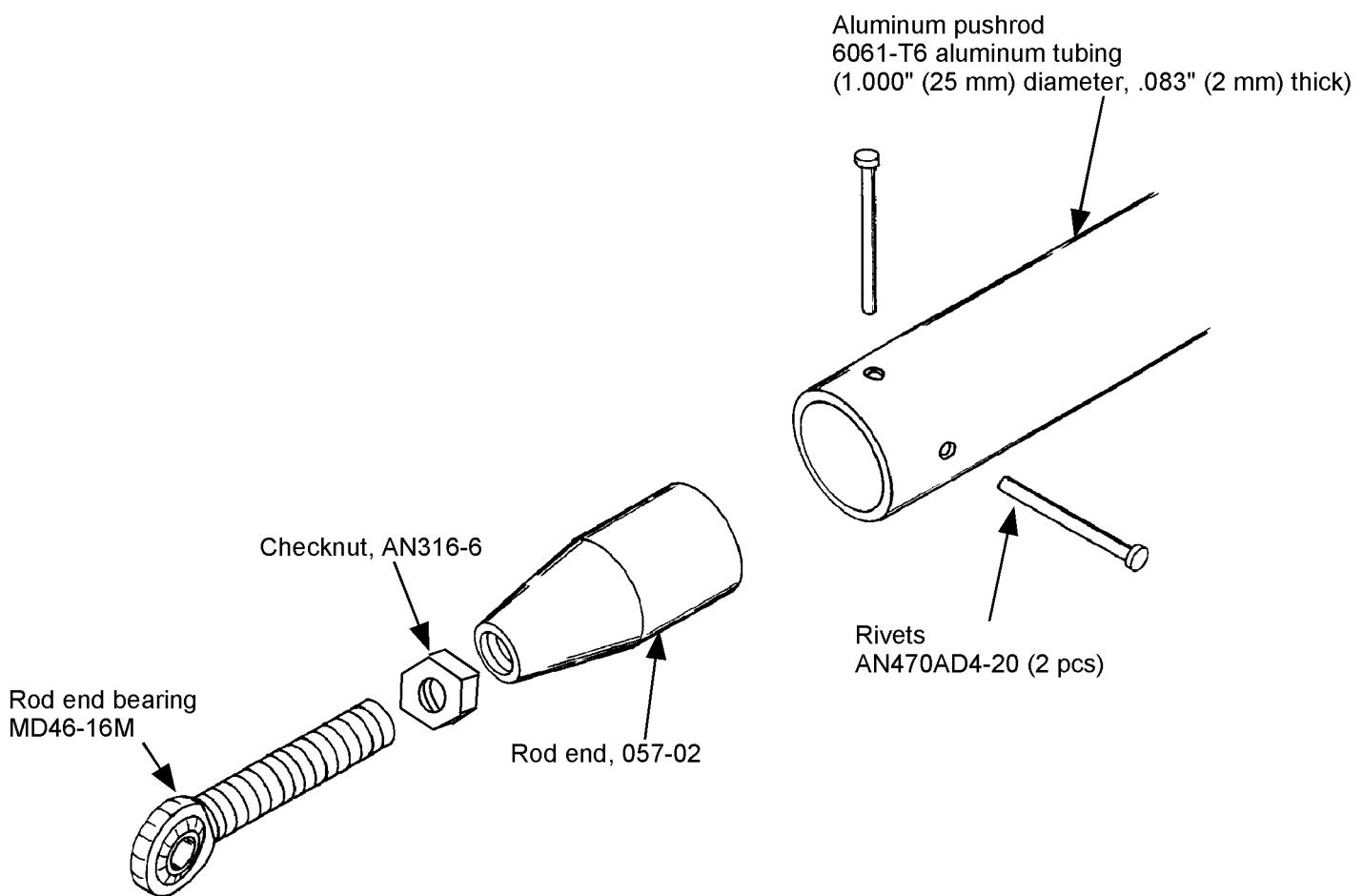


4. Slide a rod end (057-02) into both ends of each pushrod.
5. Secure the rod ends to the pushrods with two rivets (AN470-20) per rod end.

The rivets need to be spaced 2" (5 mm) and .4" (10 mm) from the ends of the aluminum pushrod tube. See Figure 8.3.E.2 for the spacing of the rivets.

