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P-67

COCKPIT CONTROL SYSTEM

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1.1 PROJECT SUMMARY

The purpose of this project is to provide a detail design for the cockpit control system of the Viper PFT. The statement of work for this project requires provisions for control of the ailerons, elevator, rudder, and elevator trim. The system should provide adjustment for pilot stature, rigging and maintenance. MIL-STD-1472 is used as a model for human factors criterion. The system is designed to the pilot limit loading outlined in FAR part 23.397. The general philosophy behind this design is to provide a simple, reliable control system; which will withstand the daily abuse that is experienced in the training environment without excessive cost or weight penalties.

| RUDDER | | | |
|----------------------|-----------------|------------------|----------|
| COMPONENT | f_{max} (psi) | MARGIN OF SAFETY | PAGE # |
| Toe Pedal | 7541 | 1.65 | Appendix |
| Rod & Casting | 4655 | 3.30 | Appendix |
| Pedal Actuated Crank | 16076 | .7 | Appendix |
| Bottom Mount | 6024 | 2.32 | Appendix |
| Center Cast | 8639 | 2.16 | Appendix |
| Center Mount | 17278 | .15 | Appendix |

Table 1: Rudder Analysis

| ELEVATOR STRESS ANALYSIS | | | | | | | |
|--------------------------|-----------|----------------|----------------|------------------|----------------|--------------------|--------|
| | f_{MAX} | FITTING FACTOR | f_{LL} (psi) | FACTOR OF SAFETY | f_{UL} (psi) | MARGIN OF SAFETY | PAGE # |
| Support Column | 15504 | 1.2 | 18605 | 1.5 | 27908 | 1 | 12 |
| Bolt Case 1 | 902 | 1.2 | 1082 | 1.5 | 1623.6 | 1.51 | 14 |
| Bolt Case 2 | 2204 | 2 | 4404 | 1.5 | 6606 | .41 | 14 |
| Joiner | 1803 | 1.4 | 2524 | 2 | 5048 | 10.1(Y) 6.13(U) | 14 |

*** The margin of safety at yield was only calculated for the weakest spot ie, the joiner, see drawing AE421S93ADP01-3

| | f_{max} (psi) | FITTING FACTOR | f_{LL} (psi) | FACTOR OF SAFETY | f_{UL} (psi) | MARGIN OF SAFETY | PAGE # |
|--------------------------|--------------------|-------------------|-------------------|------------------------|-------------------|------------------------|--------|
| Control Yoke(s) | 4074 | 2 | 8146 | 1.5 | 12222 | 4.64 | 11 |
| Control Yoke (brg) | 13250 | 2 | 26500 | 1.5 | 51200 | .4 | 11 |
| Rods | 11459 | 1.2 | 13571 | 1.5 | 27501 | 1.04 | 15 |

Table 2: Elevator Stress Analysis

| AILERONS | | | |
|----------------|-----------------|------------------|--------|
| COMPONENT | f_{MAX} (psi) | MARGIN OF SAFETY | PAGE # |
| Sprocket 1 & 2 | 21281 | 1.97 | 20 |
| Sprocket 3 | 3396 | 17.74 | 21 |
| Pulleys 5 & 6 | 17195 | 3.70 | 21 |

Table 3: Aileron Stress Analysis

2.0 RUDDER CONTROL SYSTEM

2.1 Description

The rudder control system provides rudder and nosewheel deflection of $\pm 20^\circ$ as well as differential braking. The differential braking is composed of a separate master cylinder, parking brake and valve (see figure in appendix). Pilot input is transferred from two sets of bottom pivoting rudder pedals, through a series of push-pull rods and bellcranks, which are routed through the driveshaft tunnel.

2.2 Loads and Loading

2.2.1 The toe brake structure pivots on a bearing at point A. A 200 lb. load supplied by the pilot generates reactant forces at A and B. The following calculation is when the master cylinder is fully compressed.

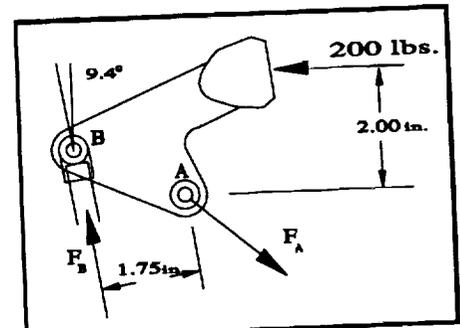


Figure 2.2.1

Summing the moments about point A;

$$\sum M_A = 0$$

$$200 \text{ lbs.} \times 2.00 \text{ in.} - F_B \times 1.75 \text{ in.} = 0$$

$$F_B = 228.6 \text{ lb}$$

Summing the forces in the X and Y plane;

$$\sum F_X = 0$$

$$F_{Ax} - 200 \text{ lbs.} - 228.6 \text{ lbs.} \times \sin 9.4 = 0$$

$$\sum F_Y = 0$$

$$228.6 \text{ lbs.} \times \cos 9.4 - F_{Ay} = 0$$

$$F_A = \sqrt{F_{Ax}^2 + F_{Ay}^2}$$

$$F_A = 282.8 \text{ lbs.}$$

2.2.2 The largest value for F_C and F_D occur when the pedal is in the neutral position. A pilot's force of 200 lbs. is applied at the toe brake to create the largest moment. Summing moments about point C and the forces in the horizontal plane;

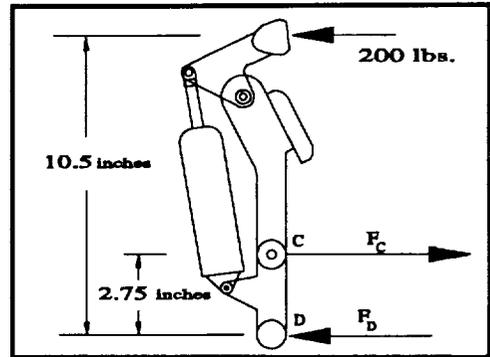


Figure 2.2.2

$$F_D \times 2.75 \text{ in.} - 200 \text{ lbs.} \times 7.75 \text{ in.} = 0$$

$$F_D = 563.6 \text{ lbs.}$$

$$F_C - 200 \text{ lbs.} - 563.6 \text{ lbs.} = 0$$

$$F_C = 763.6 \text{ lbs.}$$

2.2.3 Pedal Mount

$$\sum F_x = 0$$

$$563.6 \text{ lbs.} - 4F_{\text{bolt}} = 0 \quad F_{\text{bolt}} = 141 \text{ lbs.}$$

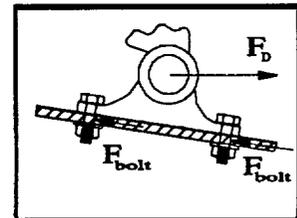


Figure 2.2.3

2.2.4 Rod Assembly

A load of 763.4 lbs. is carried through the rod connecting casting, rod, and the rod ends that attach to the pedal actuated crank.

2.2.5 Pedal Actuated Crank

The bell-cranks' maximum load occurs when the pilot uses full braking on both pedals; therefore, F_{CENTER} and F_{GEAR} are equal to 0.

$$\sum F_X = 0$$

$$763.6 \text{ lbs.} + 763.6 \text{ lbs.} - F_{PIVOT} = 0$$

$$F_{PIVOT} = 1527 \text{ lbs.}$$

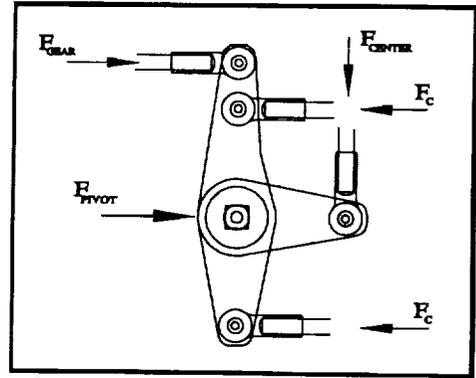


Figure 2.2.4

2.2.6 Center Rod

The maximum axial load is 736.6 lbs.. This occurs with complete resistance to pilot load on one pedal.

2.2.7 Center Crank

The limiting case occurs when both pilots act in unison.

$$\sum M_{PIVOT} = 0 \quad F_{CENTER} 2.5 - F_{ROD} 2.5 = 0$$

$$F_{ROD} = 1527 \text{ lbs.}$$

$$F_{PIVOT} = \sqrt{1527^2 + 1527^2} \quad F_{PIVOT} = 2160 \text{ lbs.}$$

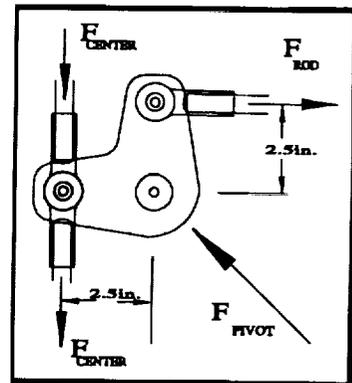


Figure 2.2.5

2.3 Substantiation

| Toe Brake Pedal | | | | | | |
|-----------------|--------|------|-----------|------------|--------------------|---------------------|
| Figure 2.2.1 | t (In) | F.F. | f_{brg} | $f_{t.o.}$ | M.S. _{LL} | M.S. _{U.L} |
| Point A | .30 | 2.0 | 7541 | 3771 | 1.65 | 1.83 |
| Point B | .25 | 2.0 | 7315 | 3658 | 1.73 | 1.92 |

Table 2.3.1 Toe Brake Pedal

| Lower Pedal | | | | | | | |
|--------------|--------|--------|--------------------|---------------------|----------------|--------------------|---------------------|
| Figure 2.2.2 | t (In) | d (In) | f_{brg} (psi) | $f_{t.o.}$ (psi) | f_s (psi) | M.S. _{LL} | M.S. _{U.L} |
| Point A | .25 | .656 | 1724 | N/A | N/A | 10.6 | 11.4 |
| Point B | .25 | N/A | 3658 | 1829 | N/A | 4.47 | 4.83 |
| Point C | 1.79 | N/A | 3413 | 1706 | N/A | 4.86 | 5.25 |
| Point D | .25 | .75 | N/A | N/A | 638 | 30.4 | 32.4 |

Table 2.3.2 Lower Pedal

| Pedal Mount | | | | | | |
|--------------|-------|-------|--------------------|---------------------|--------------------|---------------------|
| | t(In) | d(In) | f_{brg} (psi) | $f_{t.o.}$ (psi) | M.S. _{LL} | M.S. _{U.L} |
| Figure 2.2.3 | 1.0 | 1.3 | 434 | 1127 | 16.7 | 17.9 |

Table 2.3.3 Pedal Mount

| Rod End Casting | | | | |
|-----------------|-------|--------------------|--------------------|---------------------|
| t(In) | d(In) | f_{brg} (psi) | M.S. _{LL} | M.S. _{U.L} |
| .25 | .656 | 4655 | 3.3 | 3.94 |

Table 2.3.4 Rod End Casting

| Rod | | | | | | |
|-------------|---------------------|---------------------|-------------------------|-------------------------|--------------------|--------------------|
| Length (In) | A(In ²) | I(In ⁴) | f _{comp} (psi) | f _{crit} (psi) | M.S. _{LL} | M.S. _{UL} |
| 6.00 | .06943 | .001786 | 10998 | 2116 | 5.82 | 4.76 |

Table 2.3.5 Rod

| Rod End | | |
|-----------------------|--------------------|--------------------|
| F _{LL} (lbs) | M.S. _{LL} | M.S. _{UL} |
| 3025 | 2.96 | 1.64 |

Table 2.3.6 Rod End

| Pedal Actuated Crank | | | | | | |
|---------------------------|--------|------------------------|------------------------|----------------------------|--------------------|--------------------|
| Figure 2.2.4 | t (In) | f _{brg} (psi) | f _{Lo.} (psi) | M.S. _{LL} | M.S. _{UL} | |
| Point A & C | .19 | 16076 | 4257 | 1.55 | .70 | |
| Point B | .19 | 5358 | 2297 | 6.65 | 4.1 | |
| Point D | .19 | 11253 | 2993 | 2.64 | 1.43 | |
| Point E | .19 | 16076 | 4019 | 1.55 | .70 | |
| Crank Assembly In Bending | | | | | | |
| Moment Arm(In) | C (In) | I (In ⁴) | S.C Factor | f _{Bending} (psi) | M.S. _{LL} | M.S. _{UL} |
| 7.0 | 1.25 | .261 | 3.0 | 40512 | 1.23 | .053 |

Table 2.3.7 Pedal Actuated Crank

| Bottom Mount | | | | | |
|--------------|---------------------|--------------------|--------------------|--------------------|---------------------|
| | f_{tens} (psi) | f_{brg} (psi) | $f_{Lo.}$ (psi) | M.S. _{LL} | M.S. _{U.L} |
| Pivot | 4122 | 6024 | 2447 | 2.23 | 2.54 |
| Bolts | N/A | 3054 | 3054 | 5.55 | 5.98 |

Table 2.3.8 Bottom Mount

| Top Mount | | | |
|---------------------|--------------------|--------------------|---------------------|
| f_{tens} (psi) | f_{brg} (psi) | M.S. _{LL} | M.S. _{U.L} |
| 4122 | 6024 | 2.23 | 2.54 |

Table 2.3.9 Top Mount

| Center Rod | | | | | | |
|----------------------------|----------------|-------------------------|---------------------|---------------------|--------------------|---------------------|
| Area (In ²) | Length (In) | I (In ⁴) | f_{comp} (psi) | f_{crit} (psi) | M.S. _{LL} | M.S. _{U.L} |
| .06943 | 9.00 | .001786 | 10998 | 94000 | 5.82 | 4.76 |

Table 2.3.10 Center Rod

| Center Crank | | | | | |
|--------------|---------------------|--------------------|--------------------|--------------------|---------------------|
| Figure 2.2.5 | f_{tens} (psi) | f_{brg} (psi) | $f_{Lo.}$ (psi) | M.S. _{LL} | M.S. _{U.L} |
| Point A & C | N/A | 24435 | 8551 | .678 | .119 |
| Point B | 5759 | 8639 | 5759 | 3.75 | 2.16 |

Table 2.3.11 Center Crank

| Center Crank Mount | | | | | |
|--------------------|---------------------|--------------------|--------------------|--------------------|---------------------|
| | f_{tens} (psi) | f_{brg} (psi) | $f_{Lo.}$ (psi) | M.S. _{LL} | M.S. _{U.L} |
| Pivot | 2160 | 17278 | 1439 | .158 | .235 |

Table 2.3.12 Center Crank Mount

2.4 Manufacturing and Maintenance

Aluminum castings are utilized in the manufacture of most components in the system. The casting alloy is 355.0-T6, which is a light weight, high strength casting alloy. The pedal actuated crank and center crank are fabricated from 2024-T6 aluminum plate. The push pull rods are one half inch O.D. 4130 steel tubing. All other components are aircraft approved vendor supplied hardware, including the braking system.

3.0 ELEVATOR CONTROL SYSTEM (ECS)

3.1 Description

The elevator control system was designed using the loading conditions listed in FAR Part 23 and the human factors specifications given in MIL-STD-1472 Appendix Two. The first step in the design analysis was to determine how the elevator control system would function. As is typical in most aircraft, the pilot would exert a force on the control yoke, which would transfer the motion horizontally to the control support column, which would then transmit the load to push pull rods, which connect to a bellcrank with dual universal joints that were connected to yet another rod which facilitates the proper deflection angle with a maximum angle of $\pm 20^\circ$. The next step was to organize the elevator control system into workable sections. These sections are as follows:

1. The adjustable control yoke shaft
2. The control column support (including the pivot point)
3. The actual push-pull rod assembly with interface to the elevator
4. The elevator trim

After defining each section of the ECS, the sections were thoroughly researched using typical single engine models like the Cessna 172, the Mooney and the Piper Cadet(Warrior). With this accomplished, it was time to begin the structural substantiation and material selection. For clarity, each of the sections mentioned above will be discussed individually.

3.2 Adjustable Control Yoke

The control yoke with adjustable arm was a unique idea conceived for the discriminating pilot who is not of "standard" height and arm length. The adjustable control yoke shown below, allows the pilot to achieve proper elevator deflection by compensating for his/her arm length. The control yoke can be made longer for a pilot with long arms and shorter for a pilot who has shorter arms.

This increases the pilot's comfort as well as his safety, because proper deflection can be made. The control yoke is adjusted by pushing in and simultaneously turning the fastener and moving the

inner shaft to the proper location, which is determined by the pilot's arm length, then releasing the fastener, which allows the steel pin to lock into position. This adjustment method was chosen primarily for its safety features. With the two motions required to relocate the pin, it seems unlikely that pin will be able to displace if bumped or knocked during flight.

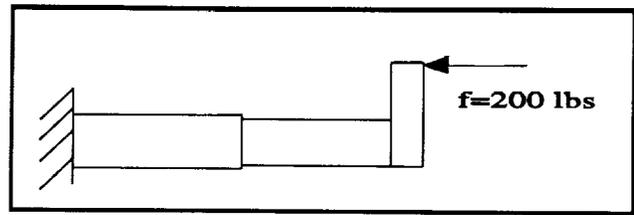


Figure 3.2.1

3.2.1 Substantiation

The adjustable control yoke was designed using the worst case scenarios of loading, ie. a 200lb force is exerted by the pilot, which is represented in figure 3.2.1. The 200 lb load will be transmitted directly through the control yoke shaft to the control column support. Of major interest is the pin attachment. The table below summarizes the results of the calculations.

| Pin Attachment | | | | | |
|-----------------------------|---------------------------|------|------|---------|-----------|
| f_{Shear} (psi) | f_{brg} (psi) | F.F. | F.S. | M.S.-LL | M.S.-U.L. |
| 4074 | 12800 | 2.0 | 1.5 | 9.06 | .40 |

Table 3.2.1 Pin Attachment Stress Summary

3.2.2 Manufacturing and Maintenance

The inner and outer shafts are made of extruded Aluminum 2219 and are engaged such that buckling will not be a problem. Located at the intersection of the dash and the control yoke is casted "dash interface" designed to provide horizontal support. A universal joint is located approximately 6 in from the interface to allow the control yoke to move horizontally with no vertical displacement, while the control column support moves radially 10.9°. The displacement of the control yoke is negligible as shown from the following calculations.

$$\delta = f/G = 200 \cdot 33 / 3843197 \rightarrow \delta = .0017 \text{ in.}$$

The control yoke is welded to the control column support with a needle-thrust point ball bearing to facilitate turning motion necessary for the ailerons.

3.3 CONTROL COLUMN SUPPORT

Essential to the ECS is the control column support shaft, shown in figure 3.3.1. The control column support shaft function is to pivot around the base point when the control yoke is pulled out or pushed in, thus transferring motion to the push-pull rods located approximately 3 in. above the base point.

3.3.1 Loads and Loading

This part was designed for the two worst case scenarios that the support column will encounter; 1) both pilots pushing or pulling with a 200 lb force each or 2) one pilot pulling while the others pushes with a 200 lb force each. The support column was analyzed by breaking it into three members, 2 vertical and 1 horizontal. The static analysis is shown

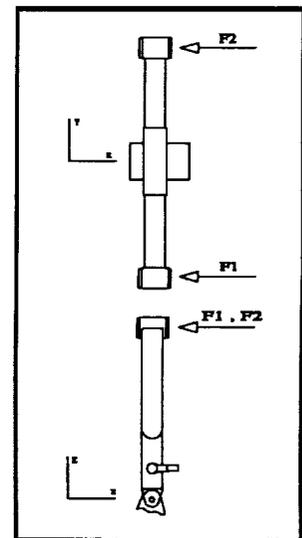


Figure 3.3.1

below, where H = Reaction load and E = load that the push-pull rod will see.

$$\Sigma F_x = 0 \quad 2 \cdot 200 - E - H = 0 \quad \Sigma M_y = 2 \cdot 200 \cdot 16.8 - E \cdot H = 0 \rightarrow E = 2203 \text{ lbs.} \quad H = 1803 \text{ lbs.}$$

The results for the members are tabulated below.

