# CHAPTER 18 — ROTOR ANALYSIS DIAGNOSTIC SYSTEM

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### FIGURES



### TABLES

# ROTOR ANALYSIS DIAGNOSTIC SYSTEM

## 18-1. ROTOR ANALYSIS AND DIAGNOSTIC SYSTEM — ADVANCED TECHNICAL (RADS-AT).

The RADS-AT system provides the necessary information to track and balance the rotor system using Scientific Atlanta Rotor Analysis Diagnostic System — Advanced Technical (RADS-AT) or Chadwick-Helmuth analyzer.

## 18-2. THEORY OF OPERATIONS.

If a perfectly balanced circular disc is mounted on a rigid center spindle and rotated, outward centrifugal forces created will be constant everywhere along the edge of disc (**figure 18-1**). Consequently, disc edge will appear to maintain a perfectly stable circular orbit around spindle axis, with no uneven or extraneous forces being transmitted to the surrounding environment.

If a weight is added to the edge of disc, the increased centrifugal force created when disc is rotated will perturb its orbit, inducing a mass imbalance around center of rotation and a “wobble” along the spinning shaft (**figure 18-2**). A supporting spring placed under the shaft at point of maximum wobble would accordingly feel effects of this imbalance, experiencing an up-and-down vibration once per revolution as weighted disc edge passes through top and bottom of its rotary trajectory. This is called a *lateral* mass imbalance because direction of the vibration is aligned with (i.e., parallel to) rotor systems plane of rotation.

The vibration forces created by a lateral mass imbalance are transferred with equal intensity to opposite end of spinning shaft, and from there to any components wobbling spindle may contact. In large, rapidly spinning rotor systems such as helicopters and propeller airplanes this phenomenon may be felt by passengers and crew as an uncomfortable, resonating “buzz” caused by propagation of vibrations through the airframe and cabin. A second consequence is far more serious: damage to system hardware. If an excessive rotor imbalance is left untreated, components that are continually subjected to associated vibrational energies can, over a period of time, suffer wear, abrasion, fatigue, or even breakage. Such damage is costly in terms of helicopter maintenance, and dangerous to the helicopter and its occupants.

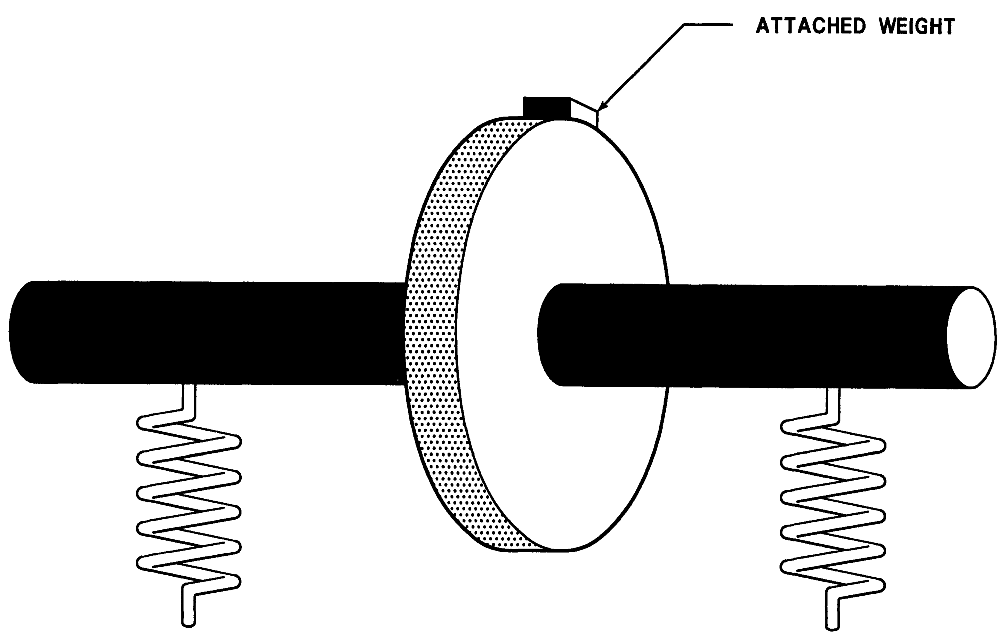


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**Figure 18-1. Ideal rotor with weight and supporting springs**

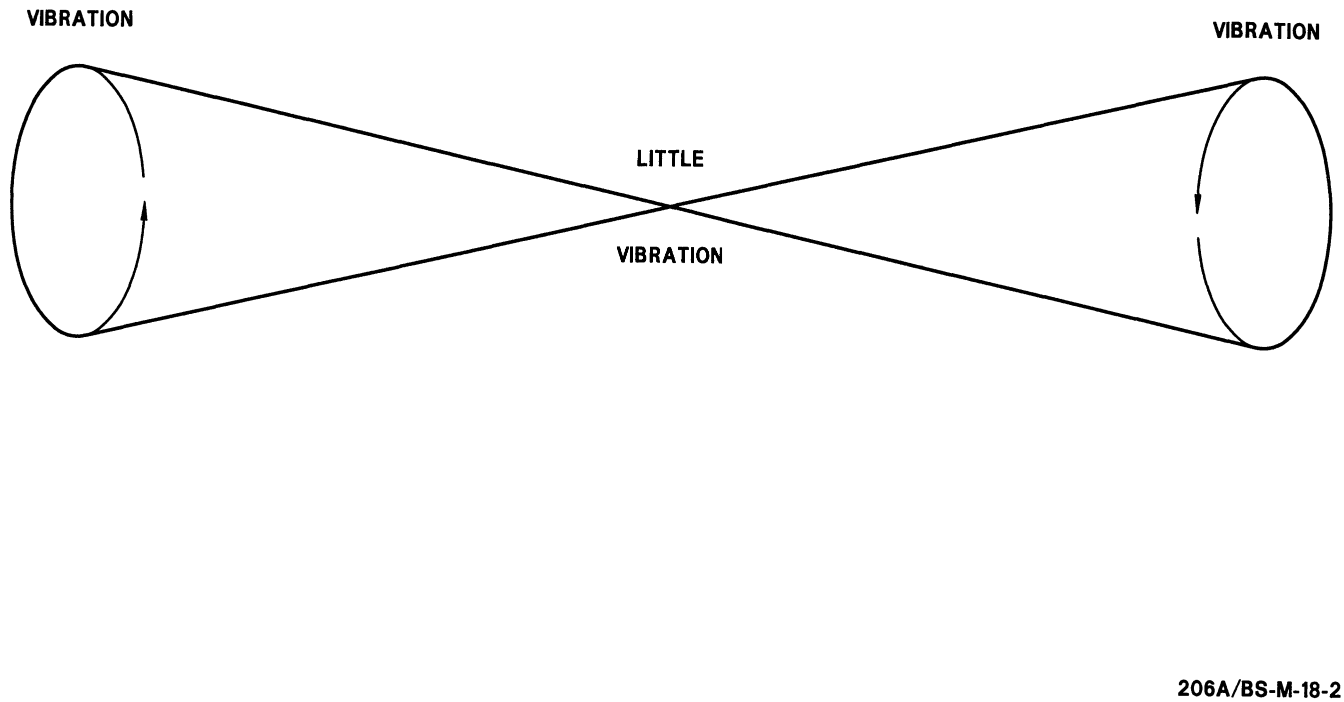


**Figure 18-2. Shaft wobble induced by mass imbalance**

How can we locate and neutralize a lateral mass imbalance in a rapidly spinning disc? Since we know that the weighted edge of the rotating disc must be at top of its rotary travel when vibrating spring reaches point of maximum expansion (positive amplitude), and at bottom of its arc when spring reaches the point of maximum contraction (negative amplitude), it follows that location of weight can be determined from spring position alone. That is, if we could stop the spinning disc at point of maximum vibrational amplitude, weighted edge would appear at top of its trajectory. The expansion and contraction of the spring can be measured as positive and negative vibration amplitude, respectively, and plotted in terms of displacement versus time (figure 18-3). The position of disc at any given moment is called its *angular position* (or *phase angle* or *clock angle*); it is a measure of relationship between a given point on the edge and some fixed artificial reference (the *azimuth*), and is computed in terms of central angle subtended by two points. The angular position of disc thus tells us exactly where destabilizing mass is located. Moreover, the magnitude of the vibrational amplitude — the amount of expansion and contraction seen in the spring — is directly related to weight of the mass. With this information we can now pinpoint the source of the imbalance and either remove appropriate amount of weight or add a counter-balancing weight to the opposite edge of disc; either action should correct the out-of-balance condition.

Figure 18-3 actually describes a simple harmonic oscillator (sine curve) with time period $T$ and frequency $f$, whose displacement, $y$, may be described mathematically by the equation

$$y = r \sin \theta$$

where $r$ is the amplitude of vibration and $\theta$ the phase angle.

The Vibration Balancer (Analyzer) determines angular position and vibrational amplitude of an unbalanced rotor with help of a device called a *velocimeter*, or velocity sensor. A velocimeter is an electronic transducer that measures displacement velocity — the rate of change of displacement with respect to time. The velocity, $v$, of a simple harmonic oscillator can be expressed mathematically by

$$v = 2\pi f r \cos \theta$$

where $f$ is the frequency of rotation, $r$ the amplitude of vibration, and $\theta$ the phase angle. The waveform produced by this equation can be seen in figure 18-4. Note the 90° phase shift from displacement waveform.

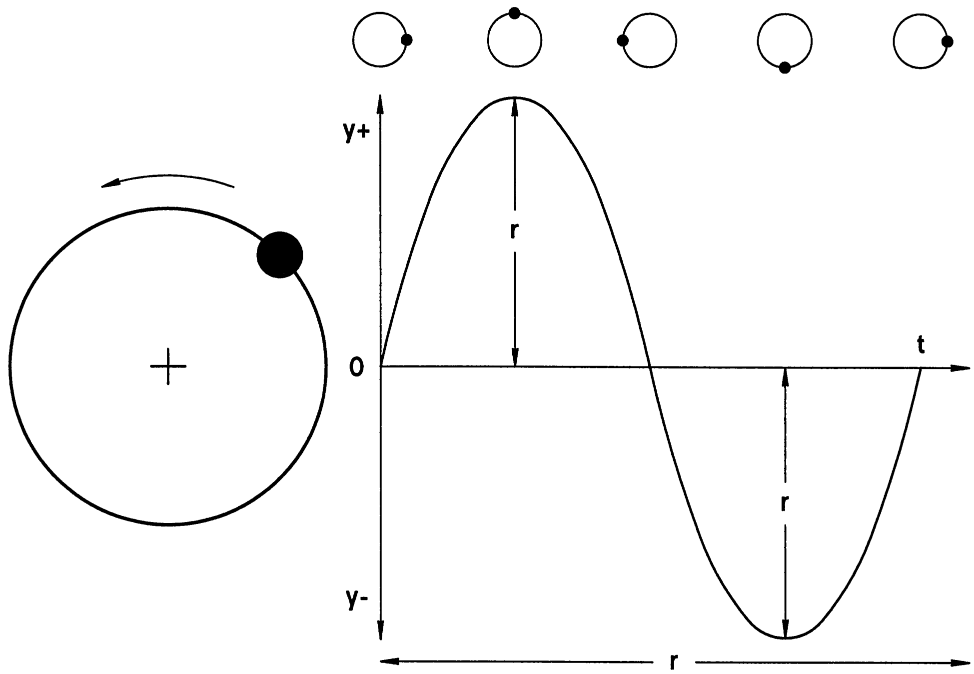


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Figure 18-3. Displacement in an imbalanced rotor

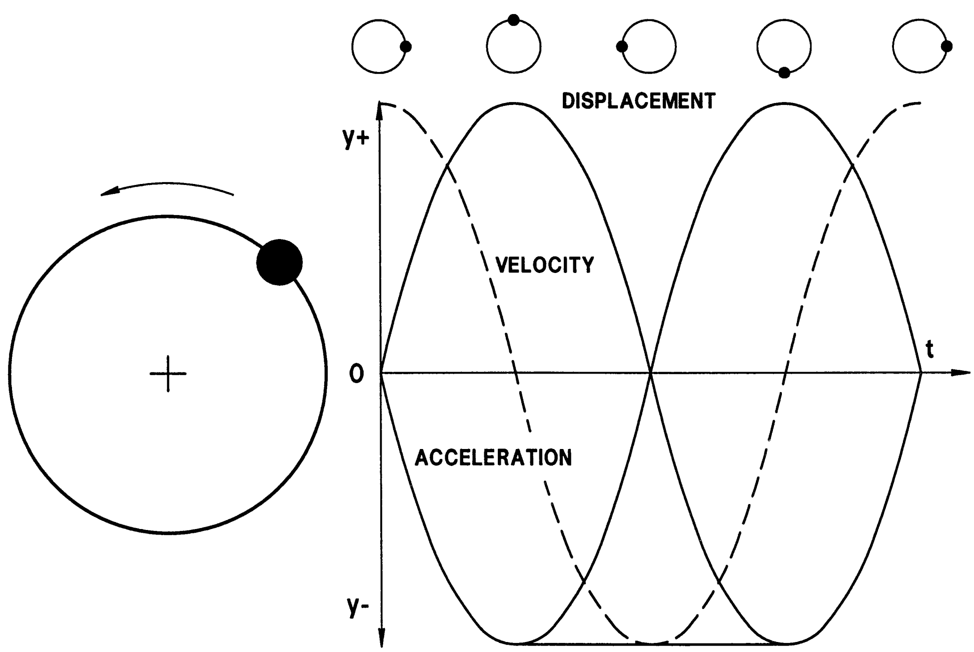


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Figure 18-4. Displacement, velocity, and acceleration in an imbalanced hub

A velocimeter is usually attached directly to a rotor system support structure and oriented in direction of vibration. It generates an electrical signal whose voltage varies from plus to minus as the support structure moves up and down during each revolution. This varying voltage is directly proportional to the amplitude of vibration and actually represents the physical motion of point to which velocimeter is attached. The analyzer samples this signal, transforms it, and extracts the frequency component of the vibration, otherwise called the *Balance Frequency* of the system. Out-of-balance rotors are often subjected to several different kinds of vibration. The analyzer extracts a profile of these different vibration amplitudes across a broad range of frequencies and displays the values in a plot of frequency versus amplitude. The largest of the peaks is usually the Balance Frequency of the lateral mass imbalance; this frequency must be selected by user before balance can continue. In one approach, the Balance Frequency is used to time a one-per-rev triggering pulse to the Strobex (figure 18-5). The Strobex flashes a stroboscopic light with each trigger, and if it is aimed at a special retro-reflective target attached to the spinning rotor, target will appear “frozen” at some angular position. This angular position indicates exact location of the mass imbalance. the analyzer can modulate the Strobex trigger so we can visually “move” the target toward the rotors reference azimuth. When two points converge, the analyzer fixes the exact angular position and amplitude of vibration, and then computes the balance solution.

The Strobex is one way to locate a lateral mass imbalance. We can also use a magnetic pickup and interrupter or photocell and reflective target to generate a one-per-rev reference signal for the spinning rotor. If interrupter or reflective target has been secured to a known point on spinning rotor, the analyzer can compare this signal against the velocimeter output to compute angular position of the out-of-balance element.

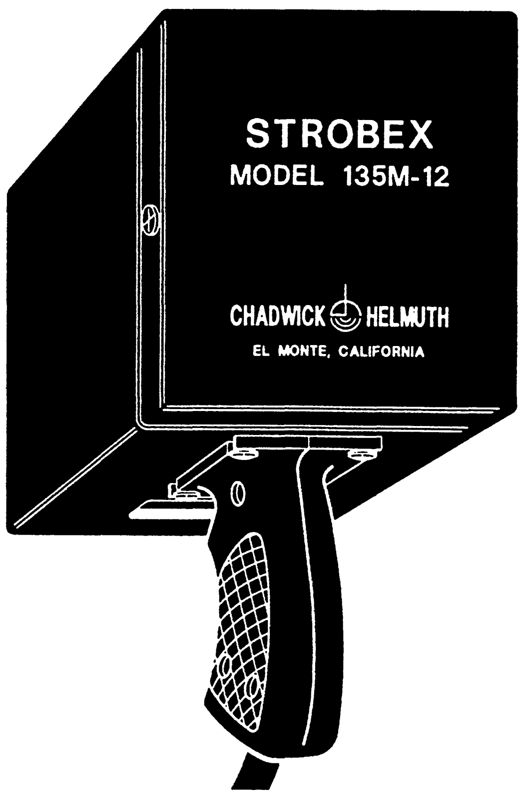


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**Figure 18-5. Strobex**

A rotor system track describes geometry of the circular path made by the blades as they rotate. A blade that is out of track may follow a slightly different path because its alignment in the plane of rotation is skewed. The result is a one-per-view vibration whose direction is perpendicular to plane of rotation. We can analyze this condition either by measuring the amplitude and frequency of vibration or by visually characterizing the track to determine extent of the imbalance. The former technique is called a *track* or *vertical balance* and employs principals and procedures nearly identical to those used to correct a lateral mass imbalance. The latter technique is called a *visual track* and uses the Strobex to illuminate relative position of blades as they rotate. In both cases the goal is to match aerodynamic qualities of all blades and thereby eliminate vertical vibrations caused by out-of-track condition.

The major difference between vibrations generated by a lateral mass imbalance and those generated by a track or vertical imbalance is direction of vibrational forces. Otherwise, the principals governing them are nearly identical. To solve a track imbalance we therefore have only to orient the velocimeter perpendicular to plane of rotation. The analyzer extracts from the velocimeter signal the amplitude of vibration and Balance Frequency and uses a reference signal from a magnetic pickup or photocell to determine phase angle of the out-of-track vibration. With this information, compute a solution based on the adjustment of trim tabs or pitch-links that physically modify blade track.

In a visual track the one-per-rev signal from a magnetic pickup or photocell is used to drive the Strobex flash. If each rotor blade has secured to it a retro-reflective target, we would be able to identify each target as it is illuminated by the strobe flash. In a perfectly tracked system the images will line up precisely along planar path of rotation established by all the blades. The extent to which any blade image deviates from path is an indication of relative degree of track imbalance. Adjustments to helicopter trim tabs and/or pitch-links will usually bring the anomalous blade back into alignment.

## 18-3. BLADE SWEEP.

*Blade sweep* or *lead/lag* refers to the angle of separation between individual blades within the plane of rotation. Blade spacing that is not equiangular can cause significant perturbations to system lateral balance. For this reason, balance solutions may call for modification of the rotor blade sweep or addition/subtraction of chord balance weights.

## 18-4. BALANCE CHARTS.

Analyzer can identify the vibrational characteristics of a rotor system by providing us with two essential measurements, vibration amplitude and angular position. But in order to compute an actual balance solution — i.e., *how much* weight to add or subtract, and *where* to apply changes — we first need to know something about the relationship between physical balance points of the system and values for amplitude and position. In particular, we need to be able to predict how vibration amplitude and angular position will change when we make specific adjustments at the balance points. This information has been experimentally determined for most helicopter types and organized into a unique form called a *Balance Chart*. Each balance chart contains data that describe a single rotor element from a particular helicopter type. They may also be represented graphically, and can be found in almost any Chadwick-Helmuth paper balance chart. Paper balance charts provide a simple way to visually fix a balance measurement and calculate weight adjustments required to balance the rotor.

## 18-5. Paper Balance Chart.

A paper balance chart consists of a clock face whose 12 radial lines represent the clock angle of the balance measurement (figure 18-6). Concentric circles drawn around center of the clock face delimit different values of vibration amplitude. Finally, a graph is laid over clock face whose axes represent the geometrical relationship between the weight attachment points of the helicopter. The axes are labelled with weight amounts; their values are inversely proportional to the length of moment arm formed by center of rotation and weight attachment point (a weight has more effect the further out it is placed along a blade, so smaller amounts are needed).

A balance measurement reading allows us to plot the intersection of vibration amplitude and phase angle on clock face. Extrapolation of this point to the axes of the graph determines location and magnitude of required adjustments. In most cases a balance point will indicate two corrective moves — one for each blade whose axis encompasses the balance point. The exact procedure required to balance rotor depends on chart being used.

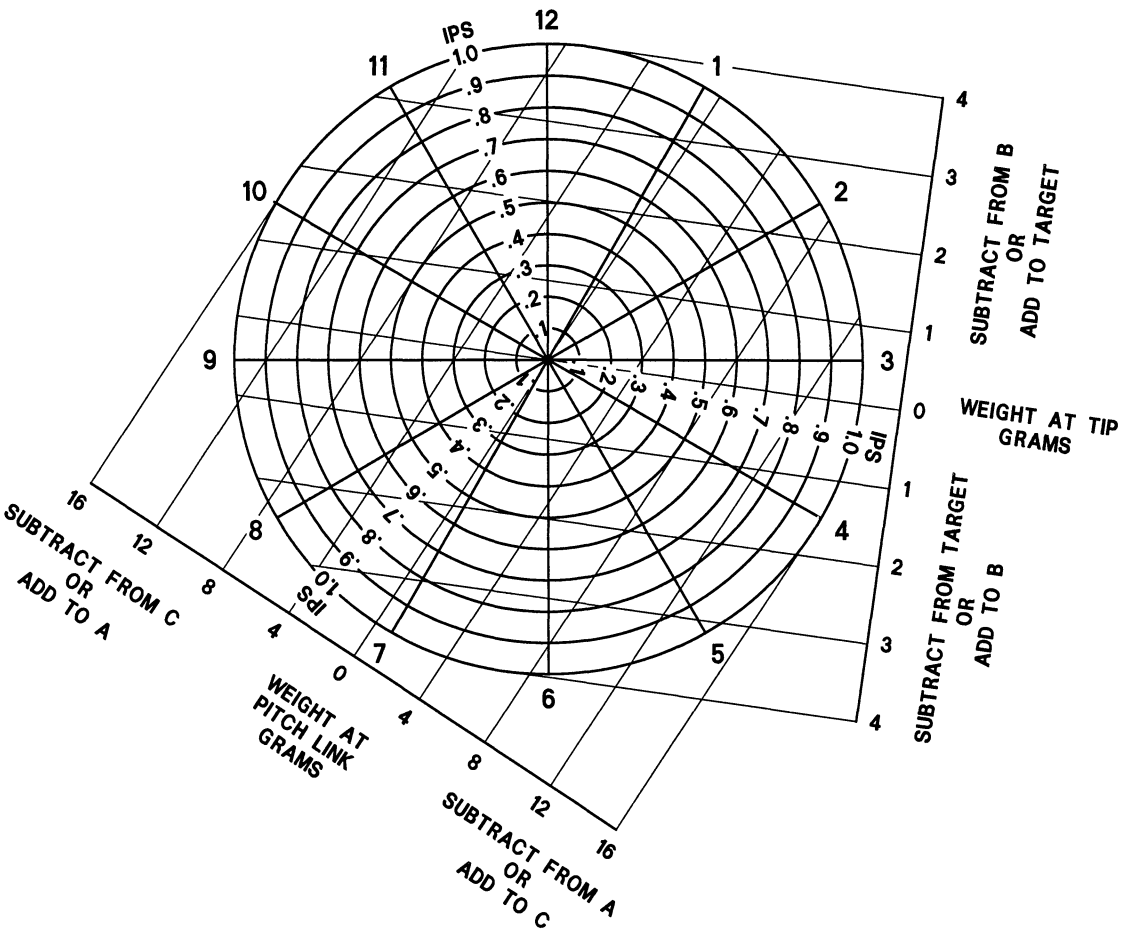



Figure 18-6. Example paper balance chart

## 18-6. Theory of Chart Creation and Correction.

Individual rotor systems of a particular type rarely exhibit identical vibrational characteristics. Differences in manufacture and repair, and variations in airframe stiffness and resonant frequency often call for different balance solutions. The uniqueness of each system mechanical response thus precludes using a single set of “ideal” parameters to build balance charts. As a result, charts do not exemplify abstract theoretical models of rotor performance; instead, they are created by carefully averaging many experimental measurements of a particular rotor type. This approach means that charts may not always accord with actual rotor measurements, in some cases diverging enough to prevent proper balancing.

We can compensate for these inherent biases by using analyzer to correct individual balance charts, modifying them so that each chart can be tuned to the unique physical characteristics of individual systems.

Chart corrections compare actual effects of weight on vibration amplitude and clock angle against changes predicted by the chart. We can quantify the comparison by means of a special calculation, the *Move Line*. The Move Line is the vector difference between two balance measurements. On a paper balance chart it is identified by the straight line drawn between two balance points. Normally, the direction of the Move Line will change in a predictable manner as we make weight adjustments prescribed by the chart. If, for example, both corrective moves are made, the Move Line should go toward or through the center of the chart. If only one move is made, the Move Line should run parallel to the fine lines extending from the axis of the unmodified blade — in other words, the weight on this blade has not been changed. The difference between the observed direction and the expected direction indicates the amount of phase angle correction that must be applied to subsequent measurements. This is usually accomplished by rotating the clock face or writing new clock numbers around the paper chart. This correction factor is thereafter applied to all calculations involving the phase angle.

The magnitude of the Move Line (i.e., its length) also signifies a particular vibration level or amplitude. It should also change in a predictable manner as we make the weight adjustments prescribed by the chart. Making only one of the corrective moves should bring the Move Line directly to the zero weight change axis for that blade. (In other words, the weight change required by this blade has been implemented.) The length of the Move Line is therefore directly related to size of the weight adjustment, and ratio of the observed magnitude to the expected magnitude indicates the percentage weight correction — as well as the percentage amplitude adjustment — that must be applied to subsequent measurements. (For example, if the Move Line is too long, too much weight has been added; if it is too short, not enough weight has been used.) Use this ratio to develop the correction factor for vibration amplitude. It is added to the balance chart data and thereafter applied to all calculations of weight adjustment.

## 18-7. BALANCE MEASUREMENT AND SOLUTION.

Balance measurement is similar to spectrum data acquisition in that both operations collect spectral frequency data from the rotor system being tested. Balance measurement, however, focuses on data from a particular vibration signal, with the goal of providing a solution to the vibration problem. Two types of out-of-balance conditions may be analyzed here: lateral mass imbalances and vertical track imbalances. Lateral imbalances create vibrations that are oriented parallel to the plane of rotation. Vertical imbalances stem from track misalignments in the rotor blades and produce vibrations that are perpendicular to the plane of rotation. The correct solution to both problems only requires that the appropriate balance chart be used and that the velocimeter cylindrical axis be oriented in the same direction as the vibrational forces. The solution is based on the unique characteristics of rotor system being balanced, and is presented in terms of prescribed adjustments to rotor hardware. These adjustments include:

- The incremental addition or removal of weights at the balance points of the helicopter.
- Adjustments to the sweep of the blades.
- Adjustments to the trim-tabs.
- Adjustments to the pitch-links.

Due to the complex interaction between vertical and lateral vibrations, it is considered essential that helicopter track be adjusted and verified before performing a lateral balance paragraphs 18-7 thru 18-9).

## 18-8. BLADE TRACK OBSERVATION.

We have seen how the analyzer can be used to correct both lateral mass and vertical track imbalances.

A rotor system *track* describes the geometry of the circular path made by the blades as they rotate. A blade that is out of track may follow a slightly different path because its alignment in the plane of rotation is skewed. The result is a one-per-rev vibration whose direction is perpendicular to the plane of rotation. We can analyze this condition either by measuring the amplitude and frequency of vibration or by visually characterizing the track to determine extent of the imbalance. The former technique is called a *vertical balance* and employs principals and procedures nearly identical to those used to correct a lateral mass imbalance. The latter technique is called a *visual* and uses the Strobex to illuminate the relative position of the blades as they rotate. In essence, the goal in both cases is to match the aerodynamic qualities of each blade in the system.

Due to the complex interaction between vertical and lateral vibrations, it is considered essential that a helicopter track be adjusted and verified before a lateral balance is attempted (paragraph 18-7).

## 18-9. VERTICAL BALANCING.

A vertical balance attempts to analyze the vertical (i.e., perpendicular to the plane of rotation) vibration amplitude that is caused by an out-of-track rotor blade. Essentially, the only difference between these vibration signals and those generated by a lateral mass imbalance are their orientation to the plane of rotation. Analysis of the problem otherwise involves very similar principals. The technique we use to solve a vertical imbalance is therefore nearly identical to the technique of solving a lateral mass imbalance (paragraph 18-7). The only differences to note are the orientation of the velocimeter — its cylindrical axis must be aligned in the direction of the out-of-track vibration — and the balance chart selected. Chadwick-Helmuth supplies charts for vertical or track balancing of many helicopter rotor systems. Otherwise, you should closely adhere to the procedure for deriving balance solutions described in paragraph 18-7.

In general, the refined electronic measurements taken during a vertical balance provide a more sophisticated balance solution than visual tracking. However, in those situations where a vertical balance has been performed, visual tracking can be used to independently verify the balance solution. Moreover, performing a visual track *before* a vertical balance provides important information about the track characteristics of each blade: this information can then be used during vertical balance to help select the best alternate balance solution.

## 18-10. VIBRATION ANALYSIS.

The Nodal-beam system provides a very low vibration level. When there is a definite deterioration from this level, immediate action should be taken to correct the condition.

Sources for these vibrations are the rotating or moving components of the helicopter. The availability of electronic vibration and tracking devices such as the Chadwick and RADS-AT provide both immediate and positive determination of these sources.

Extreme low frequency, low frequency, and most medium frequency vibrations are caused by the rotor or dynamic controls.

Certain vibrations are inherent in the helicopter, and are considered normal. Two per revolution (2/rev), is the most prominent, with 4/rev or 6/rev the next most prominent. There is always a small amount of high frequency present.

For purposes of this manual, vibrations are divided into four general frequencies and are described in the following paragraphs.

## 18-11. EXTREME LOW FREQUENCY VIBRATION.

Extreme low frequency vibration is limited to a two to three cycles per second, pylon rock, which is inherent with the rotor, mast, and transmission system.

When this “rock” is noticed during normal flight, it is an indication that something is wrong with the transmission mounts or transmission restraints and should be inspected to determine cause and corrective action (Chapter 63).

## 18-12. LOW FREQUENCY VIBRATION.

Low frequency vibrations of 1/rev and 2/rev are caused by the main rotor. These are of two basic types; vertical or lateral.

A 1/rev vertical is caused by one blade developing more lift at a given point than the other blade develops at the same point.

A lateral vibration is caused by an imbalance condition of the rotor due to:

A difference of spanwise or chordwise weight between the blades.

The CG alignment of the blades with respect to the spanwise axis which affects the chordwise balance.

Hub imbalance: Initially the rotor is brought into a low speed ground track by rolling the grip on the high blade to fly it down in track with the low blade. This is normally accomplished at 70 to 75 percent N2. A high speed reference track is then made at 100 percent N2. Record tracking data for possible use during flight check.

Generally, verticals felt predominately in low power descent at moderate airspeeds (60 to 70 knots) are caused by a basic difference in blade lift and can be corrected by rolling the grip slightly out of track.

