1550 ATTW

D/P/SG/E

APRIL 1977

H-1N PILOT

ACADEMIC STUDENT GUIDE

ENGINEERING

AEROSPACE RESCUE AND RECOVERY SERVICE

FOR INSTRUCTIONAL PURPOSES ONLY

ATTW STUDENT GUIDE
D/P/SG/E

1550 ATTW (ARRS)
KIRTLAND AFB, NM
APRIL 1977

UH-1N PILOT ACADEMIC STUDENT GUIDE - ENGINEERING

F O R E W O R D

This student guide was designed to guide you through your study assignments in the most logical sequence for easy understanding and to provide you with practical problems or work to be completed in conjunction with each study assignment. It is intended to supplement rather than replace the aircraft flight manual. A thorough knowledge of this student guide will be the first step in becoming a safe and precise helicopter pilot.

This student guide will be reviewed annually in conjunction with the Course Evaluation Schedule in 1550 ATTWR 51-1, C1, Attachment 8. Upon completion of the review, a report will be submitted to DOTET IAW 1550 ATTWR 51-1.

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Deputy Commander for Operations

SUMMARY OF REVISED, DELETED OR ADDED MATERIAL

This is a major revision. Pertinent data was extracted from four chapters and consolidated into three chapters. Outdated material was deleted. This student guide has been rearranged to agree with the organization of the classroom presentation.

Supersedes the January 1975 Student Guide
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C O N T E N T S

CHAPTER 1

POWER PLANT

1. OBJECTIVE. The student should be able to describe the operation of:

a. Major sections of the engine and their function.

b. Combining gearbox (CGB).

2. REQUIREMENTS. See assignment sheet.

3. SOURCE REFERENCES:

a. TO 1H-1(U)N-1, Flight Manual.

b. TO 1H-1(U)H-2-1, Organizational Maintenance.

4. SUPPLEMENTAL INFORMATION. While many students are familiar with jet or turbine engine operation, it is important to know the differences of turbine engine application in helicopters and in particular those with the free turbine principle.

a. Free Turbine Principle. This turbine principle, as applies in the T400-CP-400, represents a means of converting the power produced by a jet engine into mechanical power which may be used to drive the rotor systems.

(1) A pure jet engine is desirable because of its high power-to-weight ratio, simplicity of operation, reliability and other considerations. It produces power in the form of reactive thrust produced by hot expanding gases. In fixed wing applications, these gases are exhausted to the rear of the aircraft at high velocities, driving the aircraft through the air to produce lift. In helicopter applications, the "wings" must be rotated by a mechanical drive system; therefore, a means must be found to extract energy from the engine exhaust system.

(2) In the T400-CP-400 a "free" turbine is placed in the exhaust stream to convert the energy of the expanding gases into mechanical energy. The gases are then directed to the curved blades of the free turbine wheel and provide both impulse and reactive forces to spin the wheel. In essence the engines are composed of a pure jet engine (gas generator) which is self-sustaining and provides hot, expanding gases to drive a free turbine (power turbine) which is connected to the rotor drive system.

(3) The free turbine design of the T400-CP-400 has several inherent advantages for helicopter use. Some of them are:

(a) Selected power changes occur quickly since only the gas generator must change speed. Thus, the engine is extremely flexible throughout its operating range.

(b) The engine is, to some extent, self-correcting for transient load. As load is placed on the power turbine and it begins to decelerate, torque will be increased due to the constant power output of the gas generator.

(c) Ease of starting is insured because only the gas generator section has to be brought up to self-sustaining speed.

(d) Maintenance is simplified since the gas generator section can be easily separated from the power turbine section and one may be repaired or replaced without affecting the other.

b. Terminology. The following is a list of abbreviations commonly used in discussing the engines:

(1) Ng - Gas generator speed.

(2) Nf - Power turbine speed.

(3) Nr - Main rotor speed.

(4) P3 - Compressor discharge pressure (CDP).

(5) ITT - Inner turbine temperature (Also called TIT and T_5).

(6) CGB - Combining gearbox.