3.3.2 Substantiation

| Case | Member | Shear(psi) | Moment | Torque |
|------|--------|------------|--------|--------|
| # 1 | #1 | 200 | 1980 | |
| | #2 | 400 | 4520 | 1980 |
| | #3 | 2203 | 5179 | |
| # 2 | #1 | 200 | 1980 | |
| | #2 | 200 | 2260 | 3960 |
| | #3 | 0 | 0 | 4520 |

* Denotes maximum values that were designed to

Table 3.3.2 Control Column Support Stress Analysis

The calculations shown below substantiate that the control column support can be made of extruded Aluminum 2219 and that AN4C-24 bolts can be used to connect the control column joiner to the control column attachment plate.

$$f_{\max 1} = Tc/J$$

$$= 4520 \cdot 1 / .57$$

$$f_{\max 1} = 2879 \text{ psi}$$

$$f_{\max 2} = MC/I$$

$$= 5179 \cdot 1 / .785$$

$$f_{\max 2} = 6597 \text{ psi}$$

$$f_{\max 3} = VQ/It$$

$$= 2203 \cdot .537 / .785 \cdot .25$$

$$f_{\max 3} = 6028 \text{ psi}$$

$$\Sigma F = f_{\max 1} + f_{\max 2} + f_{\max 3} = 15504 \text{ psi} \rightarrow f_{LL} = 1.2 \cdot \Sigma f_{\max} \rightarrow M.S._{yield} = 36000 / 18605 - 1 = .93$$

$$\rightarrow f_{UL} = 1.5 \cdot f_{LL} \rightarrow M.S._{ult} = 56000 / 27908 - 1 = 1.0$$

The maximum load for the bolts will be found at point E (push-pull rod location). Four bolts will have to sustain 3606 psi. Thus, each bolt will see 902 psi.

$$\Sigma F_x = 0 \quad V - 1803/2 = 902 \text{ psi} \rightarrow f_{LL} = 1.2 \cdot V = 1082 \text{ psi} \rightarrow f_{UL} = 1.5 \cdot f_{LL} = 1623.6 \text{ psi} \rightarrow$$

$$\text{M.S.} = (F_{tu} / f_{ul}) - 1 = 4080/1623.6 - 1 = 1.51$$

The weakest spot will be where the control column attachment plate , which will be machined as well as the control column joiner, is welded to the aircraft structure. The substantiation calculations are shown below.

| | | | |
|--|----------------------------------|---|---|
| $f = P/A$ | $F.F. = 1.2 + .2 \text{ (weld)}$ | $f_{LL} = F.F \cdot f$ | $f_{UL} = F.S. \cdot f_{LL}$ |
| $= 1803/2 \cdot .5$ | $= 1.4$ | $= 1.4 \cdot 1803$ | $= 2.0 \cdot 2524$ |
| $f = 1803 \text{ psi}$ | $F.F. = 1.4$ | $f_{LL} = 2524 \text{ psi}$ | $f_{UL} = 5048 \text{ psi}$ |

$$\text{M.S.}_{\text{yield}} = 36000/5048 - 1$$

$$\text{M.S.}_{\text{yield}} = 6.13$$

$$\text{M.S.}_{\text{ul}} = 56000/5048 - 1$$

$$\text{M.S.}_{\text{ul}} = 10.1$$

3.4 PUSH-PULL ROD ASSEMBLY

The push-pull rods were selected for the D-2 for several reasons. First the push-pull rods have a "better" feel to them thus the student pilot has a better idea of the deflections necessary to create proper elevator motion. Second, the push-pull rods, have a greater coefficient of thermal expansion than the traditional cable. This is an important factor considering that the ECS is located several inches below the engine. These push-pull rods are connected to the control column support by means of a NAS-660-R4-11 rod end. The rods are extruded 4130 Steel and will see a load of 2200 lbs, see control column calculations. The rods will be supported approximately every 48 inches, using a fabricated idler arm assembly(see rudder). The calculations for this are shown directly below.

3.4.1 Structural Substantiation

$$\begin{array}{llll}
 f = P/A & f_{LL} = 1.2 \cdot f & f_{UL} = F.S. \cdot f_{LL} & M.S._{yield} = F_{ty}/f_{ty} - 1 \\
 = 2200/616 & = 1.2 \cdot 11459 & = 2 \cdot 13751 & = 39000/13751 - 1 \\
 f = 11459 \text{ psi} & f_{LL} = 13751 \text{ psi} & f_{UL} = 27501 \text{ psi} & M.S._{ul} = F_{tu}/f_{tu} - 1 \\
 & & & = 56/27.5 - 1 \\
 & & & M.S._{ul} = 1.04 \\
 & & & M.S._{yield} = 1.84
 \end{array}$$

$$P_{crit} = \pi^2 \cdot E \cdot I / L^2 = \pi \cdot \pi \cdot (30E6) \cdot (.001766) / L^2 \rightarrow L = 48.6 \text{ in}$$

The push-pull rods transfer the displacement of the control column support to a bellcrank (see rudder) has dual universal joints on

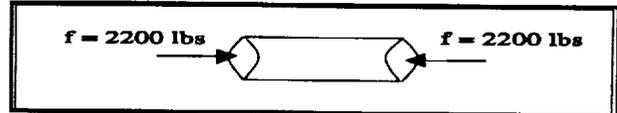


Figure 3.4.1

MS20271-B10 on either end which oscillate the elevator around two internal hinges. These U-Joints were selected according to the maximum torque that was calculated for the pivot point.

3.5 Elevator Trim

The elevator trim was conceptualized as a cable and pulley system attached to a jackscrew that controls the elevator trim deflection. The system is lightweight and is not used as frequently as the elevator, therefore the "feel" is not as important and using push-pull rods cannot be justified. According to the MIL Handbook, a pilot can only exert 59 lbs by gripping the trim wheel and turning it. It was then decided that in the interest of producibility, the trim system would use the same pulleys, sprockets and cable as the aileron system, which was designed for 160 lbs. This creates a factor of safety of approximately 4.0 for the elevator trim system. The trim wheel and indicator are located on the control panel in between the pilot's seats and can be rotated clockwise or counterclockwise which turns the cable and, producing motion in the jackscrew, which connects to a piano hinge to create a $\pm 10^\circ$ maximum deflection.

3.6 Manufacturing and Maintenance

The entire elevator control system was designed with maintainability and life cycle in mind. Access panels are located on the bottom portion of the fuselage and on the cowling to provide easy access to both the push-pull rods, the trim system and the control column support. . The stretch in the cable can be adjusted using the turnbuckles and cable joiners. The motion of the part and its use were kept in mind while selecting the proper material to withstand the stresses. The same part was used throughout the cockpit control system, ie the idler arms were used for both the rudder and elevator, to minimize the number of parts that have to be stocked or ordered. In conclusion, the elevator control system meets the requirements of the SOW for the Viper D-2, FAR Part 23 and MIL Handbook. The pin attachment was originally conceptualized as a cog wheel track with a locking pin but was changed to the pin idea presented in this report.

4.0 AILERON CONTROL SYSTEM

4.1 Description

The aileron control system provides aileron deflections of positive 20 degrees and negative 15 degrees. The system is operated by rotating the control yoke 90 degrees in either direction; clockwise for right roll and counter-clockwise for left. The cockpit portion of the system uses sprockets and chains to transfer yoke rotation to the lower portion of the control column. This is translated through cables which run through the driveshaft tunnel to a set of bellcranks which transfer displacement to the ailerons.

4.2 LOADS AND LOADING

The analysis of the "cockpit" portion of the aileron system will begin with the determination of the static loads created by the application of the forces which correspond to the maximum possible forces as prescribed by the Federal Aviation Administration (F.A.R. 23.397). It will also be taken into consideration that the system has been preloaded to 115 percent of these F.A.R. values prior to the current application of the forces. It should also be noted that these forces will be added to the system in a way as to simulate the worst possible condition that could occur in the flight environment.

4.2.1 The first of the two worst case scenario's includes both pilots turning their wheels inboard simultaneously at the prescribed torque. The resultant static loads are shown below. Remember each closed system is preloaded to 620 pounds.

Summing the forces at sprocket S1 to find the resultant force on the bolt.

$$T1=T2=81lb$$

$$T3=T4=1159lb$$

$$T5=T6=620lb$$

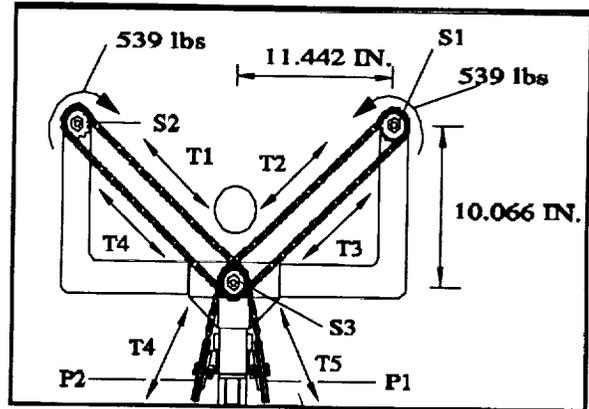


Figure 4.2.1

$$\Sigma F_{YS1} = -\cos(48.66) 81 - \cos(48.66) 1159$$

$$F_{RYS1} = 819.05 lb$$

$$\Sigma F_{XS1} = -\sin(48.66) 81 - \sin(48.66) 1159 + F_{RYS1}$$

$$F_{RXS1} = 931.0 lbs.$$

$$F_{RS1} = 1240.0 lb$$

By symmetry the resultant force on sprocket S2 is equal to S1

$$F_{RS2} = 1240.0 lbs.$$

Summing the forces at sprocket S3 to find the resultant force on the bolt.

$$\Sigma F_Y = (819) 2 - (570) 2 + F_{RYS3}$$

$$F_{RYS3} = F_{RS3} = 498 \text{ lb}$$

Summing the forces, in the plane parallel to the pulley, at pulley P5 to find the resultant force on the bolt.

$$\Sigma F_X = \cos 11.83 (620) + F_{RXP5}$$

$$F_{RXP5} = 606.83 \text{ lb}$$

$$\Sigma F_Y = 620 - \sin 11.83 (620) - F_{RYP5}$$

$$F_{RYP5} = 492.89 \text{ lb}$$

$$F_{RP5} = 781.78$$

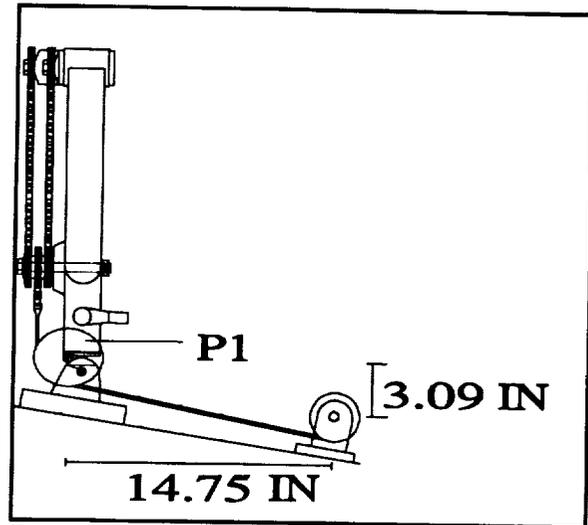


Figure 4.2.2

4.2.2 For the second worst case scenario the yoke wheels are both turned outward simultaneously with the same torque the values. In this case T1,T2,T3, and T4 will swap values but will result in identical resultant values on the bolts.

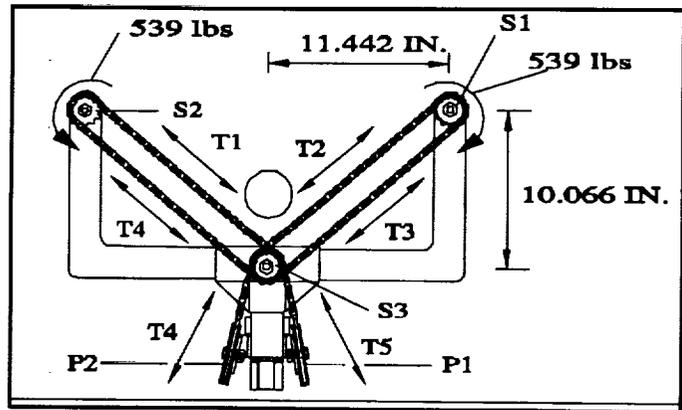


Figure 4.2.3

4.3 STRUCTURAL SUBSTANTIATION

Now that the system has been statically defined these values will be used to evaluate the structural fortitude of the members that are recipients of these loads. This will be done by evaluating the various stresses and the corresponding factor and margin of safety. It should be noted that all forces have been multiplied by a fitting factor of 1.5.

4.3.1 Sprockets 1 and 2.

$$f_{shear} = \frac{P}{A} = \frac{1860}{0.11} = 16909.09 \frac{lbs}{in.^2}$$

$$f_{br} = \frac{P}{td} = \frac{1860}{0.23(0.38)} = 21281.46 \frac{lbs.}{in.^2}$$

Due to bearing stress:

$$M.S._{L.L.} = 1.97, F.S._{L.L.} = 2.97, M.S._{U.L.} = 3.45, F.S._{U.L.} = 4.45$$

4.3.2 Sprocket assembly 3.

$$f_{shear} = \frac{P}{A} = \frac{498.1}{0.22} = 3396.00 \frac{lbs.}{in.^2}$$

$$f_{bearing} = \frac{P}{td} = \frac{498.1}{1.60(0.53)} = 585.17 \frac{lbs.}{in.^2}$$

Due to shear:

$$M.S._{L.L.} = 17.74, F.S._{L.L.} = 18.74, M.S._{U.L.} = 27.11, F.S._{U.L.} = 28.11$$

4.3.3 Pulleys 5 and 6

$$f_{shear} = \frac{P}{A} = \frac{1172.67}{0.09} = 13029.67 \frac{lbs.}{in.^2}$$

$$f_{bearing} = \frac{P}{td} = \frac{1172.67}{0.20(.341)} = 17194.57 \frac{lbs.}{in.^2}$$

Due to bearing:

$$M.S._{L.L.} = 3.70, F.S._{L.L.} = 2.70, M.S._{U.L.} = 4.55, F.S._{U.L.} = 5.55$$

4.4 Manufacturing and Maintenance

The aileron control system consists largely of aircraft approved, vendor supplied hardware; including all fasteners, fittings, chain, and cable. Manufactured components include the bellcranks and female jack-screw assembly which are cast from 355.0-T6 aluminum. The sprocket assemblies require welding which will be done in-house.

5.0 WEIGHT SUMMARY

| COMPONENT | WEIGHT (lbs) |
|----------------------------------|--------------|
| Rudder | |
| Pedals | 4.1 |
| Bellcranks | 2.0 |
| Brakes | 3.0 |
| Rods | 4.4 |
| Hardware | 7.1 |
| Elevator | |
| Adjustable Control Yoke Assembly | 2.9 |
| Control Column Support Assembly | 3.1 |
| Push-Pull Rods | 4.2 |
| Trim | 3.2 |
| Allerons | |
| Chains | 3.1 |
| Sprockets | .49 |
| Pulleys | .9 |
| Cable | 6.0 |
| Bellcrank | 4.0 |
| TOTAL | 47.8 |

6.0 CONCLUSION

The goal of this design project was to provide a simple yet effective cockpit control system, meeting FAR specifications and designed with human comfort in mind. It has been shown that his design meets the above listed criteria, but their is always room for improvement. Several components have been designed with excessive margins of safety, and weight reduction is possible by removing excess material.

APPENDIX

Design substantiation was done for all cockpit control system components. Analysis consisted of Margin of Safety calculations for the limit load and ultimate loading cases. Fitting factors were applied to both rotating and non-rotating joints. It should also be noted that a stress concentration factor of 3.0 was applied to the pedal actuated crank in bending. The following equations were used in the substation analysis.