Verticals noted primarily in forward flight, that become worse as airspeed increases, are usually due to one blade developing more lift with increased airspeed than the other (a climbing blade). A slight raising of the trim tab on the low blade will generally correct this condition.

Flight test after adjustment is required to determine acceptability. Analysis of flight test data will be required if further action is deemed necessary.

The intermittent 1/rev is essentially initiated by a wind gust effect, causing a momentary increase of lift in one blade. The momentary vibration is normal but if it is picked up by the rotating collective controls and fed back to the rotor causing several cycles of 1/rev, then it is undesirable.

Sometimes during steep turns, one blade will "pop" out of track and cause a hard 1/rev vertical. This condition is usually caused by too much differential tab in the blades and can be corrected by rolling one blade at the grip and removing some of the tab (as much as can be done without hurting the ride in normal flight).

When a rotor or rotor component is out of balance, a 1/rev vibration called a lateral will be present. This vibration is usually felt as a vertical due to the rolling motion it imparts to the helicopter, causing the crew seats to bounce up and down out of phase. When the pilot seat is going up, the copilot will be going down.

A severe lateral can be felt as a definite sideward motion as well as a vertical motion.

Laterals existing due to imbalance in the rotor are of two types; spanwise and chordwise.

Spanwise imbalance is caused simply by one blade and grip being heavier than the other (i.e., an imbalance along the rotor span).

A chordwise imbalance means there is more weight toward the trailing edge of one blade than the other. Both types of imbalance can be caused by the hub as well as the blades.

Generally, a chordwise lateral imbalance condition is more pronounced at 95 percent N1 and a spanwise lateral is more pronounced at 100 percent N2.

If spanwise imbalance is indicated, a wrap of one or two turns of 2-inch (50 mm) masking tape (or equivalent weight of another type) around one blade, a few inches in from the tip so that it will not be easily torn off by the wind.

Hover the helicopter, either in or out of ground effect, wherever the lateral was most pronounced, and note the effect. An increase in vibration means that the tape was applied to the wrong blade.

Once the correct blade is determined, further tape is added in amounts depending on the severity of the vibration. Utilize one-half wraps of tape until best balance is obtained.

If the lateral remains excessive or if the tape is of no help on either blade, a chordwise imbalance exists and it is necessary to sweep a blade.

One blade is arbitrarily selected and swept aft 1/4 point of blade latch nut. When sweeping a blade aft, always loosen leading edge and tighten trailing edge latch nuts the same amount; each nut one-quarter point (paragraph 18-26).

To determine the effect of this sweep adjustment, hover the helicopter. When it is determined that the proper blade is being swept, continue sweep adjustments in amounts based on the severity of the vibration until the lateral imbalance is eliminated or further sweep fails to help.

When it is necessary to sweep either blade more than two points, the rotor assembly should be removed, aligned, and statically balanced. If this action does not correct the problem, it will be necessary to return to taping and adjust tape and sweep until the optimum combination is obtained.

If the lateral is still not eliminated, a small amount of grip rolling should be attempted as in the 1/rev vertical procedure, being careful not to adversely affect forward flight. Should the lateral still be present, a small amount of tab may be tried.

If the condition still exists, the hub and blades should again be removed and a careful check of the alignment and a static balance should be accomplished.

Two per rev (2/rev) vibrations are inherent with a two bladed rotor system and a low level of vibration is always present. A marked increase over the normal 2/rev level can be caused by two basic factors: a loss of designed damping or absorption capability or an actual increase in the 2/rev vibration level of the rotor itself.

The loss of damping can be caused by such factors as deteriorated transmission mounts, nodal beam attachments, or an airframe component loosening and vibrating in harmonics with the inherent 2/rev. An increase in the 2/rev level of the rotor itself can be caused by worn or loose components in the rotor hub or looseness in the rotating controls.

Occasionally tab settings and sweep will affect the overall 2/rev level. If no mechanical cause of excessive 2/rev can be found, an attempt to decrease the level by rotor adjustments may be made.

Tabbing both blades down (usually) or up (rarely) a few degrees sometimes helps. A recheck of boost off forces should be made. Sometimes both blades may be swept in the same direction in small amounts and thus decrease the 2/rev.

## 18-13. MEDIUM FREQUENCY VIBRATION.

Medium frequency vibrations (4/rev and 6/rev) are another inherent vibration associated with most rotors. An increase in the level of these vibrations is caused by a change in the capability of the fuselage to absorb vibration. Contributing factors may be a loose airframe component, such as skids, vibrating at that frequency.

Changes in the fuselage vibration absorption can be caused by such things as fuel level, external stores, structural damage, structural repairs, internal loading or gross weight. Abnormal vibration levels can nearly always be attributed to one of these conditions.

The vibration is felt as a rattling of the fuselage structure. The most common cause is loose skids caused by loose, worn or improper skid attachments. Loose skids can be detected by shaking the helicopter with cyclic and watching the skids vibrate. (Excessive or severe shaking is not recommended and may even make tight skids vibrate.)

Many times skids will cause excessive vibration during turns and maneuvers if they are extremely loose.

Other sources of medium frequency vibrations are caused by the elevator, access doors, cargo hook, electronic equipment, a safety belt hanging out the door, and engine/transmission cowling.

Occasionally portions of the cabin roof, side panels or doors will “oil can” rapidly in flight, giving the same sensation as a medium frequency vibration.

## 18-14. HIGH FREQUENCY VIBRATION.

High frequency vibrations can be caused by anything in the helicopter that rotates or vibrates at a speed equal to or greater than that of the tail rotor.

Included are many unusual situations such as hydraulic lines buzzing, or starter relay buzzing. The most common and obvious causes are a loose elevator linkage, loose elevator, or tail rotor imbalance or out of track.

An experienced pilot can often detect the cause because he has experienced the exact vibration previously.

Balance should be checked by removing the tail rotor hub and blade assembly and checking it on a balance stand or it may be checked on the helicopter utilizing a Vibrex C Tracker/Balancer.

Should the tail rotor balance check out, an inspection of the complete driveshafting should be made.

Observing the shaft with the cover removed and the rotor turning may show up a bent driveshaft, faulty bearing or some other obvious discrepancy.

Attempting to locate the source of the vibration by feeling the fuselage in various locations while ground running can sometimes localize the cause and eliminate some potential sources.

It should be recognized that vibrations being closely watched always appear more severe than when no particular attention is being directed to them. Many points on the airframe, such as the engine mounts, have a surprisingly high level of high frequency vibration and it is easy to decide that the level is higher than normal when actually it is not. A comparison between the feel of a helicopter without excessive vibration and the helicopter with the vibration is helpful in precluding erroneous conclusions.

## 18-15. INSTALLATION — ACCELEROMETER EQUIPMENT.

**1.** Remove forward transmission cowling (Chapter 71).

**2.** Install vertical accelerometer and bracket as shown in figure 18-7.

**3.** Remove nut and washer from swashplate support (figure 18-8).

**4.** Install lateral accelerometer and bracket on top of transmission at swashplate support attachment studs. Secure bracket with washer and nut.

**5.** Install magnetic rpm sensor to left front horn of the fixed swashplate, from top with studs pointing down (figure 18-9).

**NOTE**

Do not tighten nuts so that clamps are distorted. Replace any nuts when self-locking feature of nut is worn.

**6.** Install sensor clamp on bottom studs of swashplate and secure with 1/4-28 inch self-locking nuts. Torque nuts BHT-ALL-SPMI).

**7.** Install single interrupter into drain hole of rotating swashplate pitch link arm web from bottom. Pitch link arm shall be pointed forward.

**8.** Place a number 8 size self-locking nut onto threaded stud of interrupter. While tightening self-locking nut position interrupter so that interrupter blade is radial to the mast and ahead of the mounting screw.

**9.** Rotate rotor so that interrupter is directly over magnetic pickup.

**10.** Using feeler gage adjust magnetic sensor until gap between magnetic sensor and interrupter is 0.06 inch (1.52 mm).

**11.** Tighten jamnut to secure sensor in place. Lockwire sensor to sensor bracket.

## 18-16. MAIN ROTOR SPANWISE BALANCE WEIGHTS.

Main rotor spanwise balance weight shall be in grams. A positive (+) move means to add a weight to a designated blade and a negative (–) move means to remove weight from a designated blade. If reading specifics to remove weight from a blade with no weight installed, add weight to opposite blade. The effect will be identical. Recommended balance weight is number 44 caliber lead shot (9 grams).

**1.** Review spanwise balance weights to determine adjustments. Blade over nose of helicopter when single interrupter is over magnetic pickup is target blade. Spanwise balance location is inside blade bolts (figure 18-10).

**2.** Identify blade to be adjusted and remove plastic plug from top of blade bolt requiring adjustment.

**3.** If available, use scale to measure weight to be added to blade bolt (one number 44 ball=9 grams).

**4.** Add weight required to blade bolt. If weight is present in opposite blade, then remove weight from that blade prior to adding the remainder of weight to light blade.

**5.** Install plugs in blade bolts.

## 18-17. REMOVAL — ACCELEROMETER EQUIPMENT.

**1.** Remove accelerometer and bracket from instrument panel (figure 18-7).

**2.** Remove accelerometer bracket from top of transmission at swashplate support (figure 18-8).

**3.** Remove magnetic rpm sensor bracket from left front horn of fixed swashplate (figure 18-9).

**4.** Remove sensor clamp from bottom of swashplate.

**5.** Remove single interrupter from drain hole of rotating swashplate.

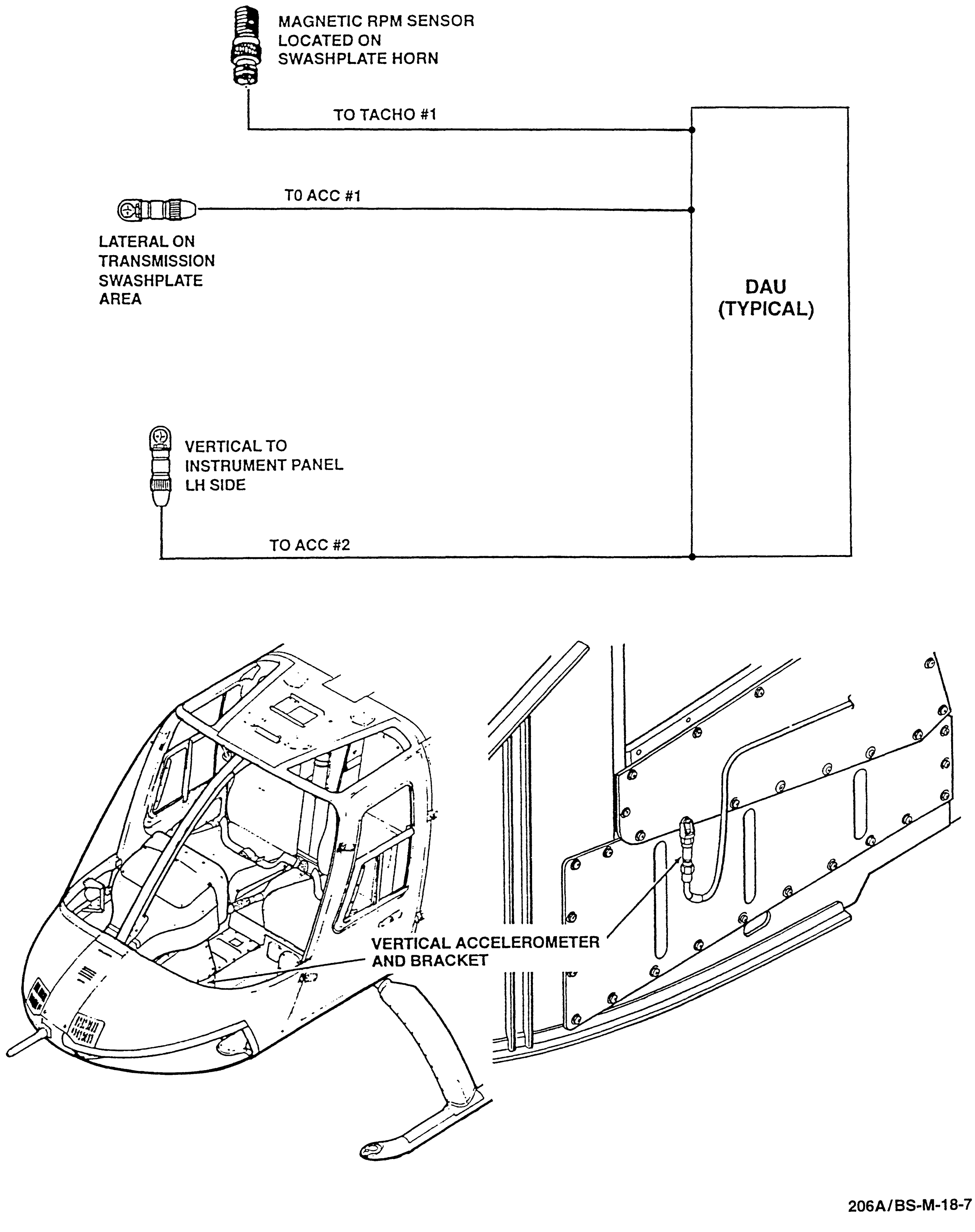



Figure 18-7. Installation of accelerometers

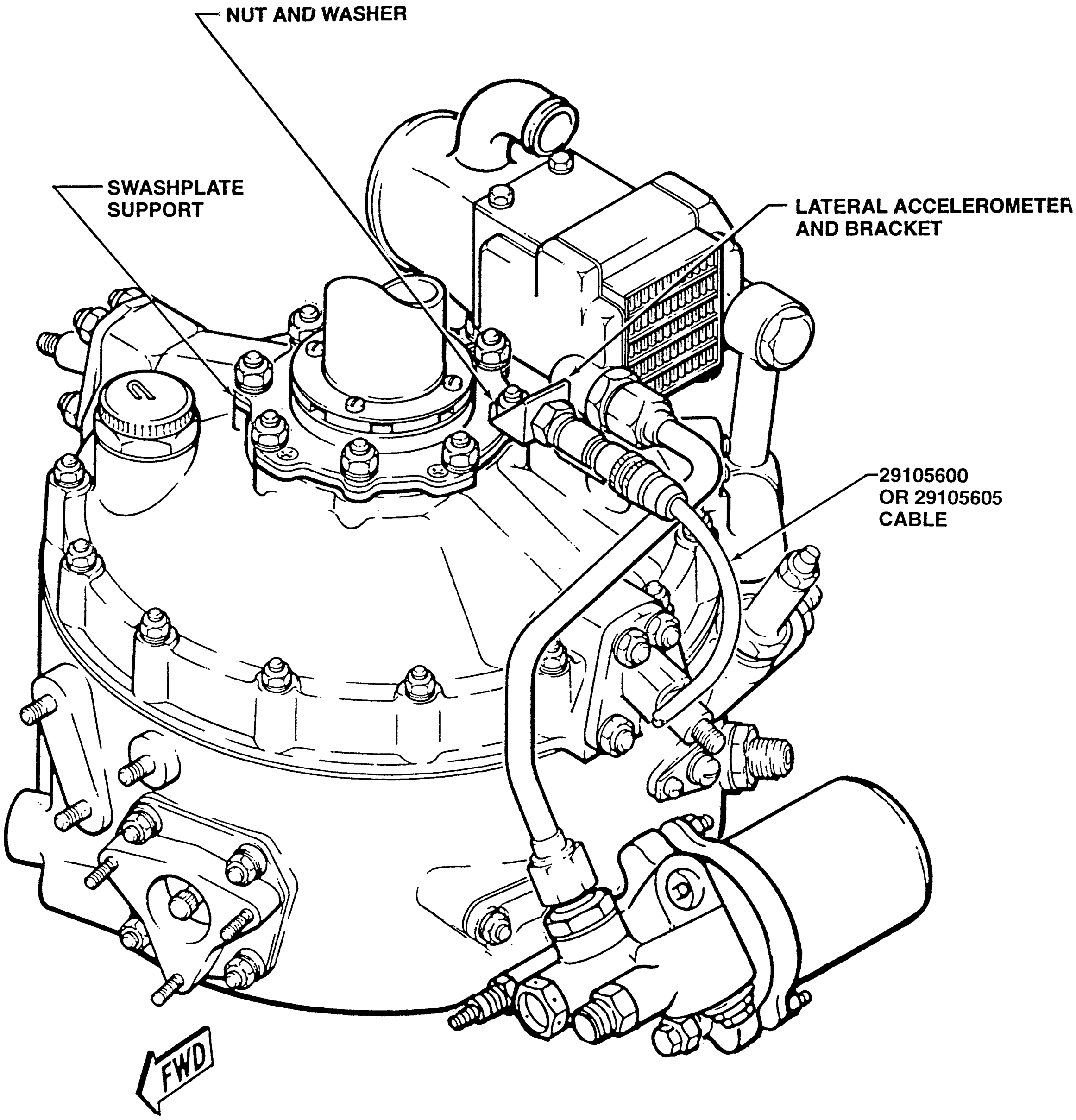



**Figure 18-8. Installation of swashplate bracket**

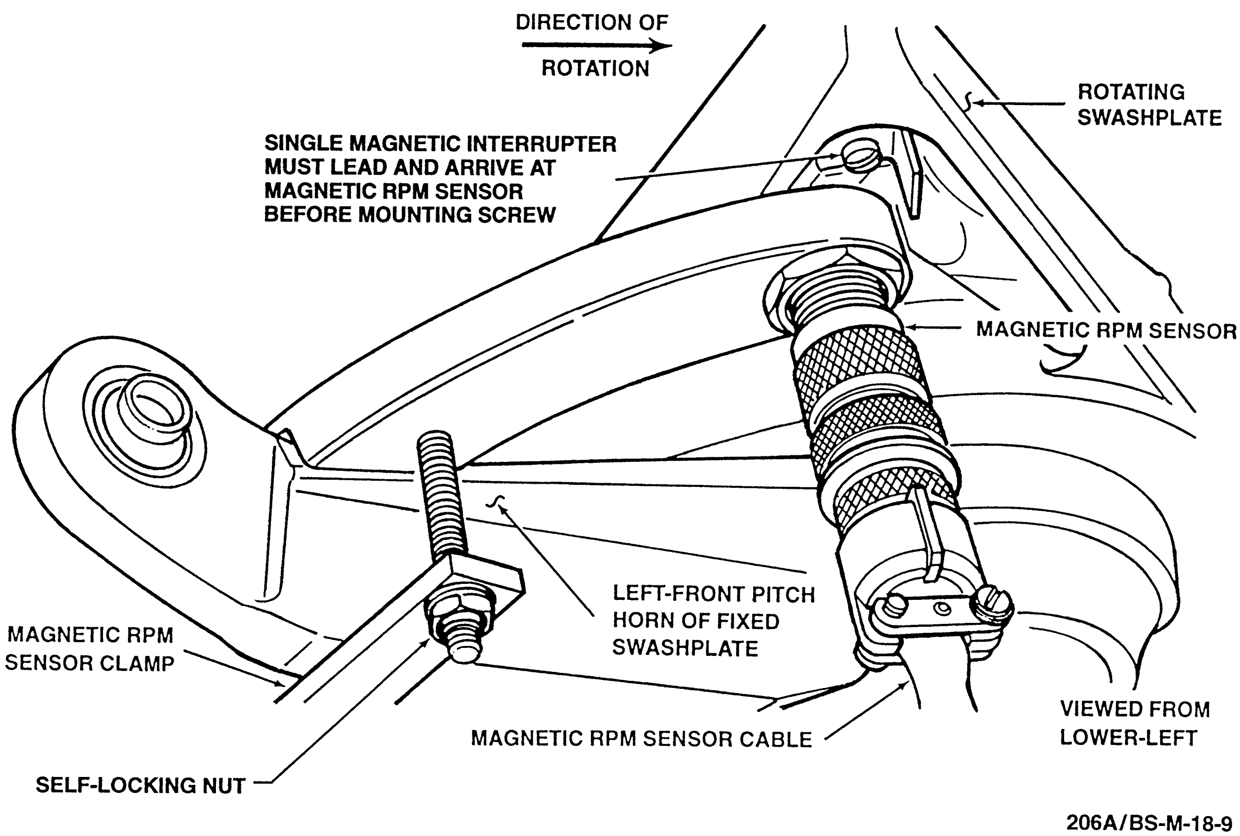



Figure 18-9. Installation of magnetic interrupter

## 18-18. TROUBLESHOOTING.

Potential troubles that may occur in the main rotor assembly are listed in figure 18-11 with the probable causes indicated and corrective action recommended.

**SPECIAL TOOLS REQUIRED**

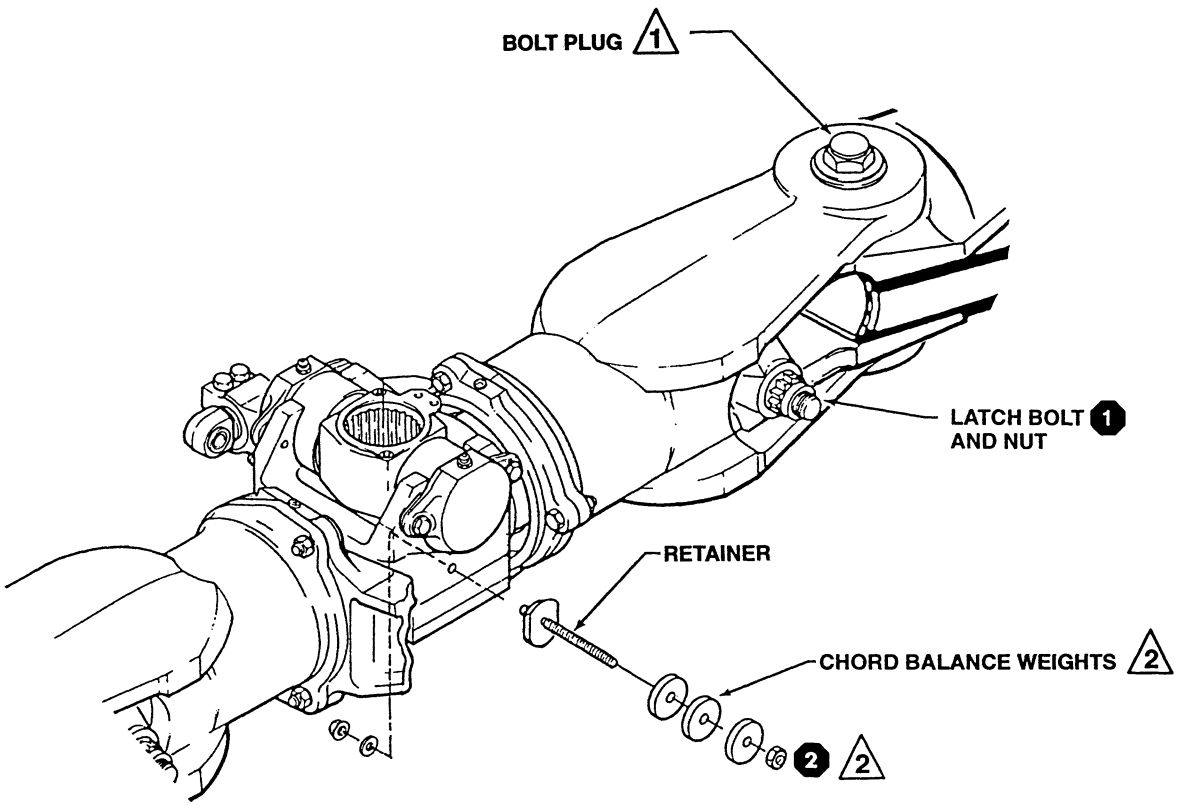
| NUMBER | NOMENCLATURE |
|---|---|
| ⚠1 Model 135M-10A | Strobex Blade Tracker |
| ⚠1 Model 177M-5 | Balancer |
| ⚠1 Model 171 | Phazor |

**SPECIAL TOOLS REQUIRED (Cont)**

| NUMBER | NOMENCLATURE |
|---|---|
| 206-215-001-101 | Trim Tab Bender |
| 206-215-002-101 | Trim Tab Gage |
| ⚠2 Model AT | Rotor Analysis and Diagnostic System (RADS-AT) |

⚠1 Part of Chadwick Helmuth Kit. Additional items, such as magnetic pickups, brackets, cables, interrupters, accelerometer, etc., shall be used.

⚠2 Scientific Atlanta RADS-AT equipment may be used for main rotor vibration correction.




NOTES

1. Install lead weight blade bolts for span balance.

2. Installed on 206-011-100-127 and subsequent hub and blade assemblies.

1. 75 TO 95 FT-LBS (102.00 TO 129.00 Nm)

2. 50 TO 70 IN-LBS (5.65 TO 7.91 mm)

206A/BS-M-18-10

Figure 18-10. Main rotor spanwise balance weights

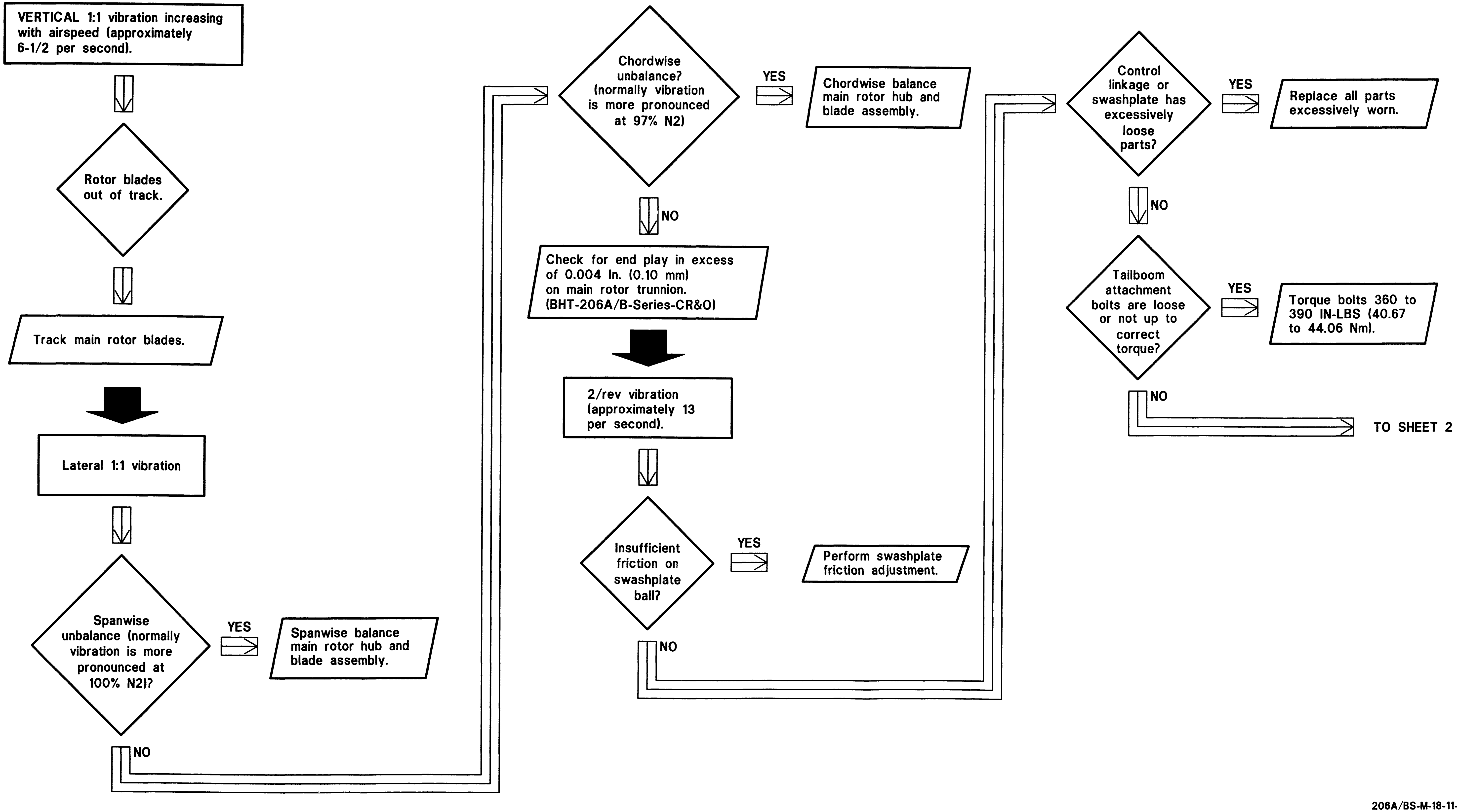



Figure 18-11. Main rotor troubleshooting (Sheet 1 of 2)

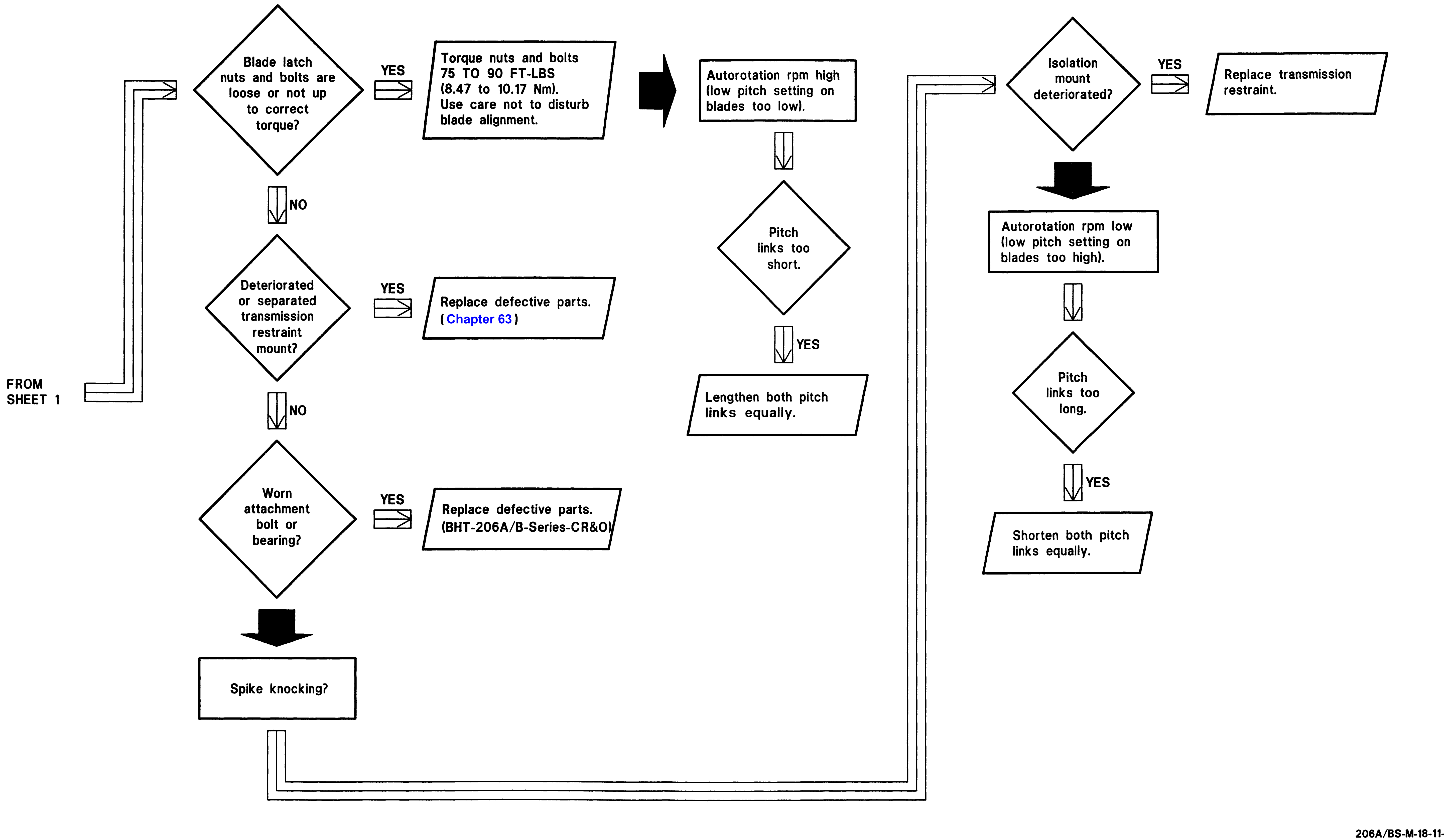



Figure 18-11. Main rotor troubleshooting (Sheet 2)

## 18-19. INBOARD TRIM TABS.

Some main rotor blades, when operated as a set, will not permit the 1:1 vertical vibration to be reduced to a target level of 0.2 ips or less. During normal tracking procedures, the plotted points (move line) may not move to the center of the chart, but may develop as a tangent at an ips circle. Since outboard tab and pitch link adjustments generate a move line in the same direction, this point of tangency will be the best track attainable under the given conditions.

