

CHAPTER 4

ALIGNMENT AND TRACKING PROCEDURES

This chapter discusses procedures required for alignment and balancing of rotor blades. Specific procedures for aligning blades vary with different types of helicopters. Prior to aligning blades, consult the appropriate technical manual for specific instructions and maximum allowable tolerance. This chapter also includes a description of the Vibrex balancing kit.

MAIN ROTOR BLADE ALIGNMENT

Main rotor blade alignment is the centering of the mass (distribution of weight) of the main rotor assembly across the center of rotation to balance it. The alignment of the rotor system has a distinct effect on balance because of the great weight and long arm involved. A greater weight on one side of the center of rotation will cause a lateral vibration. The requirement for manually aligning the main rotor blades applies to rigid and semirigid rotor systems only. The fully articulated rotor system automatically aligns itself as centrifugal force increases and pulls the blades into a pure radial position. The most common method of manually aligning main rotor blades is the telescope method.

A small bore rifle telescope is the basic tool used to align the main rotor assembly (Figure 4-1). A fixture to hold the telescope is fitted onto the hub directly over the center of rotation. A repairer should be concerned with the vertical cross hair only. Ignore the horizontal cross hair. Place a zeroed telescope in the holding fixture and sight the vertical cross hair on a reference point of the blade. The reference point normally used is a rivet in the skin at the tip of the blade in line with the feathering axis. Adjust a misaligned rivet by moving the blade in the hub to bring the rivet into alignment. Align the other (opposite) blade using the same procedure. Alignment of the main rotor assembly has been achieved when both blades have been adjusted so that the vertical cross hair of the telescope is positioned at the center of both rivets.

UNBALANCED SEMIRIGID ROTOR SYSTEMS**Lateral**

When troubleshooting a semirigid main rotor system, the repairer must understand the basics of alignment and balance to act quickly yet skillfully. An unbalanced system causes the most problems in the field. The trouble that results is called lateral vibration. A few indicators of lateral vibration are worn parts and bearings, broken parts and bearings, loose parts and fittings, and cracked parts and fittings. The repairer must determine if the unbalanced condition is caused by chordwise or spanwise torque before it can be corrected.

Chordwise

To differentiate between a chordwise and a spanwise unbalanced condition, apply a strip of tape to the tip of one blade and hover the helicopter. If the lateral vibration decreases and then increases, this indicates that spanwise balance is okay but chordwise unbalance exists. To balance a rotor system chordwise, select a blade and sweep it to the rear by shortening the drag brace. Before making adjustments, matchmark all drag brace parts so that they can be returned to the same setting to regain alignment. Hover the helicopter. Should the lateral vibration increase, you have selected the wrong blade. Return the drag brace to the original alignment as matchmarked. Repeat drag brace sweeping on the opposite blade. Make small sweep corrections until the vibration stops. Secure and safety the drag braces.

Spanwise

To isolate spanwise balance, apply a strip of 2-inch tape to the tip of one blade. Hover the helicopter. Should the vibration increase, the wrong blade has been selected. Remove the tape and apply it to the opposite blade. Add the tape one strip at a time until the vibration is gone. Then replace the tape with