$$f_{bearing} = \frac{P}{td} \times F.F.$$

$$f_{t.o.} = \frac{P}{2Xt} \times F.F.$$

$$f_{tens} = \frac{P}{(h-d)t} \times F.F.$$

$$f_{shear} = \frac{P}{A} \times F.F.$$

$$f_{comp.} = \frac{P}{A}$$

$$f_{crit. axial} = \frac{\pi^2 EI}{Al^2}$$

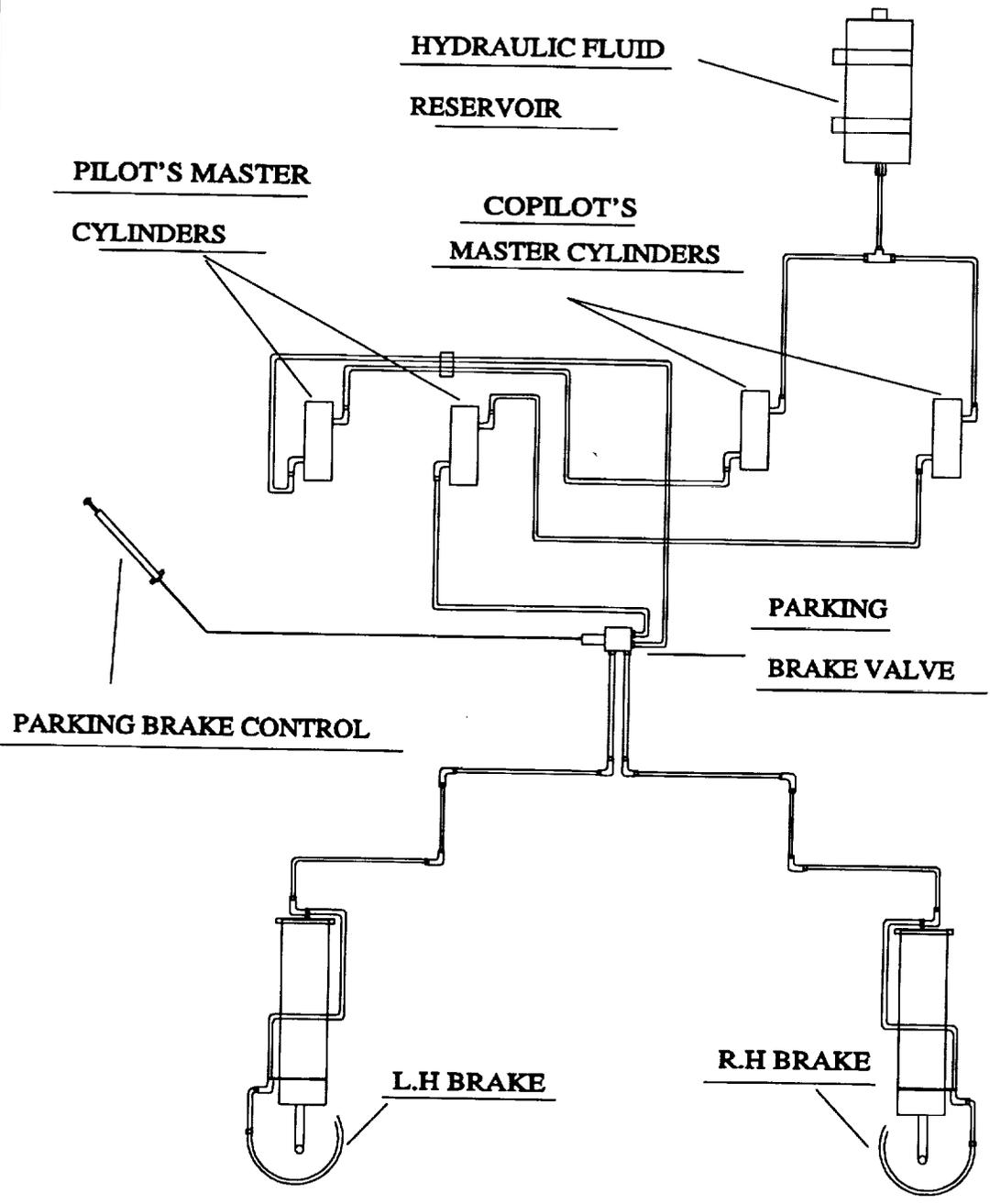
$$F.F._{rotating} = 2.0$$

$$F.F._{non-rotating} = 1.2$$

$$M.S._{L.L.} = \frac{F_{yield}}{F_{L.L.}} - 1$$

$$M.S._{ULT} = \frac{F_{ULT}}{F_{L.L.} \cdot 1.5} - 1$$

BRAKE SYSTEM



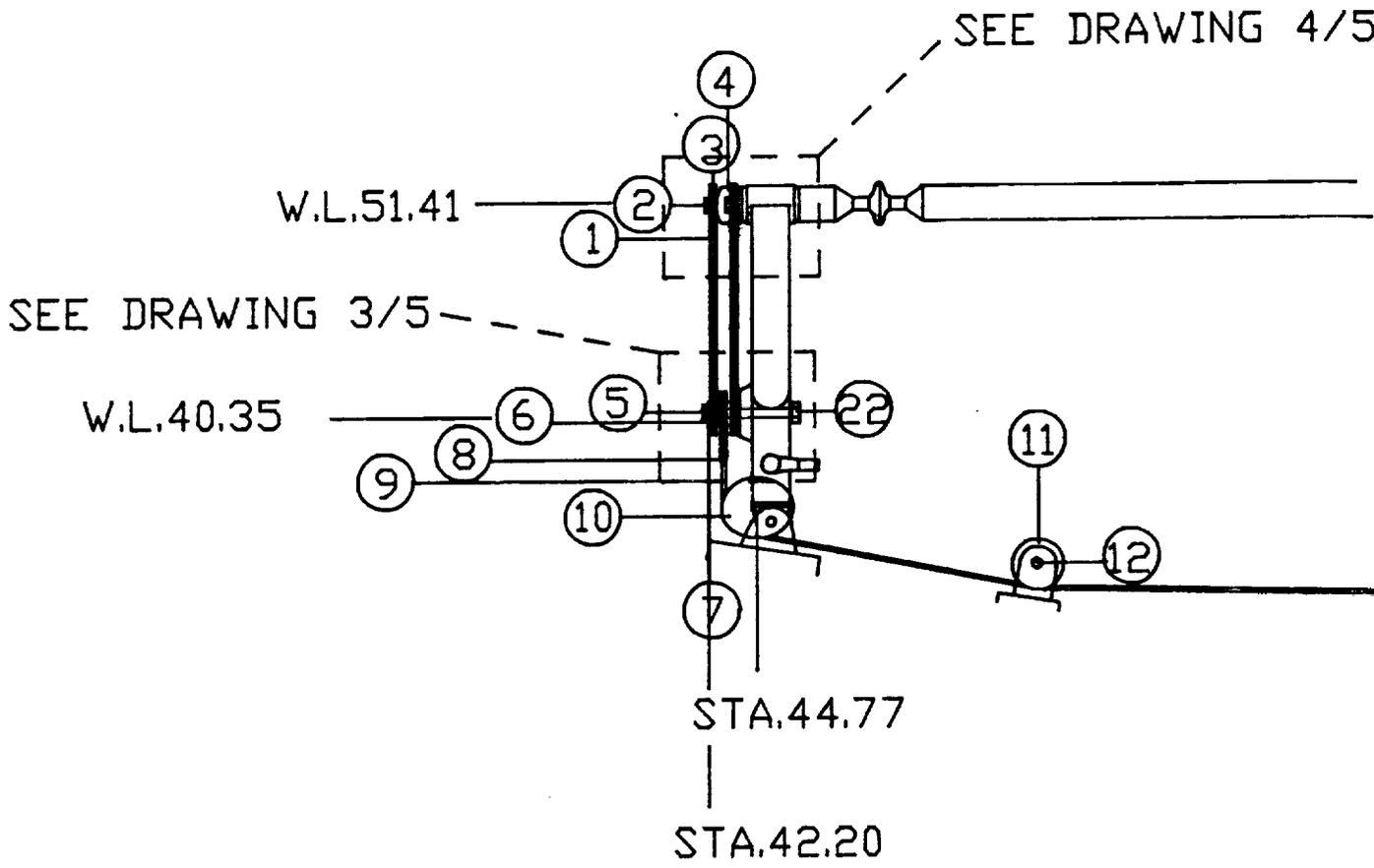
| | | | |
|----|-------|--------------------------------|--------------|
| 16 | 2 | ROD BEARING AND FEMALE JACK | 421S9303D188 |
| 15 | 2 | HORN ASSEMBLY | 421S9303D186 |
| 14 | 4 | TERMINAL | MS20667-5 |
| 13 | 2 | BELL CRANK | 421S9303D184 |
| 12 | 8 | BOLT | NAS1305-1 |
| 11 | 8 | PULLEY | AN221-1 |
| 10 | 2 | INNER DIA. STEEL PULLEY | 421S9303D182 |
| 09 | 680IN | 3/16 FLEXIBLE STEEL CABLE | MIL-C-5424 |
| 08 | 2 | CABLE, CHAIN UNION | 421S9303D180 |
| 07 | 1 | TRIPLE SPROCKET ASSEMBLY | 421S9303D178 |
| 06 | 1 | BEARING | 421S9303D176 |
| 05 | 1 | .532IN DIA. 4.883IN LEN. STEEL | 421S9303D174 |
| 04 | 2 | SPROCKET SUPPORT BRACKET | 421S9303D172 |
| 03 | 5 | 0.500 PITCH SPROCKET | 41EM-B-12 |
| 02 | 2 | .379IN DIA. 1.00IN LEN. STEEL | 421S9303D170 |
| 01 | 60IN | 0.500 PITCH CHAIN | RC4155 |

| | | | | |
|----|------|-----|-------------|--------|
| 92 | ITEM | QTY | DESCRIPTION | PART # |
|----|------|-----|-------------|--------|

| | | | | |
|--|---|------|-------|--------------|
| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL .XX ± .01 .XXX ± .001 ANGULAR ± 1/2° | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA | | | |
| | SIZE | DATE | SCALE | DRAWN BY |
| | B | 3/14 | 1/20 | G. SCHNEIDER |
| | TITLE | | | |
| AILERON CONTROL SYSTEM | | | | |
| DRAWING NO. | | | SHEET | |
| 421S9303D166 | | | 1/5 | |

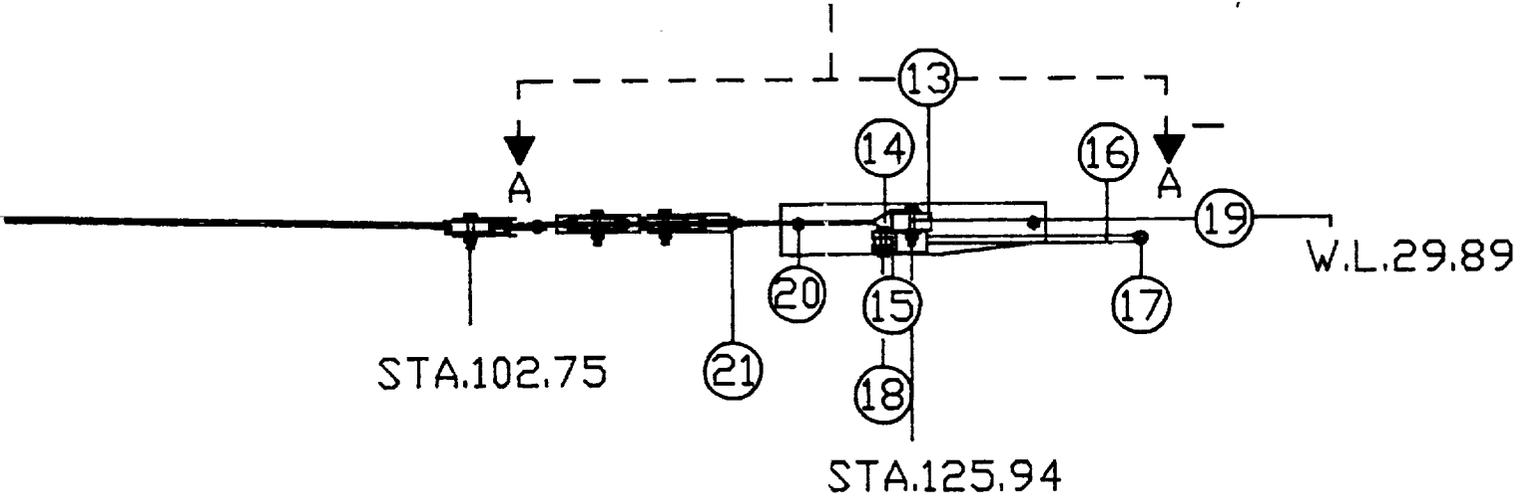
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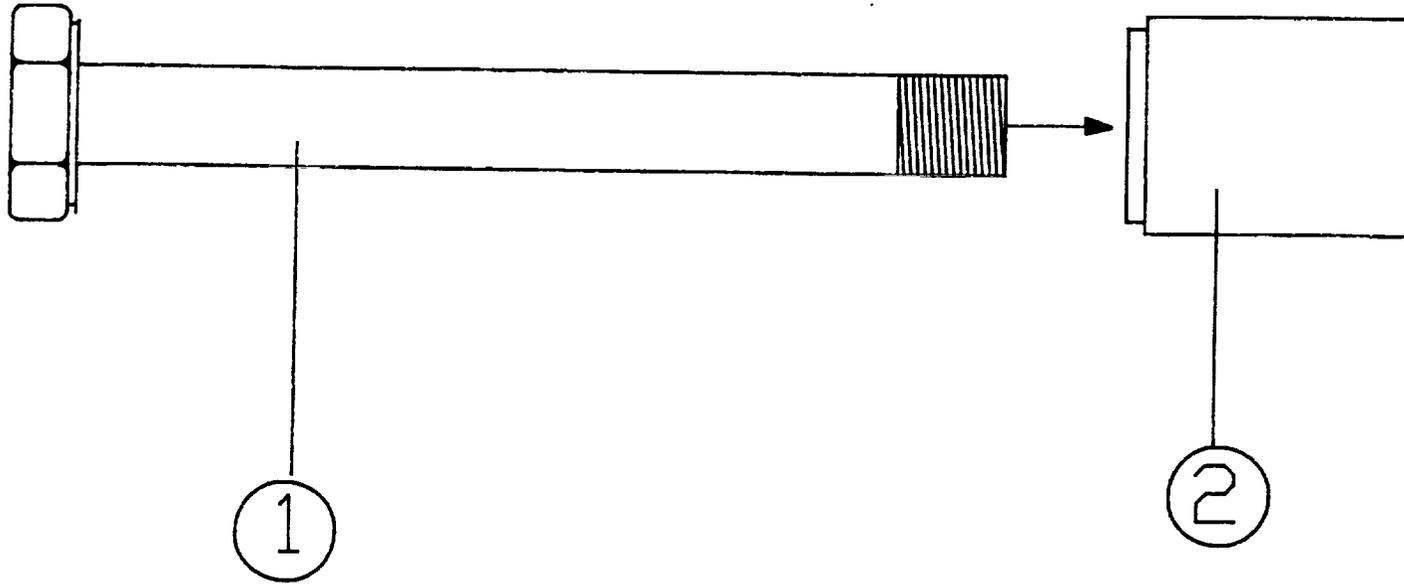
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SEE DRAWING 5/5

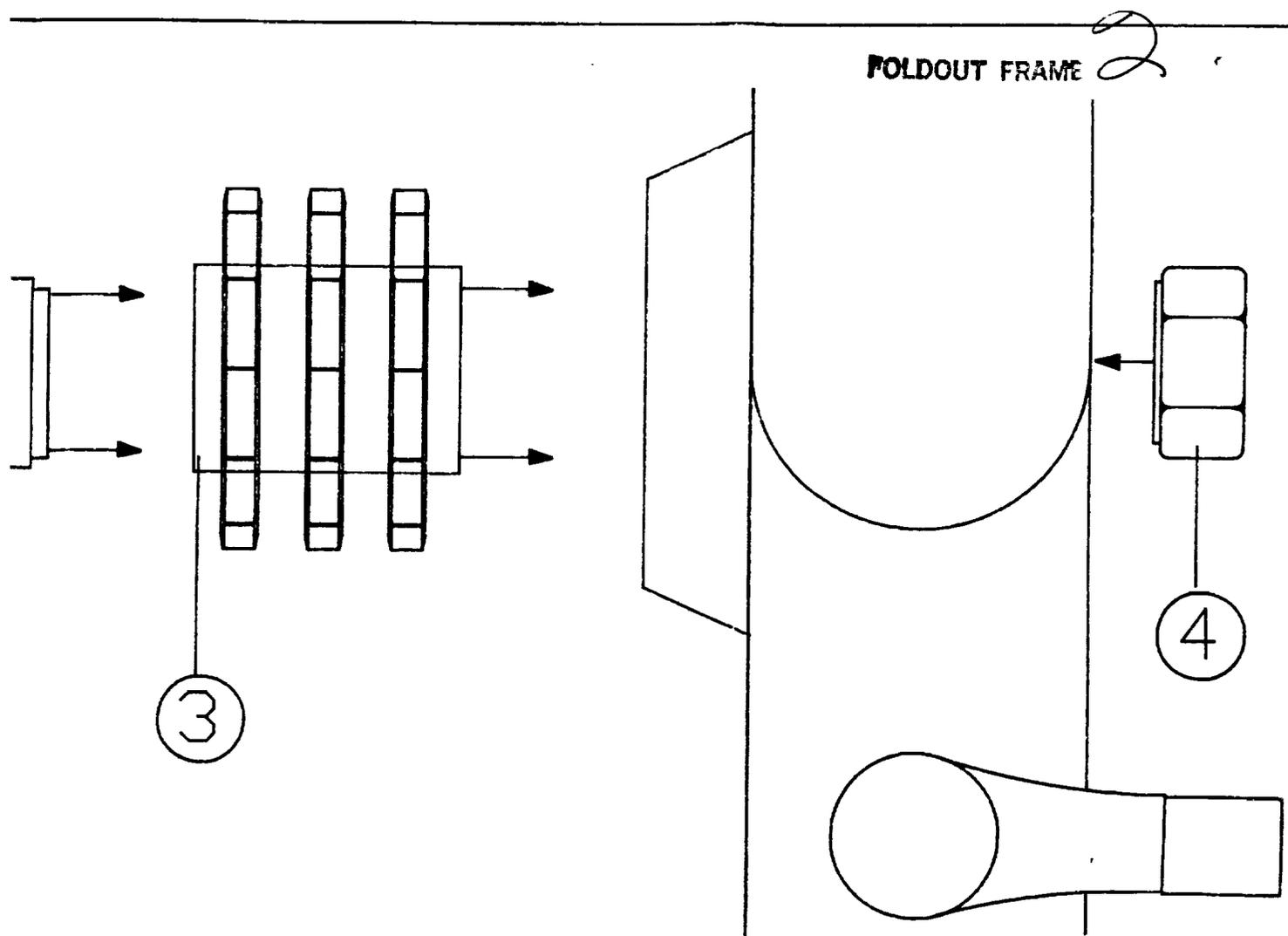


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| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01</p> <p>.XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | | |
| | <p>SIZE</p> <p>B</p> | <p>DATE</p> <p>3/14/93</p> | <p>SCALE</p> <p>1/10</p> | <p>DRAWN BY</p> <p>G. SCHNEIDER</p> | |
| | <p>TITLE</p> <p>AILERON CONTROL SYSTEM</p> | | | | |
| | <p>DRAWING NO.</p> <p>421S9303D166</p> | | | <p>SHEET</p> <p>2/5</p> | |

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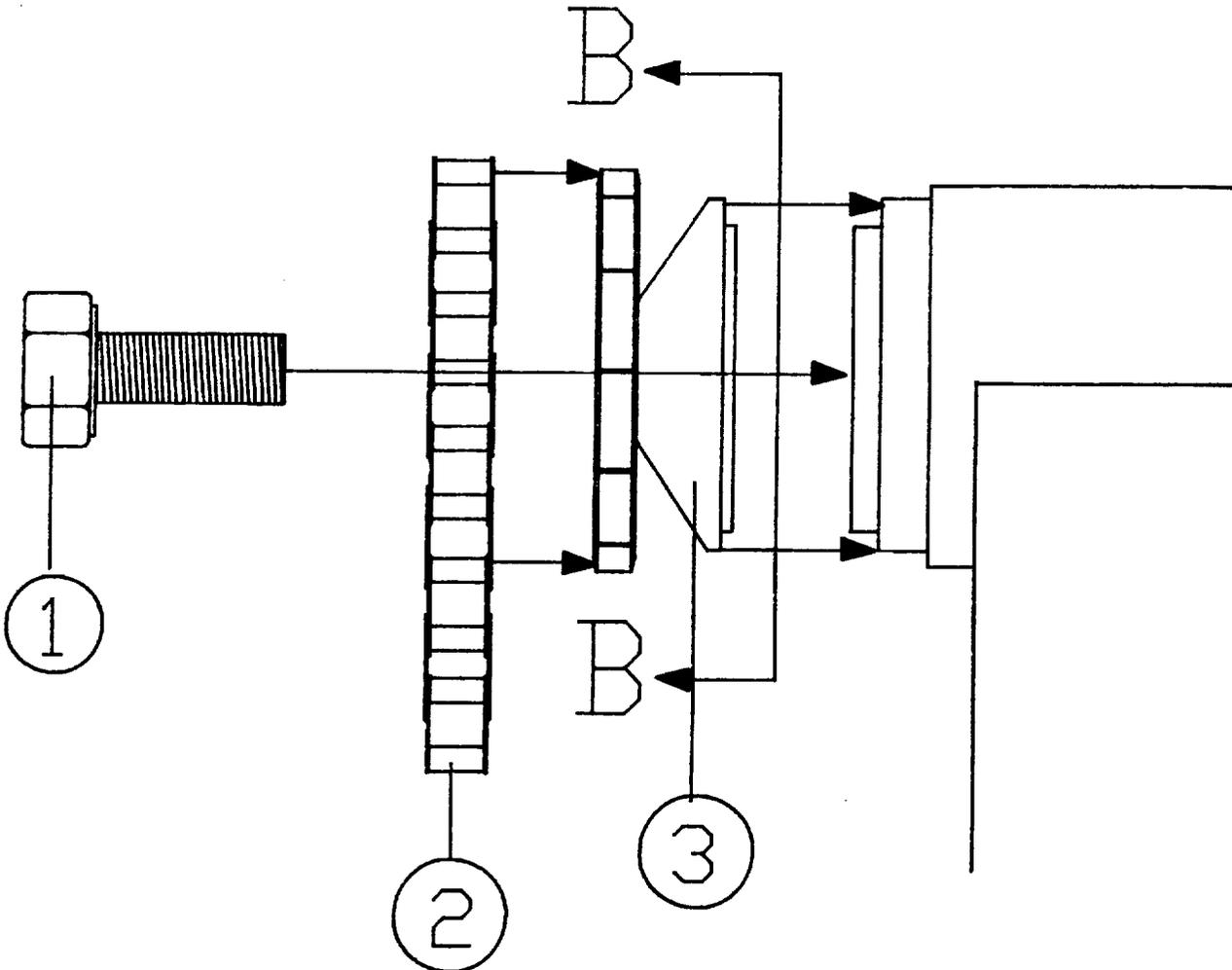
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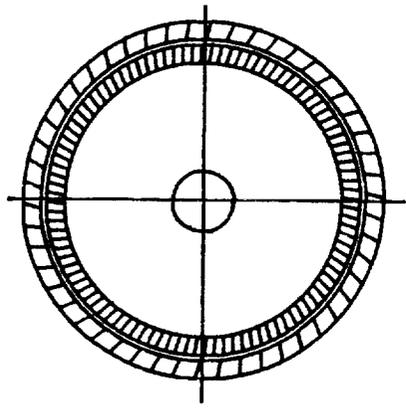
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|------|-----|---------------|--------------|
| 4 | 1 | NUT | 421S9303D19 |
| 3 | 1 | TRIPLE SPROK. | 421S9303D178 |
| 2 | 2 | BEARING | 421S9303D176 |
| 1 | 1 | .532IN DIA. | 421S9303D174 |

| | | | | |
|---|---|------|------------|-------------|
| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01</p> <p>.XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | |
| | SIZE | DATE | SCALE | DRAWN BY |
| | B | 3/14 | 1/1 | G.SCHNEIDER |
| | TITLE | | | |
| <p>AILERON CONTROL SYSTEM</p> | | | | |
| DRAWING NO. | | | SHEET | |
| <p>421S9303D166</p> | | | <p>3/5</p> | |