Adjustment of inboard trim tabs will cause the 1/rev move line to shift toward the main roll and tab move line allowing the 1/rev to be reduced using normal techniques (**figure 18-12**).

Use 206-215-001-101 trim tab bender (1, figure 18-13) and 206-215-002-101 trim tab gage (2) to adjust inboard trim tabs (7).

**1.** Place trim tab gage (2) next to inboard trim tab (7). Spring (3) shall be in contact with lower surface of main rotor blade.

**2.** Attach handle (4) and plate (8) to inboard trim tab (7). Install bolts (9), washers (6), and wingnuts (5).

**3.** Using handle (4) and trim tab gage (2), bend inboard trim tab (7) required number of degrees. For inboard trim tabs, maximum adjustment allowable is 15 degrees up or 15 degrees down.

**4.** Loosen wingnuts (5), and remove handle (4) and plate (8).

**5.** Remove trim tab gage (2).

**CAUTION**

ONLY EXPERIENCED PILOTS AND TECHNICIANS SHOULD TRACK MAIN ROTOR BLADES.

IF DYNAMIC TRACKING AND BALANCING AND VIBRATION ANALYSIS IS CARRIED OUT USING CHADWICK HELMUTH EQUIPMENT, ACCOMPLISH IN ACCORDANCE WITH THE CHADWICK HELMUTH OPERATION AND SERVICE INSTRUCTION HANDBOOK. IF THERE ARE ANY QUESTIONS CONCERNING USE OF THIS EQUIPMENT, CONTACT THE MANUFACTURER.

IF DYNAMIC TRACKING AND BALANCING AND VIBRATION ANALYSIS IS CARRIED OUT USING SCIENTIFIC ATLANTA RADS-AT EQUIPMENT, ACCOMPLISH WITH REQUIRED SOFTWARE (206A/B SERIES) AND ASSISTANCE FROM BELL HELICOPTER TEXTRON PRODUCT SUPPORT ENGINEERING.

IF DYNAMIC TRACKING AND BALANCING AND VIBRATION ANALYSIS IS CARRIED OUT USING OTHER EQUIPMENT, ACCOMPLISH IN ACCORDANCE WITH THE PROCEDURES OF THE EQUIPMENT MANUFACTURER.

## 18-20. CORRECTING VERTICAL 1/REV IN A HOVER USING OUTBOARD TABS.

**1.** Install Chadwick Helmuth or Rotor Analysis and Diagnostic System — Advanced Technical (RADS-AT) equipment. Refer to equipment manufacturer manual for installation.

**2.** Hover helicopter with tail into wind. Refer to applicable JetRanger Flight Manual.

**3.** Record magnitude and clock angle of vertical 1/rev.

**4.** Plot this on tracking chart (**figure 18-12**).

**5.** If the clock angle is below the zero line, bend the target tab up or the blank tab down approximately 1 degree for every 0.1 ips.

**6.** If the clock angle is above the zero line, bend the target tab down or blank tab up approximately 1 degree for every 0.1 ips.

**7.** Use roll for forward flight vertical 1/rev.

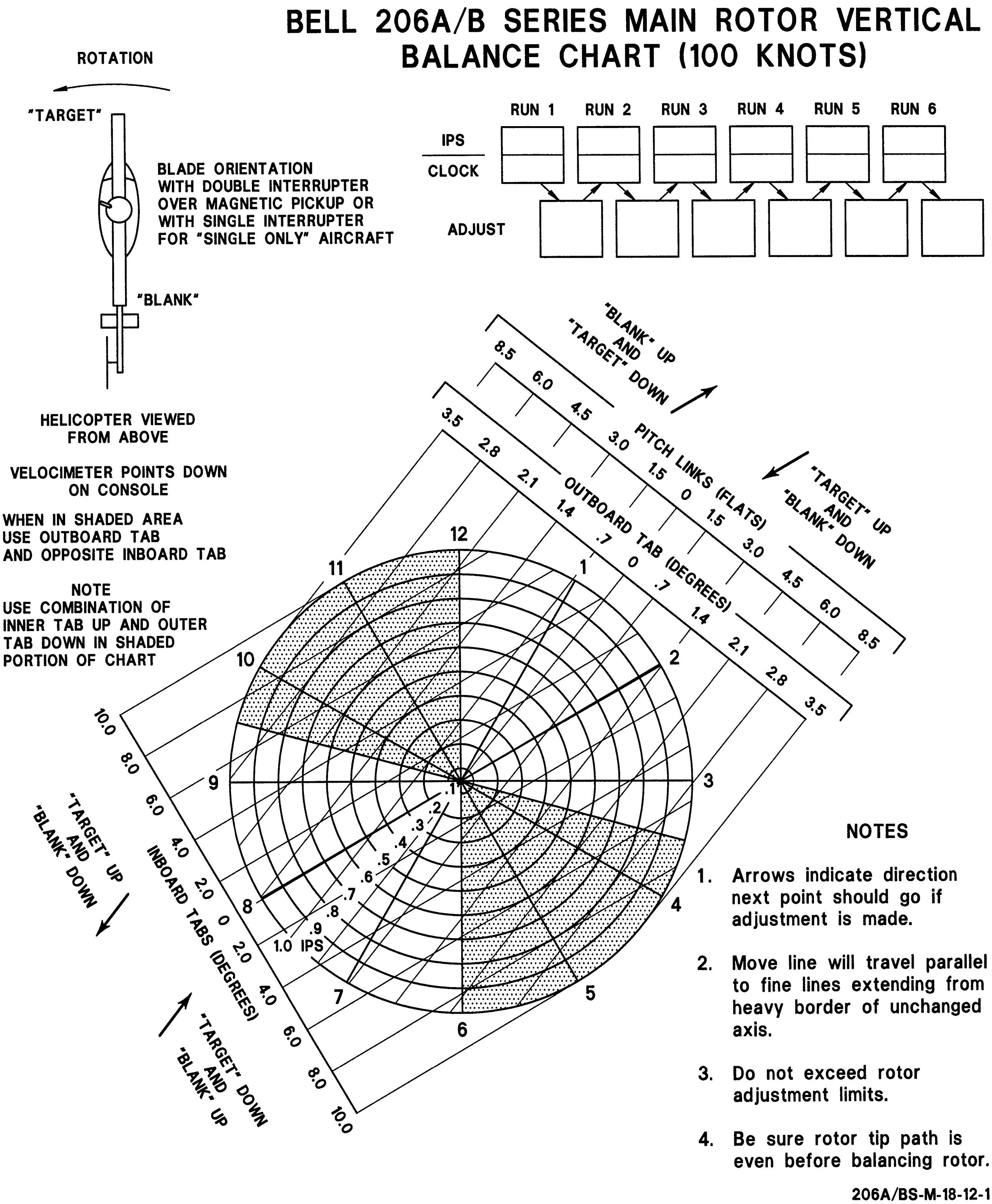
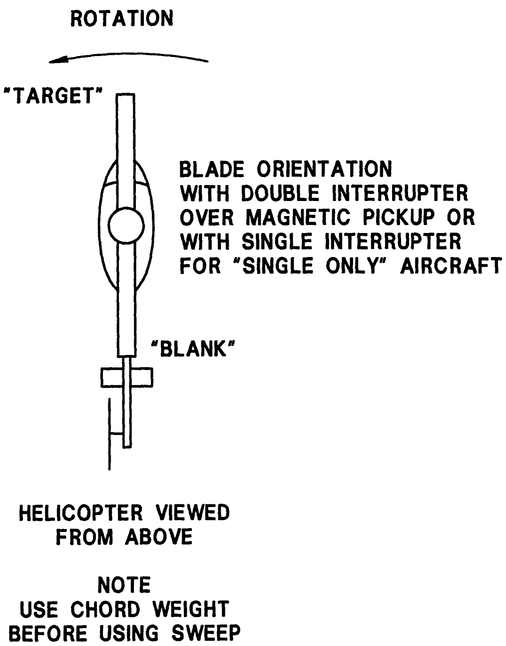
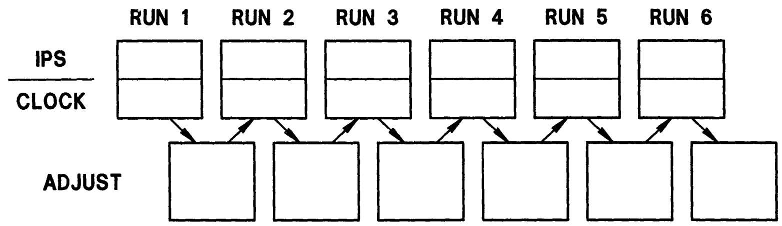



Figure 18-12. Main rotor tracking chart (Sheet 1 of 2)

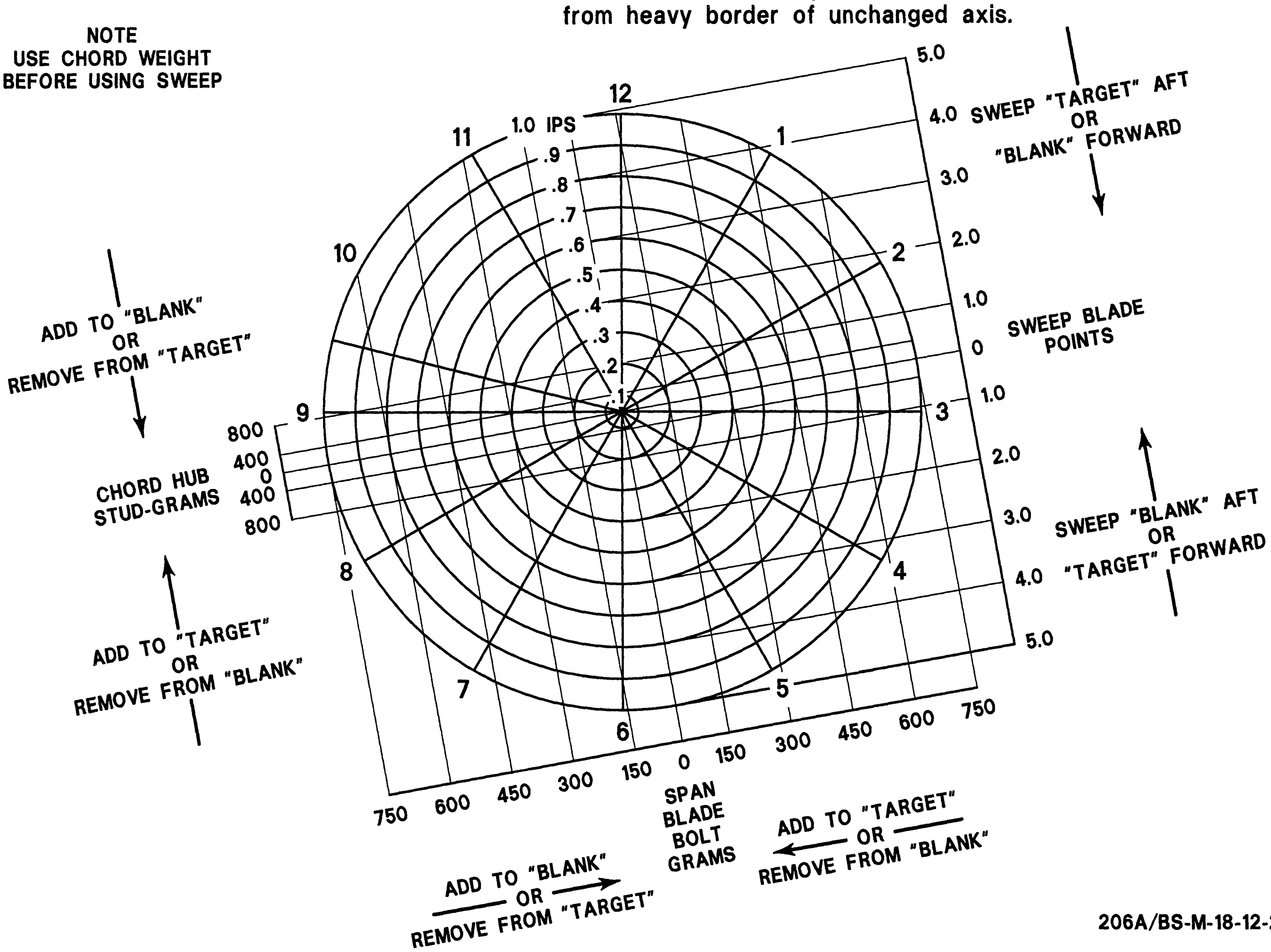
# BELL 206A/B SERIES MAIN ROTOR HOVER LATERAL BALANCE CHART



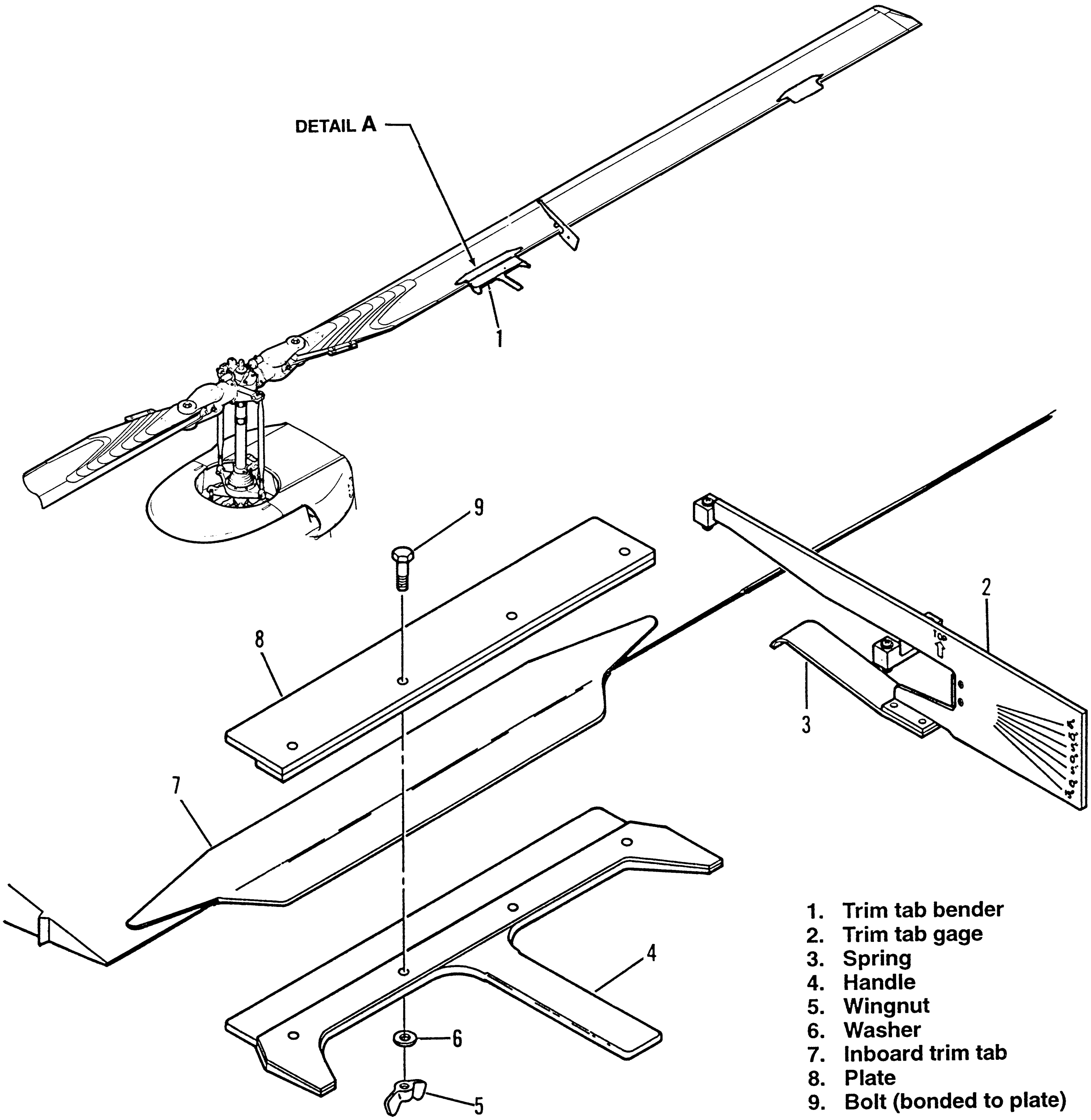

NOTES

1. Be sure rotor path is even before balancing rotor.
2. Arrows indicate direction next point should go if adjustment is made.
3. Move line will travel parallel to fine lines extending from heavy border of unchanged axis.




206A/BS-M-18-12-2

Figure 18-12. Main rotor tracking chart (Sheet 2)




1. Trim tab bender
2. Trim tab gage
3. Spring
4. Handle
5. Wingnut
6. Washer
7. Inboard trim tab
8. Plate
9. Bolt (bonded to plate)

DETAIL A

TRIM TAB BENDER AND TRIM TAB GAGE

206A/BS-M-18-13

Figure 18-13. Use of trim tab bender and trim tab gage

# MAIN ROTOR TRACKING AND BALANCING

## 18-21. MAIN ROTOR TRACKING AND BALANCING.

The following paragraphs provide instructions for the tracking and balancing of the main rotor system. These operational checks are to be accomplished after completion of all other maintenance requirements.

**SPECIAL TOOLS REQUIRED**

| NUMBER | NOMENCLATURE |
|---|---|
| ⚠1 Model 135M-10A | Strobex Blade Tracker |
| ⚠1 Model 171 | Phazor |
| ⚠1 Model 177M-5 | Balancer |
| T101538 | Trim Tab Bender |
| T101537 | Trim Tab Gage |
| 206-215-001-101 | Trim Tab Bender |
| 206-215-002-101 | Trim Tab Gage |

⚠1 Part of Chadwick Helmuth Kit. Various part numbers are available with this system; additional required items, such as magnetic pickups, brackets, cables, interrupters, accelerometer, etc., shall also be used.

## 18-22. DYNAMIC TRACKING AND BALANCING.

**NOTE**

ONLY EXPERIENCED PILOTS AND TECHNICIANS SHOULD TRACK MAIN ROTOR BLADES.

IF DYNAMIC TRACKING AND BALANCING AND VIBRATION ANALYSIS IS CARRIED OUT USING CHADWICK HELMUTH EQUIPMENT, ACCOMPLISH IN ACCORDANCE WITH THE CHADWICK HELMUTH OPERATION AND SERVICE INSTRUCTION HANDBOOK. IF THERE ARE ANY QUESTIONS CONCERNING USE OF THIS EQUIPMENT, CONTACT THE MANUFACTURER.

IF DYNAMIC TRACKING AND BALANCING AND VIBRATION ANALYSIS IS CARRIED OUT USING SCIENTIFIC ATLANTA RADS-AT EQUIPMENT, ACCOMPLISH WITH REQUIRED 206A/B SERIES SOFTWARE AND ASSISTANCE FROM BELL HELICOPTER TEXTRON PRODUCT SUPPORT ENGINEERING.

IF DYNAMIC TRACKING AND BALANCING AND VIBRATION ANALYSIS IS CARRIED OUT USING OTHER EQUIPMENT, ACCOMPLISH IN ACCORDANCE WITH THE PROCEDURES OF THE EQUIPMENT MANUFACTURER.

## 18-23. FLAG TRACKING.

**NOTE**

The need to track main rotor blades will be indicated by a 1:1 vertical vibration. Vertical vibrations are airspeed sensitive. They can usually be detected in a zero airspeed hover, but normally become worse as airspeed is increased.

**1.** Construct a tracking flag from aluminum or steel tubing. The flag portion should be made of strong, lightweight fabric tape. Reinforcing tape, as used in helicopter fabric work, is a suitable material (figure 18-14).

**2.** Color-code main rotor blade tips with grease pencils (figure 18-15). Use a different color grease pencil on each main rotor blade tip.

**3.** Position trim tab (2) on both main rotor blades (3) to 0 degree position using 206-215-001-101 trim tab bender (1, figure 18-13) and 206-215-002-101 trim tab gage (2).

**NOTE**

Trim tab 0 degree adjustment is achieved when lower surface of trim tab is in line with lower surface of blade.

**NOTE**

On earlier main rotor blades a vernier trim tab is installed for fine tune adjustments. Preliminary adjustments shall be made with trim tabs (4, figure 18-15 ) and final adjustments with vernier tabs (5). Maximum trim tab and vernier tab adjustments are 7 degrees up and 7 degrees down.


**Figure 18-14. Main rotor blade flag tracking**

**4.** Position trim tab (4) and vernier tab (5) on both main rotor blades (3) to 0 degrees using T101538 trim tab bender and T101537 trim tab gage.

**5.** Position helicopter into the wind and on a level hard surface. Place extra weight in the helicopter to permit application of higher power settings without hovering during tracking.

**6.** Mark a spot on the ground at approximately the 2:00 o'clock position relative to the nose of the helicopter and about 12.0 inches (304.80 mm) outside the rotating disc area of the main rotor blades (3, figure 18-15). Position base of tracking flag on the marked spot.

**7.** Accomplish low speed main rotor blade track as follows:

**a.** Operate helicopter at 100 percent N2 rpm. Refer to applicable JetRanger Flight Manual. Apply sufficient collective pitch control to make the helicopter light on the ground. Maintain collective pitch setting (use collective friction to assist in maintaining setting) and roll throttle off to reduce rpm to 90 percent N2 rpm.

**NOTE**

Record torque readings when at 100 percent N2 rpm and light on ground, and at 90 percent N2 rpm. These same torque readings should be used during each subsequent low speed track.

**b.** Hold the tracking flag extended horizontally away from rotor tip plane. The maintenance person holding the tracking flag should stand with the flag in front of him/her and with his/her back to the advancing main rotor blades and in position to be able to see the pilot (figure 18-14).

**c.** The maintenance person, upon receiving a signal from the pilot to raise the tracking flag, will slowly raise the tracking flag until it approaches the vertical position and remains outside the tip path plane.

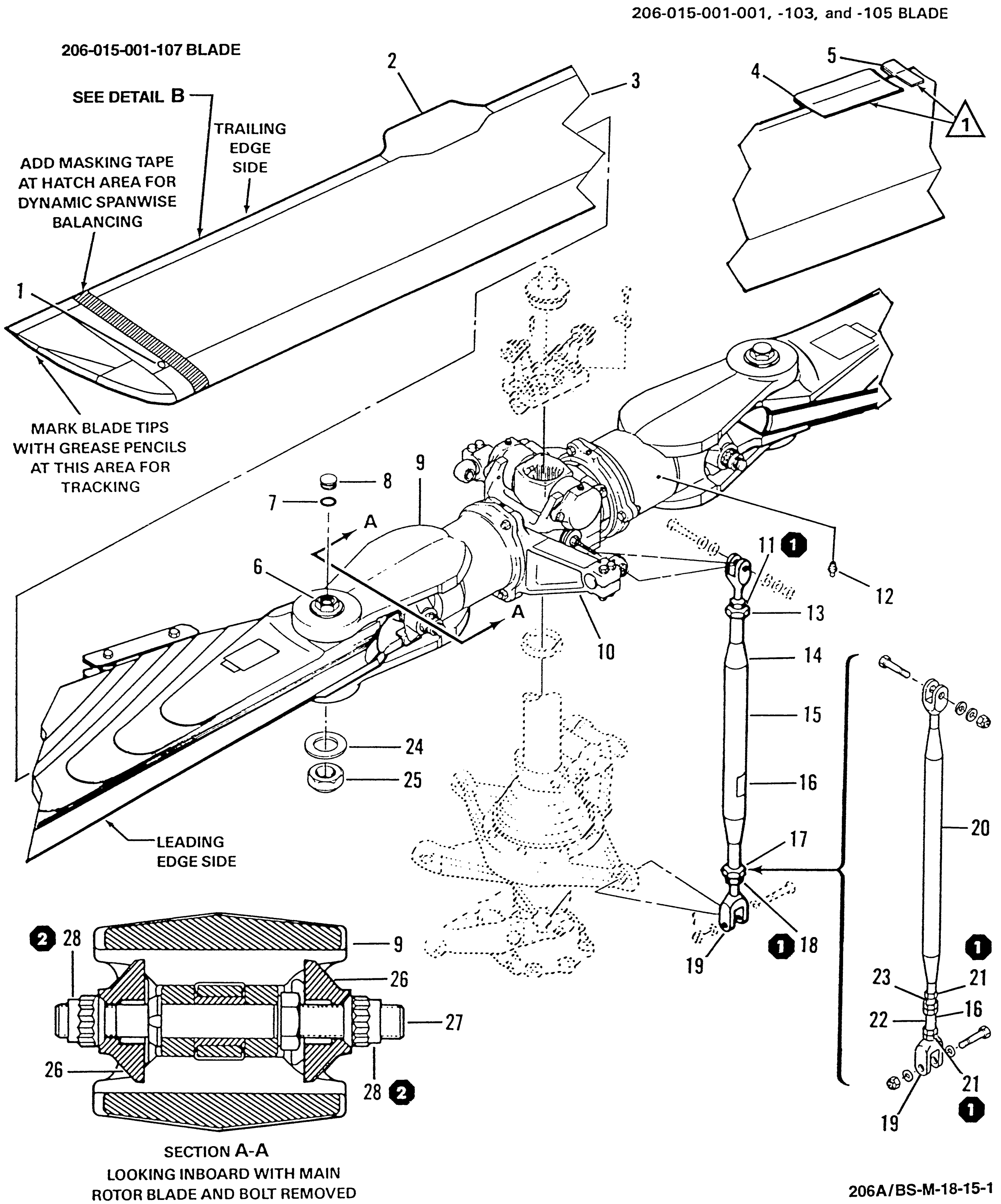
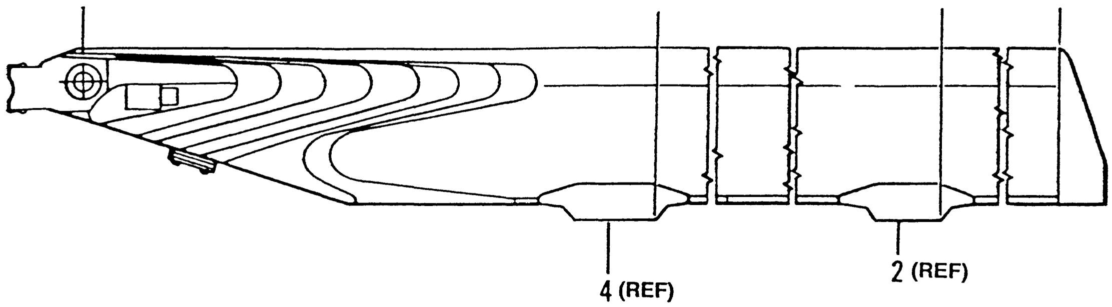



Figure 18-15. Main rotor operational adjustments (Sheet 1 of 2)




DETAIL B

1. Drivescrew blade alignment
2. Trim tab
3. Main rotor blade
4. Trim tab
5. Vernier tab
6. Blade bolt
7. Packing
8. Cap
9. Grip
10. Pitch horn
11. Jamnut
12. Grease fitting
13. Insert
14. Pitch link assembly (206-010-360)
15. Barrel
16. Decal
17. Insert
18. Jamnut
19. Clevis
20. Pitch link assembly (206-010-355)
21. Jamnut
22. Barrel
23. Insert
24. Washer
25. Nut
26. Blade latch
27. Bolt
28. Nut

## NOTES

⚠1 Outboard trim tab (2) replaces outboard trimtab (4) and vernier tab (5) on all dash number main rotor blades replacement spares.

❶ 150 TO 200 IN-LBS (16.95 TO 22.60 Nm)

❷ 75 TO 95 FT-LBS (102.00 TO 129.00 Nm)

206A/BS-M-18-15-2

Figure 18-15. Main rotor operational adjustments (Sheet 2)

**d.** At this point the pilot should observe the relative position of tip path plane to center portion of the flag. The pilot will move the cyclic stick to position tip path plane to center portion of the tracking flag. When tip path plane is in the desired position for tracking, the pilot will normally nod his head indicating a track is to be taken. If desired position is not obtained, the pilot will give a waveoff until he is ready for tracking.

**e.** The maintenance person, upon receiving a nod from the pilot to track main rotor blades, will slowly rotate tracking flag into the tip path plane. When the main rotor blade tips touch the flag, immediately tip the flag away from the main rotor blades.

**f.** The relative vertical position of the main rotor blade tips will be indicated by transfer of colored marks from blade tips to flag. There should be only one mark for each main rotor blade. It is recommended that two tracks be taken prior to making any adjustments; a wind gust or slight movement of the controls or helicopter may cause erroneous indications. Identify original marks on flag with a grease pencil prior to making the second track.

**g.** Inspect the tracking marks on the flag for an indication of an out-of-track condition. Identify the high main rotor blade by color marks and approximate distance between tracking marks. Record the high main rotor blade color and dimension.

**NOTE**

The pitch link assemblies incorporate unified national coarse and fine thread fittings. This permits precision length adjustments of the pitch link without disconnecting the clevis fittings. Use pitch link tube or barrel as a turnbuckle for marking adjustments. One nut-flat of adjustment will change blade track by 0.063 inch (1.60 mm). One full turn of pitch link tube or barrel will change blade track by 0.375 inch (9.53 mm). Maximum thread exposure is 0.56 inch (14.22 mm) from face of link insert to end of thread on clevis.