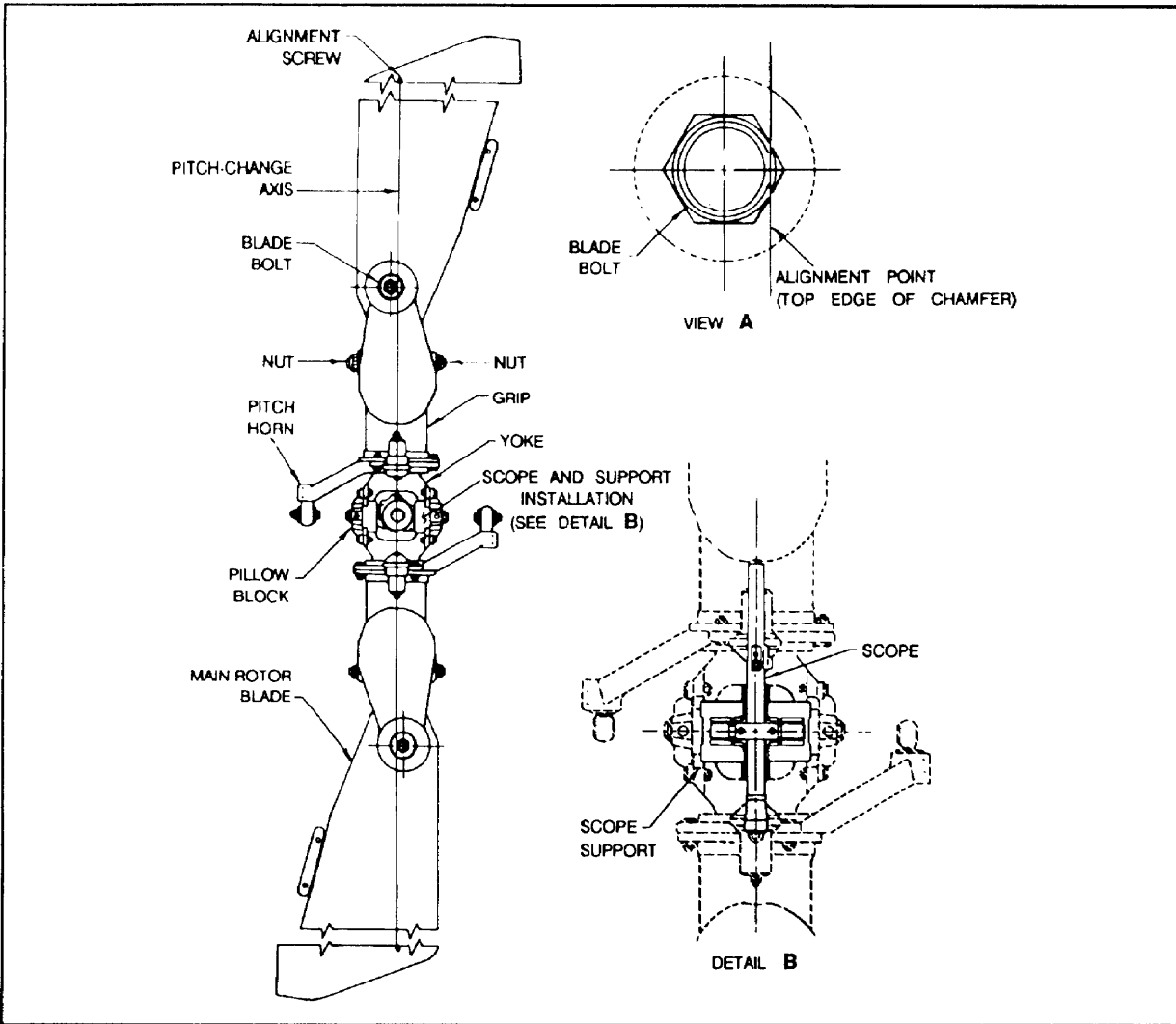


Figure 4-1. Telescopic method of alignment

equal weight or secure weight approximating equal moments at a specific location on the system. For example, apply a 3.1-ounce, lead-in retention bolt for each wrap of tape at the tip or as authorized in the applicable maintenance manual.

Combined

It is not unusual for a combined chordwise-spanwise unbalance to exist in a main rotor system. When the unit is balanced spanwise, the chordwise unbalance becomes evident. In this case, each unbalance must be corrected separately. If the system cannot be balanced by the above operations, inspect it for loose, worn, or cracked parts and for frozen Teflon bearings or ratcheting roller or ball bearings.

VERTICAL VIBRATIONS

Vertical vibrations – the bouncing of the helicopter up and down – are caused by a blade being out of track. Vibration is caused by a blade lifting the helicopter in one quadrant of rotation and suddenly losing lift in the remaining quadrant during cyclic travel. When present once during each revolution, this force is referred to as a one-per-revolution or 1-to-1 vibration. Two bounces of the fuselage is known as a two-per-revolution or 2-to-1 vibration.

Someone not familiar with the helicopter can determine vertical vibration by looking at the tips of the skids. A vertical vibration will cause the tip of the skid to bounce vertically against the ground. Depending on the shape of the main rotor and the

helicopter manufacturer, the vibration may be corrected. This is done by rolling the blade grips up or down using the pitch-change links or adjusting the trim tab to get a blade track that will stop the vibration. One method is to blade-track at low RPM using pitch-change links and at high RPM using trim tabs and links with power applied. The blades are tracked using a tracking flag or trackometer. The helicopter is then flown at cruise airspeed to see if blade crossover exists. Blade crossover occurs when blades are almost perfectly in track. During forward flight (cruise) dissymmetry of lift causes a blade to fly high through 180° of rotation and low in the remaining 180°. Corrections are made by adjusting either trim tab up or down to cause the blade to track high or low within limits. Crossover is corrected by the pressure exerted by the trim tab, which forces the blade up or down throughout 360° of rotation.

Extreme Low Frequency

Extreme low-frequency vibration is essentially limited to pylon rock. Pylon rocking of two or three cycles per second is inherent with the rotor, mast, and transmission systems. To keep the vibration from reaching noticeable levels, transmission mount dampers are installed to absorb the rocking. The damper system may be checked by the pilot while at a hover. Moving the cyclic control forward and backward at about one movement per second will cause the pylon to start rocking. How long it takes for the rocking to die out after the motion of the cyclic is stopped indicates the condition of the damper system.

Low Frequency

One-revolution and two-revolution vibrations are caused by the rotor. One-revolution vibrations are of two basic types: lateral and vertical. Low-frequency

vibration is started by a gust effect that causes a momentary increase of lift in one blade giving a one-revolution vibration. The momentary vibration is normal. However, if picked up by the rotating collective controls and fed back to the rotor causing cycles of one revolution, then it is undesirable. This condition is usually caused by too much differential tab in the blades. It can be corrected by rolling one blade at the grip and changing angular adjustment of the tab. Two-per-revolution (2/rev) vibrations are inherent with a two-bladed rotor system, and a low level of vibration is always present. When the 2/rev vibration rises to an unacceptable level, it is due to faulty vibration dampers or loose and worn hardware in the rotor system.

Medium Frequency

Medium-frequency vibrations at four to six per revolution are inherent with most rotor systems. An increase in the level of vibration is caused by a change in the capability of the fuselage to absorb vibration due to loose hardware, structural damage, or load. Normally this vibration is caused by loose parts – either a regular part of the aircraft or the external load.

High Frequency

High-frequency vibrations can be caused by anything in the ship that rotates or vibrates at a speed equal to or greater than that of the tail rotor. Unless the vibration is isolated to one part of the aircraft – under a shaft bearing, for example – the first step generally is checking the tail rotor track.