6. Thread a checknut (AN316-6) onto each rod end bearing (MD46-16M).
7. Thread the rod end bearings into the rod ends until the center of the bearing is 2-3/16" (55 mm) from the end of the pushrod tube.

Figure 8.3.E.2 Securing the rod ends and bearings



Installing the Forward Pushrod

First you will connect the pushrod to the control stick, then you will connect it to the torque tube you installed in 8.3.C *Mounting the Elevator Torque Tube* on page 8.6.

Steps...

1. Slide the bolt (AN4-25A) through the control stick.
2. Add *two* washers (AN960-416) to the bolt and slide it through the rod end bearing of the pushrod.
3. Add another washer (AN960-416) and slide the bolt through the bracket on the control stick.
4. Secure the bolt with one more washer and a locknut (AN365-428A).

The other end....

5. Connect the other end of the pushrod to the elevator torque tube by sliding a bolt (AN4-11A) through the first part of the arm on the torque tube.
6. Add a washer (AN960-416) to the bolt and slide the bolt through the rod end bearing.
7. Add another washer and slide the bolt through the second arm.
8. Secure the bolt with a locknut (AN365-428A).

Figure 8.3.E.3 Pushrod installation to the control stick

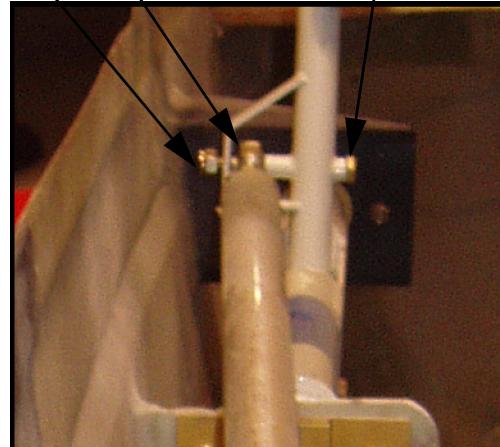
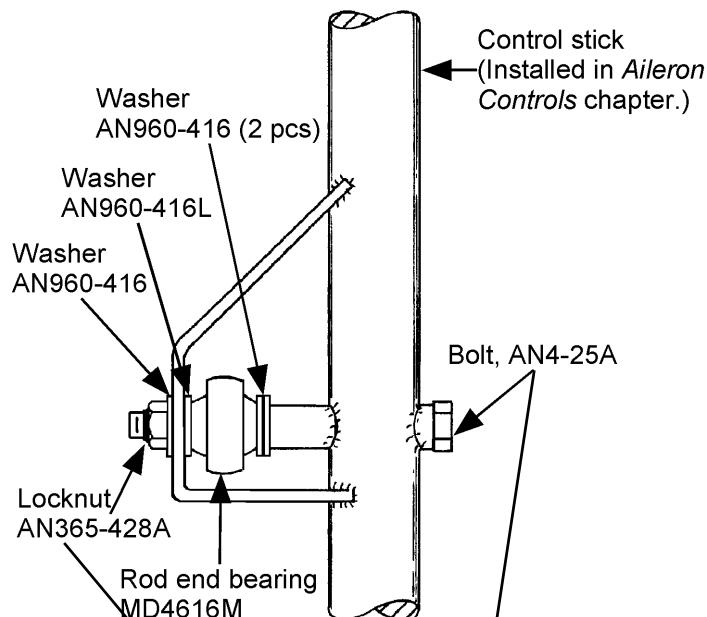
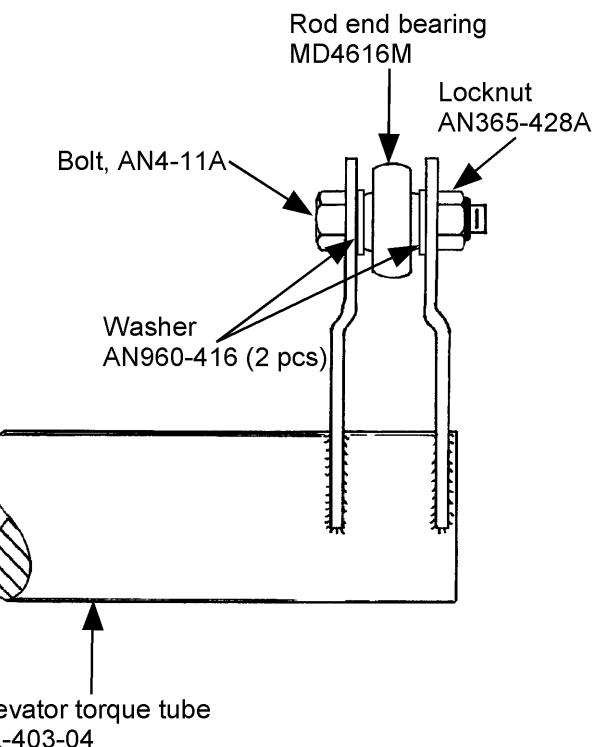