**h.** Shorten pitch link assembly (14 or 20, figure 18-15) of high blade as follows:

**(1)** Remove lockwire from inserts (13 and 17) and jamnuts (11 and 18) on pitch link assembly (14) or insert (23) and jamnut (21) on pitch link assembly (20).

**(2)** On pitch link assembly (14), loosen and back off jamnuts (11 and 18) with flats on inserts (13 and 17).

**(3)** On pitch link assembly (20), loosen and back off jamnut (21) a few turns and then align flats of jamnut (21) with flats on barrel (22).

**(4)** Rotate barrel (15) to shorten pitch link assembly (14) of high blade. Turn one flat for each 0.063 inch (1.60 mm) out of track.

**(5)** Shorten pitch link assembly (20) of high blade by noting decal (16) on barrel (22) and rotating in direction of arrow. Turn one flat for each 0.063 inch (1.60 mm) out of track.

**(6)** Hold barrel (15 or 22) stationary and tighten jamnuts (11, 18, or 21) T.

**CAUTION**

INITIAL SETUP: ENSURE PITCH LINK ASSEMBLY (20) HAS A MINIMUM THREAD DIMENSION OF 0.200 ± 0.010 INCH (5.08 ± 0.25 MM) EXPOSED BETWEEN LOWER CLEVIS AND JAMNUT, AND 0.51 TO 0.57 INCH (12.95 TO 14.48 MM) MINIMUM DIMENSION EXPOSED BETWEEN BOTTOM NUT SURFACE OF INSERT AND TOP SURFACE OF JAMNUT ABOVE BARREL. ENSURE TWO SAFETY HOLES IN BARREL ARE COVERED BY THREADS. ENSURE PITCH LINK ASSEMBLY (14) HAS A DIMENSION OF 2.28 TO 2.32 INCH (57.91 TO 58.93 MM) FROM CENTERLINE OF CLEVIS BOLT HOLE TO TOP OF TUBE INSERT. FAILURE TO COMPLY MAY RESULT IN DAMAGE TO HELICOPTER.

**(7)** Continue low speed tracking and adjustments until tracking marks on flag overlap, or appear as one mark.

**(8)** Secure inserts (13 and 17) to jamnuts (11 and 18) on pitch link assembly (14), or insert (23) to barrel (22) on pitch link assembly (20) with lockwire.

**8.** Accomplish high speed main rotor blade track as follows:

**a.** Operate helicopter at 100 percent N2 rpm. Refer to applicable JetRanger Flight Manual. Apply sufficient collective pitch control to make helicopter light on the ground. Maintain collective pitch setting, (use collective friction as required) 100 percent N2 rpm, and track main rotor blades.

**b.** Record color of high blade. This is a reference track only to determine high blade. Do not make any adjustments to trim tabs or pitch link assemblies at this time.

**NOTE**

The high speed track is a starting point only and does not indicate that the main rotor system is in the best flight configuration.

**9.** Prepare helicopter for hover and flight checks.

## 18-24. IGE HOVER CHECK.

**1.** Operate helicopter in ground effect (IGE) hover into the wind. Refer to applicable JetRanger Flight Manual. Observe the in or out of track condition of the main rotor blade tip path plane. Also observe for possible 1:1 vertical vibration in the center line of the crew area. Corrective action is not required at this time.

**2.** Maintain hovering attitude and check for a 1:1 lateral vibration at high and low beep on the governor actuator switch.

**a.** If the amplitude of the lateral vibration is worse at 100 percent N2 rpm, the lateral is probably caused by spanwise imbalance. Spanwise balance main rotor system (paragraph 18-25).

**b.** If the amplitude of the lateral vibration is worse at 95 percent N2 rpm, the lateral is probably caused by chordwise imbalance. Chordwise balance main rotor system (paragraph 18-26).

## 18-25. SPANWISE BALANCING.

**NOTE**

1:1 lateral vibrations are rpm sensitive, not airspeed sensitive.

To accomplish main rotor spanwise balancing using Marvel Mfg. Co. equipment, refer to the appropriate Marvel Mfg. Co. manual and bulletins.

**1.** Operate helicopter in an IGE hover into the wind at 100 percent then 95 percent N2 rpm. Refer to applicable JetRanger Flight Manual. Note the degree of lateral vibration (paragraph 18-24 and figure 18-16).

**2.** Apply one or two wraps of 1.0 or 2.0 inch (25.40 or 50.80 mm) wide masking tape on one main rotor blade (3, figure 18-15 adjacent to and inboard of drive screw alignment (1) at tip. If lateral vibration was mild, use one wrap of masking tape. Spanwise balance main rotor system as follows:

**a.** Operate helicopter in an IGE hover (refer to applicable JetRanger Flight Manual) and note degree of lateral vibration (paragraph 18-24). If condition is worse, remove masking tape and install equal amount on opposite main rotor blade.

**b.** If condition is improved, add masking tape in one-wrap or half-wrap increments until the smoothest high and low governor rpm range is reached.

**c.** If main rotor cannot be balanced with masking tape, it is probably out of chordwise balance. Check chordwise balance (paragraph 18-26).

**3.** If lateral vibration was corrected by spanwise balancing procedure, remove masking tape and accomplish the following:

**a.** Weigh the amount of masking tape required to obtain spanwise balance.

**NOTE**

One wrap of 1-inch (25.40 mm) wide masking tape weighs approximately 1 ounce or 28.35 grams.

One wrap of 2-inch (50.80 mm) wide masking tape weighs approximately 2 ounces or 56.70 grams.

**b.** Install a quantity of lead weight, equal to 10.8 times the weight of the masking tape, in the hollow shank of the appropriate blade bolt (6, figure 18-15) or remove the calculated amount of weight from the other (heavy) blade bolt.

**c.** Carefully remove cap (8) with a screwdriver and place calculated lead weight in appropriate blade bolt (6). Replace packing (7) if damaged or deteriorated. Install cap (8).

**d.** Record the amount of lead weight added.

**4.** Operate helicopter (step 1.) to confirm that the correct amount of lead weight has been added and vibration has been eliminated.

# VIBRATION ANALYSIS AND CORRECTIVE ACTION

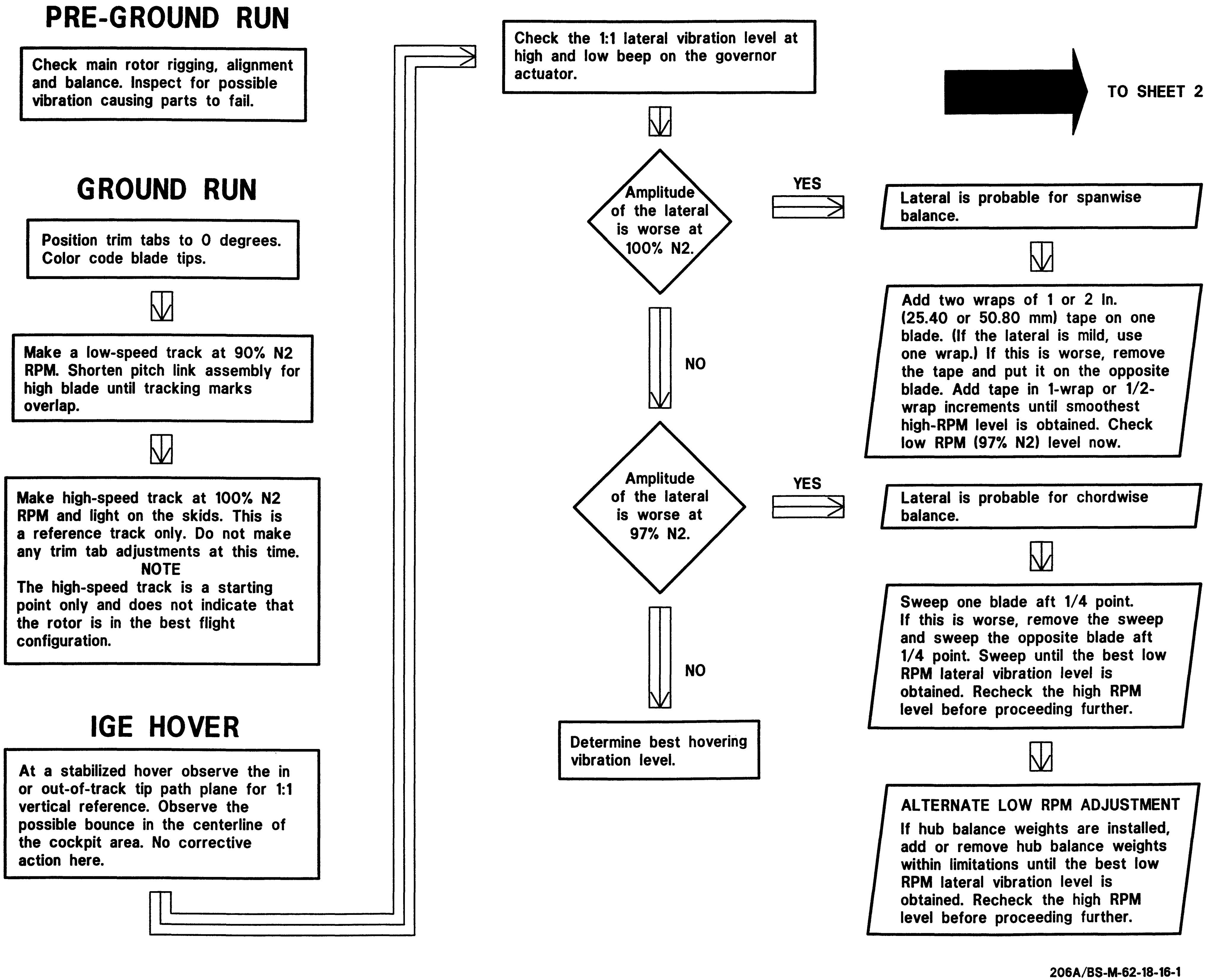



Figure 18-16. Vibration analysis and corrective action chart (Sheet 1 of 2)

# VIBRATION ANALYSIS AND CORRECTIVE ACTION

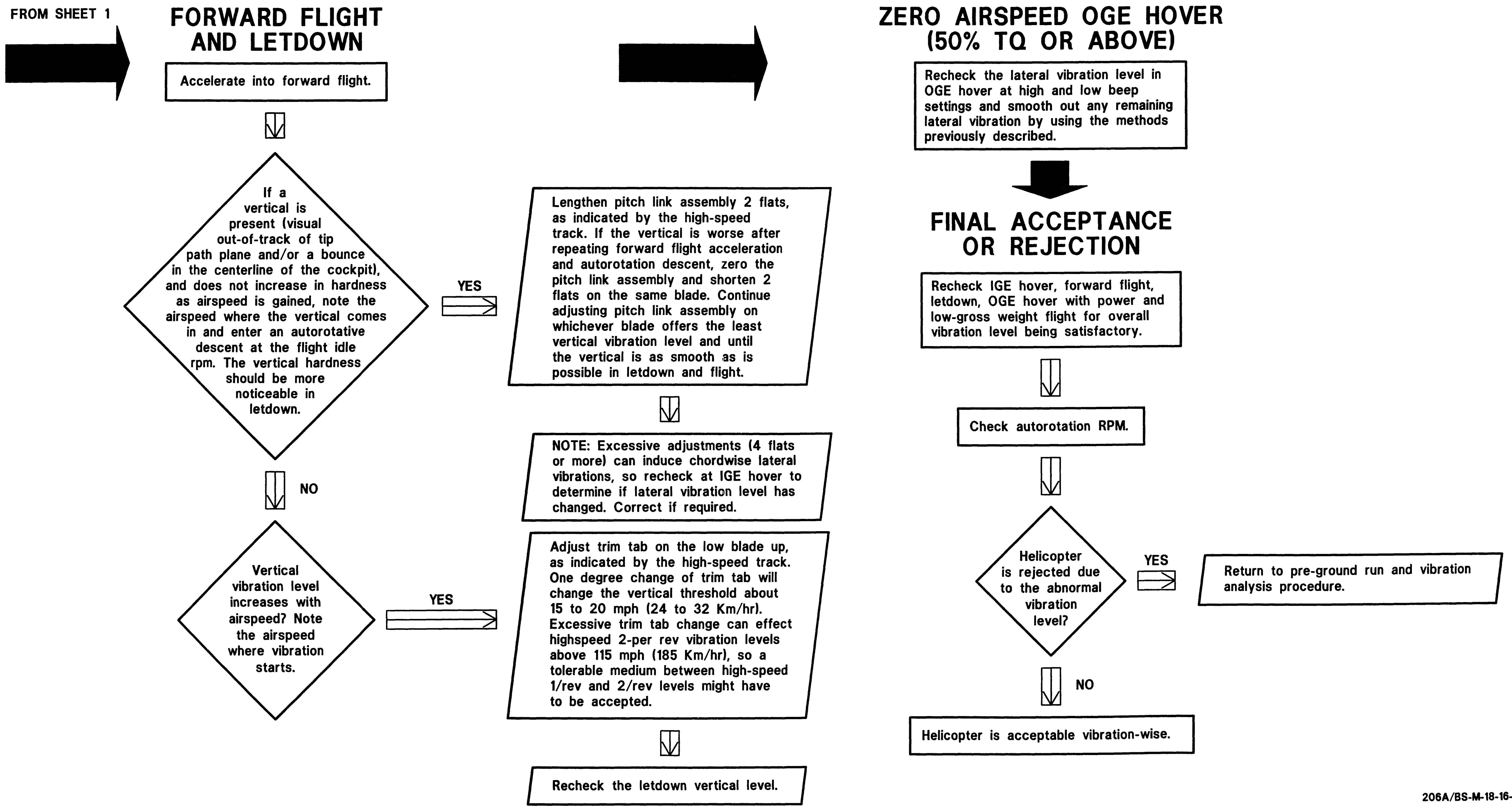



Figure 18-16. Vibration analysis and corrective action chart (Sheet 2)

## 18-26. CHORDWISE BALANCING

**CAUTION**

CHORDWISE BALANCING SHALL BE ACCOMPLISHED BY SWEEPING MAIN ROTOR BLADE AFT ONLY. BLADE SWEEP ADJUSTMENTS ARE SENSITIVE. DO NOT EXCEED A MAXIMUM OF THREE POINTS ON THE NUTS (28, FIGURE 18-15).

**NOTE**

To accomplish chordwise balancing using Marvel Mfg. Co. equipment, refer to the appropriate Marvel Mfg. Co. manual and bulletins.

**NOTE**

Improve sweeping results may be obtained if main rotor blade bolt torque is broken before latch nuts are adjusted. If blade bolt torque is broken, torque after sweeping is completed.

**1.** Operate helicopter in an IGE hover into the wind at 100% N2 RPM. Refer to applicable JetRanger Flight Manual. Note the degree of lateral vibration (paragraph 18-24 and Figure 18-16).

**NOTE**

Correct spanwise balance, if not previously accomplished, before proceeding to chordwise balancing. If balance weights are supplied, and if chordwise balance is required as determine in paragraph 18-26, perform procedure outlined in step 4, instead of that outlined in step 2 and step 3.

**2.** If chordwise balance is required, as determined in step 1, sweep one main rotor blade (3, Figure 18-15) aft slightly as follows:

**a.** Using a felt marker, index mark position of nut (28) on leading edge of main rotor blade (3). Loosen nut approximately one-quarter point. Record all adjustments.

**b.** Tighten nut (28) Ⓣ on trailing edge side of main rotor blade (3), then tighten nut (28) Ⓣ on leading edge (Figure 18-15, Section A-A).

**c.** If vibration is worse, remove sweep and sweep opposite main rotor blade (3) aft one-quarter point.

**NOTE**

If doubt exists concerning actual main rotor blade alignment, align main rotor blades by string method (BHT-206A/B-SERIES -CR&O). Repeat chordwise balancing procedure.

**d.** When approximate chordwise balance has been attained, make very small adjustments to nut (28). Follow procedure in step a and step b.

**3.** Operate helicopter (step 1) to confirm that the correct amount of sweep has been made and vibration has been eliminated.

**4.** Alternate procedure for chordwise balancing of main rotor. When hub balance weights (37, 38 and/or 39, Figure 18-17, Detail A) are supplied, balance chordwise (in lieu of step 2 and step 3) as follows:

**a.** Check alignment of main rotor hub and blades (BHT-206A/B-SERIES-CR&O).

**b.** Add or remove hub balance weights (37, 38 and/or 39) in any combination, subject to the following limitations:

**(1)** Balance chordwise within 2 inch-pounds (0.23 Nm).

**(2)** A minimum of two threads must be exposed on end of retainer (40) after nut (35) is installed.

**c.** Operate helicopter (step 1) to confirm that chordwise balance has been achieved and vibration has been eliminated.

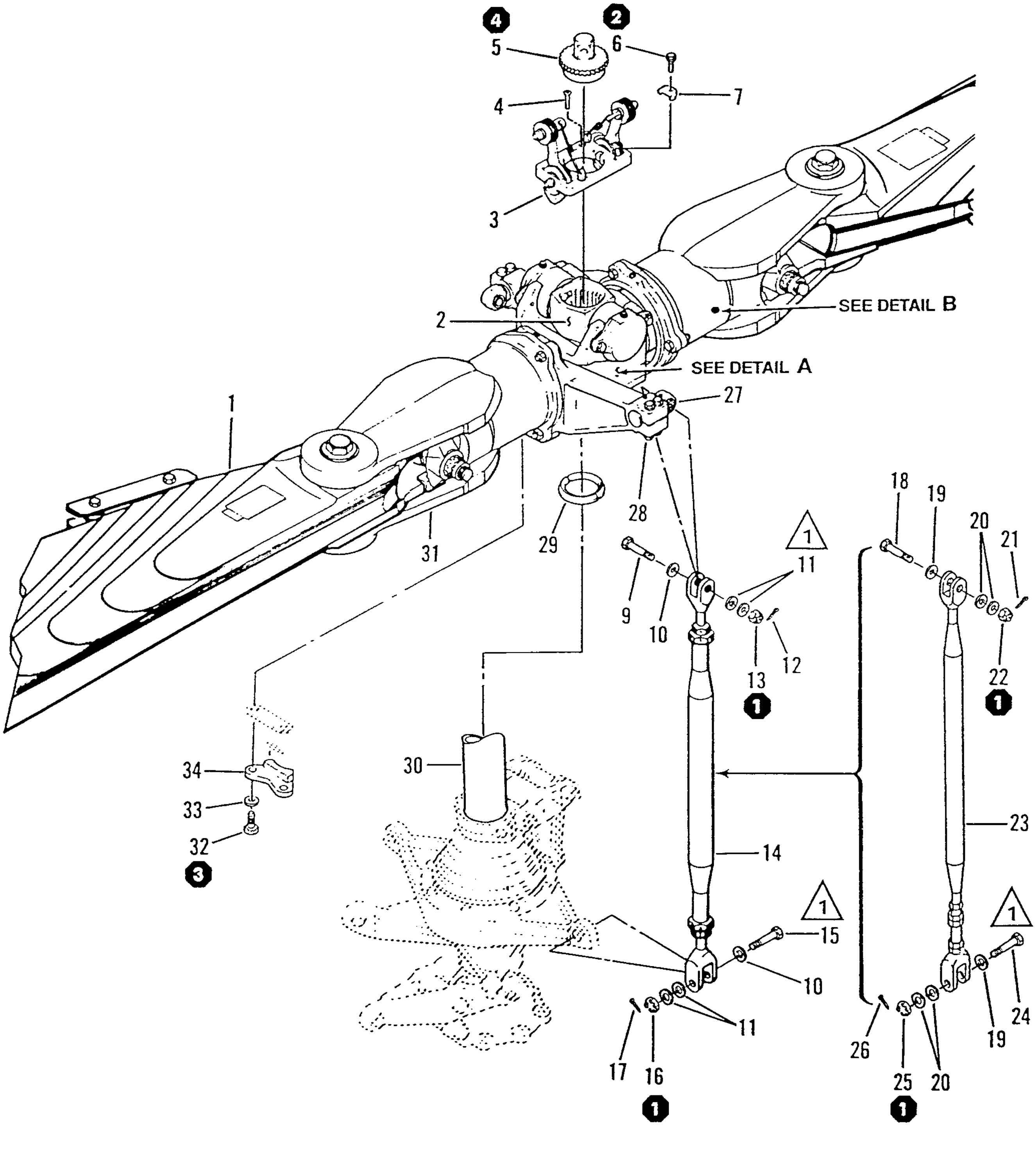
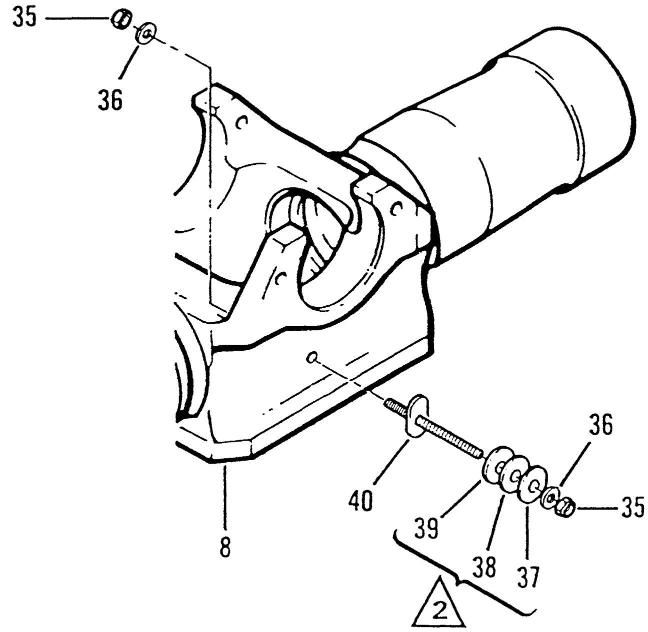
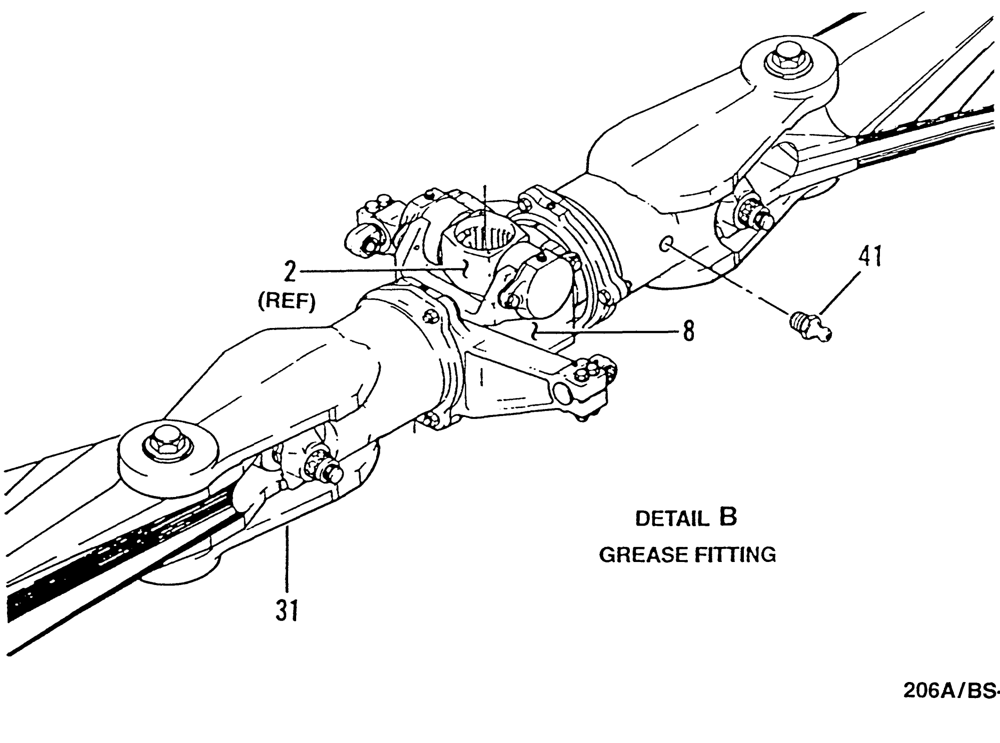



Figure 18-17. Main Rotor Hub and Blades (Sheet 1 of 3)




DETAIL A
HUB BALANCE WEIGHTS
INSTALLATION TYPICAL FOR LEFT SIDE.
RIGHT SIDE OPPOSITE EXCEPT AS NOTED.




DETAIL B
GREASE FITTING

206A/BS-M-18-17-2

**Figure 18-17. Main rotor hub and blades (Sheet 2)**

1. Main rotor blade
2. Trunnion
3. Flap restraint
4. Screw
5. Mast nut
6. Bolt
7. Lock
8. Yoke
9. Bolt
10. Thin steel washer
11. Thin steel washer (2 maximum)
12. Cotter pin
13. Nut
14. Pitch link assembly (206-010-360)
15. Bolt
16. Nut
17. Cotter pin
18. Bolt
19. Thin steel washer
20. Thin steel washer (2 maximum)
21. Cotter pin
22. Nut
23. Pitch link assembly (206-010-355)
24. Bolt
25. Nut
26. Cotter pin
27. Trunnion bearing
28. Pitch horn
29. Cone set
30. Mast
31. Grip
32. Bolt
33. Washer
34. Static stop
35. Nut
36. Washer
37. Hub balance weight
38. Hub balance weight
39. Hub balance weight
40. Retainer
41. Grease fitting

**NOTES**

**⚠1 One washer under bolthead; Maximum two washers under nut as required to locate nut for cotter pin.**

**⚠2 Hub and balance weights are to be adjusted as required during hub and blade balance.**

**3. Hub balance weight assembly may be temporarily removed to allow installation of workaid during main rotor and blade assembly removal/installation.**

**❶ 100 TO 140 IN-LBS (11.30 TO 15.82 Nm)**

**❷ 60 IN-LBS (6.78 Nm)**

**❸ 175 IN-LBS (19.77 Nm)**

**❹ 250 TO 275 FT-LBS (339.00 TO 373.00 Nm)**

206A/BS-M-18-17-3

Figure 18-17. Main rotor hub and blades (Sheet 3)

## 18-1. FORWARD FLIGHT AND LETDOWN CHECK

**SPECIAL TOOLS REQUIRED**

| NUMBER | NOMENCLATURE |
|---|---|
| T101538 | Trim Tab Bender |
| T101537 | Trim Tab Gauge |
| 206-215-001-101 | Trim Tab Bender |
| 206-215-002-101 | Trim Tab Gauge |

**1.** Accelerate into forward flight. Refer to applicable JetRanger Flight manual. If a vertical vibration is present (visual out-of-track of tip path plane and/or a bounce in the centerline of the crew area) and does not increase in hardness as airspeed is gained, note airspeed where vertical vibration comes in and enter an autorotative descent at the flight idle RPM (Figure 18-16).

**2.** Vertical vibration hardness should be more noticeable during letdown. If so, correct vertical vibration as follows:

**WARNING**

WHEN ADJUSTING LENGTH OF PITCH LINKS, OBSERVE MINIMUM THREAD ENGAGEMENT FOR CLEVISES (PARAGRAPH 18-23). LESS THAN MINIMUM THREAD ENGAGEMENT FOR CLEVISES MAY CAUSE PITCH LINKS TO FAIL DURING FLIGHT.

**a.** Helicopters with pitch link assembly (14, figure 18-15), extend length of pitch link assembly (14) of low main rotor blade as indicated by the high speed track. Remove lockwire from inserts (13 and 17) and jamnuts (11 and 18) on the affected main rotor blade (3) and index with a felt marker mark the position of jamnuts (11 and 18) and barrel (15). Rotate barrel (15) two flats to lengthen the pitch link assembly (14). Tighten jamnuts (11 and 18) (T) to inserts (13 and 17). Secure jamnuts (11 and 18) to inserts (13 and 17) with lockwire.

**b.** Helicopters with pitch link assembly (20), extend length of pitch link assembly (20) of low main rotor blade (3) as indicated by the high speed track. Cut and remove lockwire from insert (23) and jamnut (21) on affected main rotor blade (3) and index with a pencil mark the position of jamnut (21) and barrel (22). Rotate barrel (22) two flats to lengthen the pitch link assembly (20). Tighten jamnut (21) (T) to insert (23). Secure jamnut (21) to insert (23) with lockwire.

**c.** If vertical vibration is worse after accomplishing the above, shorten same pitch link assembly (14 or 20) four flats on same main rotor blade (3).

**d.** Continue adjusting pitch link assembly (14 or 20) until vertical vibration level is as smooth as is possible in letdown and flight.

**NOTE**

Excessive adjustments (four flats or more) can induce chordwise lateral vibrations. Check vibration level at IGE hover. If level has changed, correct as required.

**3.** If vertical vibration level increases with airspeed, note airspeed at which vibration starts and adjust outboard trim tabs (2) as follows:

**a.** Bend outboard trim tab (2) up on the low main rotor blade (3) as indicated by the high speed track, using 206-215-001-101 trim tab bender, and 206-215-002-101 trim tab gage (paragraph 18-19). For outboard trim tabs, maximum adjustment allowed is 7 degrees up or 7 degrees down.

**b.** One degree change of outboard trim tab (2) will change the vertical vibration threshold about 15 or 20 mph (24.14 to 32.18 km/hr). Excessive trim tab change could increase high speed 2/rev vibration levels above 115 mph (185.04 km/hr), so a medium between high speed 1/rev and 2/rev vibration level may have to be accepted.

**4.** If vertical vibration level increases with airspeed, note airspeed at which vibration starts. Adjust trim tab (4) as follows:

**NOTE**

On earlier main rotor blades a vernier tab (5) is installed for fine tune adjustments. Preliminary adjustments shall be made with trim tab (4) and final adjustments with vernier tab (5). Maximum trim tab and vernier tab adjustment is 7 degrees up or 7 degrees down.

**a.** Bend outboard trim tab (4) up on low main rotor blade (3) as indicated by high speed track using T101538 trim tab bender and T101537 trim tab gage.

**b.** One degree change of trim tab (4) will change vertical vibration threshold about 15 to 20 mph (24.14 to 32.18 kph). Excessive outboard trim tab change could increase high speed 2/rev vibration levels above 115 mph (185.04 kph), so a medium between high speed 1/rev and 2/rev vibration level may have to be accepted. Continue adjustment with vernier tab (5) until vertical vibration is as smooth as possible.

## 18-28. ZERO AIRSPEED OGE HOVER.

**1.** Check lateral vibration level in and out of ground effect (OGE) hover at high and low beep on governor actuator switch. Smooth out any remaining lateral vibrations by using methods outlined in paragraph 18-25.

**2.** Check letdown for lateral vibrations; if too much sweep was used during dynamic chordwise balancing, it can induce a roll vertical vibration during descent.

