THE ENSTROM HELICOPTER CORPORATION

MENOMINEE COUNTY AIRPORT · P. O. BOX 277, MENOMINEE, MICHIGAN 49858
TELEPHONE 906 863-9971

Date: December 2, 1981

Subject: Troubleshooting & Tracking Enstrom Articulated Rotor System

Models: All Models

Effectivity: All Serial Numbers

Helicopter vibration and cyclic feedback are often attributed to an out-of-track main rotor system when the actual cause can be traced to components within the system that are worn, damaged or out of adjustment.

The following troubleshooting guide is provided to direct maintenance personnel to possible problem areas within the rotor system that can cause vibration or roughness.

This guide covers some of the problems and related causes that can be checked prior to attempting to track the blades. Performing the suggested checks and attention to routine maintenance schedules will help reduce time unnecessarily spent in attempting to track blades that may not be the cause of the problem.

Problem

A. Aircraft develops a sudden roughness during flight.

1. Lamiflex bearing failure.

Check: Disconnect the rotor pitch links at the upper walking beams (ref. Fig. 1, Item A) and flex the blade grip in no more than a 30^{o} (i.e. $\pm 15^{o}$) arc. Failure of the blade grip to spring back indicates a failed Lamiflex bearing.

Solution: Replace Lamiflex bearing.

2. Main rotor damper seized.

   Check: Cycle blades fore and aft to move damper piston in and out. Failure of damper to cycle indicates a restrictor is plugged.

   Solution: Disassemble and clean damper and restrictor(s).

3. Leading edge tape loosening (if blade tape is used).

   Check: Inspect tape for separation from blades.

   Solution: Replace leading edge tape.

4. Main rotor blade leading/trailing edge separation occurring.

   Check: Inspect blades for evidence of separation.

   Solution: Replace or repair blade.

   Note: Replacement blades must be matched by Enstrom Customer Service. Provide serial numbers of good blades and helicopter serial number. Blade repairs must be performed by an authorized blade repair facility.

5. Main rotor blade suffered strike.

   Check: Inspect blades for evidence of strike damage.

   Solution: Extent of damage will determine if blade requires replacement.

   Note: Blades must be matched by Enstrom Customer Service.

Problem

B. Aircraft's first flight is rough (previous day it was smooth).

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1. Main rotor blade tab inadvertently bent.

   Check: Inspect tabs for damage or deformation.

   Solution: Replace tabs if damaged and reset tab angles as recorded on the "Blade Information Sheet."

   Note: If tab angles are not available, contact Enstrom Customer Service for original angles. Provide aircraft serial number.

2. Lamiflex bearing failure.

   Note: Possible caused by use of collective to slow rotor, allowing collective to spring up unrestrained (statically), etc.

   Check: Disconnect rotor pitch links at the upper walking beams and flex the blade grip in no more than a 30^{o} (i.e. $\pm 15^{o}$) arc. Failure of the blade to spring back indicates a failed Lamiflex bearing.

   Solution: Replace Lamiflex bearing.

3. Main rotor blades suffered "hangar rash" damage.

   Check: Inspect blades for evidence of damage.

   Solution: Extent of damage will determine if blade replacement is required. Contact Enstrom Customer Service for detailed information.

Problem

C. Aircraft gradually develops in increasing roughness over a period of days.

1. If it's a new aircraft, touching up blade track may be required due to wear in and seating of system components.

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Check: Check track.

Solution: Track blades.

2. Upper push rod bushing and spacers worn excessively (ref. Figure 1, Item B).

   Check: Inspect for looseness.

   Solution: Replace bushings and spacers as required.

   Note: Ream bushings with a 3/8" adjustable reamer, if required, to avoid looseness or binding.

3. Lower swashplate axes worn (ref. Figure 3, Item A).

   Check: Rotate main rotor hub to position each axis of the lower swashplate over the longitudinal push rod and move cyclic stick fore and aft. Note any play at the axes.

   Solution: Retorque nuts to take up play or overhaul the swashplate if necessary.

   Note: Preload on each axis should be equal (check after disconnecting both upper and lower controls). If unable to obtain equal preload, overhaul as necessary.

4. Upper swashplate DU bushings worn excessively (ref. Figure 4, Item A).

   Check: Move bell housing from side to side to check for looseness.

   Solution: Play in excess of .010" will require overhaul of the assembly.

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5. Dog leg uniball bearings worn excessively (ref. Figure 2, Item A).

   Check: Note looseness of the bearing and insure the bearing is secure in the dog leg.

   Solution: Replace bearings as required.

   Note: Bearings must be swaged into the dog legs with equal preload on each.

6. Excessive play in the upper collective bearing (ref. Figure 4, Item B).

   Check: Move collective walking beam, noting amount of play at the bearing.

   Solution: Replace bearing if excessive play is evident.

7. Lamiflex bearing swelled or deteriorated.

   Check:
   a. Inspect for evidence of grease in bearing area.
   b. Inspect bearing for evidence of deterioration (i.e. excessive extruded rubber or partial separation).
   c. Check for proper torque on retaining nut (12 - 15 in. lbs.).