MAIN ROTOR BLADE TRACKING

Blade tracking (Figure 4-2) is the procedure for measuring, recording, and adjusting the tip path plane of the rotor blades. The measurements taken

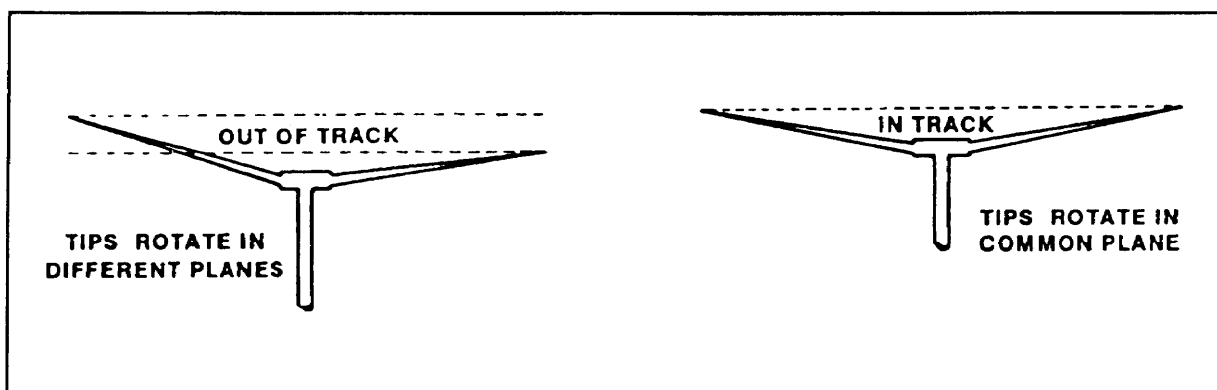


Figure 4-2. Blade tracking

while the blades are turning show the vertical position of the rotor blade tips in relation to each other. The positions of the blade tips must be kept within a certain tolerance, usually $\pm .25$ inch. Tolerance for each helicopter will be listed in the applicable maintenance manual. Several methods used to track blades are —

- Electronic blade tracker.
- Reflector tracking.
- Strobe light.

Electronic

Rotor blade assemblies may also be tracked with an electronic blade-tracking unit (Figure 4-3). The unit is made up of three major components:

- A phase detector with a magnetic pickup attached to the swash plate’s stationary ring and a sweep attached to its rotating ring.

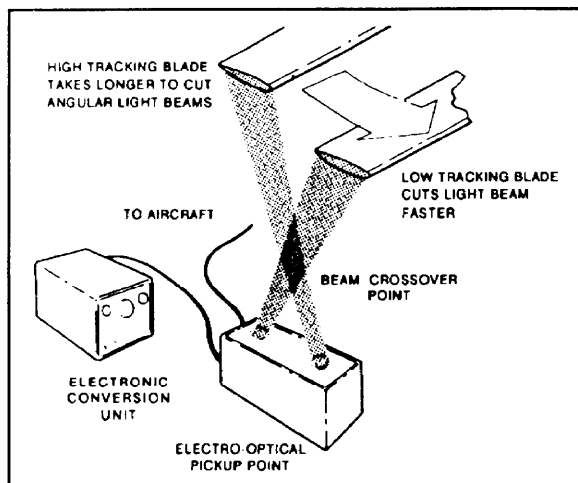


Figure 4-3. Electronic blade tracker

- A computer containing the electronic circuits, adjusting knobs, and meter.
- An electronic eye unit.

The electronic blade tracker unit permits blade tracking during adverse weather and at night. The electronic blade tracker is operated when the rotating rotor blades interrupt the electronic eye beam, sending a signal into the computer in conjunction with a signal from the phase detector. The computer then determines the blade tip path plane above an automatically selected reference plane. The meter shows the height in fractions of an inch of the rotor

blades in the set relative to the predetermined reference rotor blade. Refer to Figure 4-4 for an example.

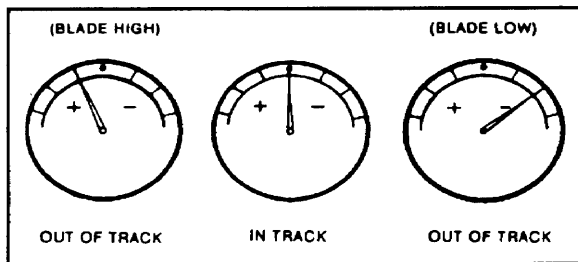


Figure 4-4. Electronic blade tracking — example

Reflector

The reflector tracking method uses the principle of persistence of vision, which occurs when looking at a beam that is being intercepted by two light reflectors. One reflector is installed at the tip of each main rotor blade. The surface of one reflector is plain white, and the surface of the other is white with a horizontal black stripe painted across the center of the face. As the blades rotate and the light beam is intercepted by the reflectors, the observer will see two white bands and one black band. One white band will be above and the other below the black band. A perfect in-track condition exists when both white bands are the same width. If one reflector image moves vertically relative to the other, one white band will become larger than the other. All tracking should be done at engine-rated RPM to obtain the best track (or as specified in the applicable repair manual). Refer to Figure 4-5 for an example.

Strobe Light

The strobe light blade-tracking system includes—

- A portable power supply.
- A hand-held strobe lamp.

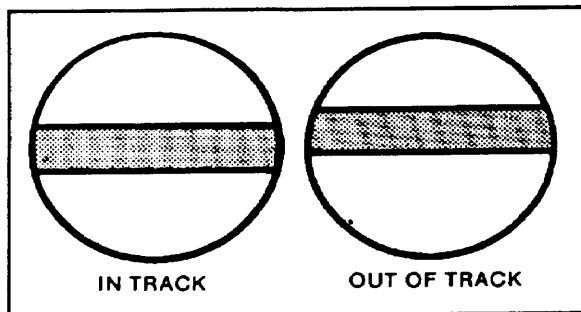


Figure 4-5. Reflector blade tracking — example

- Blade tip targets.
- Magnetic phase pickup.
- Pickup plates.