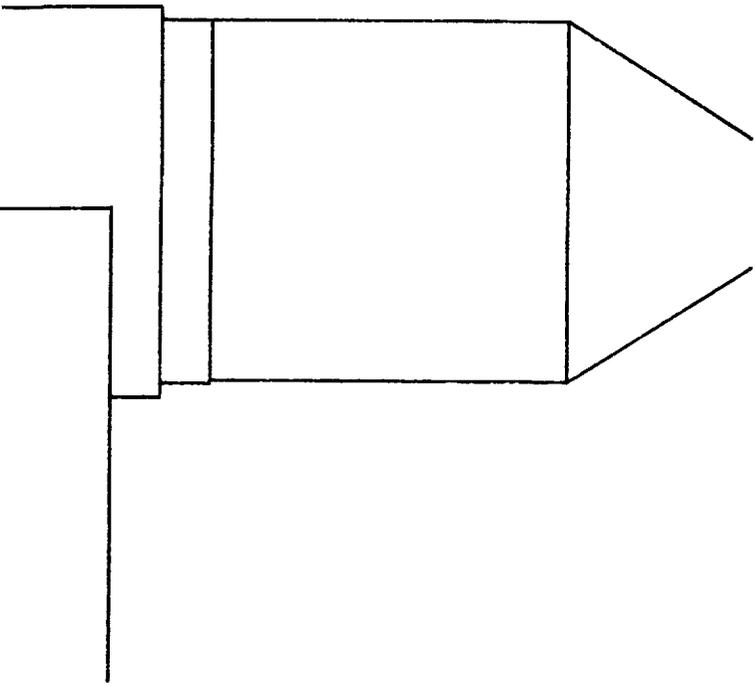
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B - B



FOLDOUT FRAME ²



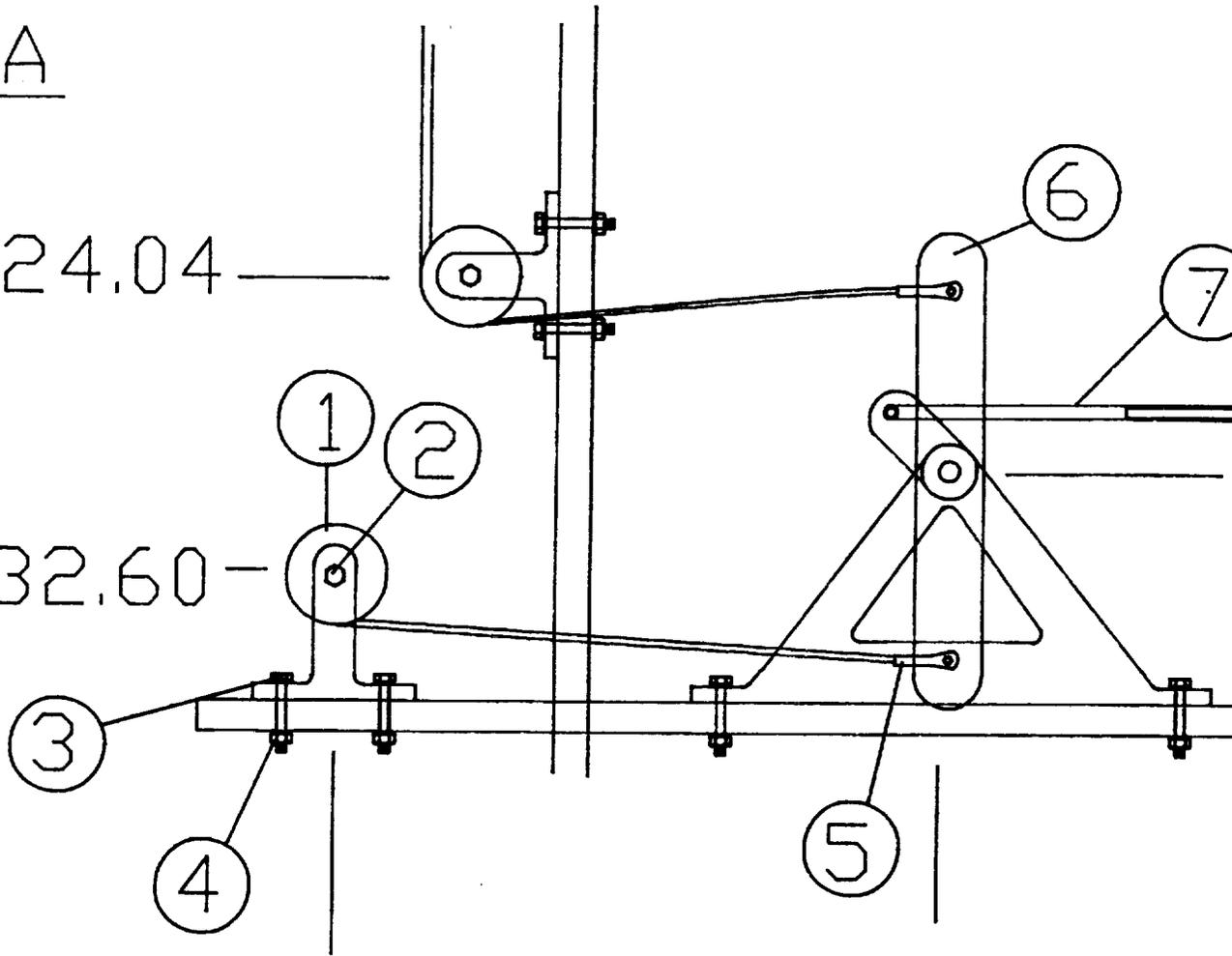
| ITEM | QTY | DESCRIPTION | PART# |
|------|------|-----------------|--------------|
| 3 | 2 | SPROCKET SUPP. | 421S9303D172 |
| 2 | 60IN | 0.50 PITCH CHN. | RC4155 |
| 1 | 2 | .379IN DIA. | 421S9303D170 |

| | | | | |
|---|---|------|-------|-------------|
| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01</p> <p>.XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | |
| | SIZE | DATE | SCALE | DRAWN BY |
| | B | 3/14 | 1/1 | G.SCHNEIDER |
| | <p>TITLE</p> <p>AILERON CONTROL SYSTEM</p> | | | |
| DRAWING NO. | | | SHEET | |
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A-A

B.L.124.04

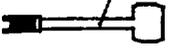
B.L.132.60



STA.109.52

STA.125.9

8



B.L.129.75

4

| | | | |
|------|-----|-----------------------|--------------|
| 8 | 2 | JACKSCREW | 421S9303D190 |
| 7 | 2 | ROD BEARING,FEMALE J. | 421S9303D188 |
| 6 | 2 | BELL CRANK | 421S9303D184 |
| 5 | 2 | TERMINAL | MS20667-5 |
| 4 | 26 | NUT | AN315-4 |
| 3 | 12 | BOLT | AN4-24 |
| 2 | 8 | BOLT | NAS1305-1 |
| 1 | 8 | PULLEY | AN221-1 |
| ITEM | QTY | DESCRIPTION | PART# |

| | | | | |
|--|---|------|--------------|--------------|
| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL .XX ± .01 .XXX ± .001 ANGULAR ± 1/2° | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA | | | |
| | SIZE | DATE | SCALE | DRAWN BY |
| | B | 3/14 | 1/10 | G. SCHNEIDER |
| | TITLE AILERON CONTROL SYSTEM | | | |
| DRAWING NO. 421S9303D166 | | | SHEET 5/5 | |

1.
FOLDOUT FRAME

| | | | |
|----|----|-------------------------|------|
| 38 | 1 | CONTROL COLUMN ASSEMBLY | |
| 37 | 2 | PIANO HINGE | MS20 |
| 36 | 1 | COLUMN ATTACHMENT | ALUM |
| 35 | 2 | HINGE 2 | MS20 |
| 34 | 2 | CONTROL COLUMN TOP | ALUM |
| 33 | 12 | NUTS | AN |
| 32 | 12 | WASHERS | AN |
| 31 | 2 | INNER YOLK SHAFT | ALU |
| 30 | 12 | YOLK SCREWS | BS |
| 29 | 2 | YOLK ASSEMBLY | |
| 28 | 1 | TRIM PUSH ROD | ALL |
| 27 | 1 | SPROCKET 2 | |
| 26 | 8 | BOLTS | AN4 |
| 25 | 1 | ELEVATOR LEVER | ALUM |
| 24 | 1 | ACTUATOR | 1260 |
| 23 | 2 | ELEVATOR HINGE | MS20 |
| 22 | 1 | BELLCRANK ASSEMBLY | 421S |
| 21 | 8 | PULLEY | AN21 |
| 20 | 1 | TURNBUCKLE | MS0 |
| 19 | 3 | CABLE | MIL- |
| 18 | 2 | CHAIN .25 PITCH | RC25 |

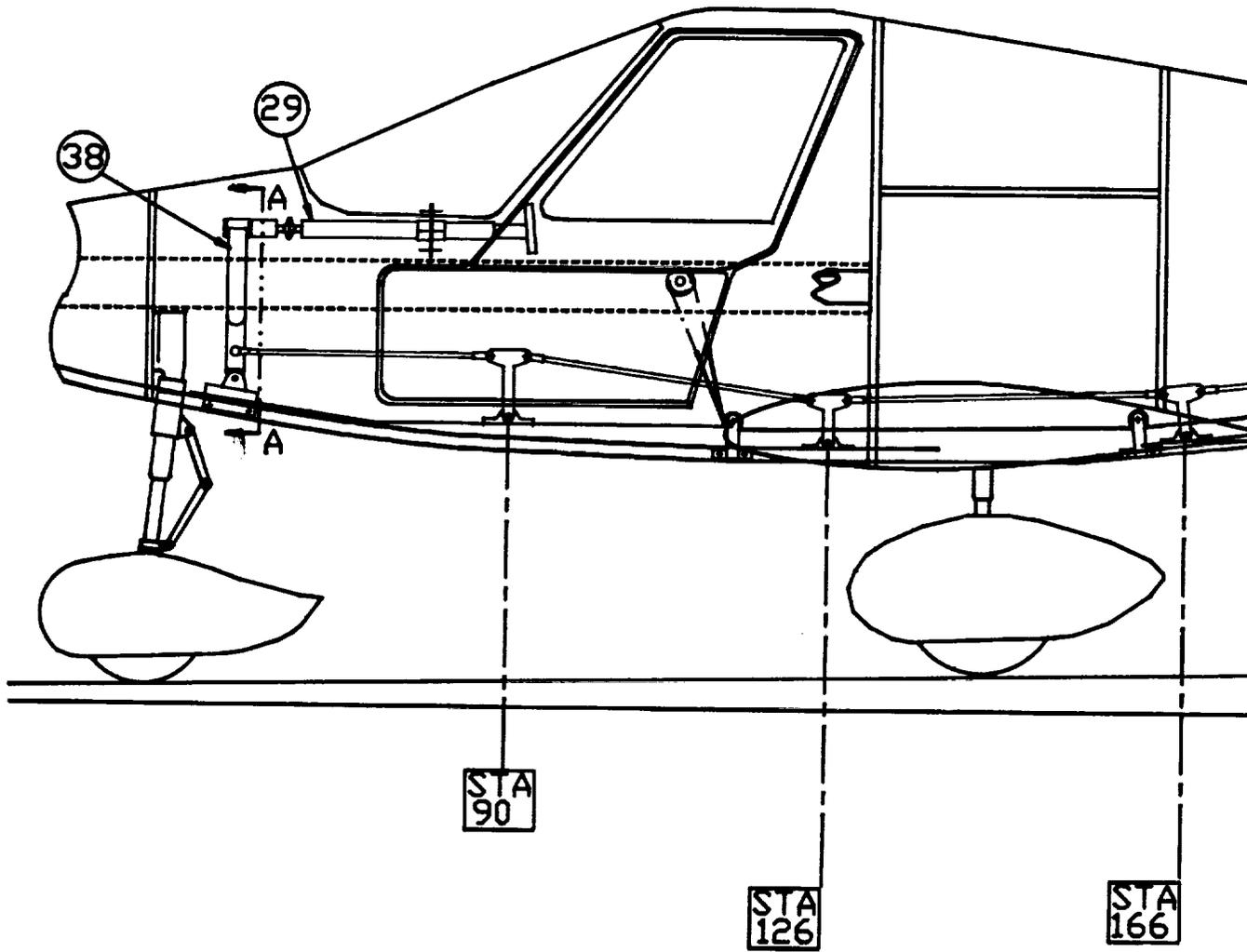
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FOLDOUT FRAME

| | | | | |
|----------|------|-----|----------------------------------|--------------|
| | 17 | 2 | BUSHING | 0713032-1 |
| | 16 | 2 | SPROCKET | 25SP175-54 |
| | 15 | 1 | TRIM WHEEL | 0713656-1 |
| | 14 | 6 | IDLER ARM ASSEMBLY | 421S93D10306 |
| | 13 | 6 | PUSH PULL RODS; 4130 STEEL | .5=D, .04=T |
| 057P2800 | 12 | 1 | PUSH PULL ROD ENDS | NAS-660R411 |
| 2219 | 11 | 1 | CONTROL COLUMN ATTACHMENT PLATE | ALUM 2219 |
| 257-P2 | 10 | 1 | CONTROL COLUMN JOINER | ALUM 2219 |
| 2219 | 9 | 1 | CONTROL COLUMN SUPPRT SHAFT | ALUM 2219 |
| 310-C4 | 8 | 1 | CONTROL COLUMN U-BAR | AMS-4162 |
| 60-1/4 | 7 | 2 | NEEDLE-THRUST POINT BALL BEARING | NKX30/DUST |
| M 2219 | 6 | 4 | UNIVERSAL JOINT | MS20271-B10 |
| -0420-1 | 5 | 1 | COLLAR | 0713032-2 |
| | 4 | 2 | YOLK SHAFT FASTENER | 5610-401-20B |
| | 2 | 2 | ADJ. YOLK SHAFT | ALUM 2219 |
| M 2219 | 3 | 2 | OUTER YOLK SHAFT | ALUM 2219 |
| -C24 | 1 | 2 | YOKE | PIN05-16610 |
| 2219 | ITEM | QTY | DESCRIPTION | MAT/PART # |

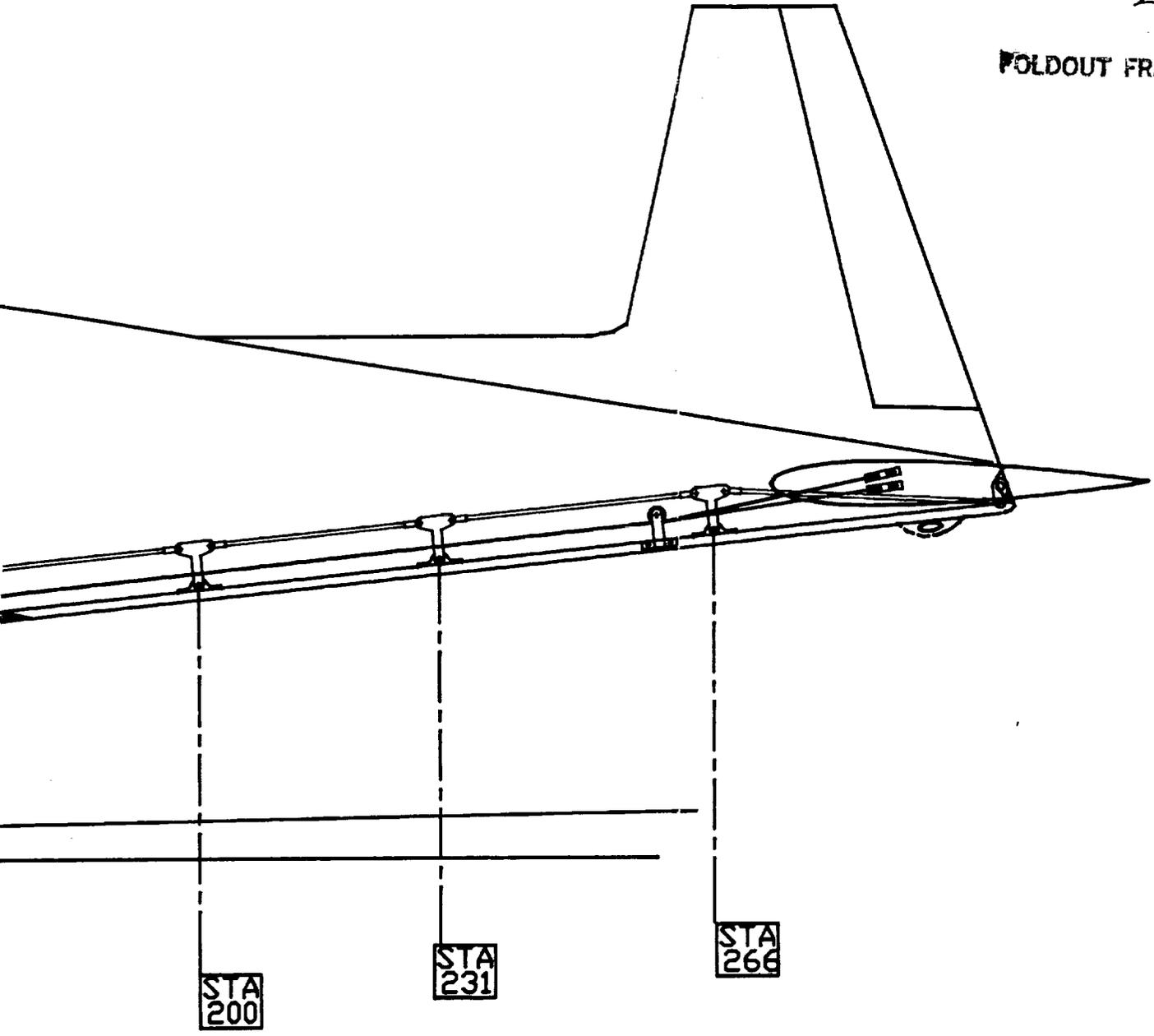
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|----------|--|---|---------|-------|------------|
| 074-1 | DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL .XX ± .01 .XXX ± .001 ANGULAR ± 1/2° | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA | | | |
| 0257-P2 | | SIZE | DATE | SCALE | DRAWN BY |
| 93D10306 | | B | 3-15-93 | | LISA COMBS |
| 0-313 | | TITLE | | | |
| 667-2 | | ELEVATOR INSTALLATION | | | |
| C-5424A | | DRAWING NO. | | | SHEET |
| SS-40 | | 421S9303D101 | | | 10F4 |