Figure 8.3.E.4 Pushrod installation to the torque tube

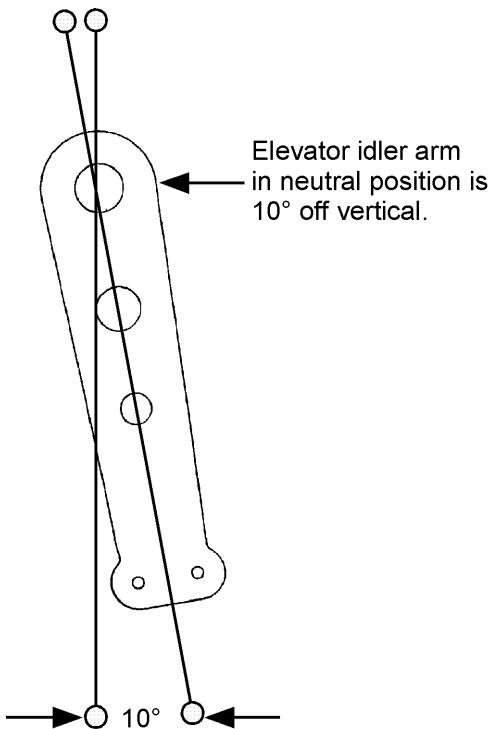


Making the Torque Tube/Idler Arm Pushrod

Steps...