A concentrated parallel light beam from the strobe light is manually directed toward a predetermined spot on the rotor blade disc to strike the blade tip targets. The strobe light trigger switch is then depressed to allow strobing of the blade tip targets. The pulse signal for strobe effect is provided by the magnetic pickup unit mounted on the stationary swash plate ring. This strobe effect sends a pulse each time one of the pickup plates passes over the magnetic pickup unit. The pickup is mounted on each rotor blade pitch-change link lower attaching bolt. The strobe light targets are attached to the blade tips with patterns facing inboard. The targets have silver reflective tape with an identifying pattern for each blade (a straight line pattern on the red blade, a right-slanting pattern on the yellow blade, a left-slanting pattern on the green blade). When the single line of the master blade target is aligned axially with the centerline of the other blade targets, the system is in track. If one target image is displayed

vertically relative to the others, the colored lines of the affected blade target will become visible to the operator. Refer to Figure 4-6 for an example.

VIBREX BALANCING KIT

The Vibrex balancing kit (hereinafter referred to as Vibrex) is used to measure and indicate the level of vibrations induced by the main and tail rotors of a helicopter. The Vibrex analyzes the vibration induced by out-of-track or out-of-balance rotors. Then by plotting vibration amplitude and clock angle on a chart, it determines the amount and location of rotor track or weight changes. The Vibrex is also used in troubleshooting to measure the RPM or frequency of unknown disturbances. DA Pam 738-751 prescribes forms, records, and reports to be used by maintenance personnel at all levels.

The Vibrex is housed in a carrying case; it consists of the components detailed in Figure 4-7. The main units of the Vibrex are the Balancer/Phazor, 177M6A; the Strobex tracker, 135M11; and the Vibrex tester 11. Three accelerometers, 4177B, and two magnetic pickups, 303AN, are the primary airframe-mounted components.

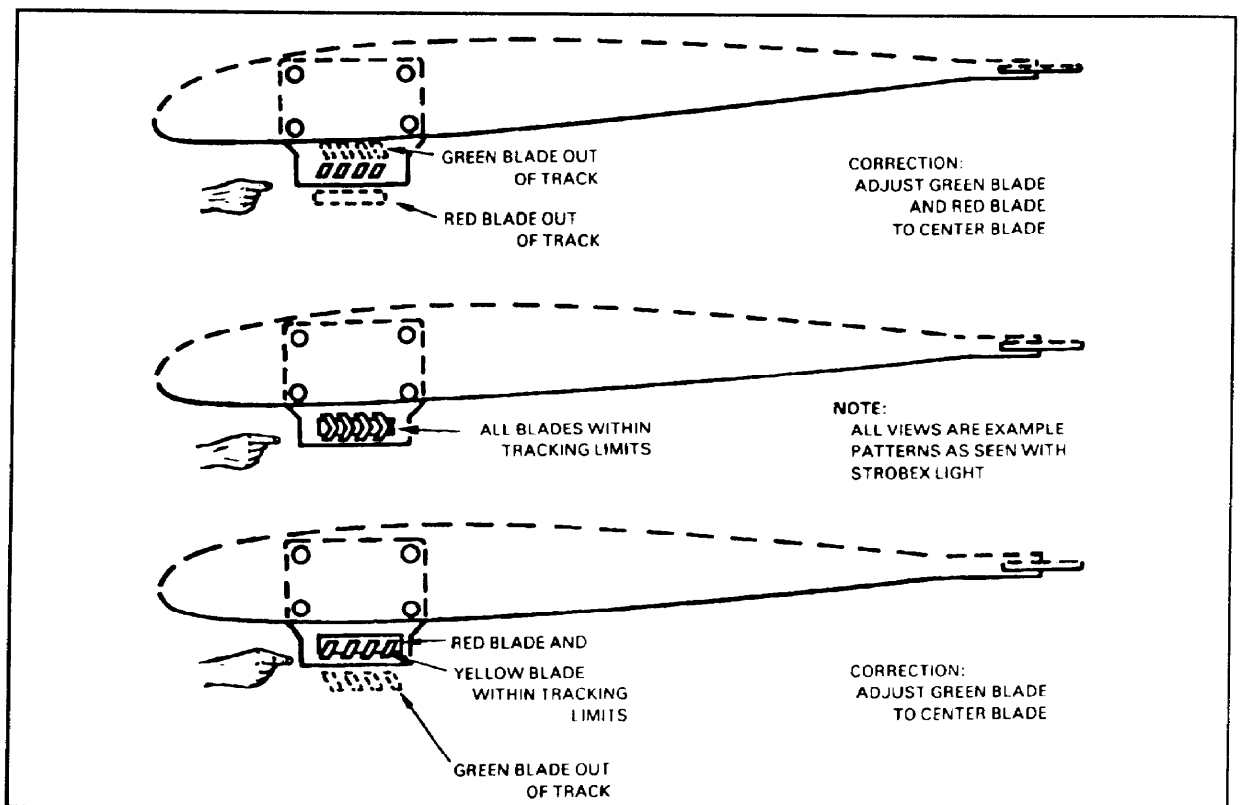
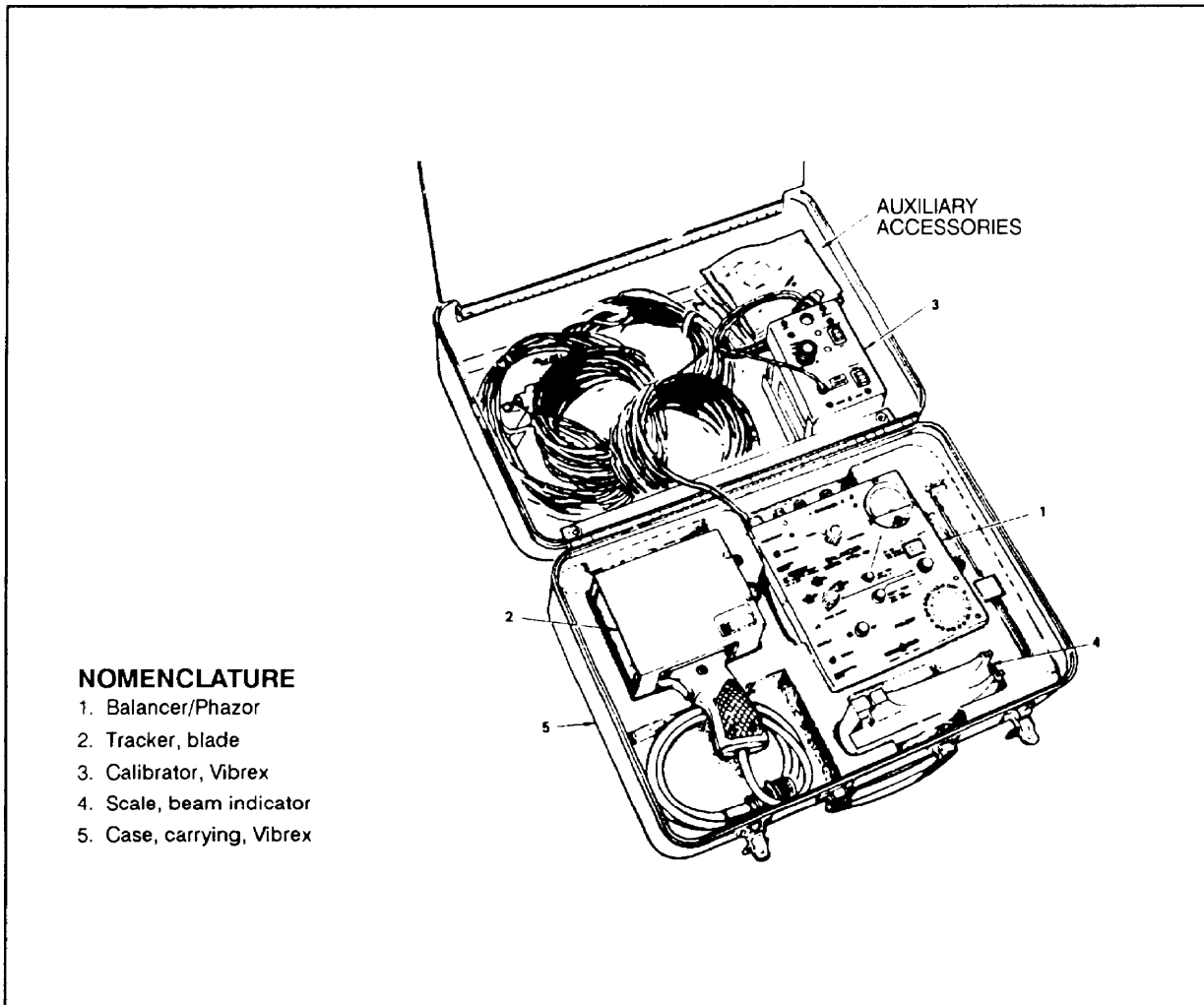