1-
FOLDOUT FRAME



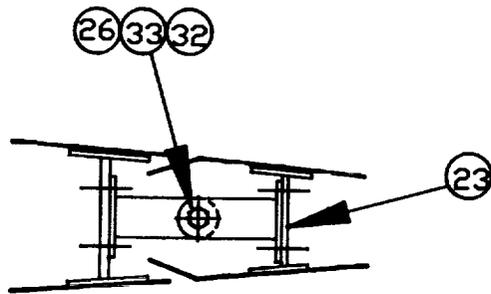
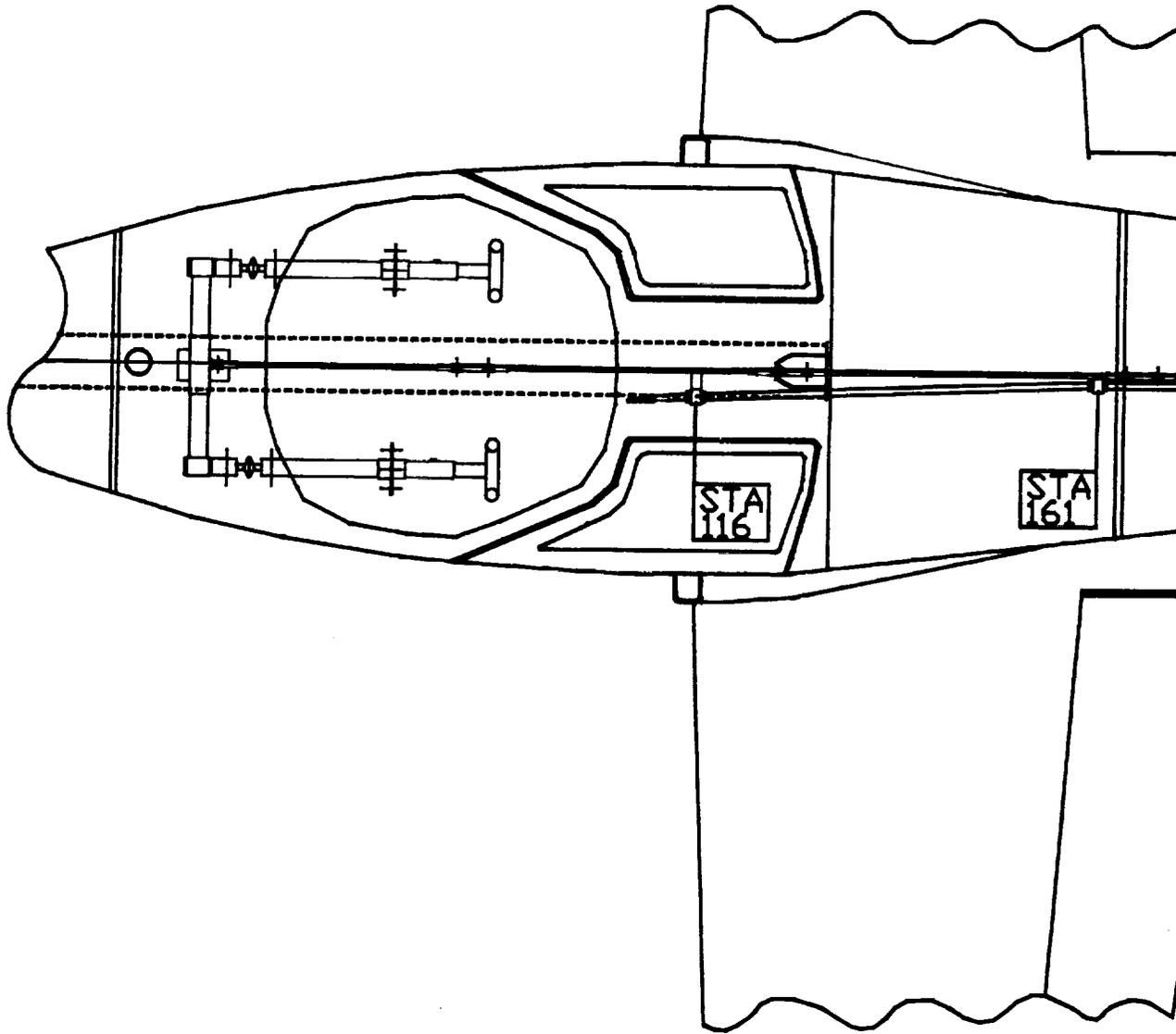
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|---|---|-----------------|---------------|---------------------------|
| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL .XX ± .01 .XXX ± .001 MILLAR ± 1/2° | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA | | | |
| | SIZE B | DATE 3-15-93 | SCALE 1/20 | DRAWN BY DAVID PAUFLER |
| | TITLE ELEVATOR INSTALLATION | | | |
| | DRAWING NO. 421S9303D101 | | | SHEET 20F4 |

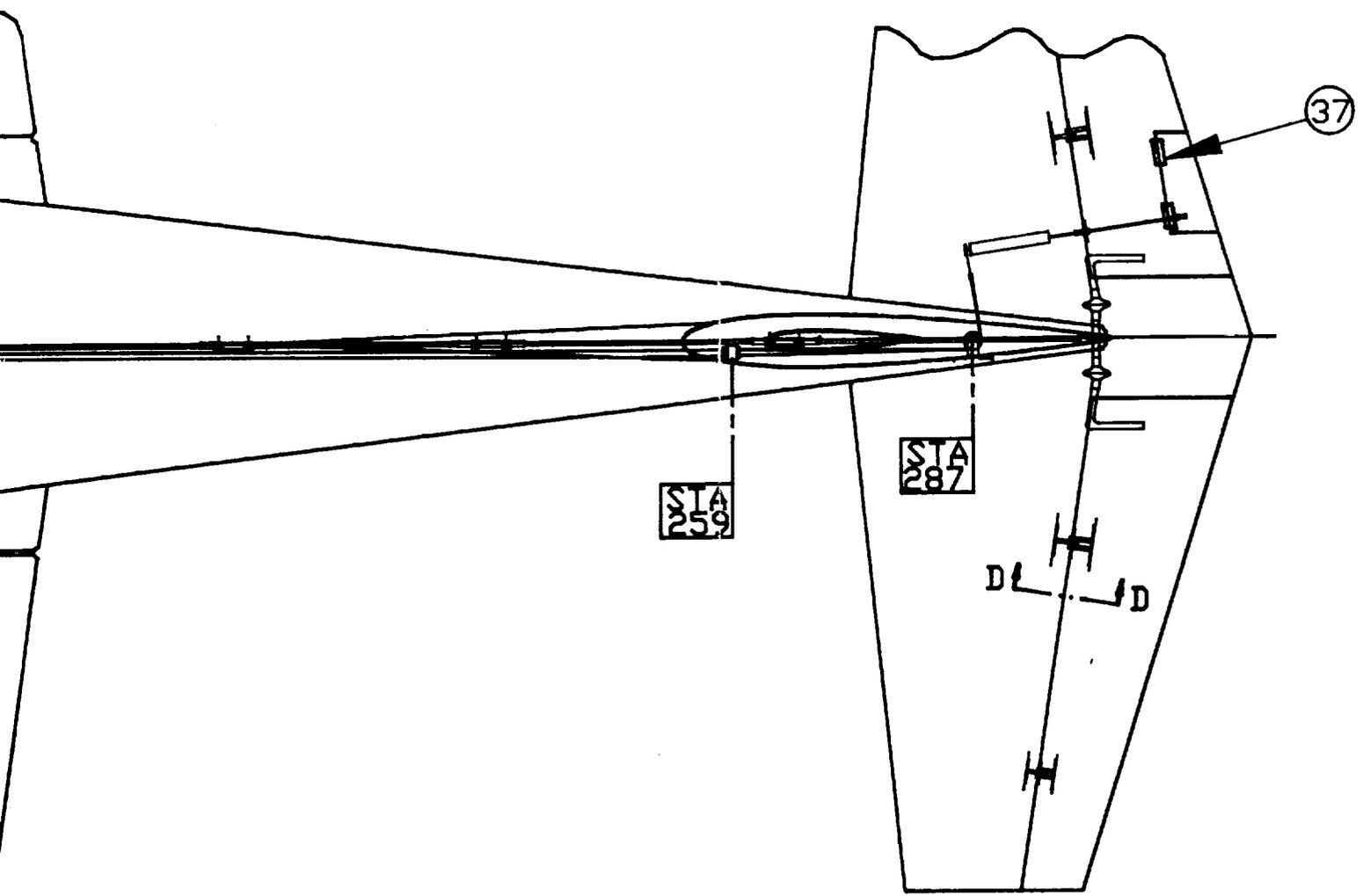
1-
FOLDOUT FRAME



SECTION D-D
1/5 SCALE

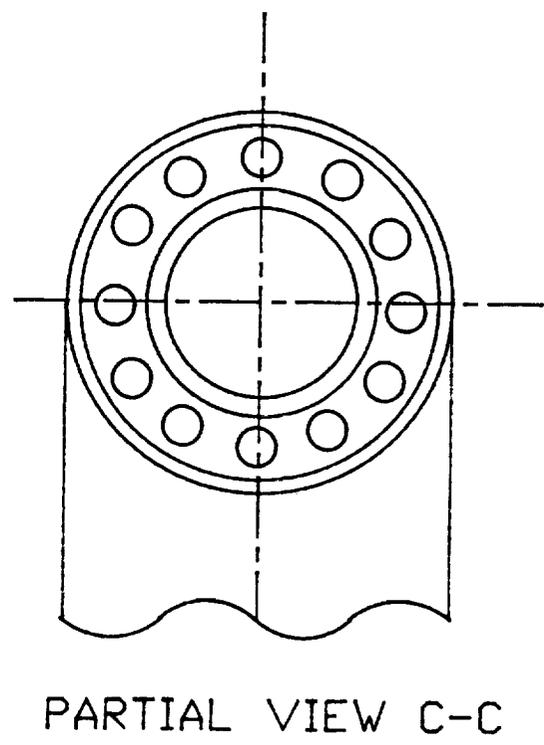
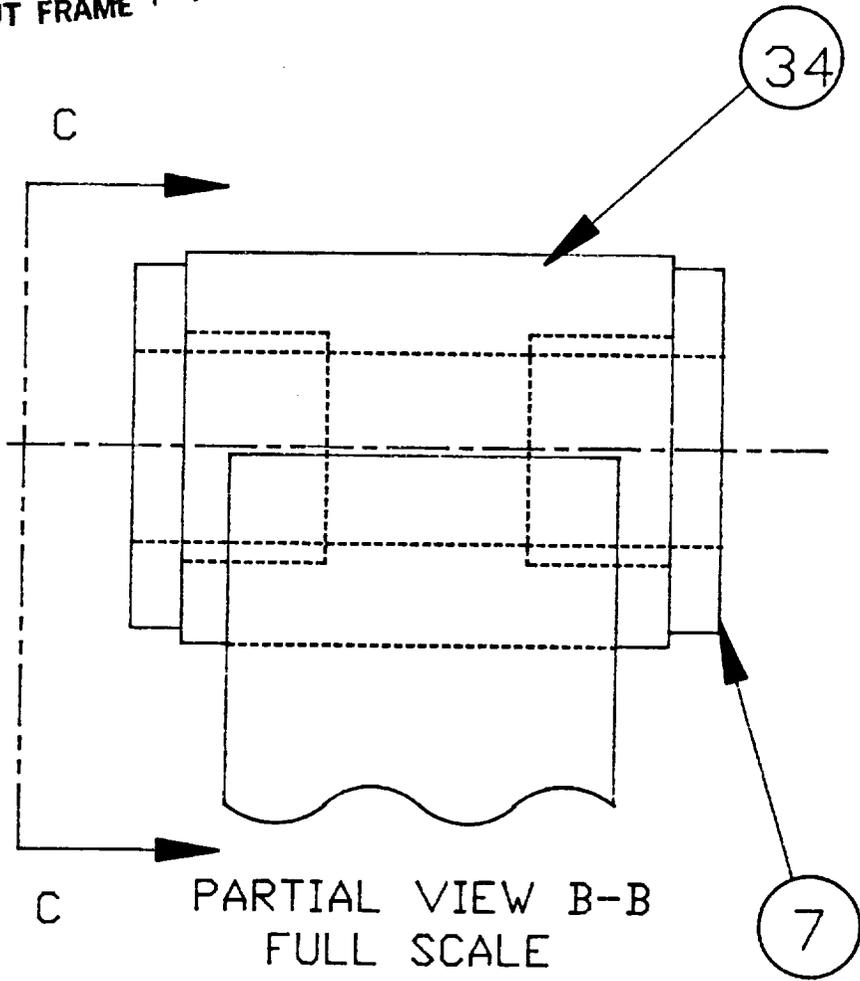
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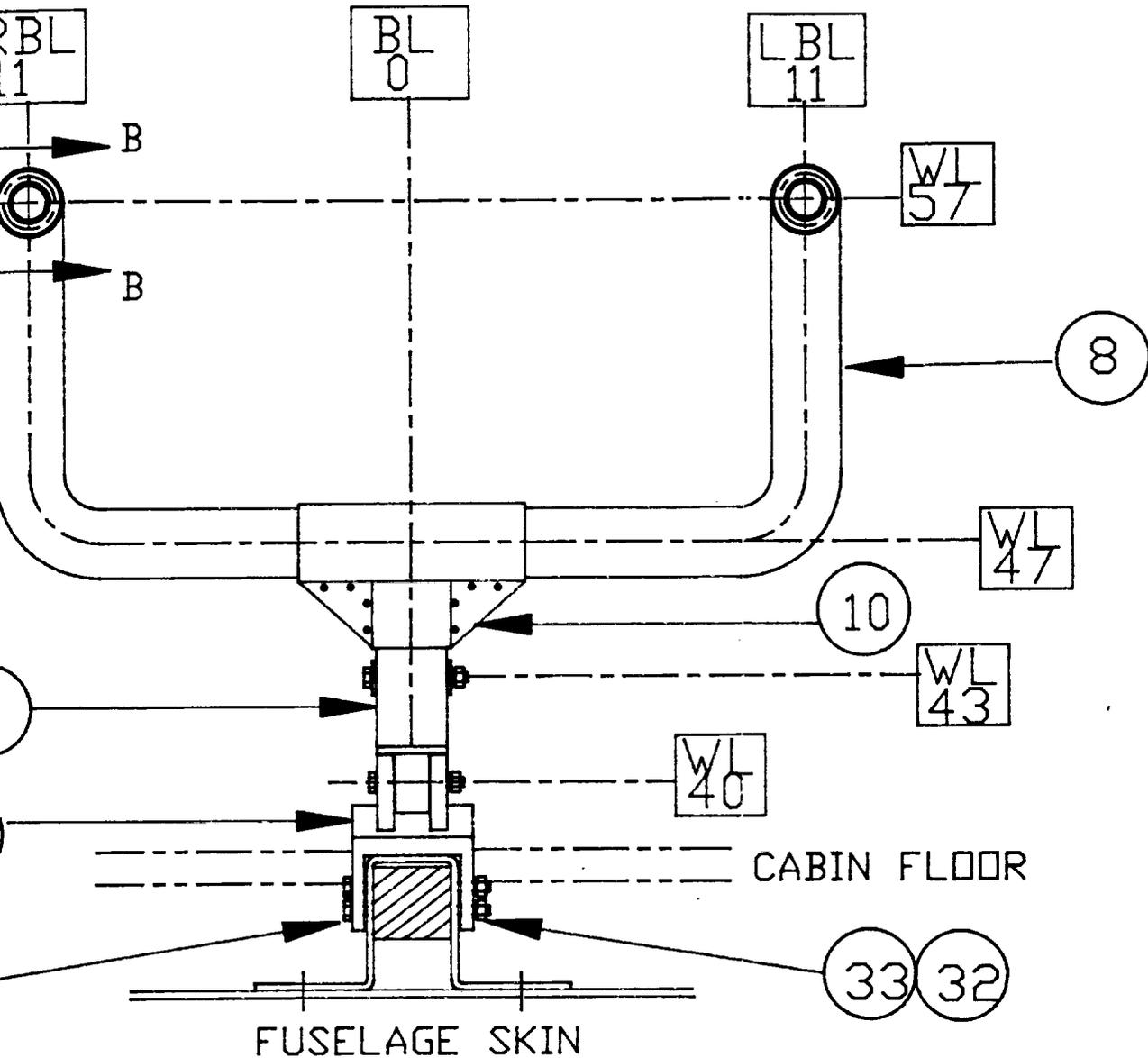
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| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL .XX ± .01 .XXX ± .001 MILLAR ± 1/2° | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA | | | |
| | SIZE B | DATE 3-15-93 | SCALE 1/20 | DRAWN BY DAVID PAUFLER |
| | TITLE ELEVATOR INSTALLATION | | | |
| | DRAWING NO. 421S9303D101 | | SHEET 30F 4 | |