   Solution: Replace Lamiflex bearing if it shows evidence of swelling or deterioration.

   Check: Inspect Nylatron strips for evidence of looseness or grooves.

   Solution: Replace Nylatron strips if loose or damaged.

8. Flapping bearings exhibit roughness, notchiness, or excessive play in lead-lag plane.

Check: Remove main rotor blades. Lift retention assembly from down stop approximately one inch at a time and check for excessive in-plane (lead-lag) looseness.

Solution: Replace DU washers or bearings as required and/or retorque hinge pin nuts.

Note: Retorquing requires removal of the main rotor dampers. If more than 20 ft. lbs. of torque is required to meet the above condition, it indicates reshimming or replacement of the DU spacers is necessary. All three retention assemblies should be equally preloaded.

Check: Lift retention assembly to the "up" stop. Assembly should remain up with only hand pressure to bring it down.

Solution: Retorque hinge pin nuts using Enstrom tool #0051.

9. Overall control system rod end bearings or bellcrank spacers/bushings are worn.

Check: Inspect control system for excessive play.

Solution: Replace worn components as required.

Problem

D. Aircraft has cyclic stick feedback.

1. Outboard tabs are not properly set.

Check: Inspect tabs for proper angle as noted on "Blade Information Sheet."

Note: If angles are not available, contact Enstrom Customer Service for original tab angles. Provide aircraft serial number.

Solution: Track blades if necessary after resetting tab angles.

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2. Lamiflex bearing failed.

   Check: Disconnect the rotor pitch links at the upper walking beams and flex the blade grips in no more than a 30° (i.e. ± 15°) arc. Failure of the blade to spring back indicates a failed Lamiflex bearing.

   Solution: Replace Lamiflex bearing.

3. One axis of lower swashplate binding.

   Check: Disconnect lateral and longitudinal push rods at the swashplate. Disconnect push rods at the upper walking beams. Pivot swashplate on axes, noting any binding.

   Note: Binding exhibits a cyclic stick whirl during rotor engagement.

   Solution: Reshim swashplate for equal preload on each axis.

4. Upper walking beam binding.

   Check: a. Disconnect pitch link at walking beam and walking beam at pivot point. Rotate walking beam on push rod, noting any binding or roughness.

   b. Check torque on 1/4" walking beam bolts. Torque to 40 in. lbs.

   Note: Binding exhibits a cyclic stick whirl during rotor engagement.

   Solution: Repair as required.

   Note: Walking beams must pivot freely.

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While this is not a complete listing of possible problems that could produce system vibration, it illustrates the fact that proper maintenance and inspection of system components can reduce maintenance time involved in trying to track blades that are reacting to problems elsewhere in the system.

When tracking is necessary, refer to the following tracking procedures.

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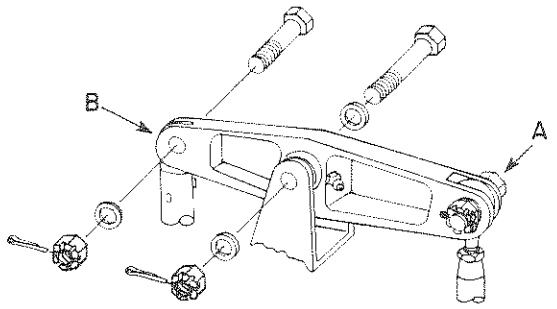