Figure 4-6. Strobe light blade tracking – example



NOMENCLATURE

- 1. Balancer/Phazor
- 2. Tracker, blade
- 3. Calibrator, Vibrex
- 4. Scale, beam indicator
- 5. Case, carrying, Vibrex

Figure 4-7. Vibrex balancing kit components

CAUTION

Use extreme care when operating the Vibrex test set. The unit contains delicate electronic components and assemblies that may easily be damaged if subjected to improper handling or physical abuse.

Balancer/Phazor, 177M6A

The key feature of the Balancer/Phazor (hereinafter referred to as a balancer) is a tunable, electronic hand-pass filter which is tuned to reject all but the one frequency or vibration under study (Figure 4-8). The meter reads the level of vibration at the rate (RPM) of concern, which indicates the amount of the required change (track or balance). The Phazor

section contains a phase meter that reads clock angle, or phase angle, between a one-per-revolution magnetic pickup azimuth signal from the rotor and a vibration signal from the accelerometer.

Strobex Tracker, 135M11

The Strobex tracker (hereinafter referred to as a Strobex) is a small hand-held, lightweight, combination power supply and strobe flash tube (Figure 4-9). It illuminates reflective targets on the tail rotor to measure tail rotor clock angle and on the main rotor to indicate rotor track and lead-lag.

Vibrex Tester 11

The Vibrex tester (hereinafter referred to as a tester) provides accurate calibration and a complete functional check of the Vibrex (Figure 4-10). The tester