## 18-29. ADJUSTMENT — FLAP RESTRAINT ENGAGEMENT RPM.

**1.** Inspect flap restraint assembly to ensure that arm assemblies (4, figure 18-18) operate freely and that springs (7) will retract arms to upright position.

**2.** Accomplish preflight inspection. Start helicopter (refer to applicable JetRanger Flight Manual). Note percent rpm at which the arm assemblies (4) move outboard as rotor percent increases. Allow engine to stabilize at completion of standard starting procedure, then shut down engine and note percent at which the arm assemblies (4) move into upright position. Both arm assemblies should operate in the rpm range of 25 to 31 percent as rpm increases or decreases.

**3.** If flap restraint arm operation occurs below 25 percent, remove steel washers (3) and replace with steel washers (2). If flap restraint arm operation occurs above 31 percent, remove steel washers (2) and replace with steel washers (3). Tighten nut (1) Ⓣ after changing washers.

**NOTE**

Make washer adjustments as required, but a maximum of eight steel washers (3) and nine steel washers (2) may be installed on each arm assembly.

**4.** If washer adjustment does not cause arm assembly to operate at correct percent rotor rpm, check springs (7). A pull of 0.84 ± 0.08 pounds (3.74 ± 0.36 newtons) should cause a 1-inch (25.40 mm) extension of spring (7).

## 18-30. FINAL ACCEPTANCE OR REJECTION.

Proper autorotation is essential to the successful accomplishment of emergency landings. At low gross weights and/or low density altitudes there is a tendency for the rotor to underspeed. At high gross weights and/or high density altitudes the tendency is to overspeed. The main rotor autorotation rpm adjustment chart figure 18-19) will guide the operator to set the autorotation rpm according to prevailing conditions. Once set, the autorotation rpm will remain within limits throughout the gross weight and density altitude range.

**NOTE**

Turns and changes in airspeed affect main rotor rpm.

It is recommended that autorotation rpm be checked at low gross weight.

**1.** Verify autorotation rpm by establishing a stabilized descent at 60 mph (96.54 kph) with collective control stick in full down position, and engine throttle at flight idle detent.

**CAUTION**

DO NOT EXCEED MAXIMUM MAIN ROTOR RPM OF 107 PERCENT. OVERSPEED MAY CAUSE DAMAGE TO MAIN ROTOR, TAIL ROTOR, AND OIL COOLER BLOWER IMPELLER.

**2.** While in stabilized descent, record main rotor rpm, pressure altitude, and OAT. Record gross weight at time of flight. To determine autorotation rpm adjustments required (figure 18-19).

**EXAMPLE**

Recorded Data:

— Pressure altitude of 2000 feet

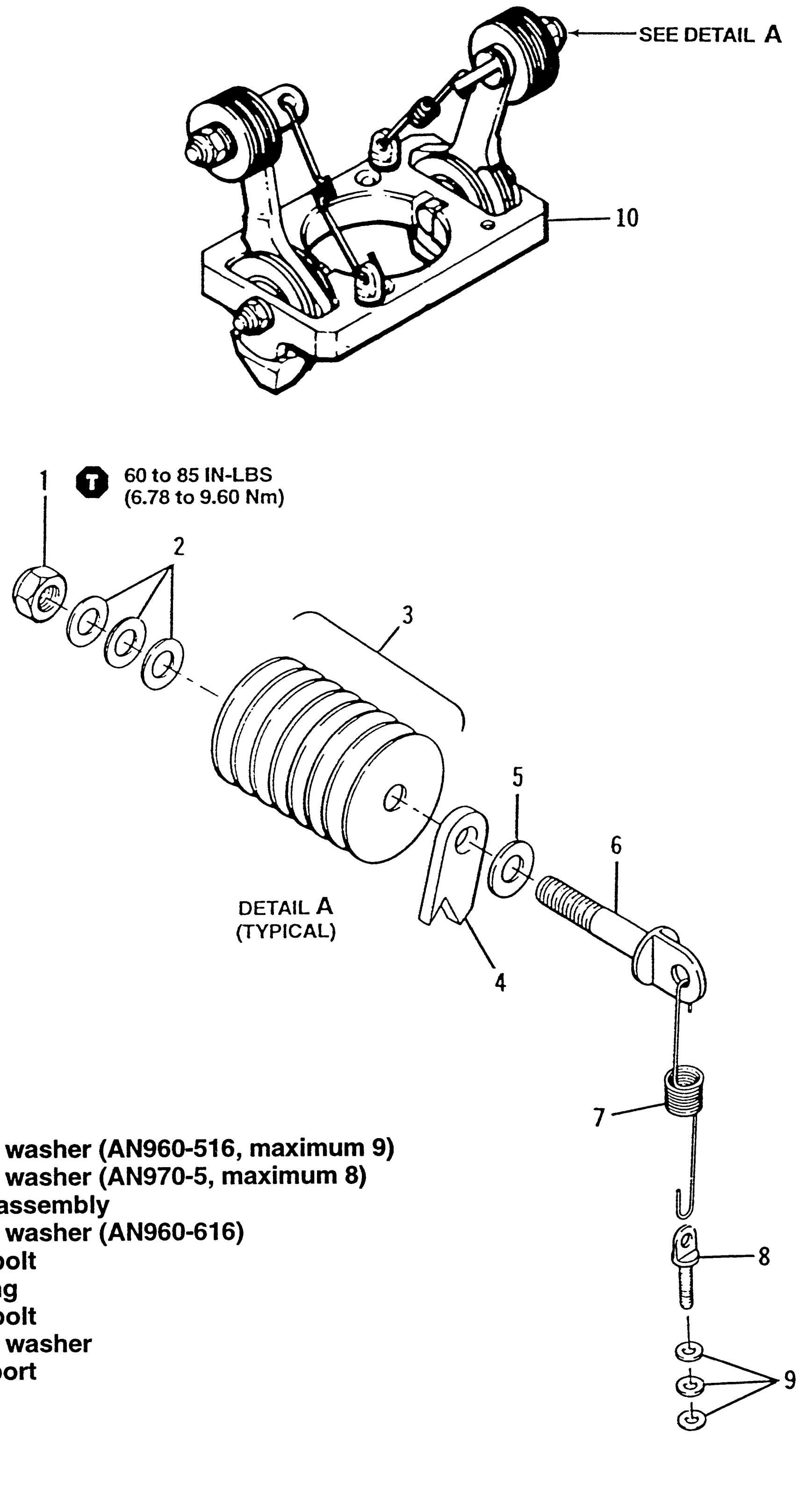
— OAT of +20°C

— Gross weight of 2800 pounds

— Main rotor rpm of 96%

**a.** Enter upper grid at recorded PRESSURE ALTITUDE (2000 feet). Extend line to OAT (+20°C). From this point, go down to GROSS WEIGHT (2800 lb). Project in straight line to left to intersect recorded ROTOR RPM (96%).

**b.** Distance between diagonal lines parallel to target rpm line represents one full turn of clevis (19, figure 18-15) of pitch link assembly (14 or 20), or about 3% NR (main rotor rpm) change.




1. Nut
2. Steel washer (AN960-516, maximum 9)
3. Steel washer (AN970-5, maximum 8)
4. Arm assembly
5. Steel washer (AN960-616)
6. Eye bolt
7. Spring
8. Eye bolt
9. Steel washer
10. Support

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**Figure 18-18. Flap restraint**

The relationship between collective pitch settings, RPM and gross weights for steady state autorotation @ 60 MPH is presented here. At low gross weight and density altitude there is a tendency to under speed and at high gross weight and density altitude there is a tendency to over speed. Thus, the full down collective needs to be set near the density altitude conditions available. The different RPM lines agree with different low collective settings.

* ROTOR 100.0%$N_R$ = 394 RPM
* MAXIMUM 107.0%$N_R$ = 422 RPM
* MINIMUM 90.0%$N_R$ = 354 RPM
* ONE FULL TURN OF THE COARSE THREADED CLEVIS OF THE CHANGE PITCH LINK ROD WILL CHANGE AUTOROTATION RPM ABOUT 3%$N_R$.
* At a fixed low collective setting. RPM will increase approximately 1% for each 1000 foot increase in density altitude or about 100 pounds increase in gross weight.

If RPM is low, decrease the length of all pitch change assemblies equally. If RPM is high, lengthen the assemblies.

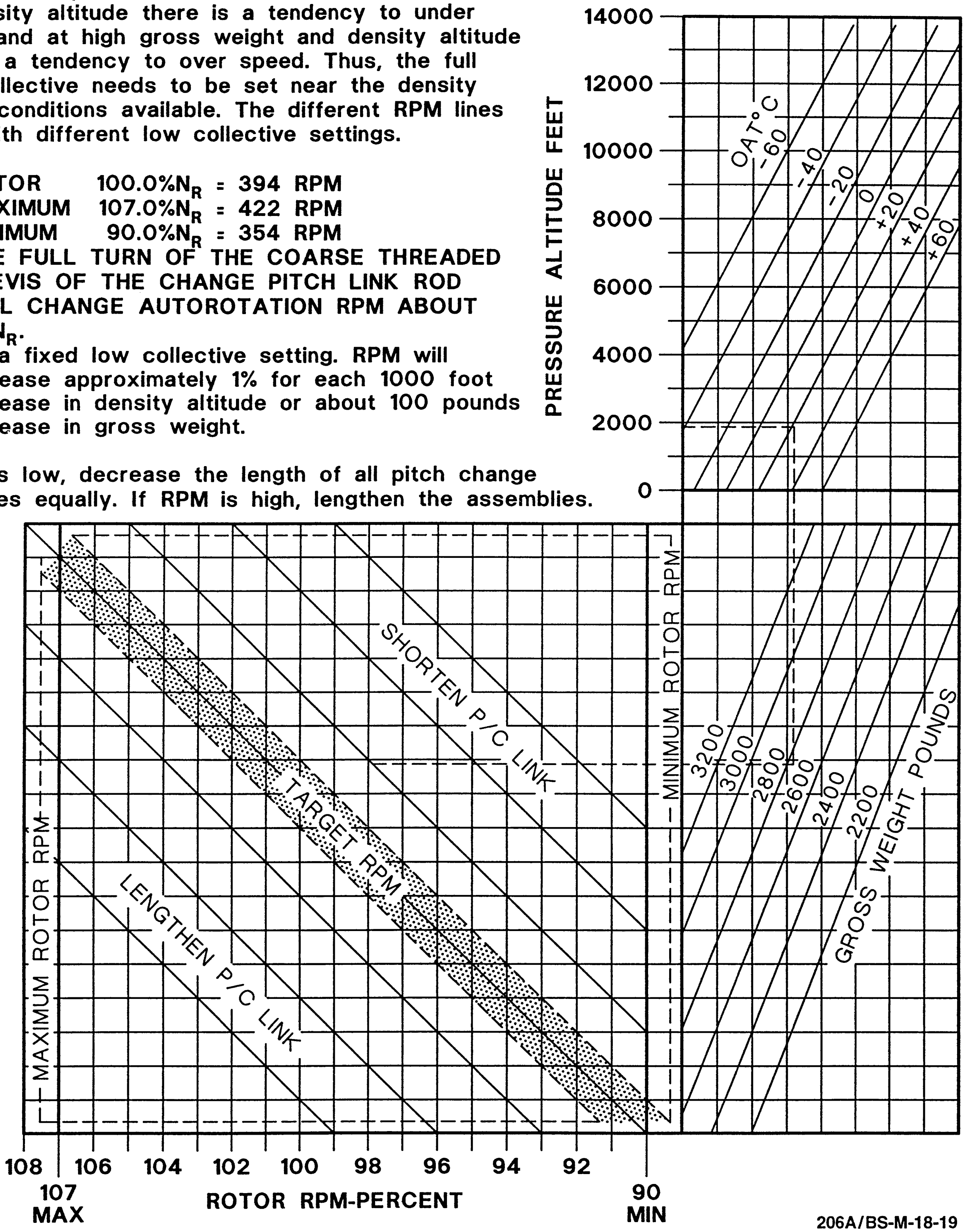



Figure 18-19. Main rotor autorotation rpm adjustment chart

**c.** Determine adjustment required to achieve target rpm ±1 percent (figure 18-19).

**d.** In the example, pitch links must be shortened by turning each clevis (19, figure 18-15) one full turn to reach target rpm of 99 ±1 percent.

**3.** Adjust pitch links as follows:

**a.** Remove cotter pin (17 or 26, figure 18-17), nut (16 or 25), thin steel washers (10 and 11 or 19 and 20), and bolt (15 or 24). Remove lockwire from insert (17 or 23, figure 18-15) and jamnut (18 or 21).

**WARNING**

WHEN ADJUSTING LENGTH OF PITCH LINKS, OBSERVE MINIMUM THREAD ENGAGEMENT FOR CLEVISES (PARAGRAPH 18-23). LESS THAN MINIMUM THREAD ENGAGEMENT FOR CLEVISES MAY CAUSE PITCH LINKS TO FAIL DURING FLIGHT.

**b.** Hold insert (17) stationary. Loosen and back off jamnut (18). Rotate clevis (19) to shorten or lengthen each pitch link assembly (14) equally as required. For pitch link assembly (20) index with a felt marker mark the position of jamnut (21) and barrel (22) to ensure accurate adjustments. Rotate barrel (22) the required direction and amount to correct autorotation rpm.

**c.** Hold insert (17) stationary, and tighten jamnut (18). Tighten jamnuts (11, 18, and 21) **T** on link assemblies (14 and 20). Secure jamnut (18) to insert (17), or barrel (22) to insert (23) with lockwire.

**d.** Install bolt (15 or 24, figure 18-17), thin steel washers (10 and 11 or 19 and 20), and nut (16 or 25) **T**.

**e.** Install cotter pin (17 or 26).

**4.** Check autorotation rpm to confirm results. Adjust if required.

## 18-31. MAIN ROTOR FINAL ACCEPTANCE CHECK.

**1.** Check IGE hover, forward flight, letdown, and OGE hover at low gross weight for overall satisfactory vibration level (paragraphs 18-24, 18-27, and 18-28).

**2.** Check autorotation rpm to confirm proper setting (paragraph 18-30).

## 18-32. ROTOR ANALYSIS AND DIAGNOSTIC SYSTEM (RADS-AT) — MAIN ROTOR TRACKING AND BALANCING.

The Scientific Atlanta Rotor Analysis and Diagnostic System (RADS-AT) automates the acquisition of blade track and vibration data as well as corrective actions required to accomplish tracking and balancing. The RADS-AT automatically obtains blade sweep information which help locate problem components in the hub and rotating control system.

## 18-33. MAIN ROTOR 1/REV CHECKS AND CONTROL.

Main rotor 1/rev checks are required to minimize 1/rev vibration from the main rotor system. There are two separate phases of procedures to accomplish these checks. The initial track and balance phase is used to track the rotor prior to flight when one or more rotor components have been changed or overhauled. The flight phase is used to reduce main rotor 1/rev throughout the flight envelope.

Refer to table 18-1 for listing of primary vibration and frequency at which vibrations occur at 100 percent main rotor rpm.

## 18-34. MAIN ROTOR PREPARATION FOR RADS-AT TRACK AND BALANCE.

**SPECIAL TOOLS REQUIRED**

| NUMBER | NOMENCLATURE |
|---|---|
| 29333301 | Basic RADS-AT kit |
| 29335500 | 206A/B Series adapter kit |
| 206-215-001-101 or Equivalent | Trim tab bender |
| 206-251-002-101 or Equivalent | Trim tab gage |
| 44 Caliber lead shots | Span balance weights |
| 206-011-157-101 | Chord balance weights |
| 206-011-157-103 | Chord balance weights |
| 206-011-157-105 | Chord balance weights |
| 29314700 | Optical rpm sensor |

SPECIAL TOOLS REQUIRED (Cont)

| NUMBER | NOMENCLATURE |
|---|---|
| 29220330 | Optical tracking bracket |
| 29313000 | Accelerometer bracket |
| 29328200 | Data acquisition unit (DAU) (included in basic RADS-AT kit) |
| 29314101 | Control and data unit (CADU) |
| 28110900 | Accelerometers (3 total) |
| 29105600 or 29105605 | Accelerometer cable 50 foot (additional) |
| 29313000 or Chadwick-Helmuth 6752 | Accelerometer bracket |
| 29338500A or 29338501 | Optical pickup bracket |
| 29136100 | Magnetic rpm sensor bracket |
| 27288400 | Magnetic rpm sensor |
| 29216300 | Magnetic interrupter |
| 29105403 | Magnetic sensor cable |
| 29726800 or 29338900 | Universal tracking device (UTD) bracket |
| 29325701 | Tracker cable |
| 29722100 | Sunprotector |
| 29325601 | Cable 10 foot |
| 29104700 | Power Cable |
| 29317100 | Power adapter cable |

**Table 18-1. Excitation frequencies**

| | 206A/B Frequency Allison 250-C20 Series | |
|---|---|---|
| **Vibration Source** | **(RPM)** | **(Hz)** |
| 1/REV Main Rotor | 394 | 6.57 |
| 2/REV Main Rotor | 788 | 13.13 |
| 4/REV Main Rotor | 1576 | 26.27 |
| 6/REV Main Rotor | 2364 | 39.40 |
| 1/REV Tail Rotor | 2550 | 42.50 |
| 8/REV Main Rotor | 3152 | 52.53 |
| 2/REV Tail Rotor | 5100 | 85.00 |
| 1/REV Main Driveshaft | 6016 | 100.27 |
| 1/REV Tail Rotor Driveshaft | 6016 | 100.27 |
| 4/REV Tail Rotor | 10200 | 170.00 |
| 1/REV Hydraulic Pump | 30625 | 510.42 |
| 1/REV Power Turbine | 30650 | 510.83 |
| Planetary Gear Mesh | 39000 | 650.00 |

**NOTE**

When using the RADS-AT, the main rotor shall be built up and maintained in accordance with applicable BHT-206A/B-SERIES-MM and BHT-206A/B-SERIES-CR&O manual.

**1.** Once rotor system has been smoothed, record trim tab settings.

**2.** Unless blade has been replaced, the last trim tab settings shall be considered the initial setting for next rotor smoothing.

**NOTE**

Span balance and sweep should not be zeroed for routine trimming. Sweep shall be zeroed if the hub assembly has undergone maintenance which would effect blade alignment. Span balance should be zeroed only if hub assembly has undergone maintenance.

**3.** Zero span balance and sweep if required.

**4.** Pitch links length shall remain as set for last rotor smoothing flight for all scenarios. Pitch links with replaced components should be set to same links they were prior to removal.

## 18-35. INSTALLATION OF RADS-AT FOR MAIN ROTOR SMOOTHING.

**1.** Install DAU in aft cabin area.

**2.** Remove forward transmission cowling (**Chapter 71**).

**3.** Install lateral accelerometer as follows:

**a.** Remove nut and washer from swashplate support (**figure 18-20**).

**b.** Install lateral accelerometer and bracket or Chadwick-Helmuth 6752 on top of transmission at swashplate support attachment studs. Secure bracket with washer and nut.

**c.** Connect accelerometer end of 29105600 or 29105605 cable to accelerometer and connect other end of cable to ACC connector of the DAU **figure 18-21**).

**NOTE**

Ensure that cables are secured so that it cannot foul rotating components or flight controls. Excess cable shall be rolled up and secured in cabin area.

**d.** Secure cable so that approximately 2 inches (51 mm) of slack are available between airframe and transmission to allow for pylon motion.

**e.** Install accelerometer and 29313000 bracket to pilot side of instrument panel console (**figure 18-22**).

**f.** Connect accelerometer end of 29105600 or 29105605 cable to vertical accelerometer.

**g.** Connect other end of cable to ACC #2 connection of DAU (**figure 18-21**).

**4.** Install magnetic rpm sensor as follows:

**a.** Install 29316100 magnetic rpm sensor bracket to left front pitch horn of the fixed swashplate, from top end with studs pointing down (**figure 18-23**).

**NOTE**

Do not tighten nuts so that clamps are distorted. Replace any nuts when self-locking feature of nut is worn.

**b.** Install sensor clamp on studs from bottom and secure with 1/4-28 inch self-locking nuts **T** (**BHT-ALL-SPM**).

**c.** Tighten jamnut on 27288400 magnetic rpm sensor. Insert sensor end of the magnetic sensor into sensor bracket from bottom and tighten until top of sensor is flush with top of sensor bracket. (Final adjustment will not be accomplished at this time).

**5.** Rotate main rotor until white blade is over right side of helicopter. This will be referred to as the target blade when performing tracking procedures.

**6.** Install interrupters as follows:

**a.** Insert the single 29216300 magnetic interrupter into drain hole of rotating swashplate pitch link arm web from bottom end. Pitch link arm shall be pointed forward.

**b.** Place a number 8 size self-locking nut onto threaded stud of interrupter. While tightening self-locking nut, position interrupter so that interrupter blade is radial to the mast and ahead of the mounting screw (**figure 18-23**).

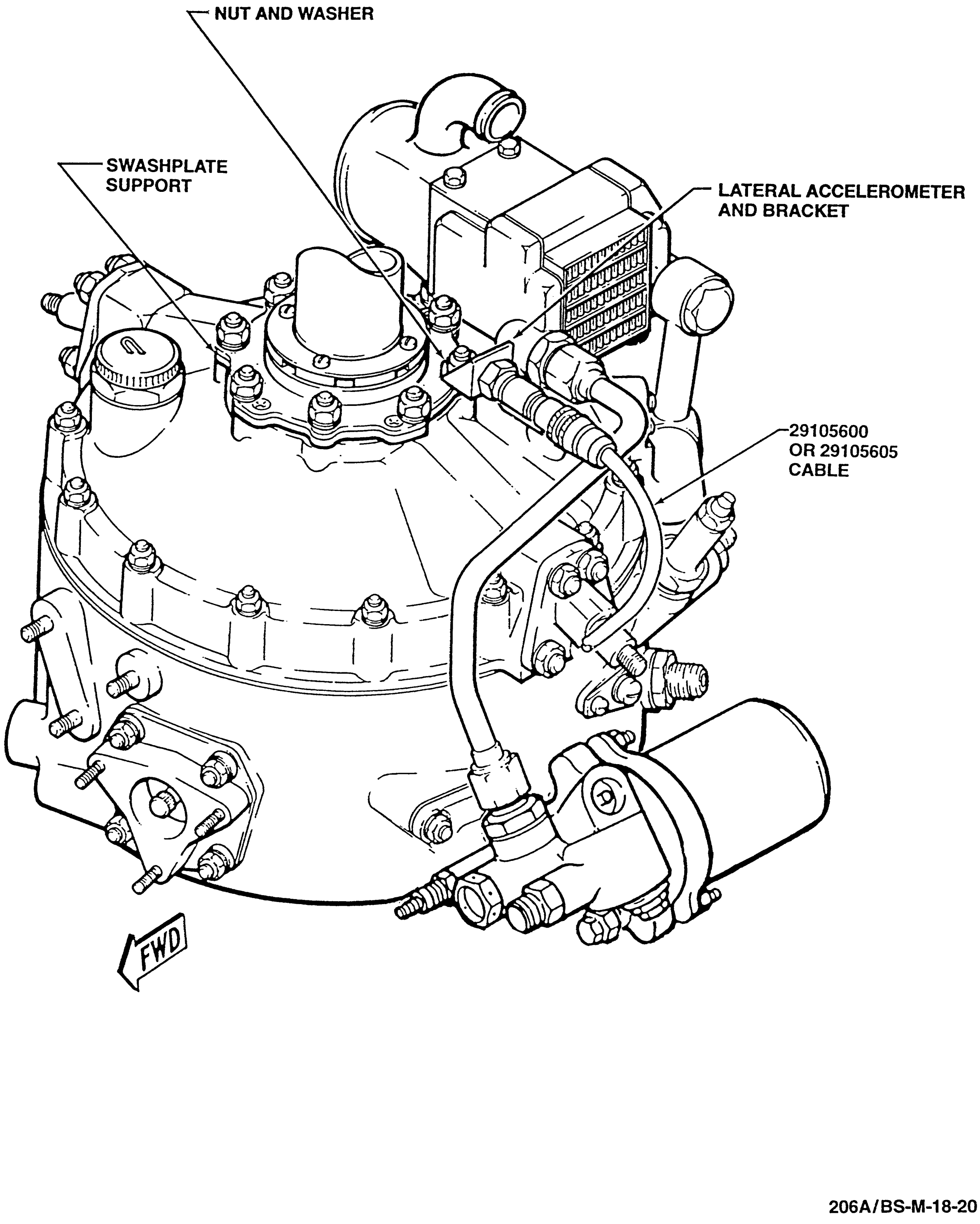



Figure 18-20. Installation of swashplate bracket

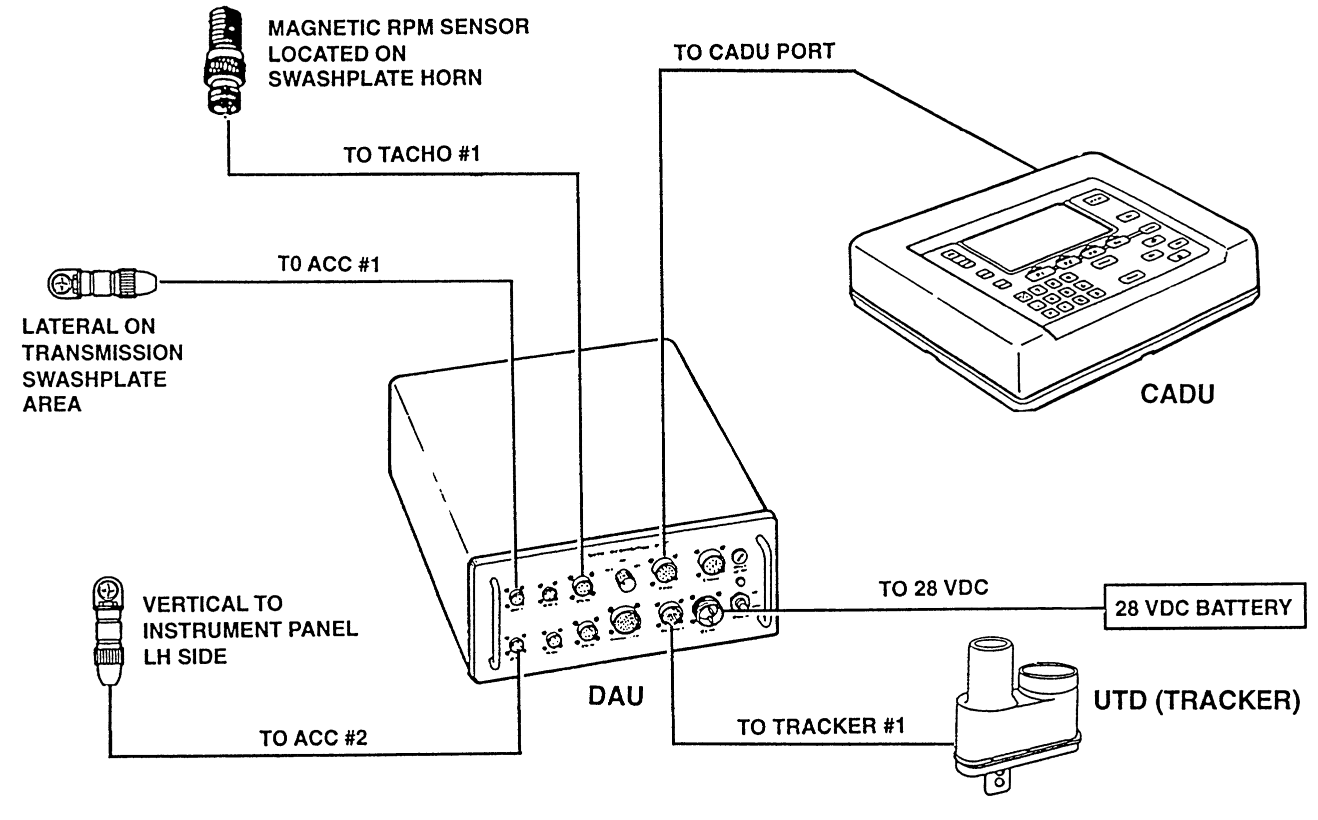



Figure 18-21. Installation for main rotor tracking and balancing

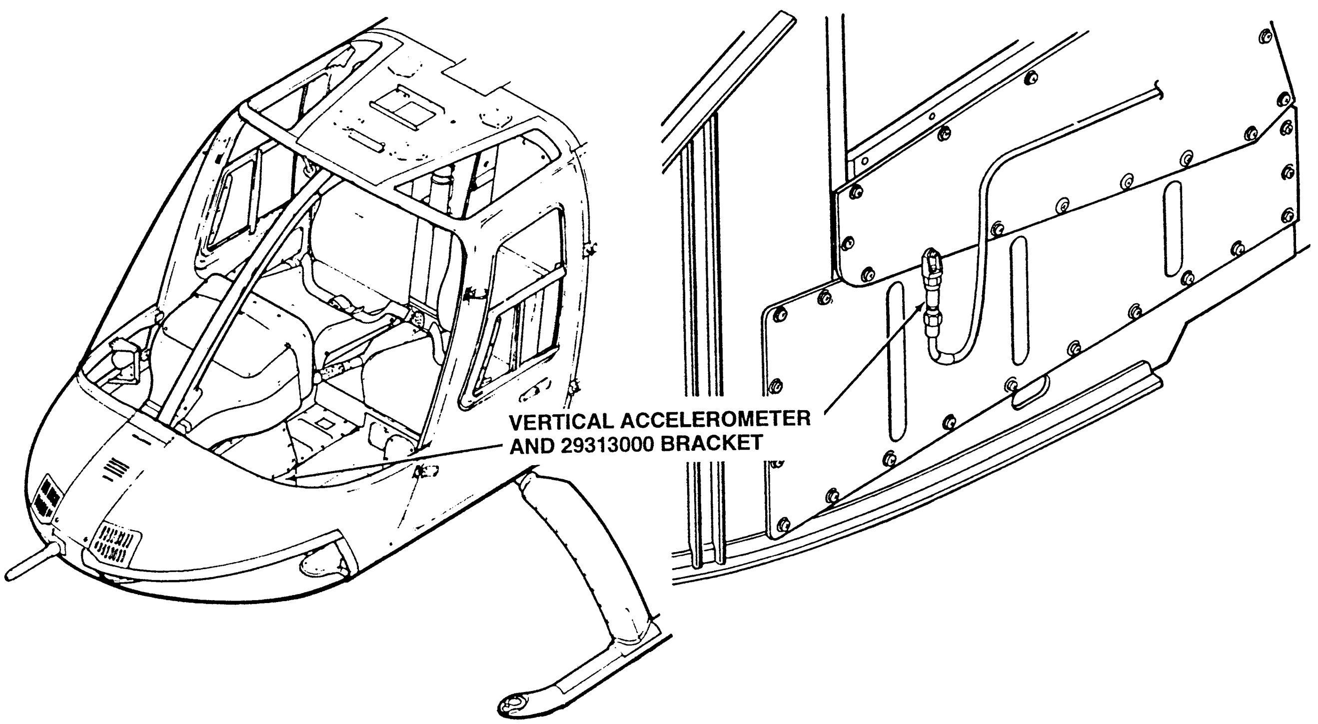



Figure 18-22. Vertical accelerometer installation

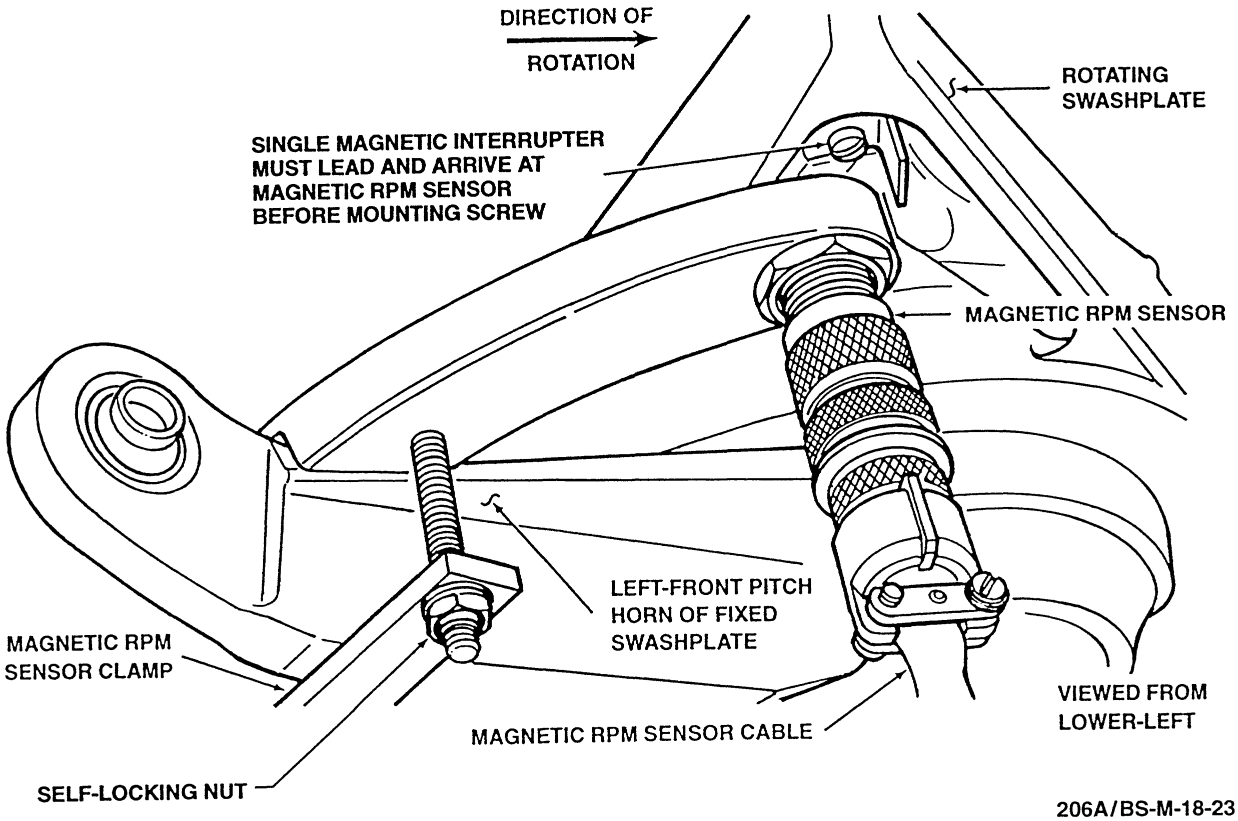



**Figure 18-23. Details of magnetic interrupter installation**

**c.** Rotate the rotor so that interrupter is directly over magnetic pickup. With interrupter over magnetic pickup, ensure that white blade is over the nose of the helicopter. If necessary repeat steps 5. and 6.