1. Position the elevator idler arm 10° aft of vertical as shown in Figure 8.3.E.5.

Figure 8.3.E.5 Idler arm position

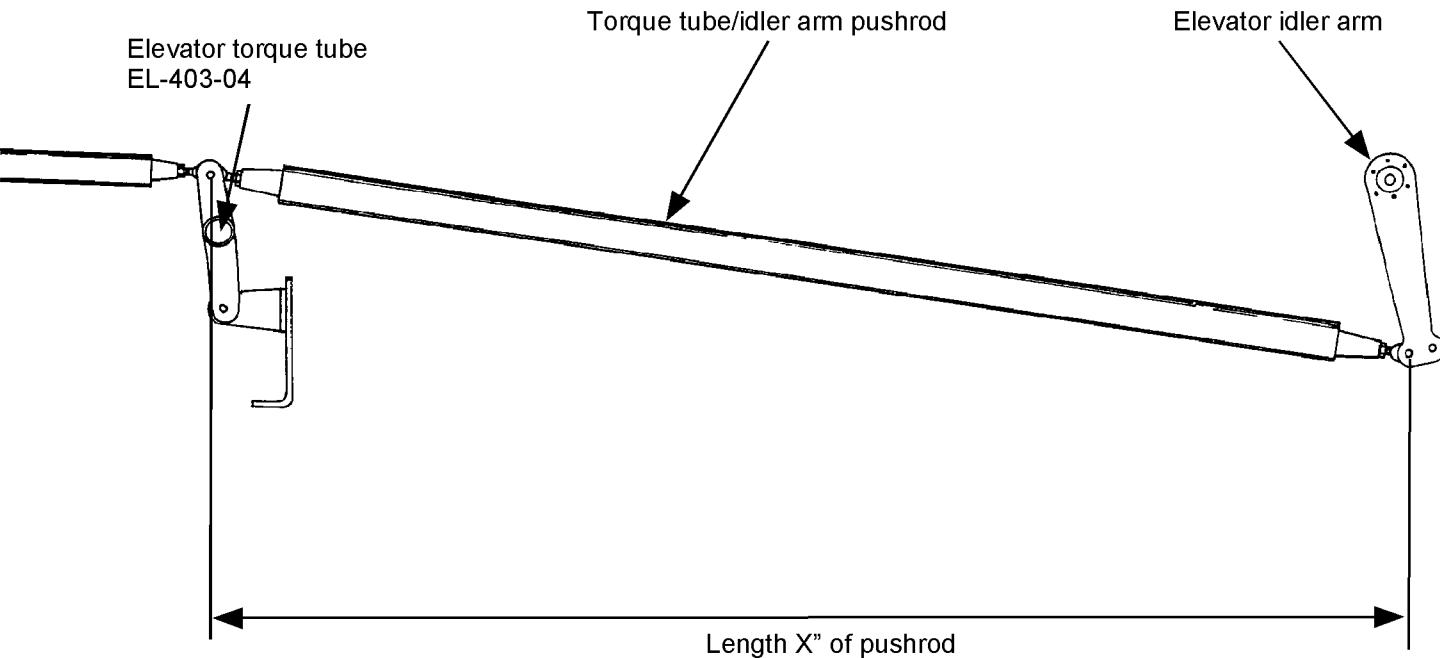


2. Grind out a transit hole in the 185 bulkhead to accommodate the pushrod.
To center this hole, grind a small hole first, and pull a string from the forward pushrod mounting hole of the idler arm to the center mounting hole of the torque tube. Gradually enlarge the hole to the required diameter with the string centered in it.

3. Grind a clearance hole in the bulkhead aft of the torque tube as required.
4. Measure the distance from the pushrod mounting holes in the idler arm to the elevator torque tube. Subtract 4-7/8" (125 mm) from the measurement.