FIGURE 1

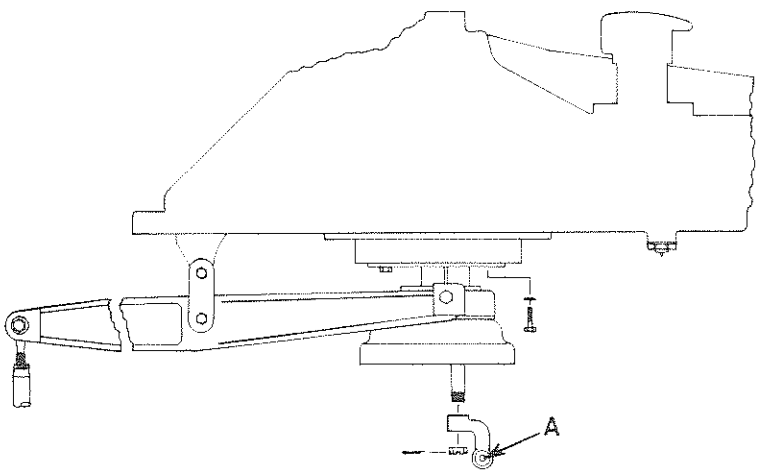

FIGURE 2

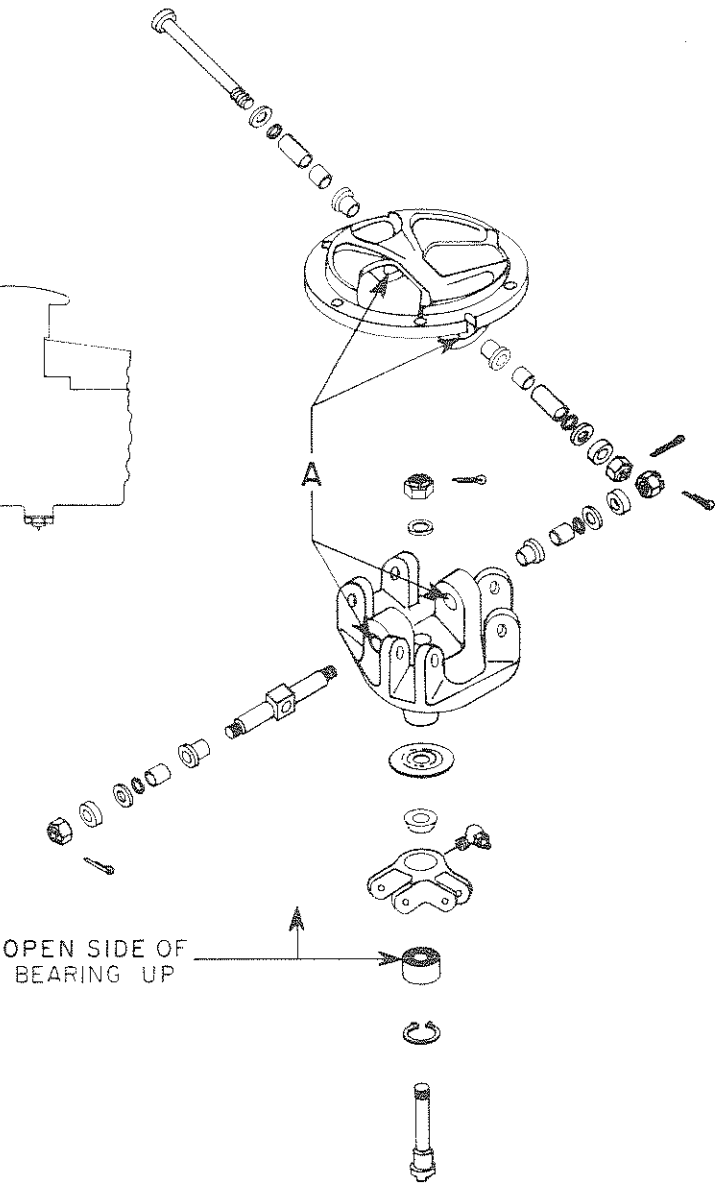

FIGURE 3

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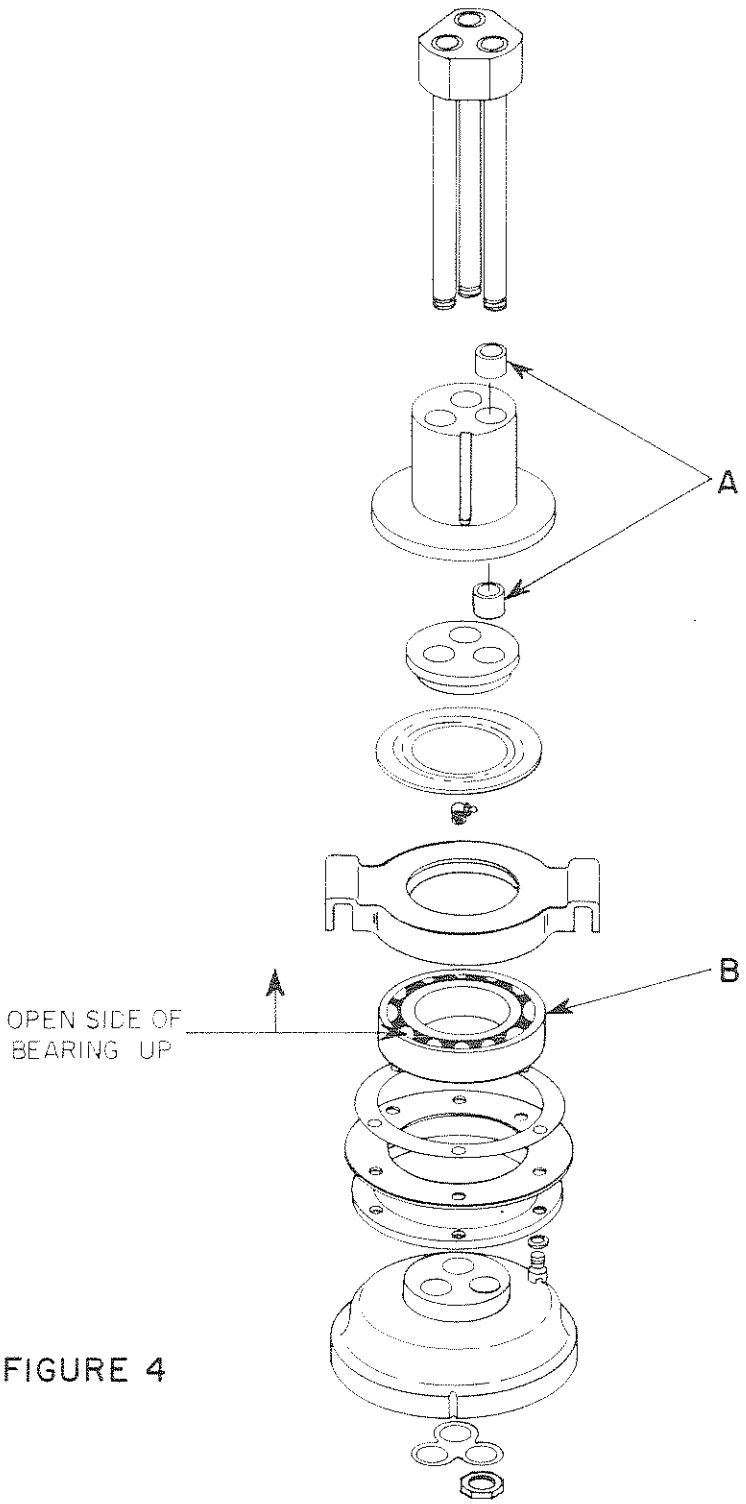