FOLDOUT FRAME



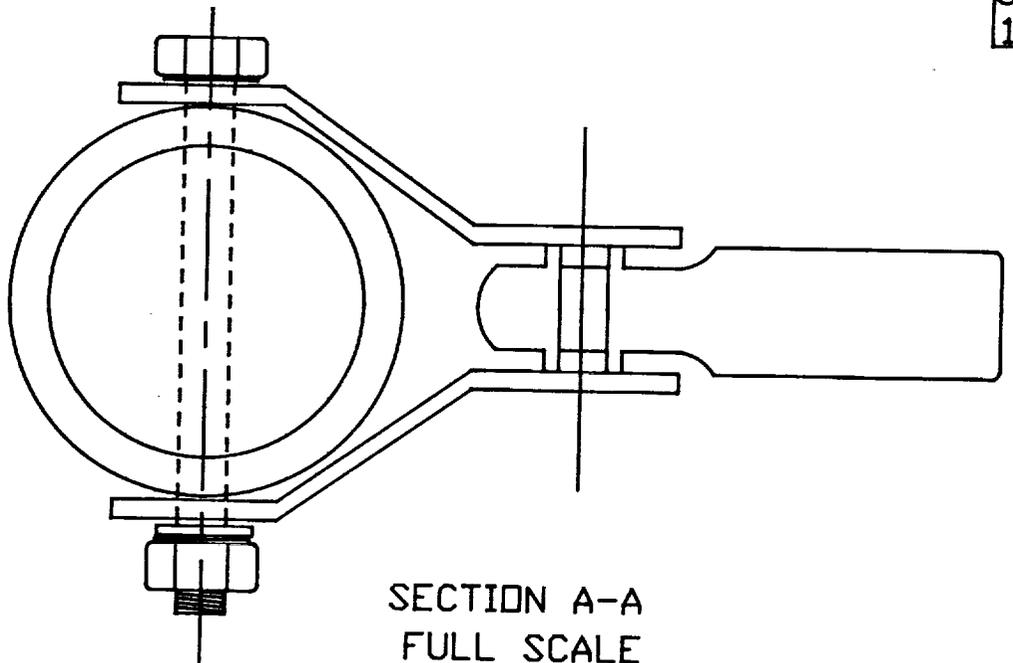
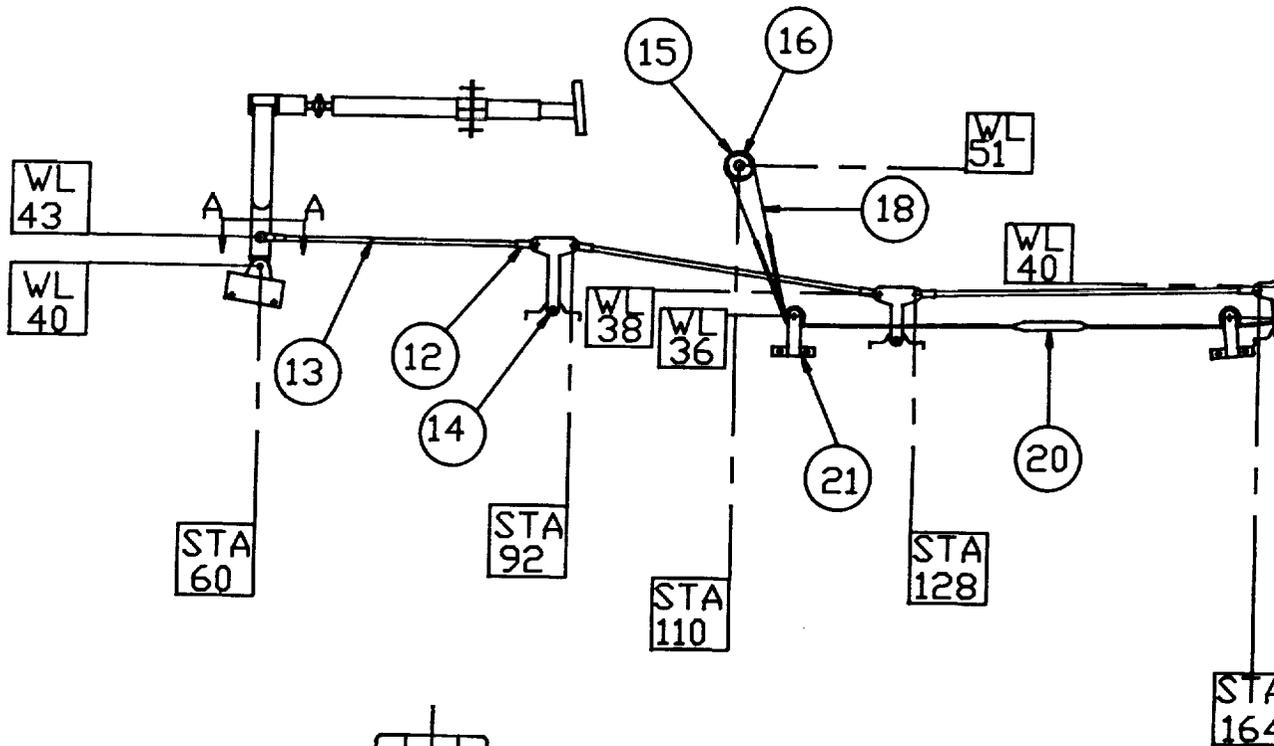
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26

FOLDOUT FRAME



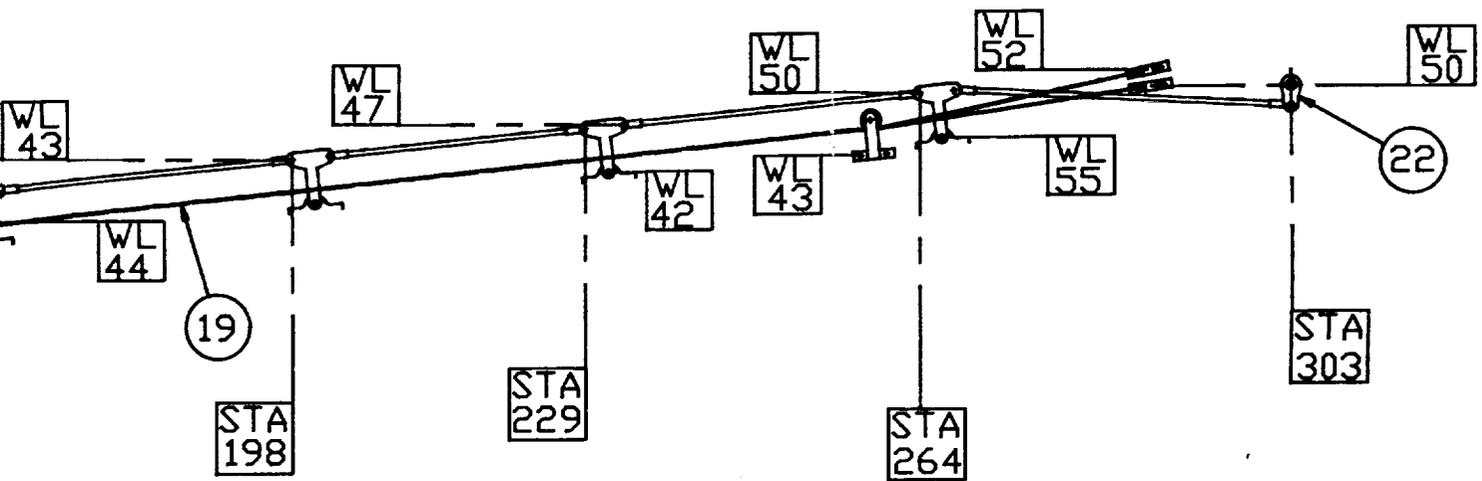
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| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01</p> <p>.XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | | |
| | <p>SIZE</p> <p>B</p> | <p>DATE</p> <p>3-15-93</p> | <p>SCALE</p> <p>1/5</p> | <p>DRAWN BY</p> <p>DAVID PAUFLER</p> | |
| | <p>TITLE</p> <p>ELEVATOR INSTALLATION</p> | | | | |
| | <p>DRAWING NO.</p> <p>421S9303D101</p> | | | <p>SHEET</p> <p>4 OF 4</p> | |

1.
FOLDOUT FRAME



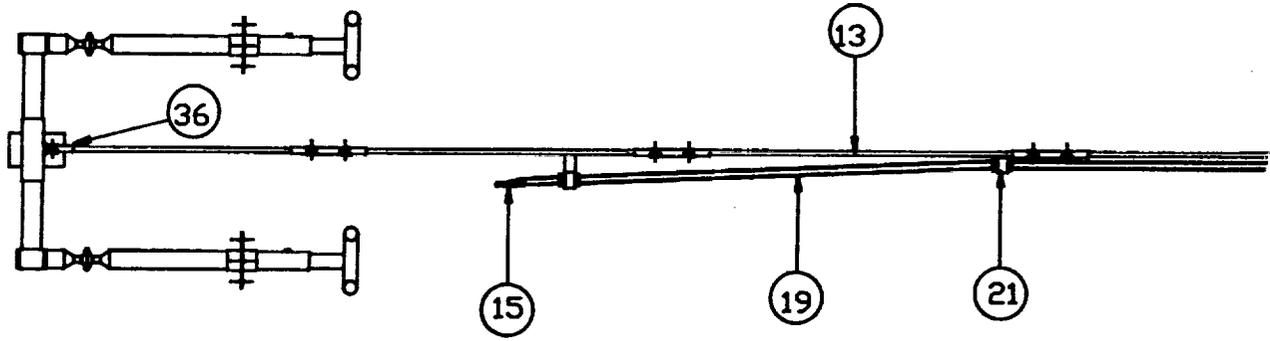
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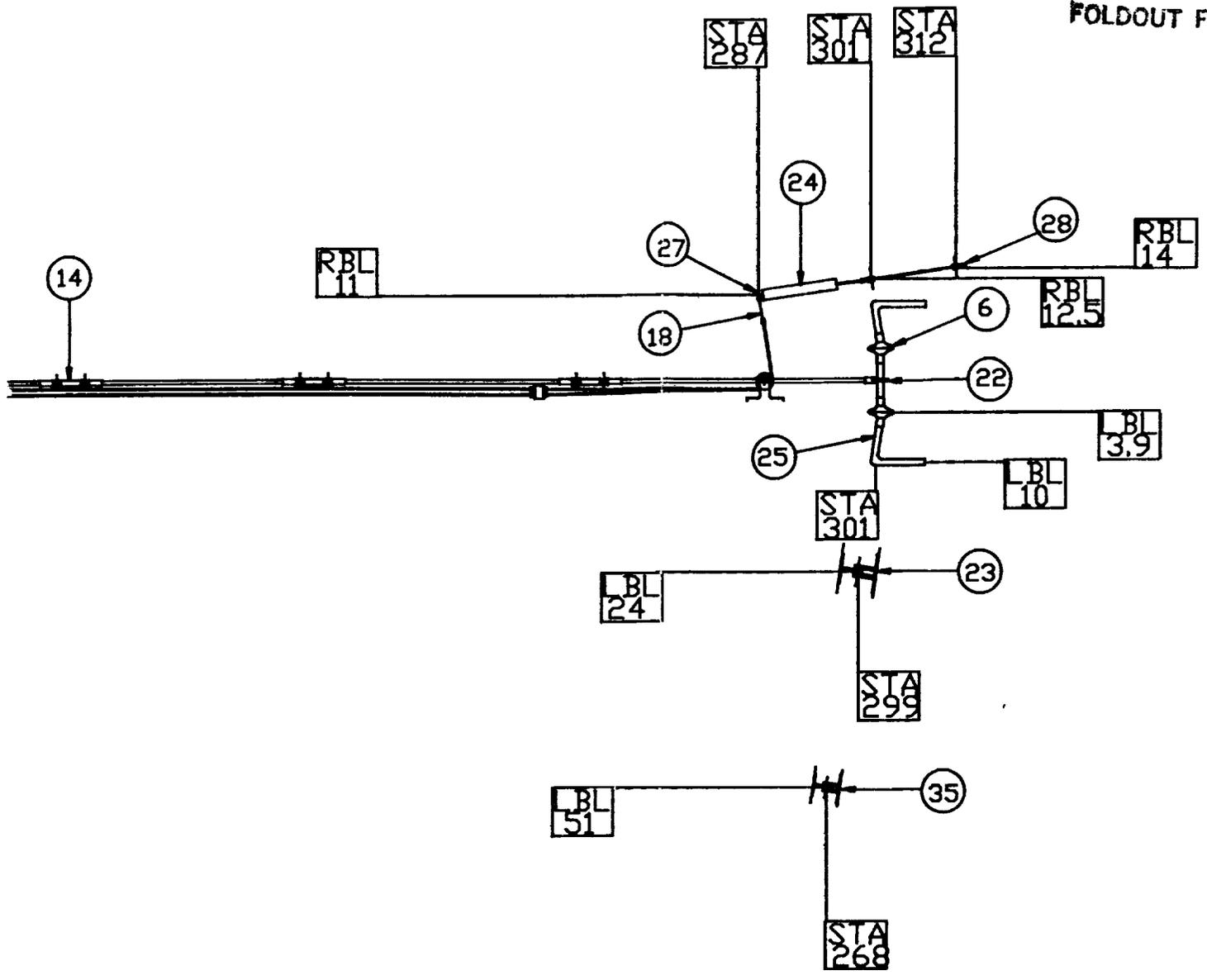
FOLDOUT FRAME



| | | | | |
|---|---|-------------------------|-----------------------|-----------------------------------|
| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01</p> <p>.XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | |
| | <p>SIZE B</p> | <p>DATE 3-15-93</p> | <p>SCALE 1/20</p> | <p>DRAWN BY DAVID PAUFLER</p> |
| | <p>TITLE ELEVATOR SYSTEM ASSEMBLY</p> | | | |
| | <p>DRAWING NO. 421S9303D103</p> | | | <p>SHEET 10F2</p> |

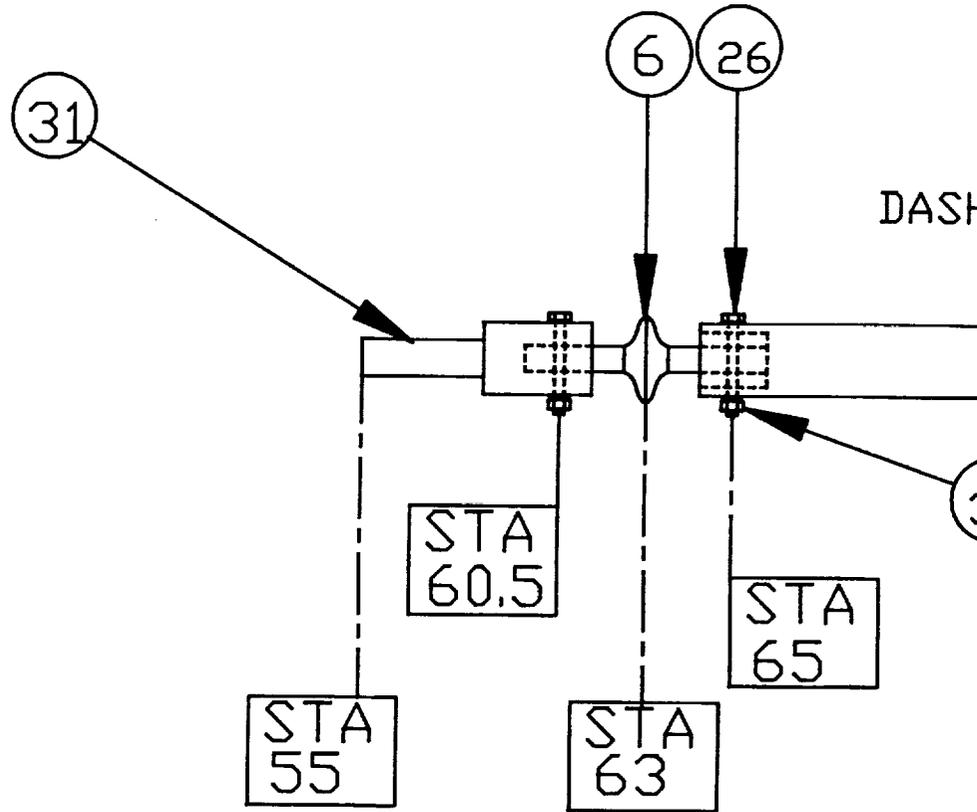
1.
FOLDOUT FRAME





| | | | | |
|---|---|----------------------------|--------------------------|--------------------------------------|
| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01</p> <p>.XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | |
| | <p>SIZE</p> <p>B</p> | <p>DATE</p> <p>3-15-93</p> | <p>SCALE</p> <p>1/5</p> | <p>DRAWN BY</p> <p>DAVID PAUFLER</p> |
| | <p>TITLE</p> <p>ELEVATOR SYSTEM ASSEMBLY</p> | | | |
| | <p>DRAWING NO.</p> <p>421S9303D103</p> | | <p>SHEET</p> <p>20F2</p> | |

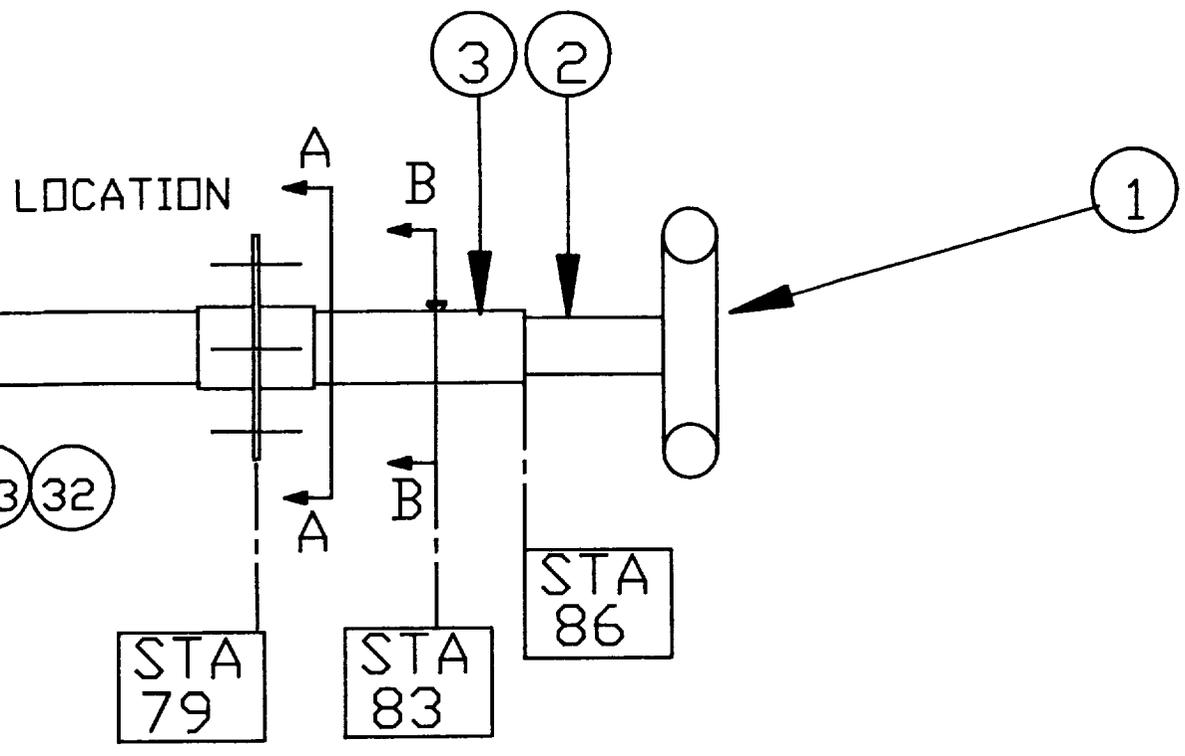
1.
FOLDOUT FRAME



NOTE: DASH INTERFACE IS AT STA 79.