$$\text{Length} = X - 4\frac{7}{8}'' (X - 125 \text{ mm})$$
5. Cut a pushrod from 6061-T6 aluminum tubing (1.375" (35 mm) diameter, .083" (2 mm) thick) to the length you calculated in the previous step.
6. Slide a rod end (057-01) into both ends of the pushrod.

Click here to review a picture of the ground-out openings.

Figure 8.3.E.6 Calculating the center pushrod length



Installing the Torque Tube/Idler Arm Pushrod

First you will connect the pushrod to the elevator torque tube, then you will connect it to the idler arm.

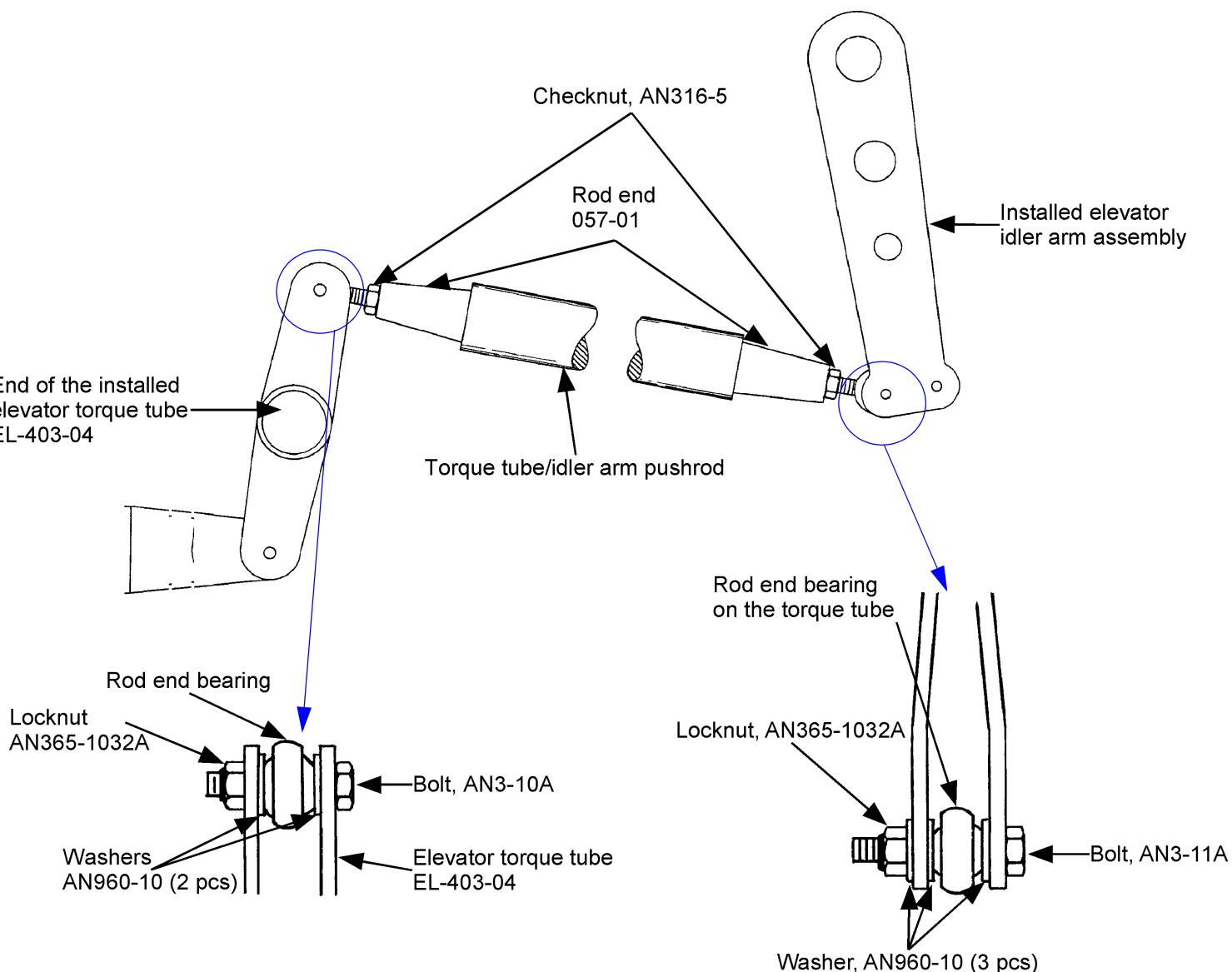
Steps...