FIGURE 4

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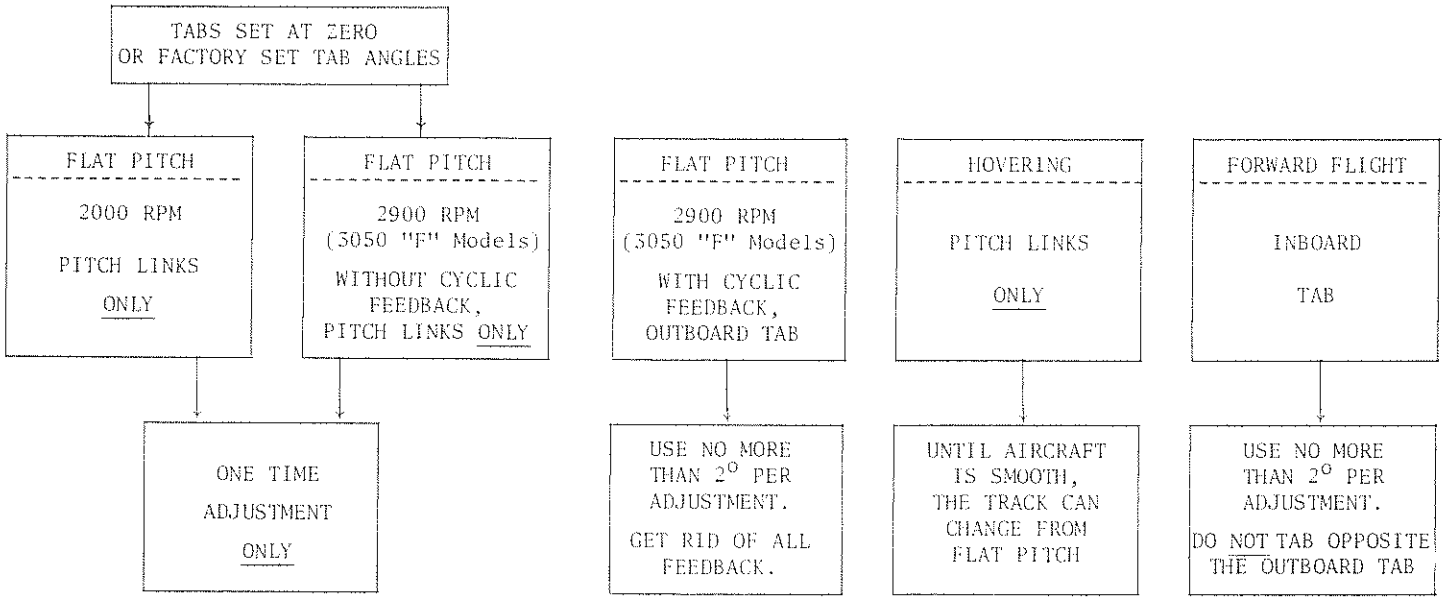
TRACKING PROCEDURE CHART



NOTE: If aircraft does not respond accordingly, as per the above chart, there is a component problem.

Common components to inspect are:

1. Dampers: Bleed or overhaul.
2. Push-Pull Olite Bushings: Worn or binding at walking beams.
3. Lamiflex Bearings: Separation or swelling.
4. Lead-Lag Spindle Bearings: Looseness and binding.
5. Lower Swash Plate: Worn or binding.
6. Guide Tube Assembly: Worn DU bushings or worn collective bearings.
7. Dog Leg Uniball Bearings: Worn or binding.
8. Excessive looseness throughout control system.

NOTE: For more detailed information, refer to the Troubleshooting section of this Service Information Letter.