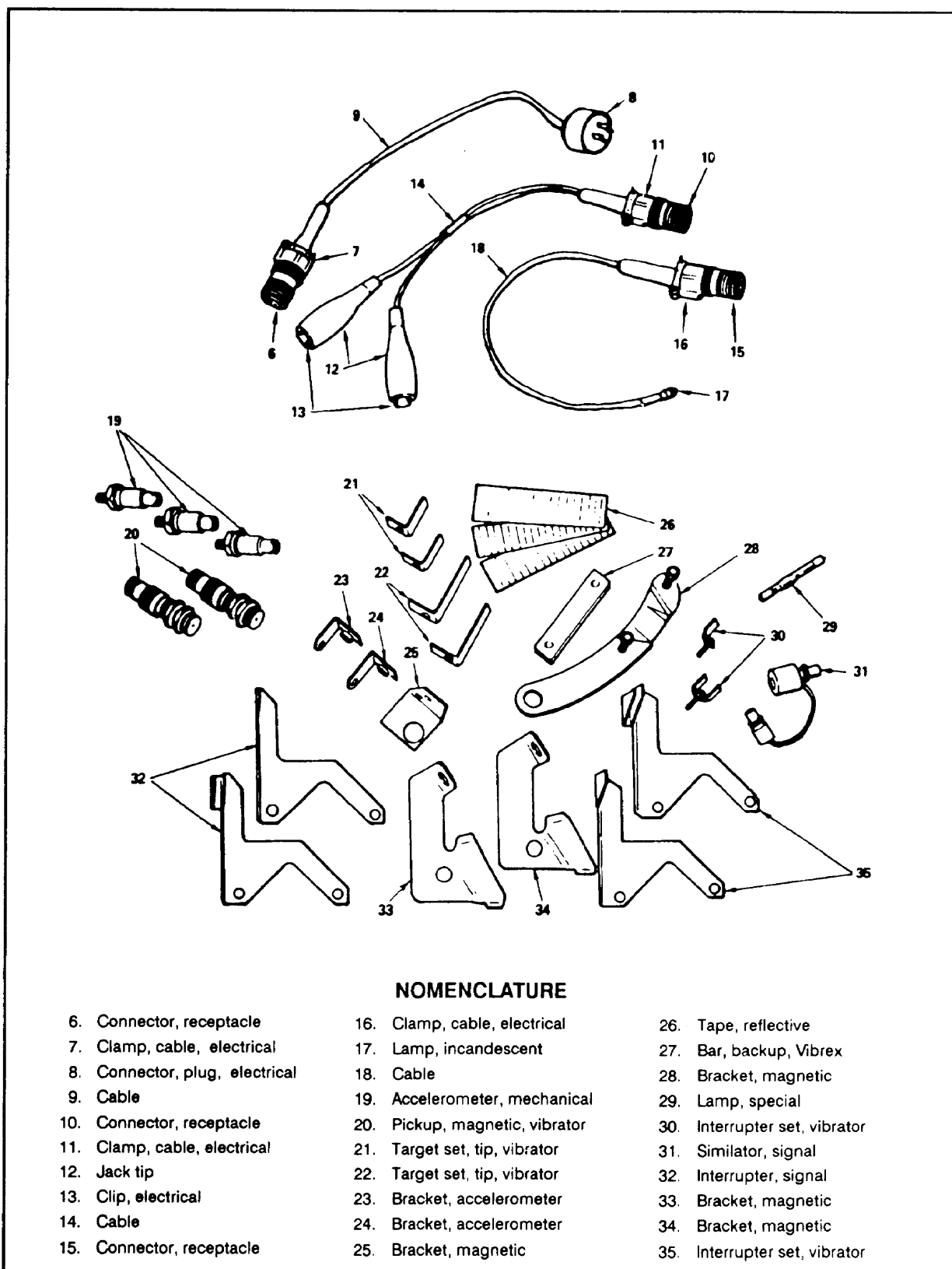
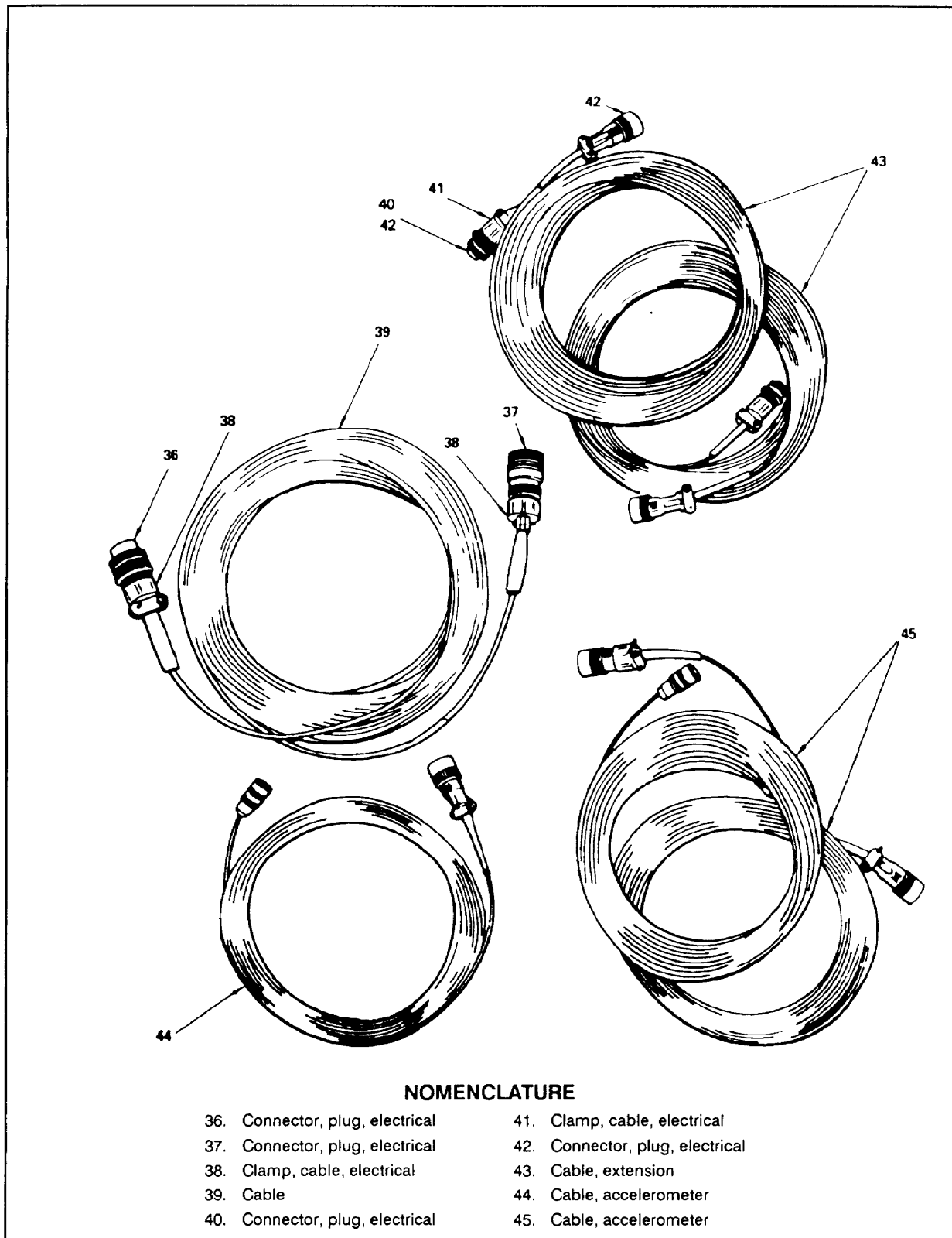