**d.** Using feeler gage adjust magnetic sensor until gap between magnetic sensor and interrupter is 0.060 inch (1.52 mm).

**e.** Tighten jamnut to secure sensor in place. Secure sensor to sensor bracket with lockwire.

**NOTE**

Ensure that cables are secured so that they cannot foul rotating components or flight controls. Excess cable shall be rolled up and secured in cabin areas.

**7.** Connect 29105403 magnetic sensor cable to magnetic sensor and to TACHO 1 connector on DAU ( figure 18-21 ). Ensure cable is secure and approximately 2 inches (51 mm) of slack are available to allow for motion of rotating components.

**NOTE**

It is recommended that tracker be used for all modes of tracking and shall be used when tracking in the "INITIAL" mode of tracking. However, the operator may elect to shorten installation time by flying without the tracker when retrimming a previously worked rotor or working forward flight at night. When flying without tracker, acknowledge "TRACKER FAILED" indication on CADU by pressing "DO" control on CADU.

**8.** Install tracker as follows:

**a.** Install 29726800 or 29338900 universal tracking device (UTD) bracket to landing light cover using screws and spacers (figure 18-24).

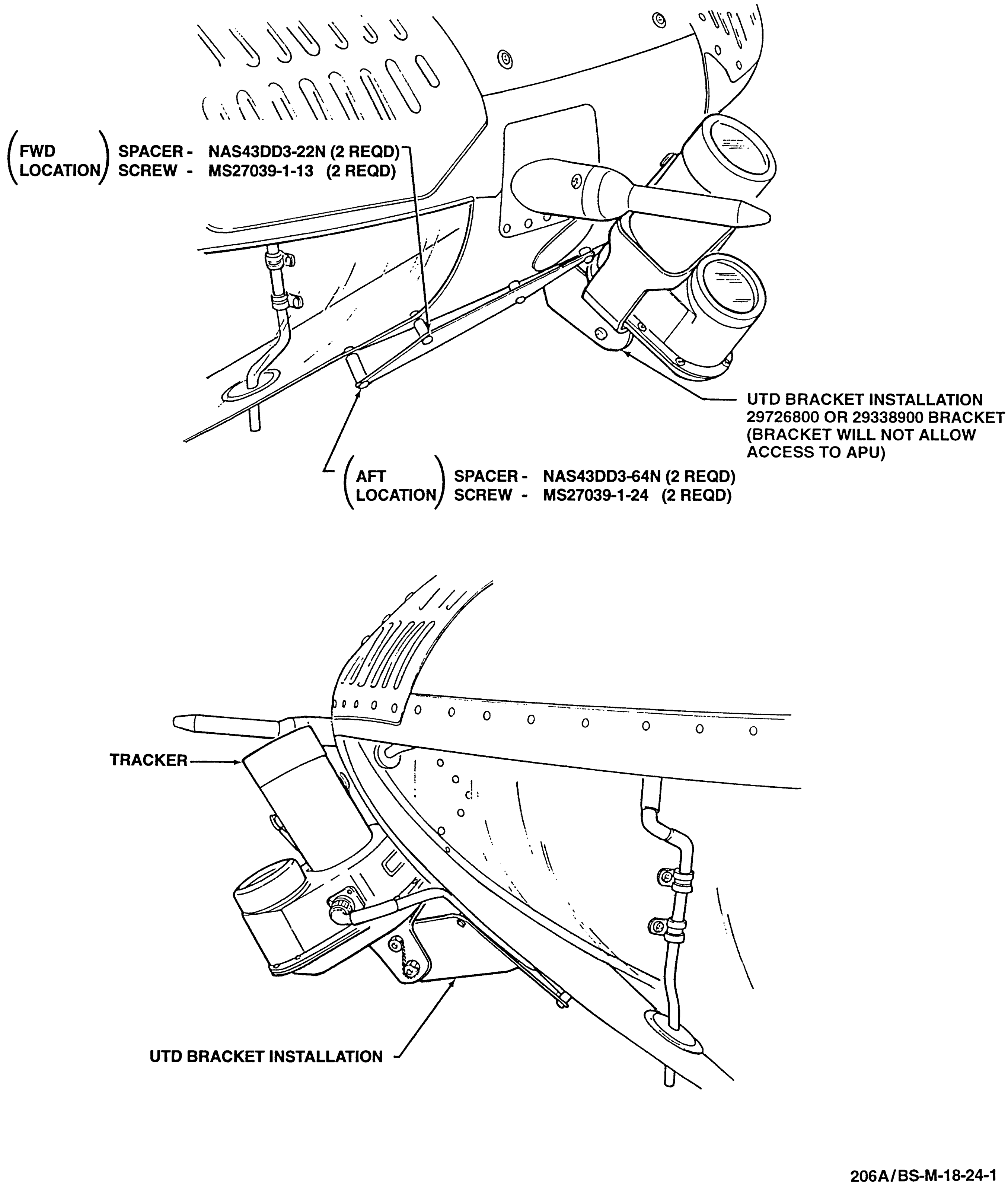



Figure 18-24. UTD bracket installation (Sheet 1 of 2)

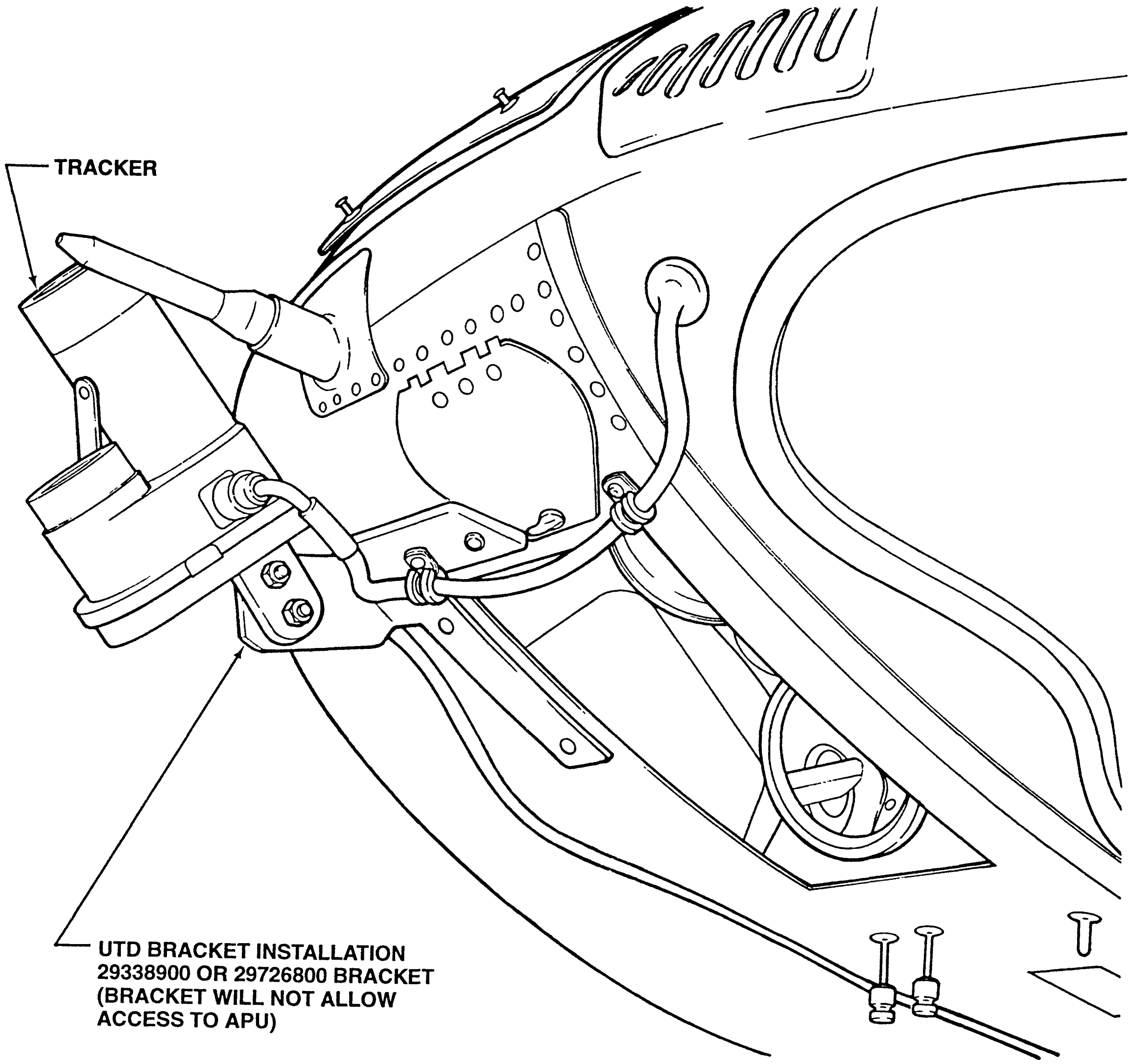



Figure 18-24. UTD bracket installation (Sheet 2)

**b.** Install tracker to bracket with black night lens pointing forward. Refer to figure 18-25 for alignment references. Ensure correct alignment and tighten tracker bolts to secure.

**c.** Connect 29325701 tracker cable to tracker and route into cabin through drain plug hole of copilot chin bubble.

**d.** Secure tracker cable to airframe with tape or tie wraps. Ensure that cable is clear of pitot static probes.

**e.** Connect tracker cable to TRACKER 1 port on DAU (figure 18-21).

**NOTE**

Use of 29722100 sun protector is optional. (Must be purchased separately from basic RADS-AT kit.) It is recommended that sun protector be used for increased reliability during periods of high ambient light conditions.

**9.** Connect 10 feet of 29325601 cable from CADU to DAU.

**10.** Connect 28 Vdc 29104700 power cable to 28 Vdc outlet on side of instrument pedestal near copilot cyclic stick. If helicopter is not equipped with a 28 Vdc outlet, connect cable to map light using 29317100 power adapter cable.

**11.** Turn power switch ON.

**12.** Prepare blade for tracking as follows:

**a.** For daylight operations paint lower blade leading edge with black lacquer paint or stencil link in area referenced in figure 18-26.

**b.** For night operations, install reflective tape (C-483) on blade.

**c.** The tracker shall be aimed within area marked in previous steps.

**13.** RADS-AT installation is complete and helicopter track and balance can be performed.

**18-36. RADS-AT TEST CONDITIONS — MAIN ROTOR SMOOTHING.**

Two modes of testing, “INITIAL” mode and “FLIGHT” mode are used to smooth the main rotor system. The “INITIAL” mode of testing is performed when one or more major main rotor components have been replaced or overhauled and the system requires a course track and balance before forward flight. The “FLIGHT” mode of testing is used to retrim the main rotor system at periodic intervals and to conduct final rotor smoothing in flight after “INITIAL” mode has been performed. Refer to table 18-2 test condition required to smooth main rotor system.

**Table 18-2. Main rotor smoothing test conditions**

| | | INITIAL | | FLIGHT | |
|---|---|---|---|---|---|
| Test Conditions | RADS-AT ID | Lateral Target (IPS) | Vertical Target (IPS) | Lateral Target (IPS) | Vertical Target (IPS) |
| Flat Pitch at 65% NR | idle | 0.7 | | 0.7 | |
| 100% NR at 35% Torque | 35/100 | 0.2 | | | |
| Hover into Wind | H-IWND | | | 0.1 | 0.1 |
| 60 Kts Climb at 1000 FPM | 60 Kts | | | | 0.1 |
| Level Flight at 100 kts | 100 Kts | | | | 0.1 |
| Level Flight/Dive to 120 Kts | 120 Kts | | | | 0.1 |
| 60 Kt descent at 1000 FPM | L/DOWN | | | | 0.1 |

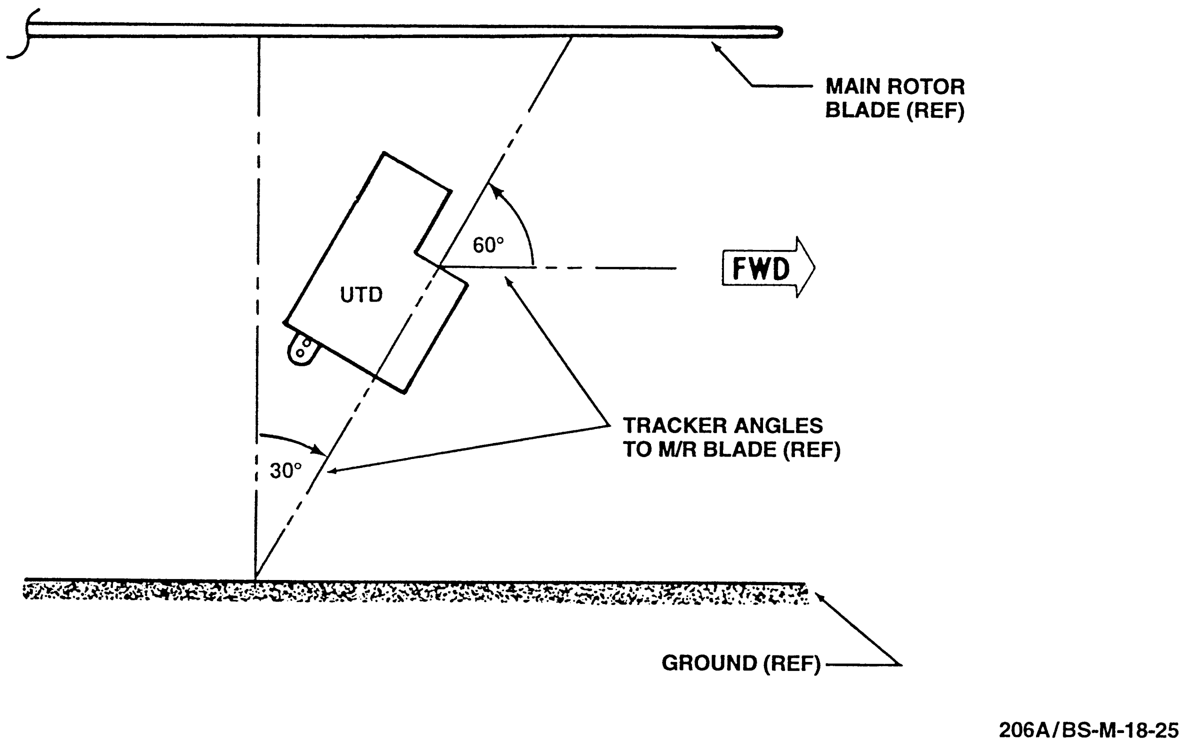



Figure 18-25. UTD alignment

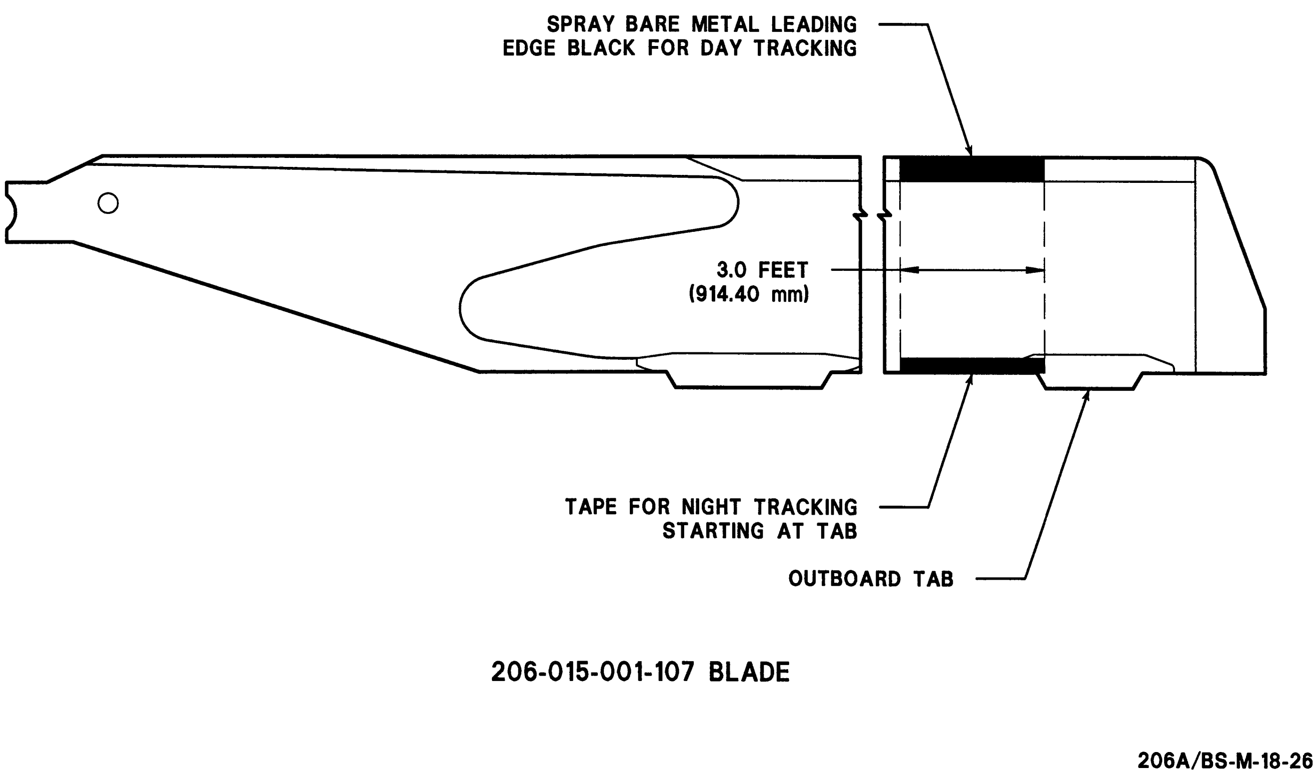



Figure 18-26. Paint and reflective tape installation on main rotor blade

## 18-37. TRACKING AND BALANCING "INITIAL" MODE — RADS-AT.

The "INITIAL" mode is performed to track main rotor on the ground at both 65 percent rpm (Low rpm) and 100 percent rpm (High rpm) and to coarsely balance main rotor at 65 percent rpm (Low rpm) and finely balance main rotor at 100 percent (High rpm) and 35 percent torque.

**1.** Install RADS-AT (paragraph 18-35).

**2.** Select "206A/B" aircraft type on the CADU main menu and enter the helicopter tail number.

**3.** Select "INITIAL" mode as the flight plan.

**4.** Verify CADU screen display (figure 18-27) as follows:

**a.** Aircraft type — 206A/B

**b.** Tail number — should be tail number of helicopter being tested

**c.** Flight plan — INITIAL

**d.** Flight I.D. — Blank

**5.** After verification CADU displays to be correct, press F1 to indicate measuring sequencing. Test conditions at which data will be taken will be displayed on CADU screen.

**6.** Start and operate helicopter. Refer to applicable JetRanger Flight Manual.

**7.** Stabilize main rotor at approximately 65 percent NR.

**8.** Center cyclic and ensure that collective is all the way down.

**9.** With "IDLE" test state highlighted on CADU, press "DO" to arm the RADS-AT.

**a.** If all internal checks are successful, the test condition title will appear at bottom of CADU screen and system will be armed to take data.

**b.** Press "DO" to acquire data.

**c.** Once data is acquired. The next test condition for which data is to be taken will be highlighted CADU screen and "DONE" will be displayed next to the test condition.

**NOTE**

If any warnings appear on CADU screen, attempt to retake data at test condition. If warning repeats, record error code, shut down helicopter and take required corrective action prior to continuing. Corrective actions will be listed on CADU screen and can be found in RADS-AT manual.

**10.** If data taken is successfully taken at idle rpm, proceed to 100 percent rpm and set torque to 35 percent.

**11.** Record data when 35/100 is highlighted by pressing "DO" to arm. Press "DO" again to record data when helicopter has been stabilized at the desired condition.

**NOTE**

The use of the word "limits" in the following paragraphs does not mean an actual limit or manufacturer specification for track or vibration that can not be exceeded, but refers to terminology used in RADS to guide track and balancing of the rotor. Guidelines to vibration levels which require corrective action are listed in paragraph 18-48.

**12.** Upon completion of data collection from both test conditions, select "DIAGNOSTICS" from CADU menu prior to shutting down. If any limits are exceeded these will be noted on CADU screen (pressing arrow up key will display all limits even if not exceeded).

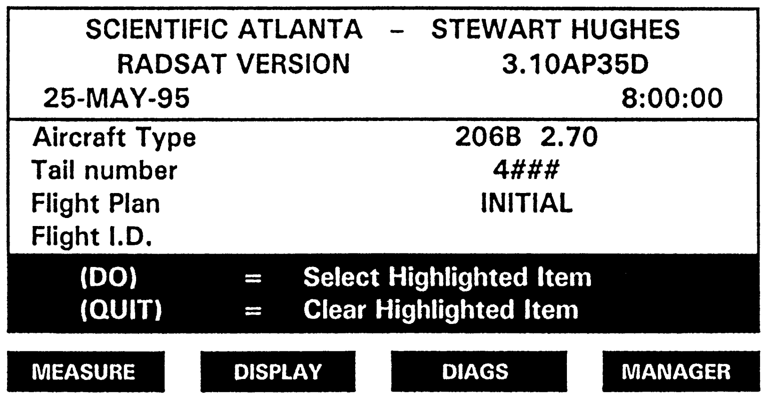
**13.** Helicopter may be tested in flight mode at this point if elected to proceed with in-flight testing. Refer to paragraph 18-35. It will be necessary to repeat the idle and 100 percent NR at 35 percent torque test conditions to obtain correct analysis.

**14.** When corrective action screen is displayed, use right arrow to scroll through adjustments recommended. Record adjustments on main rotor movelog (figure 18-28).

**15.** Press "DO" to review predicted results.

**16.** Press "DO" to review diagnostic menu.

**17.** After all moves have been recorded, select MAIN MENU and press "DO" to return to screen.




206A/BS-M-18-27

**Figure 18-27. CADU main menu display for “INITIAL” mode testing**

**18.** Make required adjustments indicated by RADS-AT (paragraph 18-39).

**19.** If necessary repeat steps 5. through 18. until all limits are met. Once all limits have been met, proceed to “FLIGHT” mode to conduct final rotor smoothing in flight (paragraph 18-38).

## 18-38. MAIN ROTOR SMOOTHING “FLIGHT” MODE — RADS-AT.

**1.** Install RADS-AT equipment (paragraph 18-35).

**2.** Select “206A/B” as aircraft type on CADU main menu and enter helicopter tail number.

**3.** Select flight plan on CADU as follows:

**a.** “FLIGHT” for helicopters with blades that do not have inboard tabs.

**NOTE**

“FLI-INB” program can be used only if one main rotor blade is equipped with inboard tabs, but inboard tab adjustment suggested will be half of value indicated.

**b.** “FLI-INB” for helicopters with blades having inboard tabs.

**4.** Verify CADU screen displays (figure 18-29) as follows:

**a.** Aircraft type — 206A/B

**b.** Tail number — should be tail number of helicopter being tested

**c.** Flight plan — FLIGHT or FLI-INB as required

**d.** Flight I.D. — Blank.

| SHIP S/N | HUB S/N | TARGET S/N | BLANK S/N |
|---|---|---|---|
| | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Date and Time | | | | | Intial | or | | Flight | | |
| Blade | Span | Balance | Chord | Balance | Pitch | Links | Out. | Tabs | Inb. | Tabs |
| TARGET | move | total | move | total | move | total | move | total | move | total |
| BLANK | move | total | move | total | move | total | move | total | move | total |
| NOTES | | | | | | | | | | |
| Date and Time | | | | | Intial | or | | Flight | | |
| Blade | Span | Balance | Chord | Balance | Pitch | Links | Out. | Tabs | Inb. | Tabs |
| TARGET | move | total | move | total | move | total | move | total | move | total |
| BLANK | move | total | move | total | move | total | move | total | move | total |
| NOTES | | | | | | | | | | |
| Date and Time | | | | | Intial | or | | Flight | | |
| Blade | Span | Balance | Chord | Balance | Pitch | Links | Out. | Tabs | Inb. | Tabs |
| TARGET | move | total | move | total | move | total | move | total | move | total |
| BLANK | move | total | move | total | move | total | move | total | move | total |
| NOTES | | | | | | | | | | |

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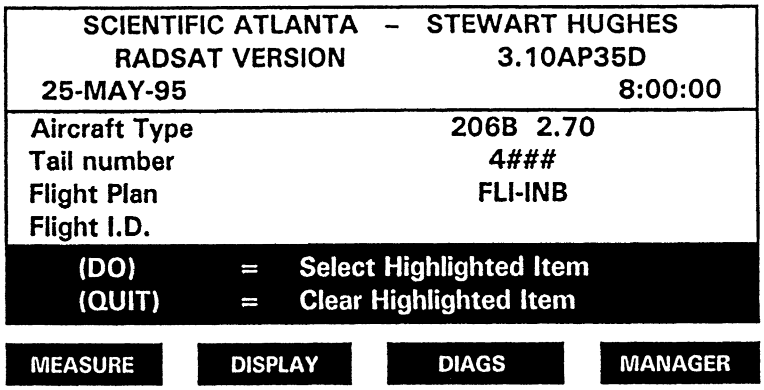
Figure 18-28. Main rotor movelog



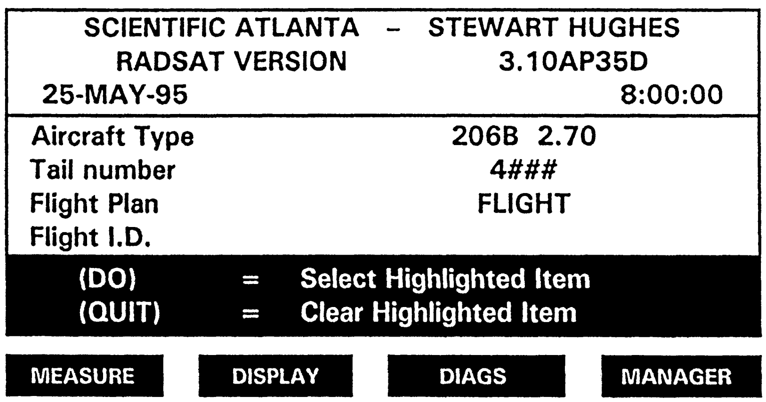




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**Figure 18-29. CADU main menu display “FLIGHT” and “FLI-INB” testing**

**5.** Press F1 on CADU to indicate measuring sequence. Test conditions will be displayed on CADU screen (table 2).

**6.** Start and operate helicopter. Refer to applicable JetRanger Flight Manual.

**NOTE**

When continuing from "INITIAL" mode of testing, repeat idle and 100 percent NR at 35 percent torque test conditions to obtain correct analysis.

**7.** Stabilize main rotor at approximately 65 percent NR.

**8.** Center cyclic and ensure that collective is all the way down.

**NOTE**

When collecting data in flight it is not necessary to obtain data at high speed test conditions if 1/rev condition becomes higher than is comfortable. When skipping test conditions or acquiring data out of sequence, the arrow keys on CADU can be used to select the desired condition. Do not store data from one condition under another label as diagnostics will not function properly.

The RADS-AT needs only hover and one forward flight condition to begin to analyze adjustments required to smooth main rotor. It is important that as the 1/rev levels are reduced to obtain data at all displayed test conditions to ensure that optimum main rotor 1/rev levels are achieved throughout flight envelope of helicopter.