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Main Rotor Blade Tracking (Spotlight/Reflector System)

General:

The purpose in tracking the main rotor blades is to obtain a smooth ride. This is accomplished by adjusting the blade track so as to have all three blades flying in the same plane. An out-of-track condition will produce a vibration, usually a one per rev which is felt as a vertical vibration. Main rotor blades do not suddenly produce a vibration unless a trim tab has been inadvertently altered or a blade has suffered other damage. Trim tab settings should be recorded in the aircraft's Log Book and referred to if an altered tab is suspected. Before attempting to remove a vibration by adjusting the track, refer to the trouble-shooting guide for other possible causes.

The following tracking procedures were established for main rotor blades incorporating an inboard and outboard trim tab, using the "Spotlight/Reflector" system.

A. Installation of Equipment

1. Connect spotlight to D.C. power. (Battery located under right-hand seat deck panel.)

2. Install reflector with strip painted across the reflector into threaded hole on bottom side of blade tip. Reflector facing inboard and aligned with end of blade.

3. Install clear reflector on next blade, reflector facing inboard.

4. Install clear reflector on last blade, reflector facing outboard.

Note: When tracking with the "Spotlight/Reflector" system you are only observing two blades at a time. The "master" and one of the two "clears."

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B. Tracking Procedure

1. Grease main rotor head.
2. Bleed main rotor dampers.
3. Zero tab all main rotor blade tabs, or set tabs at recorded angles on the "Blade Information Sheet."
4. Ground run aircraft (rotor engaged).
5. 2000 engine RPM.
6. Observe track with spotlight.
7. Record track and reverse clear reflectors.
8. Observe track and record condition.
9. Adjust track using pitch links.

C. Ground Track - 2900 RPM (Engine RPM)

1. Observe cyclic stick for any feedback.

   Note: If no feedback is evident, adjust track using pitch links. If feedback exists, proceed to No. 2.

2. Observe track with spotlight and adjust conditions using "outboard" tab.

   Note:
   a. Adjust only one tab, no more than 2 degrees per adjustment.
   b. If feedback does not exist, adjust track using pitch links.
   c. If feedback gets worse, zero the tab and adjust the next blade's outboard tab.
   d. Continue until all feedback is gone.
   e. If more than 3 degrees of tab is required, use both the inboard and outboard tab (i.e. + 3 degrees outboard, + 3 degrees inboard).

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3. Once all feedback is gone, adjust track using pitch links.

D. Hover Tracking

1. Hover aircraft into the wind (2900 RPM), ("F" models 3050 RPM).

2. Observe track and adjust using pitch links ONLY.

Note: Reverse reflectors frequently and adjust track until aircraft is smooth.

E. Forward Flight Tracking

1. Level flight, 80 to 100 mph, rpm stable.

2. Observe track with spotlight.

3. Reverse reflectors and observe condition of other clear blade.

4. Adjust out-of-track condition using "inboard" tabs.

Note: a. Adjust tabs using no more than 2 degrees per adjustment.
b. Reverse reflectors frequently.
c. Do not tab an inboard tab in the opposite direction of outboard tab. If such a move is called for, subtract a degree from the outboard tab and observe cyclic for feedback.
d. Any move made on an outboard tab will require a pitch link move to regain smooth hover.

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Main Rotor Blade Tracking (Chadwick System)

General:

The purpose in tracking the main rotor blades is to obtain a smooth ride. This is accomplished by adjusting the blade track so as to have all three blades flying in the same plane. An out-of-track condition will produce a vibration, usually a one per rev which is felt as a vertical vibration. Main rotor blades do not suddenly produce a vibration unless a trim tab has been inadvertently altered or a blade has suffered other damage. Trim tab settings should be recorded in the aircraft Log Book and referred to if an altered tab is suspected. Before attempting to remove a vibration by adjusting the track, refer to troubleshooting guide for other possible causes.

The following tracking procedures were established for main rotor blades incorporating an inboard and outboard trim tab, using the Chadwick System.

Installation of Chadwick System

A. Mounting Brackets

1. Install magnetic pickup mounting bracket and block, P/N 4385, under main rotor transmission filler cap assembly.

2. Rotate main rotor blades to place a blade directly forward or just to the right of forward.

3. Install interrupter, P/N 4393, around mast. Rotate interrupter until the straight leg of the doubler interrupter is in line with the magnetic pickup (bent double interrupter tab should trail in direction of rotation).

4. Snug the three interrupter mounting bolts, securing the interrupter to the mast.

5. Install safety clamp below interrupter and secure.

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B. Magnetic Pickup

1. Install magnetic pickup in mounting bracket. Adjust until there is a .040" clearance between magnetic pickup and interrupter leg.

2. Rotate blades, checking gap of other two legs.

C. Accelerometer Installation

1. Secure lateral (balance) accelerometer to magnetic pickup bracket with connector pointing to the left.

2. Secure vertical (track) accelerometer to instrument panel console using any convenient screw. Connector pointing down.