Figure 4-7. Vibrex balancing kit components (continued)



NOMENCLATURE

- | | |
|---------------------------------|---------------------------------|
| 36. Connector, plug, electrical | 41. Clamp, cable, electrical |
| 37. Connector, plug, electrical | 42. Connector, plug, electrical |
| 38. Clamp, cable, electrical | 43. Cable, extension |
| 39. Cable | 44. Cable, accelerometer |
| 40. Connector, plug, electrical | 45. Cable, accelerometer |

Figure 4-7. Vibrex balancing kit components (continued)

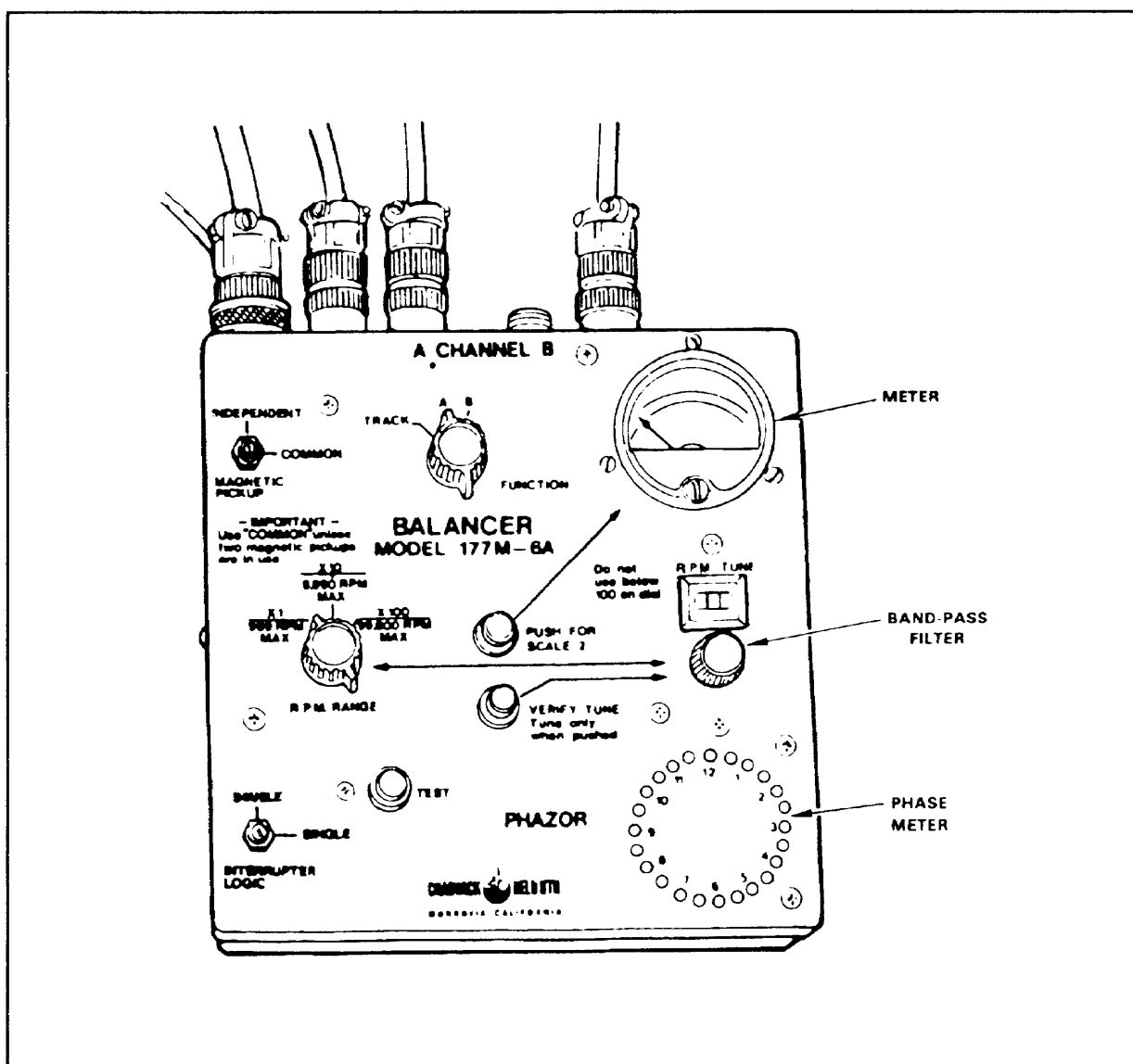


Figure 4-8. Balancer/phazor, 177M6A

shakes (vibrates) the accelerometer to measure vibration amplitude in inches per second (IPS) and rate (RPM) functions of the balancer. Phase or clock angle functions of the Phazor section are verified by a rotating interrupter plate and the magnetic pickup to provide double and single interrupter logic signals. The RPM dial of the Strobex is accurately checked against the known rotor speed of the tester motor.