**9.** With "IDLE" test state highlighted on CADU, press "DO" to arm the RADS-AT.

**a.** If all internal checks are successful, the test condition title will appear at bottom of CADU screen and system will be armed to take data.

**b.** Press "DO" to acquire data.

**NOTE**

To view a test state before full completion of measurements, select arrow keys and press F1 to select DISPLAY on CADU.

**c.** Once data is acquired, the next test condition for which data is to be taken will be highlighted CADU screen and "DONE" will be displayed next to the test condition.

**NOTE**

If any warnings appear on CADU screen, attempt to retake data at test condition. If warning repeats, record error code, shut down helicopter and take required corrective action prior to continuing. Corrective actions will be listed on CADU screen and can be found in RADS-AT manual.

**10.** If data is successfully taken at idle rpm, proceed to 100 percent rpm and set torque to 35 percent.

**11.** Record data when 35/100 is highlighted by pressing "DO" to arm. Press "DO" again to record data when helicopter has been stabilized at the desired condition.

**12.** Once data is collected, land and shut down helicopter. If data has been obtained the CADU program will automatically display menu options.

**13.** If all test conditions have not been obtained press "QUIT" to exit measurement code and use arrows to select "SAVE AND EXIT" and press "DO" to store data.

**14.** With menu options displayed, press arrows to highlight "DIAGNOSTICS" and press "DO". If main menu is displayed, press F3 to access "DIAGNOSTICS". Once accessed data obtained will be compared to the preprogrammed limits with this comparison being displayed. Refer to table 18-1 for limit values.

**15.** If no limits are exceeded in step 14., press "QUIT" to exit program. If any 1/rev levels are above limits, it is up to the operator to determine if levels require further improvement. To determine main rotor adjustments required to smooth main rotor proceed as follows:

**a.** Press "DO" when reviewing limits screen to calculate and display recommended adjustments.

**(1)** Make a note of adjustments identified.

**(2)** Press "DO" to view predicted results. Using 6.01 systems select "VIEW PREDICTIONS" from diagnostics menu.

**(3)** Make a note of any 1/rev levels and of predictions.

**b.** Once predictions have been noted, press "DO" to return to diagnostics menu.

**16.** If three or more adjustments are recommended or if recommended adjustments include outboard tab in direction opposite indicated pitch link adjustment, an acceptable ride may be obtainable with fewer adjustments. Evaluate adjustment potential as follows:

**a.** Use arrow keys to select "Edit Defaults" and Press "DO".

**b.** Maximum number of adjustments should be highlighted, if not, use up-down key to select.

**c.** Type number "1" and press "DO" to calculate the one best adjustment.

**d.** If the predicted adjustments are satisfactory, record adjustment on main rotor movelog (figure 18-28). Make adjustments required (paragraph 18-39). If not satisfactory, proceed with following steps.

**e.** If predicted adjustments are not acceptable, repeat "edit Defaults" process and select "2", then "3", and then "4" if necessary, until predicted results are acceptable or of a substantial improvement. Once minimum number of meaning adjustments have been determined, record adjustments on main rotor movelog and make required adjustments (paragraph 18-39).

**NOTE**

For diagnostics to work properly the HOVER and at least one forward speed must be obtained. If a limited number of test points has been obtained, adjustments shall be edited using the "EDIT ADJUSTABLES" option in the "DIAGNOSTIC MENU".

No forward airspeeds: turn off (use F1 to select N) both pitch links and trim tab. If this is not done these adjustments will be used to retrack main rotor on ground.

**NOTE**

When in "EDIT ADJUSTABLES" only one each span balance adjustment shall be turned on at any time.

**17.** After all required adjustments have been made to main rotor in accordance with paragraph 18-38, repeat steps 5. through 16. until optimum ride has been obtained. An optimum ride is defined as follows:

**a.** All flight levels are below target limits.

**b.** Ride is acceptable to flight crew.

**c.** Further adjustments are not predicted to result in a meaningful improvement to predicted 1/rev levels.

**18.** If ride is not acceptable, refer to paragraphs 18-47 for troubleshooting procedures.

## 18-39. MAIN ROTOR ADJUSTMENTS — RADS-AT.

## 18-40. SPANWISE BALANCE ADJUSTMENT — RADS-AT.

RADS-AT specifies amount of span balance adjustment to be made in grams with a positive (+) move meaning to add weight to designated blade and a negative (–) move meaning to remove weight from a designated blade. If RADS-AT specifies to remove weight from a blade with no weight installed, add weight to opposite blade. The effect will be identical. Recommended balance weight is number 44 caliber lead shot (9 grams).

**1.** Review span balance move recorded on main rotor movelog (figure 18-28) to determine adjustment to be made. Blade over nose of helicopter when single interrupter is over magnetic pickup is target blade. Span balance location is inside blade bolts (figure 18-30).

**2.** Identify blade to be adjusted and remove plastic plug from top of blade bolt on blade requiring adjustment.

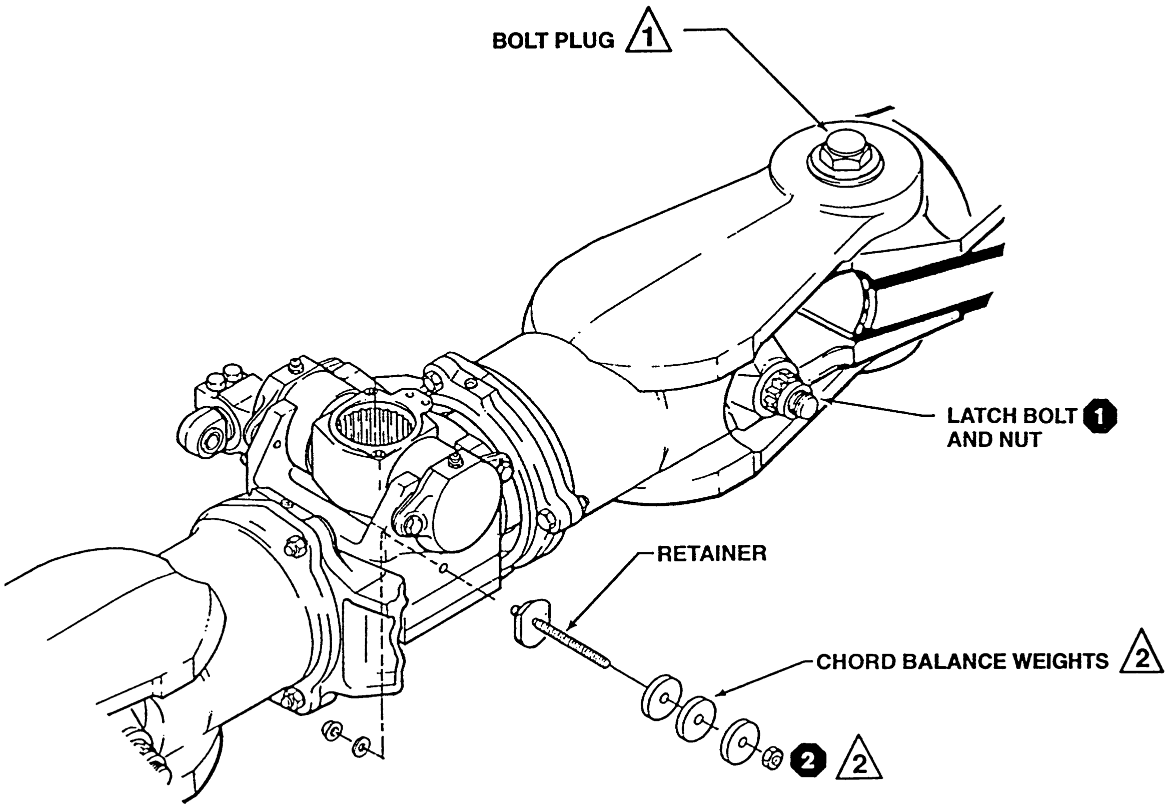
**3.** If available, use scale to measure weight to be added to blade bolt (one number 44 ball=9 grams).

**4.** Add weight required to blade bolt. If weight is present in opposite blade, then remove weight from that blade prior to adding the remainder of weight to light blade.

**5.** Install plugs in blade bolts.

## 18-41. CHORDWISE BALANCE ADJUSTMENT.

Chordwise balance can be accomplished by either sweeping a blade or by adding or removing weights from chordwise balance weight retainers on the side of the main rotor hub. Sweep moves of one point or less can be accomplished by sweeping the blade or adjusting chord weights.




**NOTES**

1. Install lead weight blade bolts for span balance.

2. Installed on 206-011-100-127 and subsequent hub and blade assemblies.

❶ 75 TO 95 FT-LBS (102.00 TO 129.00 Nm)

❷ 50 TO 70 IN-LBS (5.65 TO 7.91 mm)

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Figure 18-30. Span Balance, Sweep and Chord Balance Locations

## 18-42. BLADE SWEEP ADJUSTMENT — RADS-AT

RADS-AT specifies amount of chord balance adjustment to be made in points of sweep for helicopter with a positive (+) move meaning to sweep indicated blade forward and a negative (–) move to sweep indicated blade aft. If desired, the blade that has been indicated for adjustment does not have to be adjusted, as the same effect may be obtained by making the opposite indicated adjustment requirements on the opposite blade.

**CAUTION**

MAIN ROTOR BLADES SHOULD NEVER BE SWEPT FORWARD OF ORIGINAL ALIGNED POSITIONS. FAILURE TO COMPLY MAY RESULT IN A FALSE READING.

**1.** Index mark both leading and trailing latch bolt nuts and latch bolt ends with grease pencil lines to indicate aligned position of main rotor (starting position) (Figure 18-30).

**2.** Review starting position recorded on main rotor movelog to determine adjustment made.

**3.** Position blade over nose of helicopter and with single interrupter over magnetic pickup. (This will be the target blade.) Correct sweep adjustment specified to ensure that neither blade is swept forward of aligned position and that both blades remain close to aligned position. Remove aft sweep if possible.

**CAUTION**

BLADE SWEEP ADJUSTMENTS ARE SENSITIVE. WHEN MAKING SWEEP ADJUSTMENTS, ENSURE BLADE LATCHES REMAIN VERTICAL. DO NOT EXCEED A MAXIMUM ADJUSTMENT OF 3 POINTS ON THE LATCH BOLT NUTS. FAILURE TO COMPLY MAY RESULT IN DAMAGE TO HELICOPTER.

**NOTE**

Forward sweep is used only when blade has been previously swept aft and forward sweep is being used to return blade to initial aligned position.

**NOTE**

Improved sweeping results may be obtained if main rotor blade bolt torque is broken before latch nuts are adjusted. If blade bolt torque is broken, torque after sweeping is completed.

**4.** Sweep main rotor blade forward as follows:

**a.** On blade being swept forward note orientation of index mark of trailing edge latch bolt nut.

**b.** Loosen main rotor blade bolt one-fourth to one-third turn.

**CAUTION**

DO NOT EXCEED A MAXIMUM ADJUSTMENT OF 3 POINTS ON THE LATCH BOLT NUTS.

**c.** Loosen nut by number of points blade is to be swept (one point = one-twelfth turn of nut).

**d.** Tighten leading latch bolt nut of main rotor blade (T).

**e.** Torque main rotor blade bolt (T).

**f.** Record amount of forward adjustment made on main rotor movelog (Figure 18-28).

**NOTE**

Improved sweeping results may be obtained if main rotor blade bolt torque is broken before latch nuts are adjusted. If blade bolt torque is broken, torque after sweeping is completed.

**5.** Sweep main rotor blade aft as follows:

**a.** On blade being swept aft note orientation of index mark position of leading edge latch bolt nut.

**b.** Loosen main rotor blade bolt one-fourth to one-third turn.

**CAUTION**

DO NOT EXCEED A MAXIMUM ADJUSTMENT OF 3 POINTS ON THE LATCH BOLT NUTS.

**c.** Loosen nut by number of points blade is to be swept (one point = one-twelfth turn of nut).

**d.** Tighten leading latch bolt nut of main rotor blade Ⓣ.

**e.** Torque main rotor blade bolt Ⓣ.

**f.** Record amount of aft adjustment made on main rotor movelog (Figure 18-28).

## 18-43. CHORDWISE WEIGHT ADJUSTMENT — RADS-AT

Helicopters with 206-011-100-127 hub and blade assembly (and subsequent) incorporate chordwise balance weight retainers on main rotor yoke assembly to allow fine balance adjustments. The RADS-AT does not make a distinction between sweep and chordwise balance weights. If this procedure is used, the average effect is a positive (+) sweep move means to add chord weights to retainer adjacent to indicated pitch link. A negative (–) adjustment means to add weight to retainer adjacent to opposite blade pitch link. An opposite adjustment on opposite blade will have approximately same effect on main rotor balance.

**1.** Review sweep adjustment recorded in main rotor movelog to determine adjustment required (Figure 18-28).

**2.** Position target blade over nose of helicopter, with single interrupter over magnetic pickup.

**NOTE**

Weight retainer will accept 8, 206-011-157-101 weights. Each weight is equal to 1 point of blade sweep. Maximum number of weights installed on retainer is governed by amount of threads showing beyond retainer after torquing nut. At least 2 threads shall be visible beyond nut.

**3.** Once blade adjustment requirements have been identified, remove nut from retainer at location that weight is to be adjusted.

**4.** Using a combination 206-011-157-101 (100 grams each), -103 (50 grams each), and/or -105 (25 grams each) weights, add or subtract desired amount of weight from balance location.

**5.** After completion of adjustments, install nut **T** on retainer (figure 18-30).

### 18-44. PITCH LINK ADJUSTMENT — RADS-AT.

RADS-AT specifies amount of pitch link adjustment required in number of flats with a positive (+) to increase pitch with designated pitch link, and a negative (–) move to decrease pitch. Although RADS-AT may specify to increase pitch on an indicated blade, it is permissible to decrease pitch on opposite blade to obtain same effect.

**1.** Review main rotor movelog recording for pitch link to determine adjustment requirements (figure 18-28).

**2.** Perform required adjustments to pitch links (Chapter 62).

### 18-45. OUTBOARD TAB ADJUSTMENT — RADS-AT.

RADS-AT specifies amount of outboard tab adjustment required in degrees, a positive (+) move means to bend designated tab up and negative (–) means to bend tab down. It also specifies amount of tab to be adjusted in 1/4 degree increments of entire outboard tab. If RADS-AT specifies to bend tab up on an indicated blade, the opposite blade may be bent down if elected, and the result will be approximately the same.

**1.** Remove main rotor movelog to determine adjustment requirements for outboard tab (figure 18-28).

**2.** Identify blade to be adjusted. The target blade shall be over nose of helicopter with single interrupter over magnetic pickup.

**NOTE**

Trim tab bender (1, figure 18-13 ) is assembled with plate (8) on top of trim tab, and handle (4) on bottom of trim tab.

**3.** Install 206-215-001-101 trim tab bender (1) onto tab to be adjusted with wingnut (5) down. Position bender so there is a gap of approximately 0.125 inches (3.18 mm) between bender and trailing edge of blade. Tighten wingnut (5) handtight to secure bender to blade tab.

**4.** Install 206-215-002-001 trim tab gage (2) onto blade with scale adjacent to trim tab and spring (3) under blade. Square gage to chord line of main rotor blade with scale touching angle indicator on bender.

**NOTE**

Maximum of 7 up or down for outboard tabs is recommended. Large adjustments may be split between outboard tabs of both main rotor blades. Half of recommended tab adjustments can be made on designated blade and half can be made on opposite blade in opposite direction.

**5.** Bend outboard trim tab (2, figure 18-15) in direction indicated until tab is at rest, with no load on bender, approximately 2, beyond final desired tab angle. Bend tab back until final rest position is at desired angle. Overbending will minimize any tendency of tab to creep.

**6.** Remove tab bender from main rotor blade.

### 18-46. INBOARD TAB ADJUSTMENT — RADS-AT.

RADS-AT specifies amount of outboard tab adjustment required in degrees; a positive (+) move means to bend designated tab up and negative (–) means to bend trim tab down. RADS-AT displays inboard tab moves to be made on only one main rotor blade. However, indicated move is to be made in indicated direction on indicated blade and in opposite direction on opposite blade. Small moves of 1/2 degree can be made as a 1 move on one tab only. A 1/4 degree move is equal to bending tab on only 1/2 degree in indicated direction.

EXAMPLE: RADS–AT specifies a +4 degrees move to blank blade. The actual move made will be to bend inboard tab of blank blade up 4 degrees and bend tab on target blade down 4 degrees.

**1.** Review main rotor movelog to determine inboard tab adjustments required (figure 18-28).

**2.** Identify blade to be adjusted. Position target blade over nose of helicopter and single interrupter over magnetic pickup.

**3.** Install 206-215-001-101 trim tab bender (1, figure 18-13) on inboard trim tab (7) to be adjusted with wingnut (5) down. Position bender so there is a gap of approximately 0.125 inch (3.18 mm) between bender and trailing edge of blade. Tighten wingnut (6) handtight to secure bender to blade tab.

**4.** Install 206-215-002-001 trim tab gage (2) onto blade with scale adjacent to trim tab and spring (3) under blade. Square gage to chord line of main rotor blade with scale touching angle indicator on bender.

**NOTE**

Maximum adjustment of 14 up or down for inboard tab is recommended.

**5.** Bend inboard trim tab (7) in direction indicated until tab is at rest, with no load on bender, approximately 2 degrees beyond final desired tab angle. Bend tab back until final rest position is at desired angle. Overbending will minimize any tendency of tab to creep.

**6.** Remove trim tab bender (1) from main rotor blade.

**7.** Repeat steps 2. through 6. on opposite blade by bending an equal amount in opposite direction unless a small move is required as described in preceding example.

### 18-47. TROUBLESHOOTING — RADS-AT EQUIPMENT.

For troubleshooting RADS-AT refer to table 18-3.

### 18-48. TROUBLESHOOTING CRITERIA — MECHANICAL AND MAIN ROTOR SMOOTHING.

RADS-AT specifies minimum moves required to achieve target 1/rev levels. Indications are not limit levels but only a target used by RADS-AT to perform analysis. The level of 1/rev vibrations that is acceptable is up to operators direction. Helicopter shall be in good mechanical order for effective troubleshooting.

**NOTE**

Although 1/rev vibrations are considered a ride quality issue only, (not a wear or fatigue problem) sudden changes in level of main rotor 1/rev vibrations should not be ignored. Should any sudden changes in 1/rev vibrations appear, a thorough inspection of main rotor blades, hub and blades assembly, and hub control components should be performed as soon as possible.

**1.** Refer to table 18-4 for vibration criteria.

**2.** Refer to table 18-5 for troubleshooting procedures of main rotor 1/rev vibrations.

**3.** If acceptable level of 1/rev vibrations cannot be obtained using table 18-4 refer to paragraph 18-49 for general vibration troubleshooting.

### 18-49. TROUBLESHOOTING — GENERAL VIBRATION.

The following procedures are used to isolate an unknown vibration and to identify its source. Provided with the RADS-AT, 206A/B series software is a flight plan titled “SPECTRUM” with a 100 Hz spectrum for accelerometer and a 1000 Hz spectrum for accelerometer channels one through four. One to four accelerometers can be installed at locations of operators choosing. Data can be collected and spectrum or spectra reviewed to determine source of vibrations. 100 Hz conditions are used to troubleshoot high frequency vibrations from driveshafts and engines.

### 18-50. Installation RADS-AT for Vibration Troubleshooting.

**1.** Identify location or source of vibration and at what test condition vibration is felt.

**2.** Mount one or more 28110900 accelerometers as close to location of vibration as possible using standard or locally fabricated brackets. Orientation of accelerometer should be in direction in which vibration is felt.

EXAMPLE: Vibrations felt at copilot heel rest will be felt in vertical direction, and vibrations felt in pedals will be felt in fore-and-aft direction due to orientation of feet.

**Table 18-3. RADS-AT troubleshooting chart**

| PROBLEM | CAUSE | SOLUTION |
|---|---|---|
| Adjustments do not reduce 1/REV | Improper accelerometer installation | Refer to appropriate section in this manual for proper installation |
| Data is not stored when flight condition is completed | Operator pressing “QUIT” before data is stored | Do not press “QUIT” unless it is to clear a warning or leave the list of test conditions |
| Accelerometer saturation | Soft accelerometer bracket | Install thicker bracket |
| | Damaged accelerometer cable | Replace cable |
| | Failed accelerometer | Replace accelerometer |
| Tacho Failure | Magnetic sensor gap too wide | Adjust gap minimum is 0.025 inch (0.64 mm) maximum 0.07 inch (1.78 mm) |
| | Damaged magnetic sensor cable | Replace cable. Ensure proper connections. |
| Track failures or obviously bad track data | Wrong tracker angle | Set tracker as shown in appropriate section |
| | Bright blade leading edge | Paint leading edge blade color |
| | Corruption by sun | Install sunshield |
| Tacho out-of-bounds when checking tail rotor or driveshaft | Photocell tape not in correct position | Lengthen tape; ensure red light is on the photocell when rotor is flapped |
| | Corruption by sun | Orient aircraft so photocell is not pointing at sun for tail rotor |
| CADU will not communicate with DAU | DAU not receiving power | Check DAU switch and aircraft 28 Vdc circuit breaker |
| | Shorted tracker cable | Remove tracker cable. If problem is solved replace or repair tracker cable |

**Table 18-4. Vibration criteria main rotor**

| SOURCE | IDENTIFICATION | LEVEL – IPS | RECOMMENDED ACTION |
|---|---|---|---|
| MAIN ROTOR 1/REV | HOVER, 60 AND 110 KTS | LEVEL < 0.2 | NONE |
| | | 0.2 < LEVEL < 0.5 | HELICOPTER SERVICEABLE. REDUCE AT CUSTOMER OPTION. |
| | | 0.5 < LEVEL < 1.0 | CORRECT WHEN PRACTICAL. |
| | | 1.0 < LEVEL | REMOVE HELICOPTER FROM SERVICE; CORRECT PRIOR TO NEXT FLIGHT. |

**Table 18-5. Vibration troubleshooting chart**

| AIRCRAFT PROBLEM | PROBABLE CAUSE | SOLUTION |
|---|---|---|
| Vertical 1/ rev in hover | Static stop shimming | Inspect static stop and correct shimming |
| | Swashplate uniball friction low | Check friction on uniball. Refer to BHT-206A/B-Series-CR&O for corrective action |
| | Excessive looseness in swashplate assembly | Check swashplate pins, sliders, and sleeve bearings for looseness. Replace worn components to tighten swashplate (Refer to Chapter 62) |
| Vertical 1/rev only at low speeds | Mismatched blades | Swap blades to verify vertical follows blades (look for a 180 phase shift). Replace one blade |
| Excessive lateral 1/rev | Rotor blade out-of-balance | Balance rotor; if insufficient balance exists, check blade for water intrusion or excessive paint buildup. |

**Table 18-5. Vibration troubleshooting chart (Cont)**

| AIRCRAFT PROBLEM | PROBABLE CAUSE | SOLUTION |
|---|---|---|
| Buzz in controls; airframe | Tail rotor out-of-balance | Check tail rotor balance; correct if required. |
| | Dirty oil cooler fan | Check and clean oil cooler fan |
| | Driveshaft imbalance | Inspect hanger bearings. Replace worn bearings. Inspect driveshafts for lost balance weights; replace any shaft that has lost a weight or shows other signs of damage. Index tail rotor drivetrain aft of oil cooler. |
| High vertical 2/rev in cabin | Worn pylon mount | Inspect pylon mount; replace degraded mounts. |
| | Worn transmission support bearings | Check pylon mount and “A” frame bearings for freeplay; replace all worn bearings. |
| | Degraded landing float gear isolation spring supports | Inspect gear support; replace failed or worn components. |
| | Baggage compartment loading | Redistribute load in baggage compartments. |
| High 4/rev in cabin | Instrument panel | Inspect instrument panel and pedestal for degradation; repair cracks and tighten attachments. |

**3.** Connect each accelerometer to channel on DAU using an accelerometer cable. Record which accelerometer is connected to each channel.

**4.** Secure cables clear of controls or rotating components and engine exhausts.

**5.** Connect 29325601 communications cable to CADU port on DAU and connect opposite end to CADU.

**6.** Connect chord 29104700, 28 Vdc power cable to 28 Vdc outlet on side of instrument pedestal and connect opposite end of chord to 28 Vdc port of DAU.

**7.** Turn power switch ON.

**8.** Troubleshoot helicopter vibration (paragraph 18-51).

**18-51. Troubleshooting Data Acquisition.**

**1.** Operate helicopter. Refer to applicable JetRanger Flight Manual.

**2.** Verify RADS-AT equipment is installed in accordance with paragraph 18-40.

**3.** Select “206A/B” as aircraft type on CADU main menu.

**4.** Select tail number for helicopter to be tested.

**5.** Select “SPECTRUM” as flight plan on CADU menu.

**6.** Verify CADU screen display for proper configuration (figure 18-31).

**7.** Press F1 to initiate measuring sequence. Once F1 has been selected, four conditions will be displayed on CADU screen at which data can be collected. Data can be obtained on one, all, or any combination of channels.

**8.** Operate helicopter at test condition at which vibration complaint was noted.

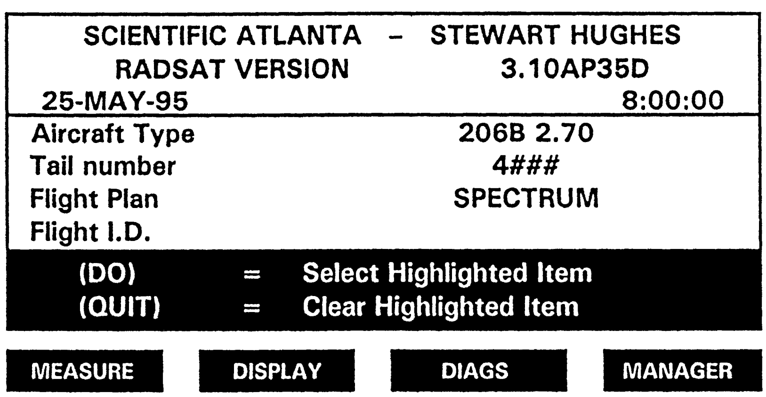


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**Figure 18-31. CADU main menu display for conducting "SPECTRUM" mode**

# TAIL ROTOR TRACKING AND BALANCING

## 18-52. TAIL ROTOR TRACKING AND BALANCING.

### 18-53. TAIL ROTOR TRACKING AND BALANCING.

This section describes the balancing of tail rotor to reduce tail rotor 1/rev vibration. The following procedures utilize the RADS-AT system and permit, with the use of an extra accelerometer and 50 foot cable, balancing the tail rotor at the same time as the main rotor using the INITIAL flight plan. Tail rotor components may also be balanced without main rotor balancing components installed.

**NOTE**

If using other manufacturer balancing equipment, such as Chadwick-Helmuth balance/analyzer, refer to the appropriate operators manual and figure 18-32.

### 18-54. TAIL ROTOR BALANCING RADS-AT — INSTALLATION.

**SPECIAL TOOLS REQUIRED**

| NUMBER | NOMENCLATURE |
|---|---|
| 29333301 | Basic RADS-AT kit |
| 29335500 | 206A/B Series adapter kit |
| 206-215-001-101 or Equivalent | Trim tab bender |
| 206-251-002-101 or Equivalent | Trim tab gage |
| 44 Caliber lead shots | Span balance weights |
| 206-011-157-101 | Chord balance weights |
| 206-011-157-103 | Chord balance weights |
| 206-011-157-105 | Chord balance weights |
| 29328200 | Data acquisition unit (DAU) (included in basic RADS-AT kit) |
| 29314101 | Control and data unit (CADU) |
| 28110900 | Accelerometers (3 total) |
| 29314700 | Optical rpm sensor |
| 29220330 | Optical tracking bracket |
| 29313000 | Accelerometer bracket |
| 29105600 or 29105605 | Accelerometer cable 50 foot (additional) |
| 29313000 or Chadwick-Helmuth 6752 | Accelerometer bracket |
| 29338500A or 29338501 | Optical pickup bracket |
| 29136100 | Magnetic rpm sensor bracket |
| 27288400 | Magnetic rpm sensor |
| 29216300 | Magnetic interrupter |
| 29105403 | Magnetic sensor cable |
| 29726800 or 29338900 | Universal tracking device (UTD) bracket |
| 29325701 | Tracker cable |
| 29722100 | Sunprotector |
| 29325601 | Cable 10 foot |
| 29104700 | Power Cable |
| 29317100 | Power adapter cable |

To balance the tail rotor assembly, install the RADS-AT as follows:

**1.** Install the DAU in aft cabin with connectors up.

**2.** Attach the 29314700 optical rpm sensor to the 29338500A or 29338501 tail rotor optical rpm sensor bracket with #440 self-locking nuts. Ensure lens is next to the vertical leg of pickup bracket (figure 18-33)

**3.** Remove the bottom forward screw of the 90 degree gearbox fairing. Use a longer screw and install the photocell bracket. Ensure that the photocell points forward and the lens points at the tail rotor (figure 18-33).