D. Cable Installations

1. Connect magnetic pickup cable, P/N 3319, to magnetic pickup.

2. Connect accelerometer cable, P/N 3284, to lateral accelerometer on magnetic pickup bracket.

3. Route magnetic pickup and accelerometer cables into cabin. Secure cables to airframe to allow for forward flights.

4. Connect other cable, P/N 3284, to vertical accelerometer on console.

5. Place balancer box in cabin and plug magnetic pickup cable into channel "A" magnetic pickup receptacle of the balancer box.

6. Plug lateral accelerometer cable into channel "A" accelerometer receptacle.

7. Plug vertical accelerometer cable into channel "B" accelerometer receptacle.

Note: Insure all cable connections are tight.

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8. Connect Strobex to balancer box.

9. Connect balancer box to aircraft's D.C. power. (Battery located under right-hand seat deck panel.)

E. Balancer Box Control Settings

1. "Magnetic pickup" to "Common."

2. "Interrupter logic" to "Double."

3. "Function" switch to "Track."

4. "RPM Range" to "X 1."

5. "RPM Tune" to "350" (F-28C, 280C, F-28F, 280F).
"332" (F-28A, 280).

Note: The 177M-5 and M-6 do not have "magnetic pickup" and "interrupter" switches. The Strobex must be plugged in to realize the double interrupter logic. Set switches as shown in C, D, and E.

F. Strobex Setting (135M-10A, B, or C)

1. Set "oscillator" switch to the "off" position.

Note: The internal oscillator of the Strobex is used for tail rotor balancing ONLY.

G. Tip Target Installation

1. Install tip targets, P/N 4479, one to each blade. Secure with a #10 round head screw. (Reflective numbers inboard.)

Note: Rotate blades until "double interrupter" is over magnetic pickup. Main rotor blade in front of ship is designated "target blade." Blade following "target blade" is designated "A" blade, and last blade designated "B" blade.

Tracking Procedure - Chadwick System

Once the Chadwick System is set up as per the preceding instructions, the aircraft is ready for tracking or balancing the rotor blades.

A. Grease main rotor hub.

B. Bleed main rotor dampers.

C. Zero tab all main rotor blade tabs, or set tabs at recorded angles on the "Blade Information Sheet."

D. Ground run aircraft (rotor engaged).

1. 2000 RPM (engine RPM).

2. Observe track with Strobex.

3. Adjust using main rotor pitch links.

E. Ground run aircraft (rotor engaged).

1. 2900 RPM (F-28A, 280, F-28C, 280C).
   3050 RPM (F-28F, 280F)

2. Observe cyclic stick for any feedback.

   Note: If no feedback is evident, adjust track using pitch links. If feedback exists, go to No. 3.

3. Observe track with the Strobex and adjust condition using the outboard tab.

   Note: a. Adjust only one tab no more than 2 degrees per adjustment.
   b. If feedback does not exist, adjust track using pitch links.
   c. If feedback gets worse, zero the tab and adjust the next blade's outboard tab.
   d. Continue until all feedback is gone.
   e. If more than 3 degrees of tab is required, use both the inboard and outboard tab (i.e. + 3 degrees outboard, + 3 degrees inboard).

4. Adjust track using pitch links.

F. Hover Tracking

1. Observe track with Strobex.

2. Switch balancer selector to vertical channel "B."

3. Record "clock angle" and "IPS" reading.

   Note: It is important for the pilot to hold a steady hover, and stabilized RPM before recording conditions.

4. Refer to channel "B" tracking chart and plot move. It should be the same as you observed with the Strobex. It is important to be able to correctly read the track with the Strobex.

5. Adjust track using pitch links.

   Note: Adjust conditions until IPS is reading less than .2 IPS, and aircraft is not smooth, follow the "Balancing Steps" listed next.

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G. Balancing a Lateral (Balancing is only done in a hover)

1. Hover aircraft into the wind.
2. Switch balancer selector to channel "A."
3. Record "clock angle and IPS" reading.
4. Refer to channel "A" balance chart and plot move.

   Note: Balancing is done using the pockets located on the outboard end of the blade.

5. Add or subtract "tip weights" until IPS is below .2 IPS and aircraft is smooth.

   Note: The addition or subtraction of tip weights will sometimes affect the "vertical." If so, revert back to "item G" for corrections.

H. Forward Flight Tracking

1. Level flight in cruise, RPM stable (2900 RPM - F-28A, 280, F-28C, 280C)
   (3050 RPM - F-28F, 280F)
2. Observe track with Strobex and record conditions.
3. Switch balancer to channel "B" and record "clock angle" and "IPS."
4. Plot move on vertical chart "B."

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5. Adjust condition using inboard tab.

Note: a. Use no more than 2 degrees per move.
b. Do not bend inboard tab in opposite direction of an outboard tab on the same blade. If this move is required, subtract a degree of tab from the outboard.
c. Observe cyclic feedback.
d. Any time a move is made on an outboard tab it will require a pitch link adjustment to make hover smooth.