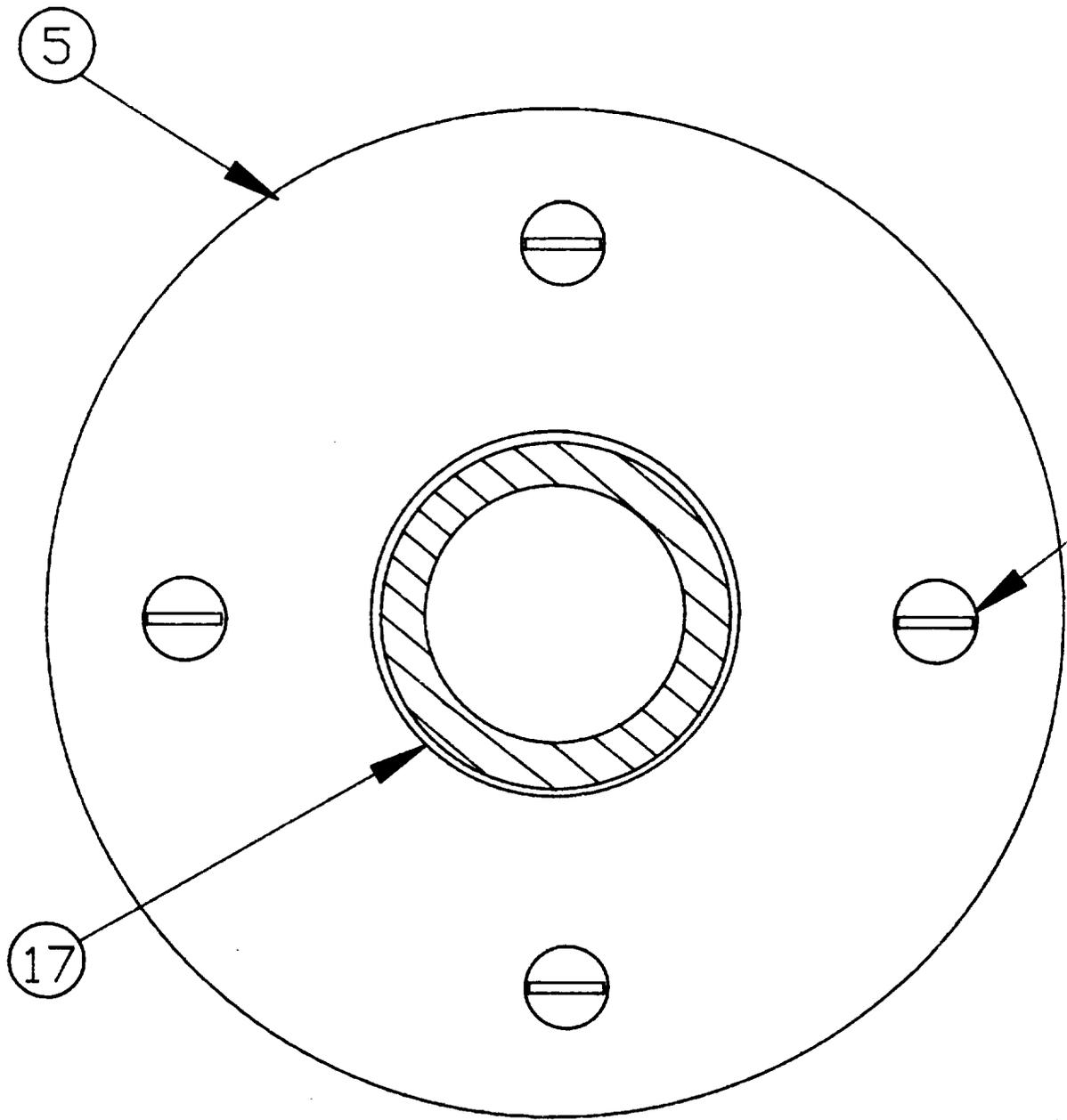
2.

FOLDOUT FRAME



| | | | | |
|--|---|-------------------------|----------------------|-----------------------------------|
| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01 .XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | |
| | <p>SIZE B</p> | <p>DATE 3-15-93</p> | <p>SCALE 1/5</p> | <p>DRAWN BY DAVID PAUFLER</p> |
| | <p>TITLE ELEVATOR YOLK SHAFT ASSEMBLY</p> | | | |
| | <p>DRAWING NO. 421S9303D105</p> | | | <p>SHEET 10F2</p> |

FOLDOUT FRAME



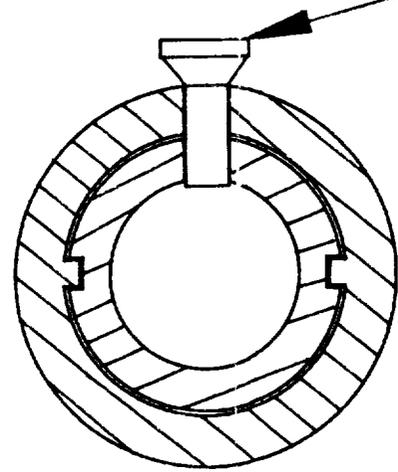
SECTION A-A

2.

FOLDOUT FRAME

30

4



SECTION B-B

| | | | | |
|---|---|-------------------------|-----------------------|-----------------------------------|
| <p>DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL</p> <p>.XX ± .01</p> <p>.XXX ± .001</p> <p>ANGULAR</p> <p>± 1/2°</p> | <p>EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA</p> | | | |
| | <p>SIZE B</p> | <p>DATE 3-15-93</p> | <p>SCALE FULL</p> | <p>DRAWN BY DAVID PAUFLER</p> |
| | <p>TITLE ELEVATOR YOLK SHAFT ASSEMBLY</p> | | | |
| | <p>DRAWING NO. 421S9303D105</p> | | | <p>SHEET 20F2</p> |

FOLDOUT FRAME

| | | | |
|----|----|--------------------------|------|
| 37 | 01 | BEARING | DW |
| 36 | 03 | IDLER ARM MOUNT | 4215 |
| 35 | 02 | BALL JOINT | AN2 |
| 34 | 01 | CENTER CRANK MOUNT | 4215 |
| 33 | 04 | ROD END CASTING | 4215 |
| 32 | 08 | PEDAL MOUNT | 4215 |
| 31 | 04 | LOWER PEDAL | 4215 |
| 30 | 04 | UPPER PEDAL | 4215 |
| 29 | 19 | ROD END | NAS |
| 28 | 20 | BRAKE LINE PER FOOT | MS2 |
| 27 | 01 | SCOTT PARKING BRAKE VALV | 4215 |
| 26 | 01 | BRAKE RESERVOIR | ACSA |
| 25 | 04 | CLEVELAND MASTER CYL. | 10-5 |
| 24 | 08 | BEARING INNER RACE | SIE1 |
| 23 | 08 | BEARING | BCH1 |
| 22 | 22 | BEARING | LHA |
| 21 | 75 | AIRCRAFT WASHER | AN9 |
| 20 | 75 | CASTLE NUT | AN3 |
| 19 | 19 | AIRCRAFT BOLT | AN4 |
| 18 | 04 | AIRCRAFT BOLT | AN4 |
| 17 | 32 | AIRCRAFT BOLT | AN4 |

2.

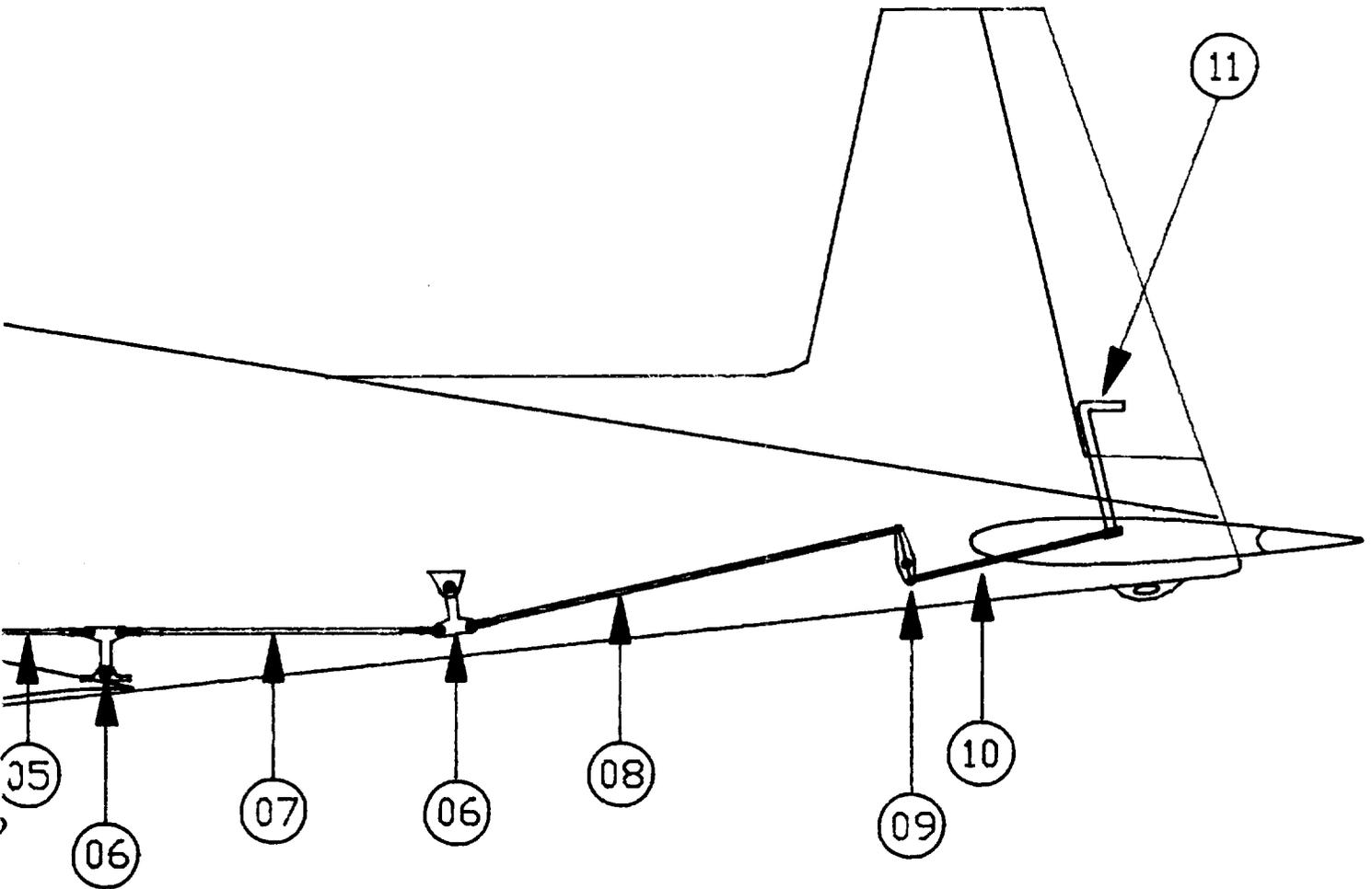
FOLDOUT FRAME

| | | | | |
|-----------|----|----|--------------------------|--------------|
| | 16 | 18 | AIRCRAFT BOLT | AN4-12 |
| K | 15 | 02 | AIRCRAFT BOLT | AN4-16 |
| 9303D158 | 14 | 02 | CIR. ROD 4130 9 IN. | 421S9303D144 |
| 76-6 | 13 | 06 | CIR. ROD 4130 6 IN. | 421S9303D128 |
| 9303D156 | 12 | 01 | GEAR BELL CRANK | 421S9303D120 |
| 9303D154 | 11 | 01 | TORQUE TUBE ASSEMBLY | 421S9303D120 |
| 9303D152 | 10 | 01 | CIR. ROD 4130 23 IN. | 421S9303D120 |
| 9303D150 | 09 | 01 | REAR BELL CRANK | 421S9303D120 |
| 9303D148 | 08 | 01 | CIR. ROD 4130 50 IN. | 421S9303D118 |
| 560-R4-11 | 07 | 01 | CIR. ROD 4130 37 IN. | 421S9303D116 |
| 3741 | 06 | 03 | IDLER ARM | 421S9303D114 |
| 9303D146 | 05 | 02 | CIR. ROD 4130 51 IN. | 421S9303D112 |
| 4315 | 04 | 01 | RGHT PEDAL ACTUAT. CRANK | 421S9303D110 |
| B | 03 | 01 | LEFT PEDAL ACTUAT. CRANK | 421S9303D108 |
| 212 | 02 | 01 | CENTER CRANK ASSEMBLY | 421S9303D106 |
| 612 | 01 | 04 | PEDAL ASSEMBLY | 421S9303D104 |

| -4 | ITEM | QTY | DESCRIPTION | | | | PART # | |
|--------|--|-----|---|------|-------|-----------|-----------------|--|
| 50-416 | DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL .XX ± .01 .XXX ± .001 ANGULAR ± 1/2° | | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA | | | | | |
| 50-4 | | | SIZE | DATE | SCALE | DRAWN BY | | |
| -14 | | | B | 2-22 | 1/20 | RUSS SNOW | | |
| -26 | | | TITLE RUDDER CONTROL ASSEMBLY | | | | | |
| -10 | | | DRAWING NO. 421S9303D102 | | | | SHEET 1 of 4 | |

2.

FOLDOUT FRAME

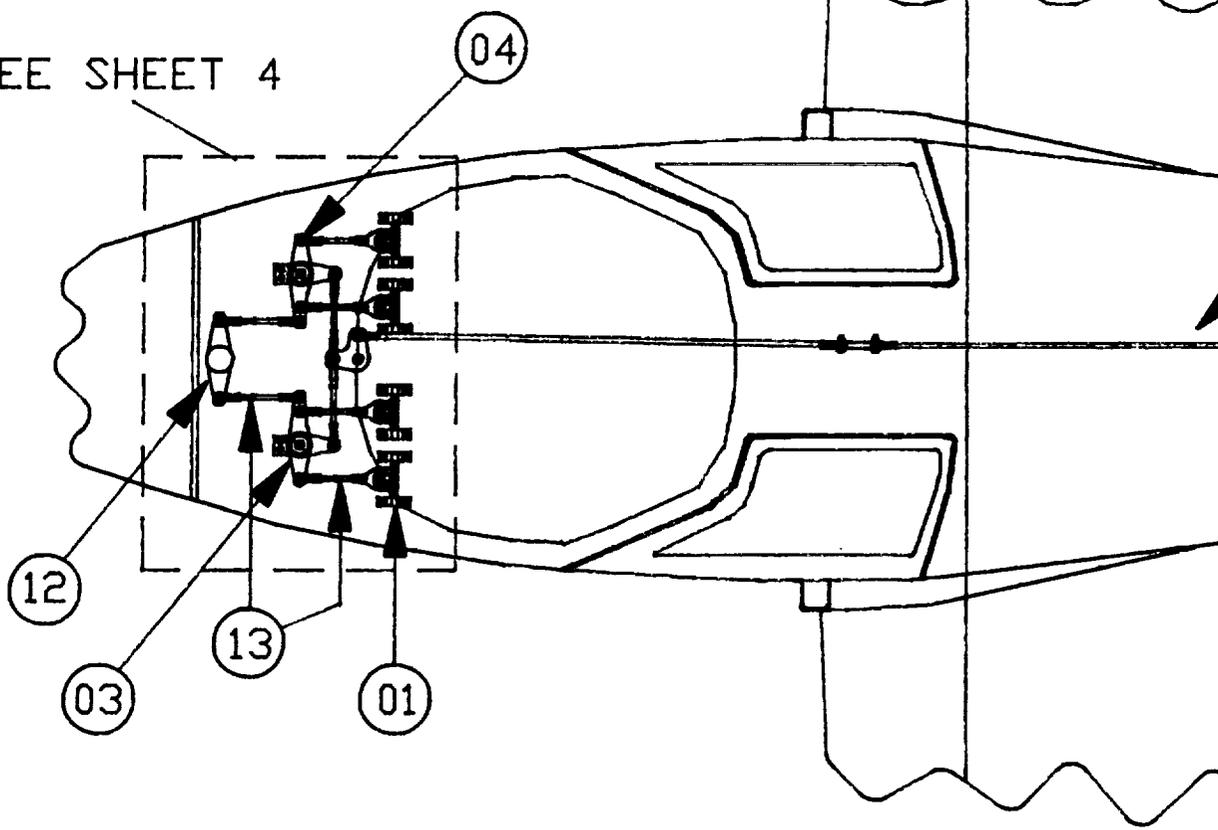


| | | | |
|----------------------------------|---------------|---------------|-----------------------|
| SIZE B | DATE 2--22 | SCALE 1/20 | DRAWN BY RUSS SNOW |
| TITLE RUDDER CONTROL ASSEMBLY | | | |
| DRAWING NO. 421S9303D102 | | | SHEET 2 of 4 |

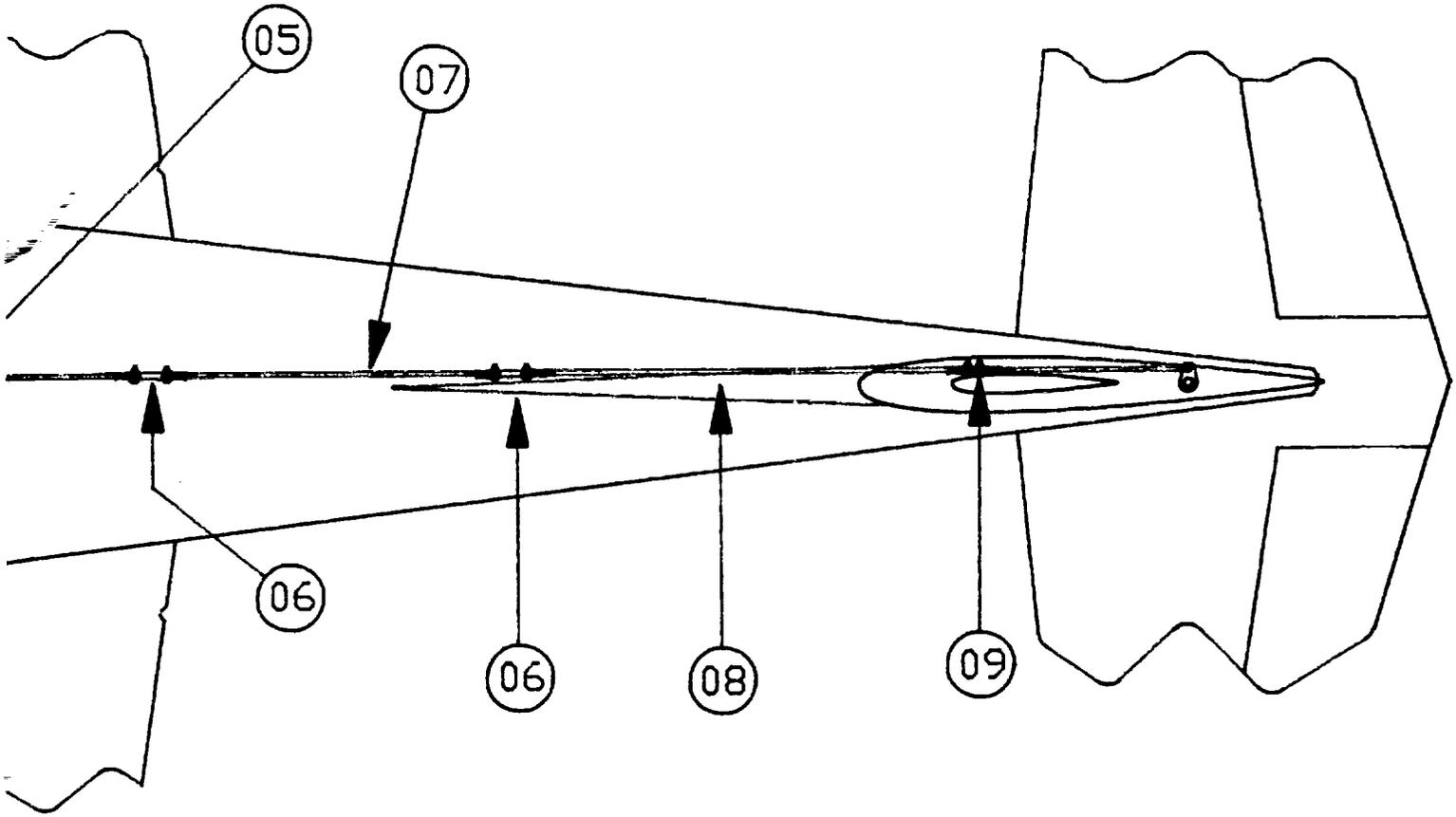
1.