1. Insert the end of the pushrod through the hole you made in the bulkhead.
2. Slide the bolt (AN3-10A) through the right arm on the elevator torque tube.
3. Add a washer (AN960-10) to the bolt and slide it through the rod end bearing of the pushrod.
4. Add another washer (AN960-10) and slide the bolt through the left arm of the elevator torque tube.
5. Secure the bolt with a locknut (AN365-1032A).

The other end....

6. Connect the other end of the pushrod to the elevator idler arm by sliding a bolt (AN3-11A) through the right idler arm.
Make sure you connect the pushrod to the forward mounting hole in the idler arm.
7. Add a washer (AN960-10) to the bolt and slide the bolt through the rod end bearing.
8. Add another washer and slide the bolt through the second arm.
9. Secure the bolt with a washer (AN960-10) and a locknut (AN365-1032A).

Figure 8.3.E.7 Pushrod installation to the elevator torque tube and the idler arm



Making the Idler Arm/Elevator Weldment Pushrod

The last pushrod completes the elevator control by connecting the elevator idler arm to the center elevator weldment. Make the pushrod slightly longer than the calculated length, make up the forward end and connect it but leave the aft end resting in the fuselage. This connection can be completed later.

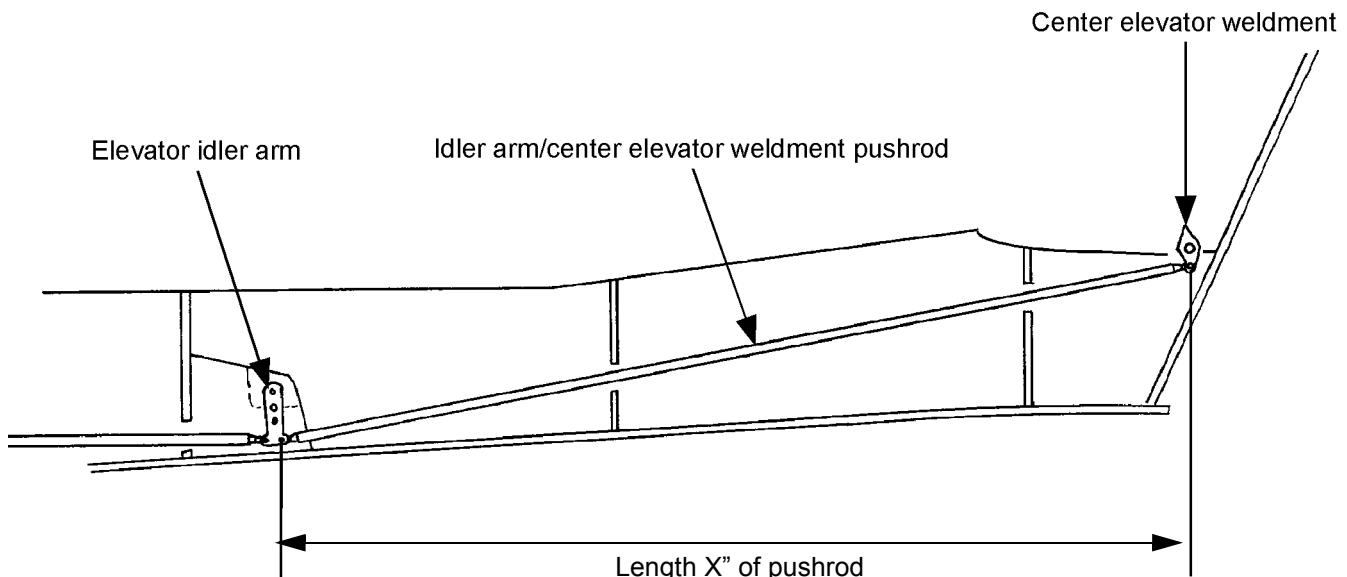
STOP Before you complete the last pushrod connection the horizontal stabilizer and the vertical stabilizer need to be installed. Complete Chapter 17 and Chapter 18 before making the center elevator weldment connection as described after *The other end....* on page 8.16.

Before you begin, the elevators, control sticks, torque tube and idler arm need to be in a neutral position.

Steps...

1. Clamp the elevators, control sticks, torque tube and idler arm in the neutral position.
2. Measure the distance from the aft pushrod mounting point on the idler arm to the pushrod mounting point on the center elevator weldment. Subtract 4-7/8" (125 mm) from this measurement. The result is the length you should cut your pushrod.
$$\text{Length} = X - 4 \frac{7}{8}'' \quad (X - 125 \text{ mm})$$
3. Cut a pushrod from 6061-T6 aluminum tubing (1.375" (35 mm) diameter, .083" (2 mm) thick) to the length you calculated in the previous step.
4. Slide a rod end (057-01) into both ends of the pushrod.
5. Secure the rod ends to the pushrods with two rivets (AN470AD4-26) per rod end.
The rivets need to be spaced 2" (5 mm) and .4" (10 mm) from the ends of the aluminum pushrod tube. See Figure 8.3.E.2 for the spacing of the rivets.
6. Thread a checknut (AN316-5) into each rod end bearing (MD35-14M).
7. Thread the rod end bearings into the rod ends until the bearing hole is 2 7/16" (62 mm) from the end of the pushrod tube.

Figure 8.3.E.8 Length of the idler arm/elevator weldment pushrod



Installing the Idler Arm/Elevator Weldment Pushrod

First you will connect the pushrod to the idler, then you will connect it to the center elevator weldment.

Steps...

1. Connect the end of the pushrod to the elevator idler arm by sliding a bolt (AN3-11A) through the right idler arm.
2. Add a washer (AN960-10) to the bolt and slide the bolt through the rod end bearing.
3. Add another washer and slide the bolt through the second arm.
4. Secure the bolt with a washer (AN960-10) and a locknut (AN365-1032A).