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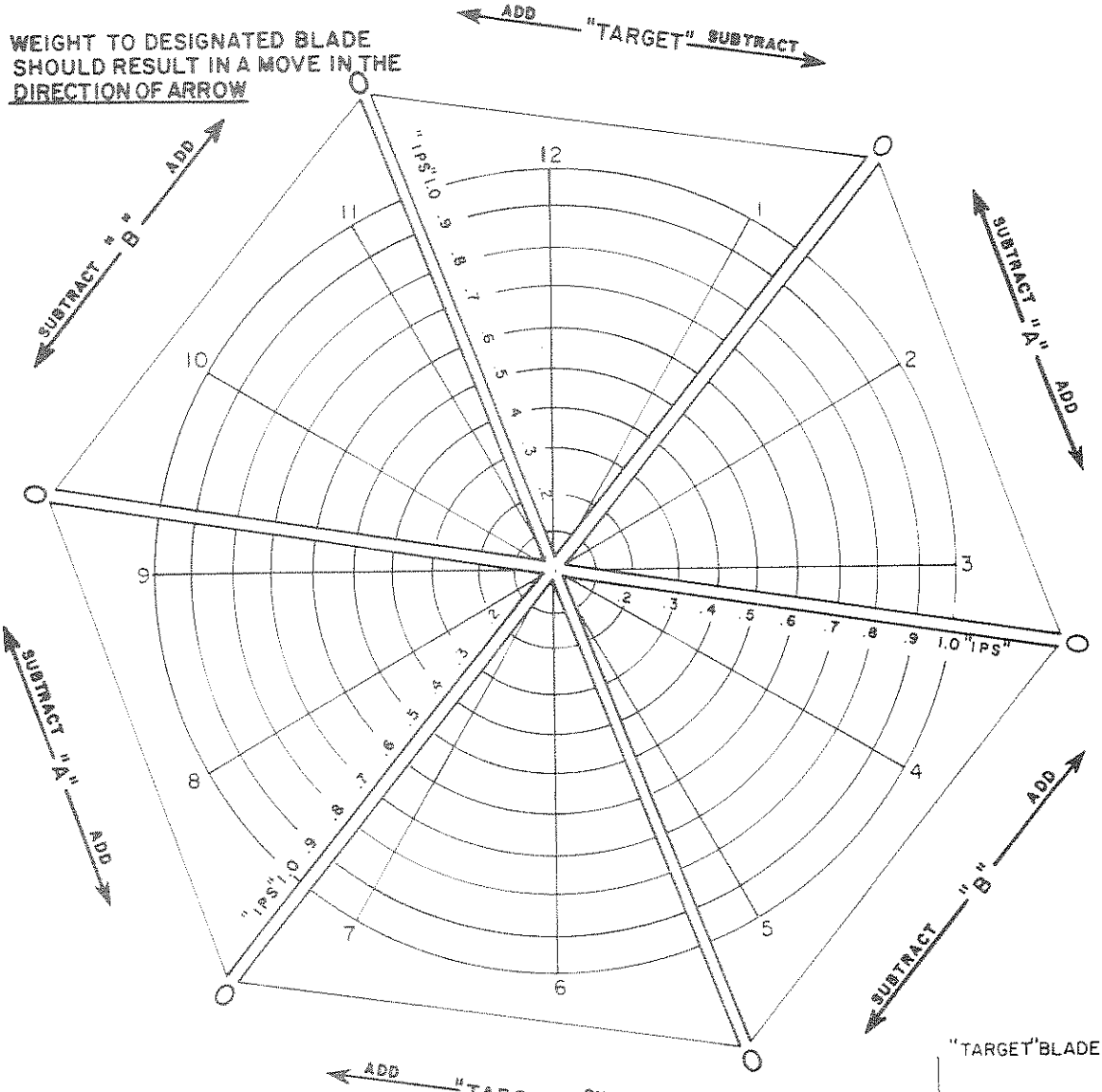
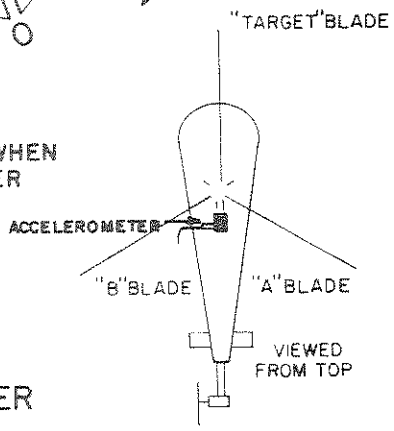