FOLDOUT FRAME

SEE SHEET 4

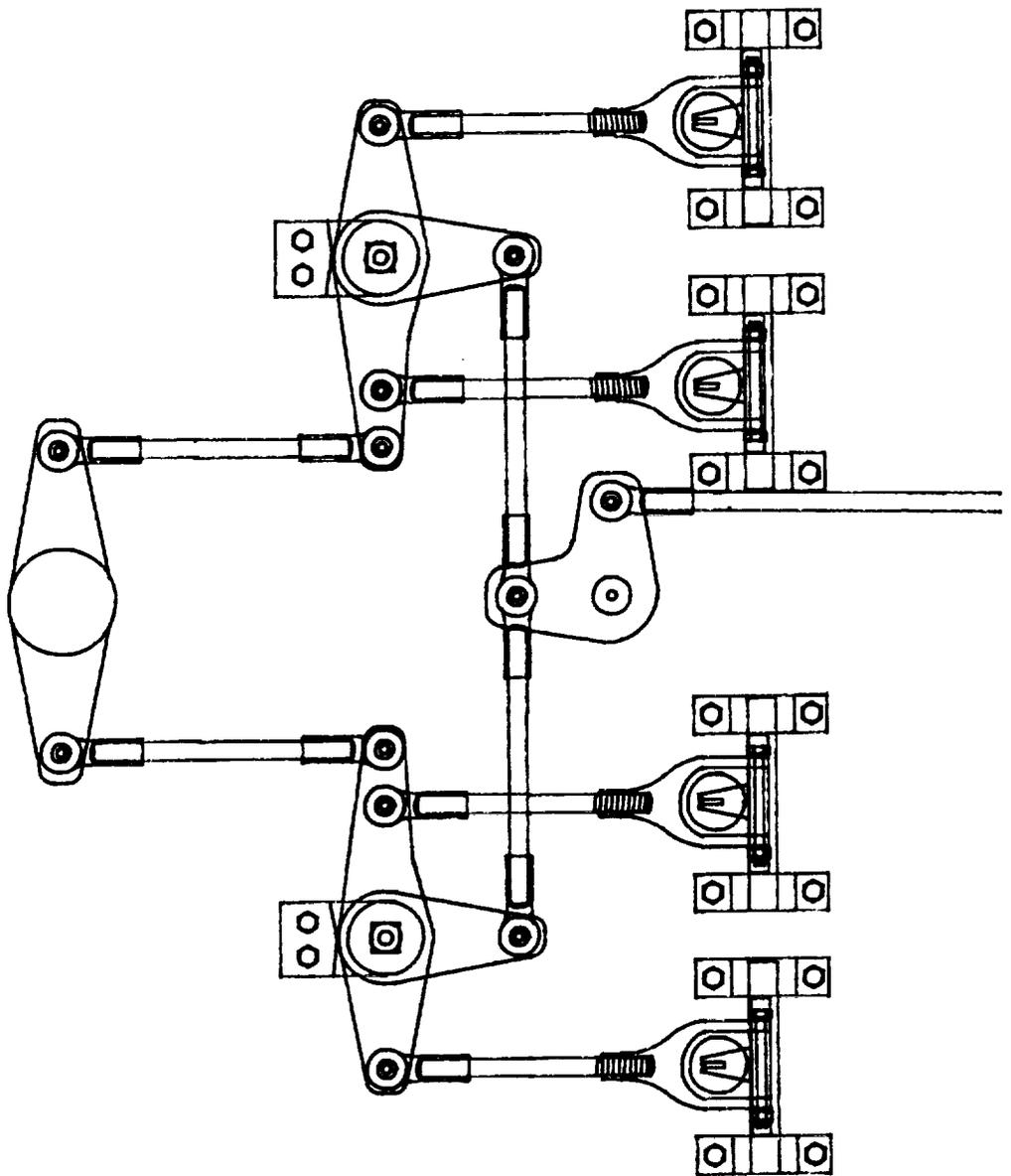


FOLDOUT FRAME

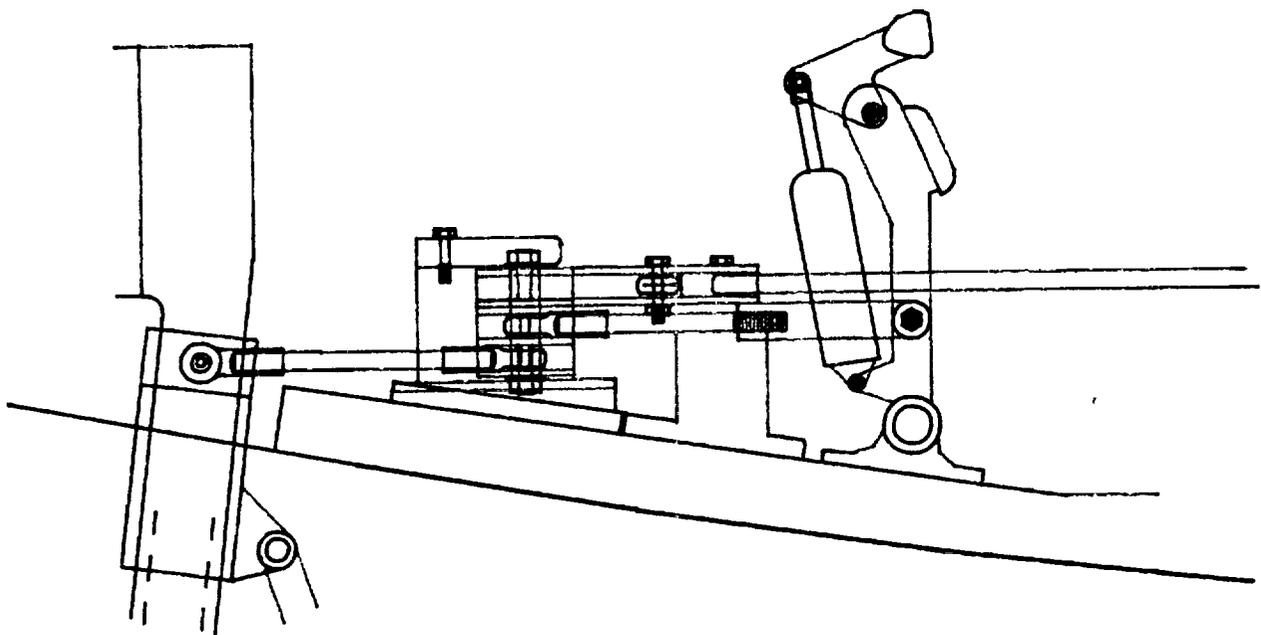


| | | | |
|----------------------------------|--------------|---------------|-----------------------|
| SIZE B | DATE 2-22 | SCALE 1/20 | DRAWN BY RUSS SNOW |
| TITLE RUDDER CONTROL ASSEMBLY | | | |
| DRAWING NO. 421S9303D102 | | | SHEET 3 of 4 |

1.
FOLDOUT FRAME

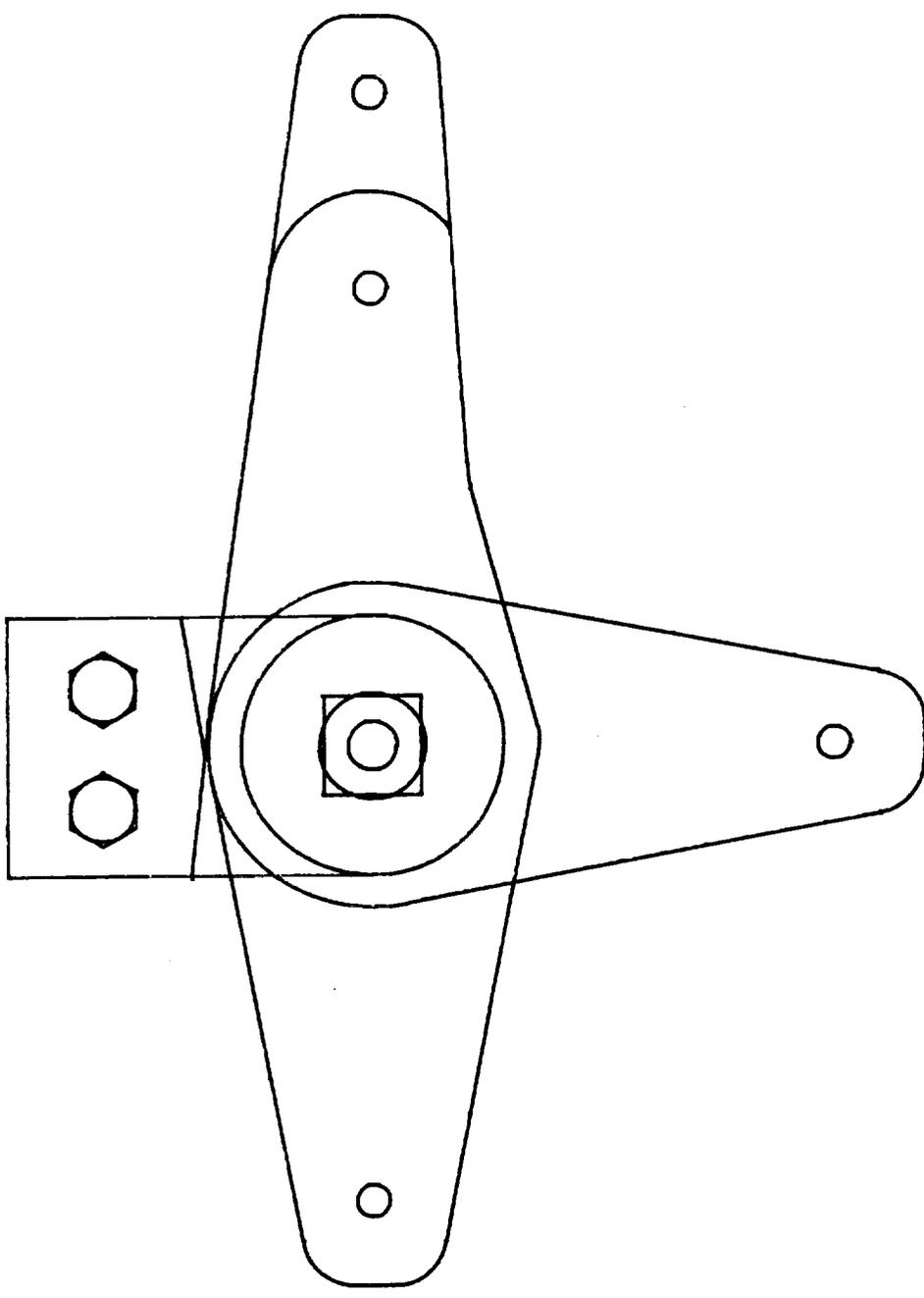


FOLDOUT FRAME



| | | | |
|----------------------------------|--------------|--------------|-----------------------|
| SIZE B | DATE 2-22 | SCALE 1/5 | DRAWN BY RUSS SNOW |
| TITLE RUDDER CONTROL ASSEMBLY | | | |
| DRAWING NO. 421S9303D102 | | | SHEET 4 of . |

1.
FOLDOUT FRAME



11-14800-101

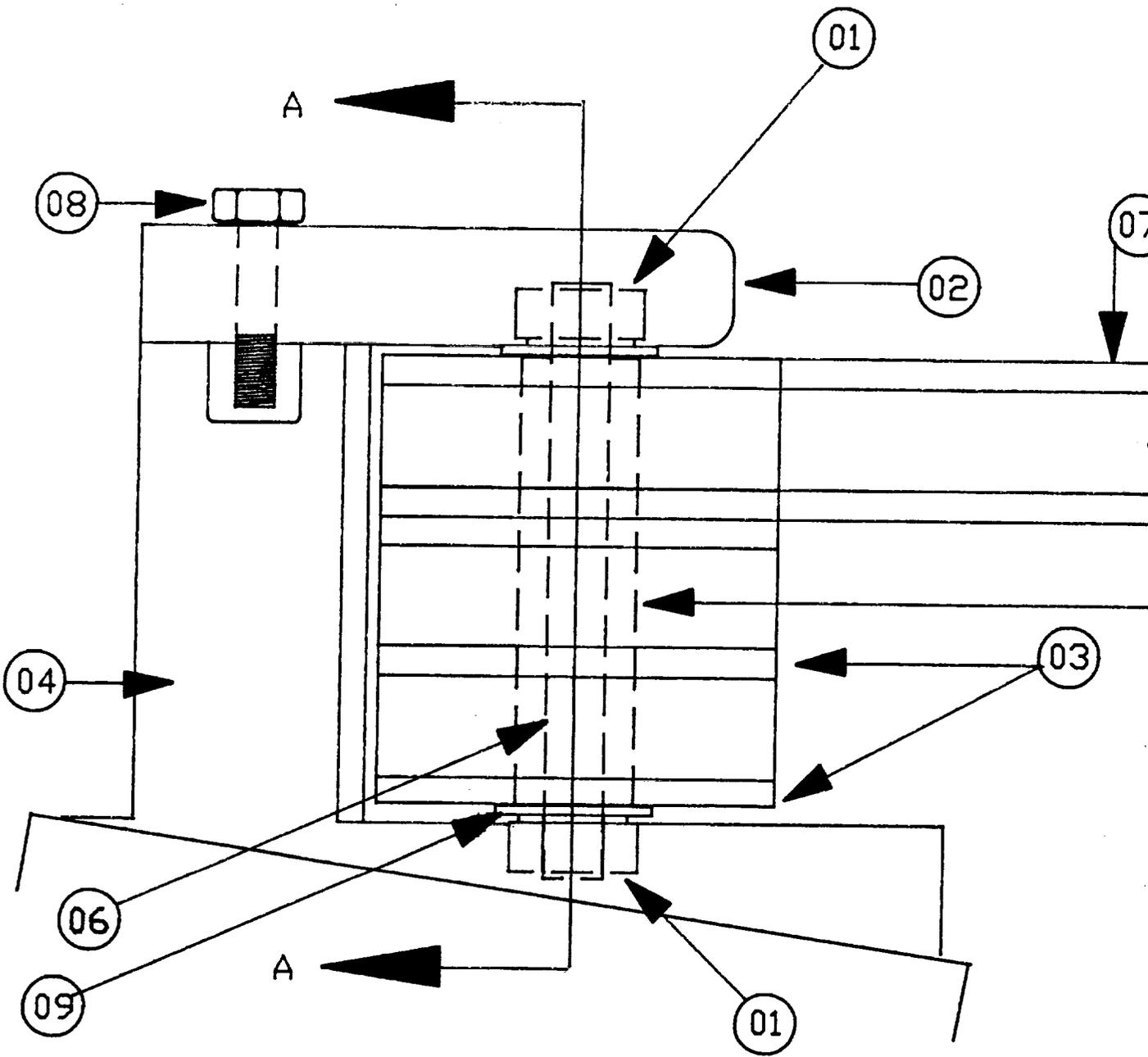
2.

FOLDOUT FRAME

| 09 | 04 | WASHER 4130 | 421S9303D142 |
|---------|----------|---------------------------|--------------|
| 08 | 04 | AIRCRAFT BOLT | AN4-11 |
| 07 | 04 | PEDAL CRANK PLATE, UPPER | 421S9303D140 |
| 06 | 01 | 3/8 INCH STEEL ROD | 421S9303D138 |
| 05 | 01 | SQUARE EXTRUSION | 421S9303D136 |
| 04 | 04 | BOTTOM MOUNT, PEDAL CRANK | 421S9303D134 |
| 03 | 04 | PEDAL CRANK PLATE, LOWER | 421S9303D132 |
| 02 | 02 | TOP MOUNT, PEDAL CRANK | 421S9303D130 |
| 01 | 04 | BEARING | LHA-6 |
| ITEM NO | QTY REQD | DESCRIPTION | PART NUMBER |

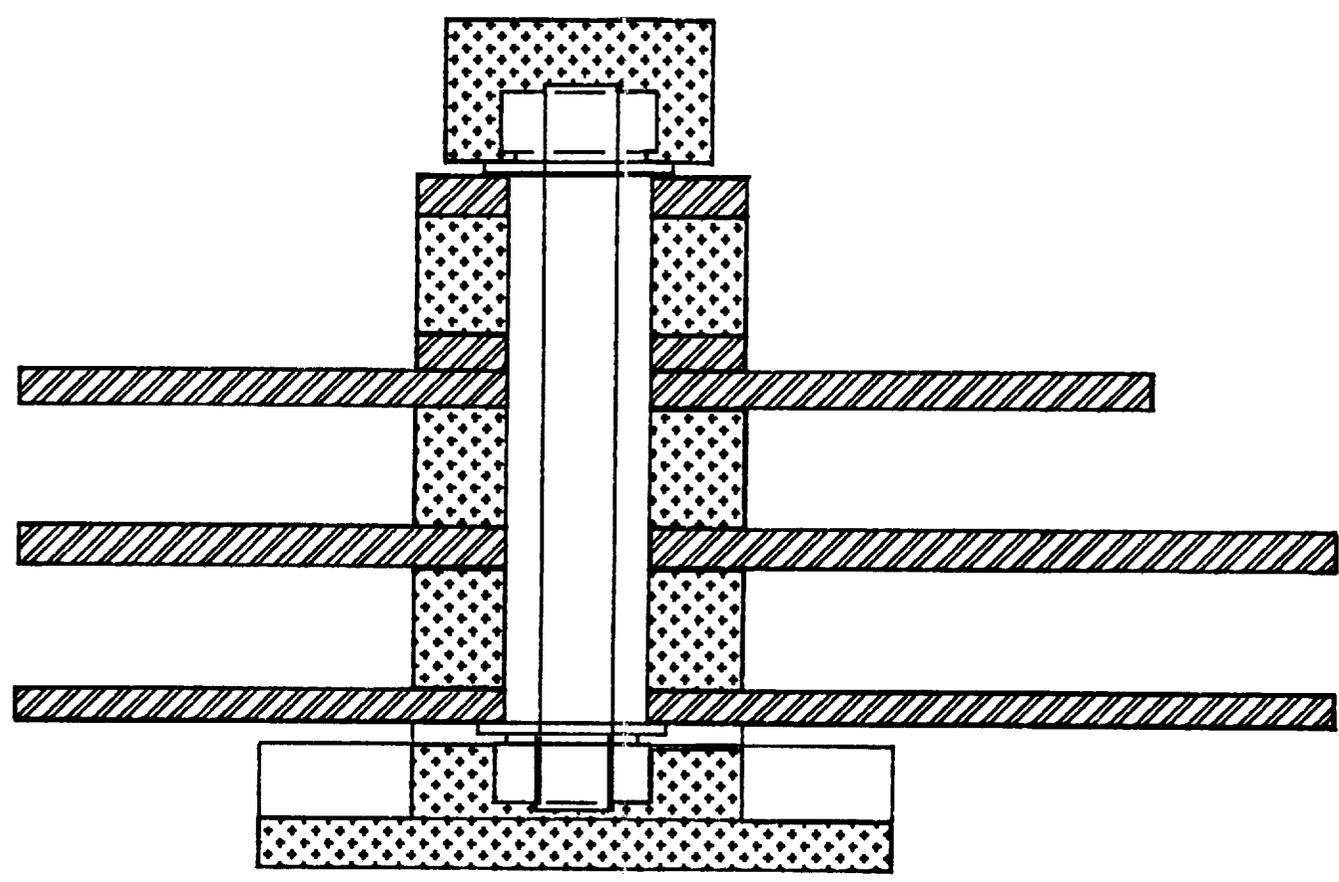
| | | | | |
|--|---|--------------|--------------|-----------------------|
| DIMENSION TOLERANCES UNLESS OTHERWISE SPECIFIED DECIMAL .XX ± .01 .XXX ± .001 ANGULAR ± 1/2° | EMBRY-RIDDLE AERONAUTICAL UNIVERSITY DAYTONA BEACH FLORIDA | | | |
| | SIZE B | DATE 2-22 | SCALE 1/1 | DRAWN BY RUSS SNOW |
| | TITLE PEDAL AND CRANK ASSEMBLY | | | |
| | DRAWING NO. 421S9303D108 | | | SHEET 1 of 2 |

FOLDOUT FRAME



2.

FOLDOUT FRAME



SECTION A-A

| | | | |
|-----------------------------------|--------------|--------------|-----------------------|
| SIZE B | DATE 2-22 | SCALE 1/1 | DRAWN BY RUSS SNOW |
| TITLE PEDAL AND CRANK ASSEMBLY | | | |
| DRAWING NO. 421S9303D108 | | | SHEET 2 of 2 |