Accessories

Following is a list of accessories that are used with the balancer, Strobex, and tester:

- Magnetic pickups and interrupter sets. These devices provide magnetic impulses from rotor to balancer. Magnetic pickups are located on stationary platforms; interrupter sets are located on rotating platforms.
- Accelerometers. Accelerometers provide the balancer with an electrical representation of the physical motion of the point to which it is attached.
- Reflective and tip target sets. These sets reflect Strobex flash pulses back to the Strobex operator.

- Balancer and tracking charts. These charts are used to calculate weight, sweep, pitch link, tab, and so forth to correct rotor problems.

NOTE: For further information on how to use the Vibrex, refer to TM 55-4920-402-13&P.

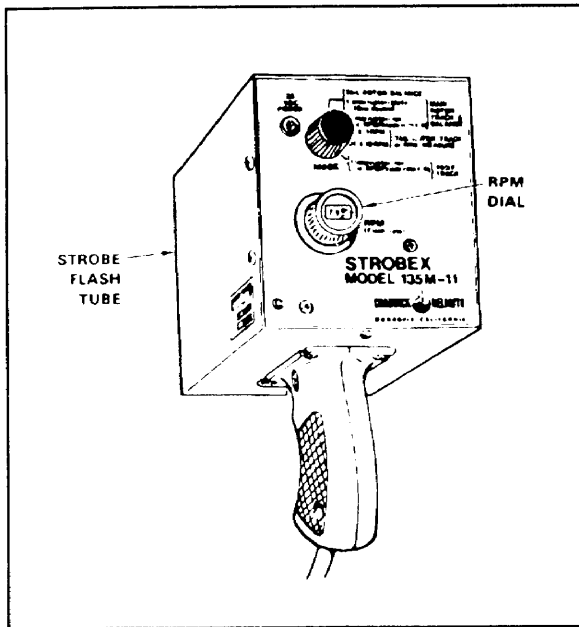


Figure 4-9. Strobex tracker, 135M11

PRESERVATION

Preservation is the term used for protection of equipment against deterioration due to exposure to atmospheric conditions during storage and shipment. The following items are needed for preservation:

- Mild soap and water.
- Solvent – PD-680.
- Moisture-absorbent cloth or filtered compressed air.
- Corrosion-preventive compound (CPC).
- Greaseproof paper.
- Desiccant bags.
- Padded contours (jute felt).
- Historical records.
- Parking and stenciling materials.

Temporary Preservation and Storage

When rotor blades are removed from an aircraft and stored for any length of time, they must be properly preserved to remain in serviceable condition. Preservation procedures are the same for all rotor blades in the Army inventory. After the blades have been removed from the aircraft, clean painted surfaces with mild soap and water and unpainted surfaces with solvent, PD-680. Never use solvent on painted blade surfaces because it can

SPECIFICATIONS

- **INPUT POWER**
+ 25 to + 34 VDC (from aircraft)
- **POWER CONSUMPTION**
100 watts maximum at ± 28 VDC
(3.3 amps nominal)
- **FLASH TUBE OUTPUT**
Approximately 3000-beam candle seconds per flash at 15 feet
- **FLASH TUBE STROBE RATE**
POS A = 60 Hz max
POS B = 42.2 Hz max
POS C = 16.6 Hz max
POS D = 166.6 Hz max
POS E = 1666 Hz max

Figure 4-10. Vibrex tester

loosen the bonding. After cleaning dry rotor blades with a moisture-absorbent cloth or filtered compressed air, make sure all surfaces and contours are completely dry. Then apply a corrosion-preventive compound to the blades. CPC is a liquid; it should be spread only on the machined surfaces and only with a brush. Be careful to include the inside of all retention bolt holes. The painted surfaces should not be coated. If the blades are to be stored for no longer than 3 months, they may be placed in a slotted rack. Periodic inspection of stored blades is essential to prevent corrosion of machined surfaces and to keep painted surfaces clean. Blades are stored in slots with the leading edge down and the trailing edge up.

Shipment and Long-Term Storage

When preparing a rotor blade for immediate shipment or long-term storage, use the procedures explained above to first clean, dry, and process it. Then prepare the blade for shipment in a container. Metal containers are used Armywide for shipment and storage of rotor blades.

After preserving the blade with a CPC, wrap the blade, sockets, cuffs, retention plates, and machined surfaces with greaseproof paper and tape them. This further protects the blade at these areas from moisture, condensation, and wear during shipment.

Place a bag of desiccant inside the container to aid in dehumidifying the interior. The desiccant (silica

gel) absorbs moisture. Jute felt padding comes with blade containers from the manufacturer. The padding is a plant fiber made to the shape of the blade and used to support the blade at different points along its span. Place the blade in the container with the jute felt padding supporting it.

Main rotor blades are secured inside containers at the root ends by either of two methods: by bolting a cuff fixture to the blade and its container wall, or by welding along bolt at one end of the container, which protrudes through the retention bolt holes and is secured with a nut.

Place the lid on the container and secure it. Make sure that the outside of the container is stenciled with the sender, receiver, and serial number of item being shipped. Remove the container's old serial number. A new center-of-balance line should also be stenciled on at this time.

Use DA Form 2402 (Exchange Tag) and DA Form 2410 (Component Removal and Repair/Overhaul Record) to ship rotor blades. Prepare two copies of DA Form 2402. Tie one to the item being shipped. Tape one on the outside of the shipping container or place it in the cylinder, which is used for historical records. Complete one copy of DA Form 2410 and place it in the cylinder. If blades are to be stored, the containers can be stacked on top of each other in a warehouse. Check stored blades periodically for corrosion and for forms required by TM 55-1500-344-23.