SET BALANCER TO -
350 R.P.M. FOR F28C, F28F, 280C, 280F
332 R.P.M. FOR F28A, 280

SHIP TO BE IN GOOD TRACK AND BALANCED IN HOVER ONLY

ADD OR SUBTRACT NO MORE THAN 20 GRAMS PER MOVE

TARGET BLADE IS FORWARD WHEN DOUBLE INTERRUPTER IS OVER MAGNETIC PICKUP



READ CHANNEL "A"
LATERAL ACCELEROMETER

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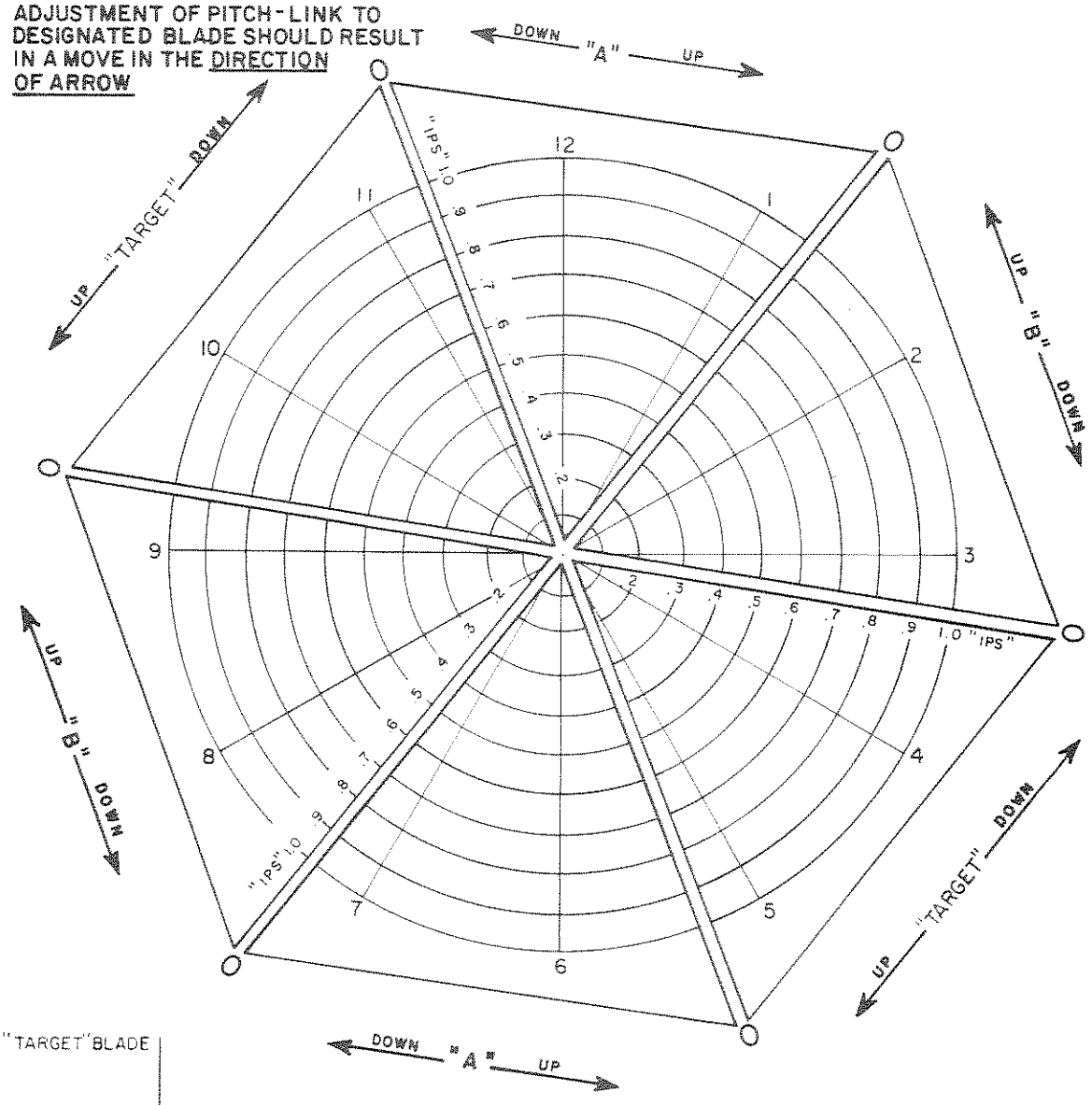
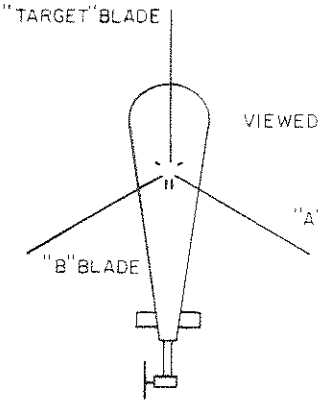
ADJUSTMENT OF PITCH-LINK TO DESIGNATED BLADE SHOULD RESULT IN A MOVE IN THE DIRECTION OF ARROW





TARGET BLADE IS FORWARD WHEN DOUBLE INTERRUPTER IS OVER MAGNETIC PICKUP

SET BALANCER TO -
350 R.P.M. FOR F28C, 280C, F28F, 280F
332 R.P.M. FOR F28A, 280

READ VERTICAL ("IPS" AND CLOCK ANGLE) AND OBSERVE TRACK AT HOVER AND CRUISE. PLOT CHANNEL "B" VERTICAL READING

READ CHANNEL "B" VERTICAL ACCELEROMETER