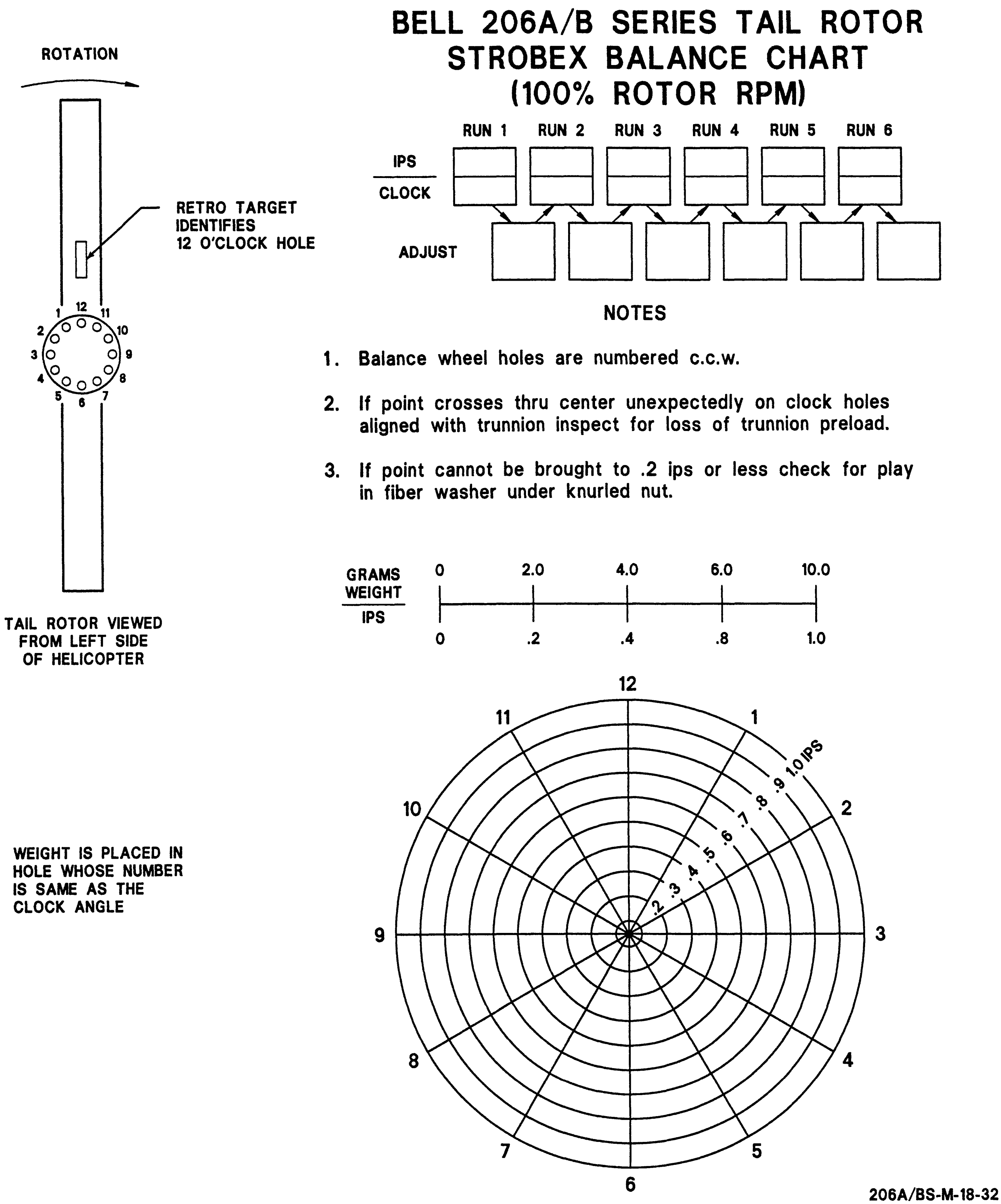


Figure 18-32. Tail rotor balance chart

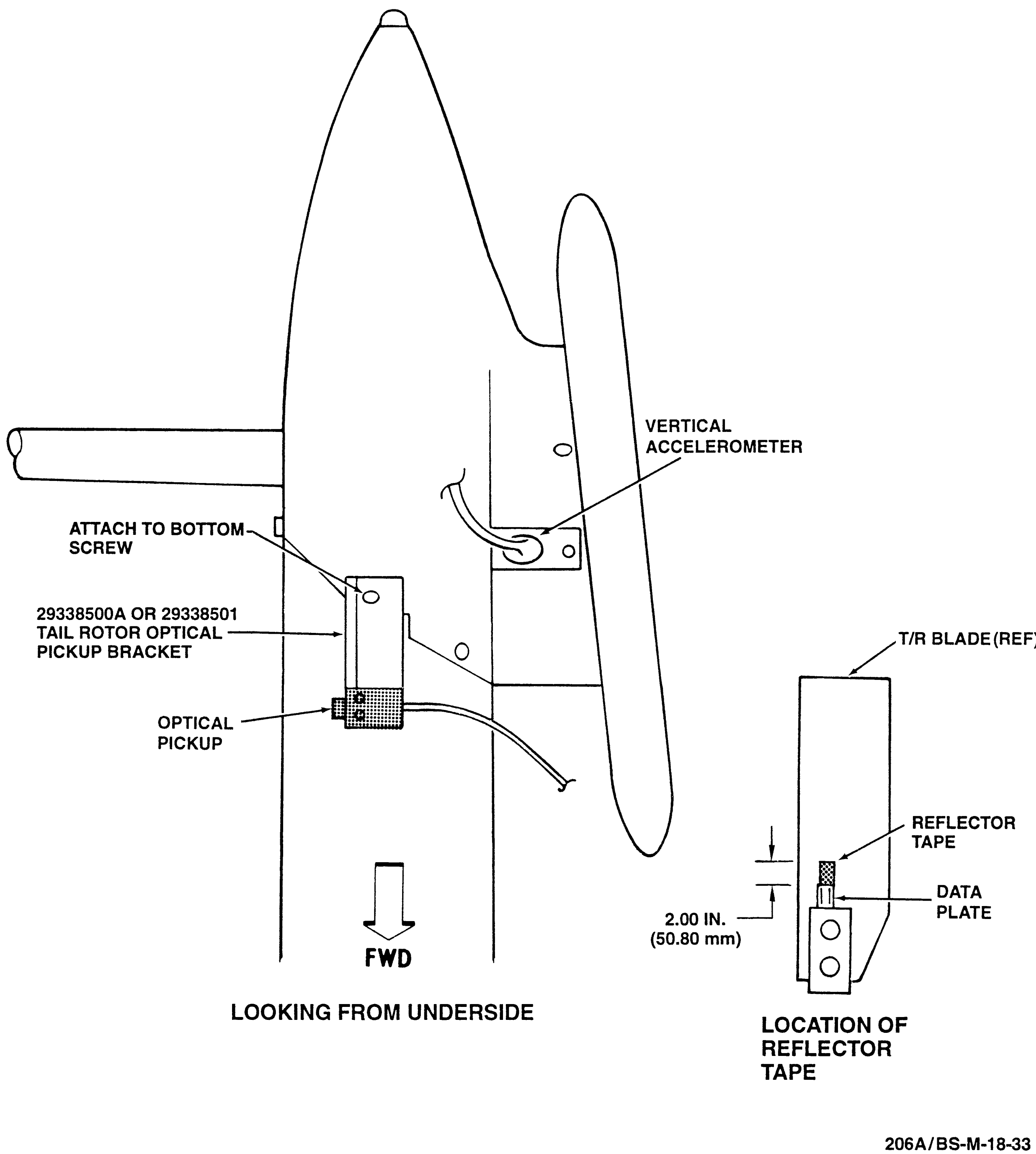


Figure 18-33. RADS-AT installation for tail rotor tracking

**4.** Insert the 28110900 accelerometer into hole on side of the photocell bracket. Ensure the cable connector points toward tail rotor. Attach accelerometer with a self-locking nut.

**CAUTION**

LEAVE A LARGE LOOP IN THE 50 FOOT ACCELEROMETER CABLE, TO MAKE SURE IT STAYS LOOSE. THIS WILL PREVENT INTERNAL DAMAGE TO CABLE.

**5.** Connect accelerometer end of the 29105600 50 foot accelerometer cable to tail rotor accelerometer.

**6.** Install optical rpm sensor cable and the 29105600 or 29105605 50 foot accelerometer cable along side of tailboom opposite the tail rotor. Install two cables from tailboom to the flight compartment. Safety both cables to the tailboom. This ensures that none of the cables can get caught in helicopter components that rotate and the cables do not block the photocell lens.

**7.** On the DAU, connect the optical rpm sensor cable to TACHO #2. Connect the 27105600 or 29105605 50 foot accelerometer cable to CH 4 (**figure 18-33**).

**8.** Connect the 29104700 28 Vdc power cable to the 28 Vdc outlet on the left side of the instrument pedestal near the copilot cyclic control stick. Connect the other end of the 28 Vdc power cable to the 28 Vdc port on the DAU (**figure 18-33**).

**9.** Connect the 29325601 cable from the CADU to the CADU port on the DAU (**figure 18-34**).

**10.** Cut two pieces of reflective tape (tape) (**C-483**) 2.5 inches (63.50 mm) long by 1 inch (25.40 mm) wide. Install one piece of tape on tailboom side of tail rotor blade. Start 2 inches (50.80 mm) outboard of outer blade bolt (**figure 18-32**). This is the target blade. A counterweight, install second piece of tape on the opposite tail rotor blade at same location, but on the side of blade that is away from the tailboom.

**11.** Apply power to the DAU. Slowly rotate tail rotor. Monitor red light on back of the optical rpm sensor. It should stay off until the reflector is seen by the sensor. When the sensor sees the reflector, the red light should come on. Flap tail rotor to ensure light stays on for the entire flapping range. If light does not come on or does not stay on, do the troubleshooting steps that follow:

**a.** Ensure that the optical rpm sensor is getting power.

**b.** Adjust reflector until red light comes on. The photocell should be located in such a way that it is opposite to center of the piece of reflective tape (**C-483**).

**12.** The RADS-AT is now installed and ready to balance the tail rotor (**figure 18-33**).

## 18-55. TAIL ROTOR — BALANCE.

Collect the tail rotor balance data and balance the tail rotor as follows:

**1.** With the RADS-AT installed, select 206A/B as the AIRCRAFT TYPE on the CADU main menu.

**2.** Set or create the tail number for the helicopter.

**3.** Use Tail as the flight plan. When the CADU is correctly set for the Tail flight plan, the CADU display is as shown in **figure 18-35**.

**4.** Begin the measuring sequence, press F1. The test condition title for which data will be taken shows on the display (100% Tr).

**5.** Put cyclic control stick in center position and ensure the collective control stick is all the way down. Press the directional pedals to the left 1.5 inches (38.10 mm). Operate helicopter as close to 100% rpm as possible. On CADU, the 100% Tr test condition is highlighted. Press the “DO” button to arm the RADS-AT. If all internal checks are successful, the test condition title will appear at bottom of the display and the system is armed to collect data. When all data is collected, the RADS-AT shows the test is completed. Select FINISH. Select DIAGNOSTICS to review the tail rotor 1/rev levels. Make a decision whether any adjustments are required. If a TACHO error occurs during data collection, do the test again at least two times. If the TACHO error still occurs, do the steps that follow:

**a.** Shut down the helicopter.

**b.** Inspect reflective tape (**C-483**) and ensure it is still in place and that it is still clean. If necessary, replace tape.

**c.** With power supplied to the DAU, ensure red light on back of optical rpm sensor comes on when reflector is in front of the optical sensor.

**d.** Ensure the optical rpm sensor is connected to TACHO #2 port.

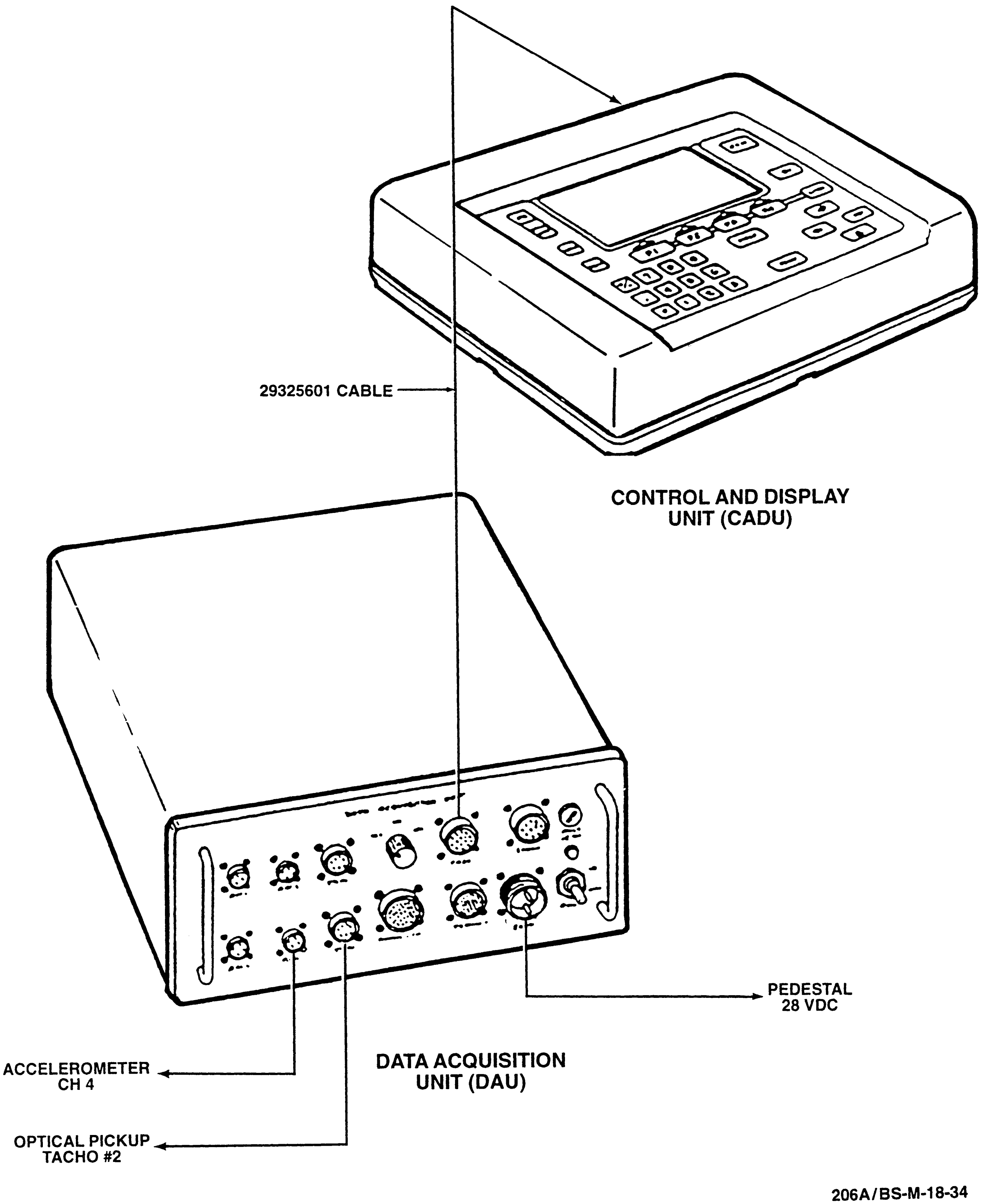


Figure 18-34. RADS-AT Installation for Tail Rotor Balancing

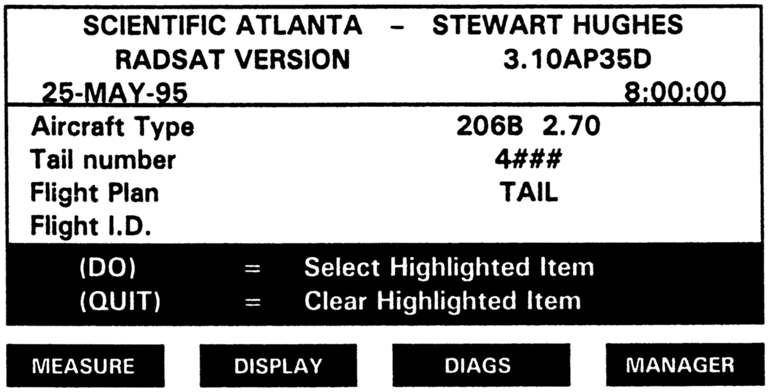


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Figure 18-35. CADU Main Menu Display “TAIL” Plan

**e.** If all of the preceding is correct, and if red light still does not come on, remove clear cover from the optical RPM sensor. Gently turn the brass screw clockwise to increase gain until you feel a slight click. With optical RPM sensor pointing at the reflector, the red light should come on during this step. Install the clear plastic cover.

**6.** If tail rotor balance is satisfactory, go to paragraph 18-56. If it is necessary to balance the tail rotor, record the recommended adjustments on a copy of the tail rotor adjustment log (Figure 18-36).

**NOTE**

The RADS-AT is operating on set limits of 0.2 IPS for the tail rotor balance. If you want to decrease the level to below 0.2 IPS, press the DO button on the LIMITS display. The RADS-AT shows the adjustments that are required to get a 0.0 IPS balance.

**7.** Do the previous step 1 through step 6 again until the tail rotor is balanced (Table 18-6).

## 18-56. TAIL ROTOR BALANCE — ADJUSTMENTS

**1.** Review adjustments recorded on adjustment log (Figure 18-36).

**NOTE**

Tail rotor balance weights are in grams (Figure 18-32).

Always replace previously used nuts with new nuts.

Positive (+) adjustment means to add weight and negative (–) adjustment means to remove weight. Remove weights whenever possible.

**2.** If weight is not present where RADS-AT indicated, then remove weight from opposite location.

**a.** Adjust tail rotor balance as follows:

**(1)** To adjust tail rotor balance weights, identify the location on balance wheel (3, Figure 18-37).

| Ship Type: |
| --- |
| Ship S/N: |

| FLIGHT ID | LOCATION | MOVE | COMMENTS |
| --- | --- | --- | --- |
| | 12:00 | | |
| | 3:00 | | |
| | 6:00 | | |
| | 9:00 | | |

| FLIGHT ID | LOCATION | MOVE | COMMENTS |
| --- | --- | --- | --- |
| | 12:00 | | |
| | 3:00 | | |
| | 6:00 | | |
| | 9:00 | | |

| FLIGHT ID | LOCATION | MOVE | COMMENTS |
| --- | --- | --- | --- |
| | 12:00 | | |
| | 3:00 | | |
| | 6:00 | | |
| | 9:00 | | |

FINAL SETTINGS

| LOCATION | MOVE |
| --- | --- |
| 12:00 | |
| 3:00 | |
| 6:00 | |
| 9:00 | |

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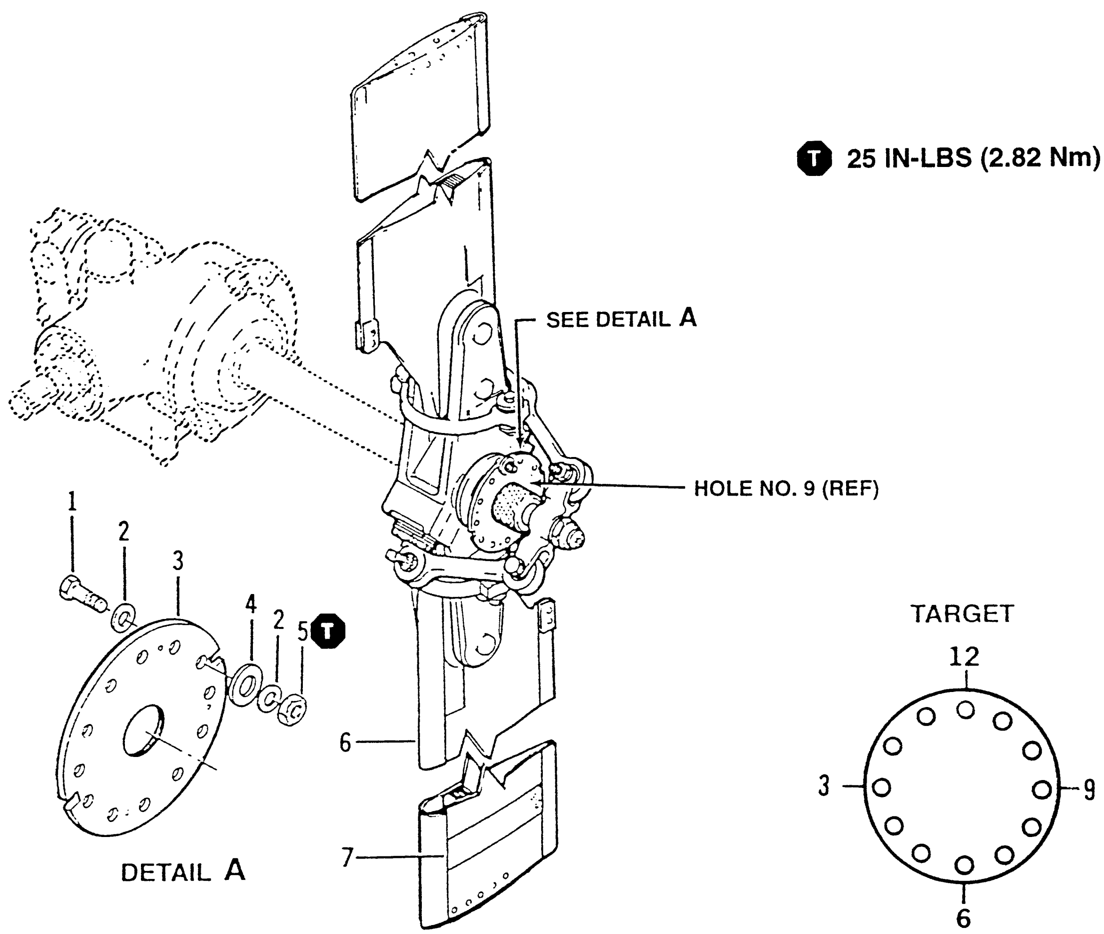
Figure 18-36. Tail rotor adjustment log




1. AN3-4A thru -7A Bolt
2. AN960-10 washers
3. Balance wheel
4. AN970-3 washers
5. MS21042L3 nut
6. Tail rotor blade
7. Balance strip (masking tape)

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Figure 18-37. Tail rotor balancing

**Table 18-6. Tail rotor balance criteria**

| | | | |
|---|---|---|---|
| TAIL ROTOR 1/REV | TAILBOOM LATERAL AT 100% RPM | LEVELS < 0.2 | NO ACTION RECOMMENDED |
| | | 0.2 < LEVELS < 0.6 | LEVELS SERVICEABLE, REDUCE AT CUSTOMER OPTION. NO ACTION REQUIRED |
| | | 0.6 < LEVELS | REDUCE AS SOON AS PRACTICAL |

**NOTE**

A maximum of three washers may be used per hole on balance wheel (3, figure 18-37). If maximum weight is insufficient to balance tail rotor, additional weight may be achieved by adding weight to the hole on either side of desired hole.

**(2)** Use weights in table 18-7 for balancing tail rotor to correct balance.

**(3)** When installing selected hardware, head of bolt (1) and one washer (2) shall be towards tail rotor, remaining washers (2 and 4) on side away from tail rotor.

## 18-57. TASKS TO BE ACCOMPLISHED AFTER BALANCING TAIL ROTOR.

When tail rotor tracking and/or balancing is complete, accomplish the following:

**1.** Remove the RADS-AT components from the helicopter.

**2.** Attach the gearbox fairing with new bolts.

**3.** Apply corrosion preventive compound (C-104) to the shank of any new bolts. Ensure corrosion preventive compound is not applied to threads.

**4.** Replace all nuts which have lost their self-locking torque. Tighten nuts to applicable torque values.

**5.** Apply corrosion preventive compound (C-101), to bolts, nuts, and the weight packages.

## 18-58. GENERAL VIBRATION TROUBLESHOOTING — PURPOSE.

This section explains how to isolate the source of an unknown vibration (table 18-8).

## 18-59. GENERAL VIBRATION TROUBLESHOOTING RADS-AT — INSTALLATION.

**1.** Look at the complaint. Decide at which location for which test condition the problem vibration is felt (table 18-9).

**2.** Attach one or more accelerometers as close to location of the problem vibration as possible. Use either standard or locally made brackets. Point accelerometer in the direction where vibration is felt. For example: vibration that is felt at the copilot heel rest will be in the vertical direction, while vibration that is felt in the pedals will be in the fore and aft direction, due to orientation of feet.

**3.** Use accelerometer cables and connect each accelerometer to a channel on the DAU. Make a note of which accelerometer is connected to which channel.

**Table 18-7. Balance hardware for tail rotor**

| PURPOSE | DESCRIPTION | PART NO. | WEIGHT (GRAMS) | QUANTITY |
|---|---|---|---|---|
| BALANCE WHEEL | BOLTS | AN3-4A | 3.36 | A/R |
| | | AN3-5A | 3.73 | A/R |
| | | AN3-6A | 4.41 | A/R |
| | | AN3-7A | 4.60 | A/R |
| | WASHERS | AN960-10 | 0.87 | A/R |
| | | AN970-3 | 4.57 | A/R |
| | NUT | MS21042L3 | 0.8 | A/R |

**Table 18-8. Vibration troubleshooting chart**

| AIRCRAFT PROBLEM | PROBABLE CAUSE | SOLUTION |
|---|---|---|
| Vertical 1/ rev in hover | Static stop shimming | Inspect static stop and correct shimming |
| | Swashplate uniball friction low | Check friction on uniball. Refer to appropriate MM for corrective action |
| | Excessive looseness in swashplate assembly | Check swashplate pins, sliders, and sleeve bearings for looseness. Replace worn components to tighten swashplate (Refer to Chapter 62) |
| Vertical 1/rev only at low speeds | Mismatched blades | Swap blades to verify vertical follows blades (look for a 180 phase shift). Replace one blade |
| Excessive lateral 1/rev | Rotor blade out-of-balance | Balance rotor; if insufficient balance exists, check blade for water intrusion or excessive paint buildup. |

**Table 18-8. Vibration troubleshooting chart (Cont)**

| AIRCRAFT PROBLEM | PROBABLE CAUSE | SOLUTION |
|---|---|---|
| Buss in controls, airframe | Tail rotor out-of-balance | Check tail rotor balance, correct if required |
| | Dirty oil cooler fan | Check and clean oil cooler fan |
| | Driveshaft imbalance | Inspect hanger bearings, replace worn bearings. Inspect driveshaft for lost balance weights, replace any shaft that has lost a weight or shows other signs of damage. Index tail rotor drivetrain aft of oil cooler |
| High vertical 2/rev in cabin | Worn pylon mount | Inspect pylon mount, replace degraded mounts |
| | Worn transmission support bearings | Check pylon mount and “A” frame bearings for freeplay, replace all worn bearings |
| | Degraded landing float gear isolation spring supports | Inspect gear support, replace failed or worn components |
| | Baggage compartment loading | Redistribute load in baggage compartment |
| | Nodal Beams Degraded | Inspect Nodal Beams and replace worn or failed components. |
| High 4/rev in cabin36 | Instrument panel | Inspect instrument panel and pedestal for degradation; repair cracks and tighten attachments |

**4.** Secure cables so they cannot touch the controls or get caught in the components that rotate while the helicopter operates. Ensure the cables are clear of the engine exhaust.

**5.** Connect one end of 29325601 communications cable to the CADU. Connect other end to the CADU port on DAU.

**6.** Connect 29104700 28 Vdc power cable to 28 Vdc outlet on the left side of instrument pedestal near the copilot cyclic control stick. Connect the other end of the 28 Vdc power cable to the 28 Vdc port on the DAU. Set the power switch to the ON position.

**7.** The RADS-AT is not installed and ready to troubleshoot the vibration.

**Table 18-9. RADS-AT troubleshooting chart**

| PROBLEM | CAUSE | SOLUTION |
|---|---|---|
| Adjustments do not reduce 1/REV | Improper accelerometer installation | Refer to appropriate section in this manual for proper installation |
| Data is not stored when flight condition is completed | Operator pressing "QUIT" before data is stored | Do not press "QUIT" unless it is to clear a warning or leave the list of test conditions |
| Accelerometer saturation | Soft accelerometer bracket | Install thicker bracket |
| | Damaged accelerometer cable | Replace cable |
| | Failed accelerometer | Replace accelerometer |
| Tacho Failure | Magnetic sensor gap too wide | Adjust gap minimum is 0.025 inch (0.64 mm) maximum 0.07 inch (1.78 mm) |
| | Damaged magnetic sensor cable | Replace cable. Ensure proper connections. |
| Track failures or obviously bad track data | Wrong tracker angle | Set tracker as shown in appropriate section |
| | Bright blade leading edge | Paint leading edge blade color |
| | Corruption by sun | Install sunshield |
| Tacho out-of-bounds when checking tail rotor or driveshaft | Photocell tape not in correct position | Lengthen tape; ensure red light is on the photocell when rotor is flapped |
| | Corruption by sun | Orient aircraft so photocell is not pointing at sun for tail rotor |
| CADU will not communicate with DAU | DAU not receiving power | Check DAU switch and aircraft 28 Vdc circuit breaker |
| | Shorted tracker cable | Remove tracker cable. If problem is solved replace or repair tracker cable |

## 18-60. VIBRATION DATA — COLLECTING

**1.** With the RADS-AT installed (paragraph 18-47), select 206A/B as the HELICOPTER TYPE.

**2.** Set or create the tail number for the helicopter.

**3.** Use SPECTRUM as the flight plan. When the CADU is correctly set for the SPECTRUM flight plan to examine the general vibration levels, the CADU display is as shown in Figure 18-38.

**4.** To begin measuring sequence, press F1. The eight test conditions for which data can be collected are shown on the display. These test conditions indicate on which channel the data will be collected and for which frequency range. Data can be collected on one, all, or any combination of channels.

**5.** Operate helicopter at the test condition where vibration complaint was made.

**6.** Collect data for specified channel by selecting the test conditions with arrow keys and press the “DO” button. Repeat until all data has been collected.

**7.** After all data has been collected, shut down the helicopter.

**8.** On the CADU, select SAVE AND EXIT or FINISH. To look at the data, select MAIN MENU. Press F2 and select SINGLE TEST. Select test condition desired and press the “DO” button. Record magnitude and frequency of the significant peaks.

**9.** Refer to the frequency list in Table 18-1. Identify the source of the vibration for each peak. Inspect the source component for serviceability. Do the applicable balance or smoothing procedure for that source.

**10.** When completing test, remove all of the RADS-AT components from helicopter.

## 18-61. RADS-AT — TECHNICAL SUPPORT

For additional technical support information, refer to paragraph 18-62.

## 18-62. RADS-AT — AVAILABLE HELP

Information about this program and help using it can be obtained by contacting the following:

| | | |
|---|---|---|
| Product Support Engineering — Light Helicopters | | |
| Phone: | | 450-971-6407 |
| | USA/Canada | 800-363-8023 |
| | USA/Canada | 800-243-6407 |
| | Canada | 800-361-9305 |
| | International (call collect) | 450-437-2862 |
| Fax: | | 450-433-0272 |
| E-mail: | pselight@bellhelicopter.textron.com | |

## 18-63. RADS-AT — SCRIPT FILES

To obtain the latest script files, please refer to the Bell Helicopter Textron Service Directive web page at www.bellcustomer.com.

## 18-64. RADS-AT — SMITHS AEROSPACE

To obtain Smiths Aerospace assistance and contact information pertaining to sales, technical support, RADSCOM and repairs, please refer to www.smiths-aerospace.com.

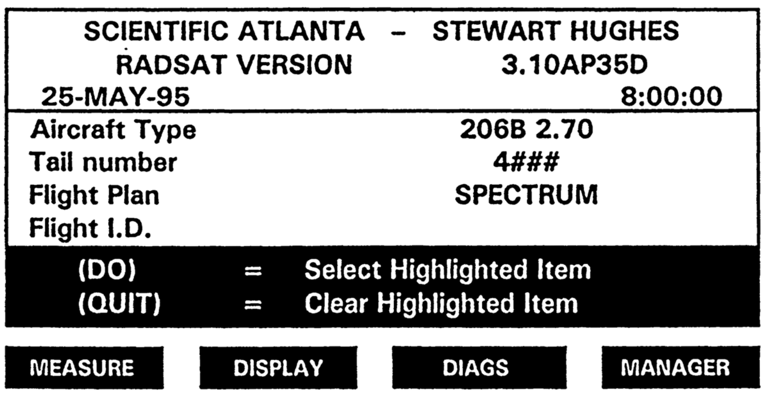


Figure 18-38. CADU Main Menu Display for Spectrum Mode