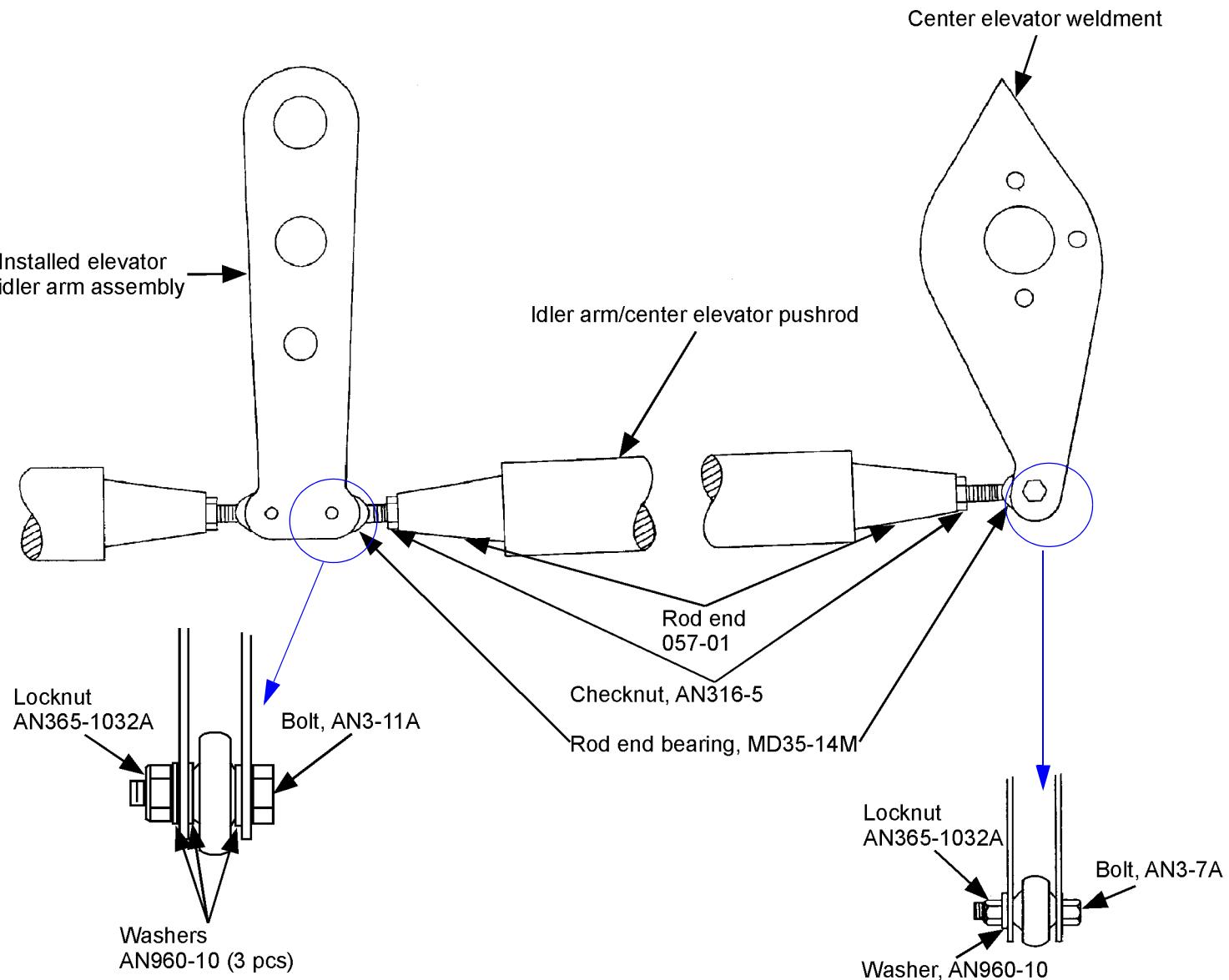
The other end....

Complete this end after the horizontal stabilizer and vertical stabilizer are completed and in place.

5. Slide the bolt (AN3-7A) through the right arm on the center elevator weldment.
6. Slide the bolt through the rod end bearing of the pushrod.
7. Slide the bolt through the left arm of the center elevator weldment.
8. Secure the bolt with a washer (AN960-10) and a locknut (AN365-1032A).

Your elevator control system is now complete. You should be able to freely move the elevator to its stops with both control sticks. For information on the elevator stops and the degree of travel, see Chapter 3, 3.3.B *Setting the Elevator Travel* on page 3.6.

Figure 8.3.E.9 Pushrod installation to the idler arm/center elevator weldment



8.3.F Adjusting the Elevator Controls

The forward elevator pushrods, that run along the side of the fuselage, may require rod end bearing adjustment to accommodate the left/right movement of the control sticks.

Checking the Elevator Controls to Aileron Travel

If the rod end bearings (MD46-16M) in the forward pushrod twist to their limits before reaching full left or right aileron travel, you will need to loosen the AN316-6 checknuts.

Steps...

1. Move the control stick through its full travel, forward and back, left and right. It should not bind during any movement.
2. Check and retighten the checknuts if any binding occurs.

When the control stick is full left and full right, you should be able to rotate the forward elevator pushrods slightly, indicating that they are not bound up.