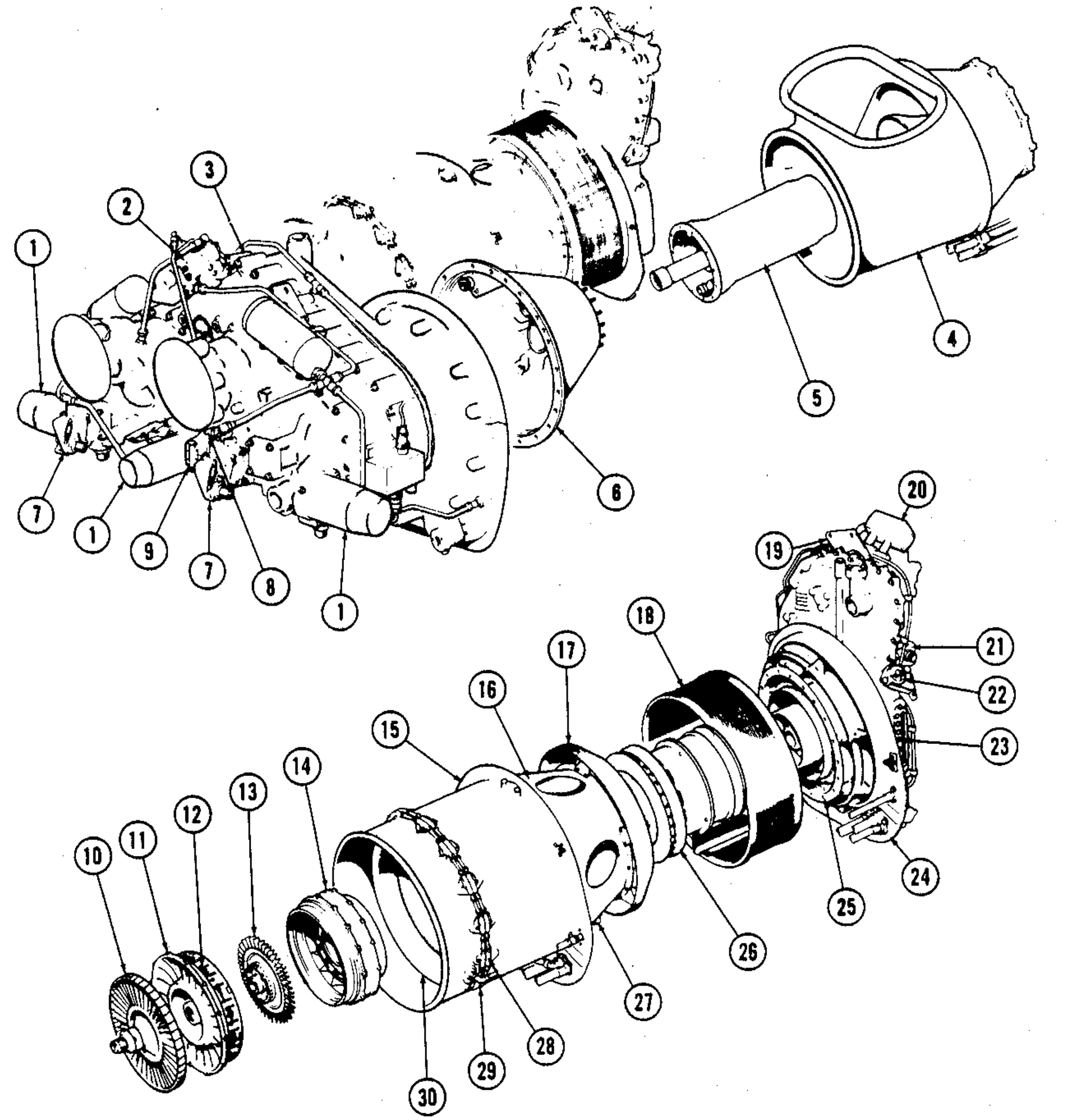
c. Major sections of the engine. (See figure 1-1.)

(1) An accessory gearbox mounted on the front of each engine houses lubrication system pumps and provides mounting pads for fuel control units, starter-generators and Ng tach generators.

(2) Inlet air enters the engine through a circular plenum chamber formed by the compressor inlet case and is directed to the compressor. The compressor consists of three axial stages and a single centrifugal stage, assembled as an integral unit. It provides a compression ratio of 7.2:1 at maximum continuous Ng.

(3) Rows of stator vanes located between rotor stages diffuse compressor air, raise its static pressure and direct it to the next rotor stage. Compressed air from the final centrifugal stages passes through 21 diffuser pipes which turn its flow direction through ninety degrees. It is then led through straightening vanes to the combustion chamber liner. Taps on two of the diffuser tubes bleed off P3 air for the engine fuel and oil systems, compressor bleed, and cabin heating.

(4) The compressor consists of two concentric casings. Inter-



1. Oil Filter
2. Torque Control
3. Reduction Gearbox
4. Exhaust Case Assembly
5. Power Turbine Shaft Housing
6. Power Turbine Shaft Housing Support
7. Nf Governor
8. Oil Filler
9. Oil Level Indicator
10. Power Turbine Disk Assembly
11. Power Turbine Guide Vane
12. Tt5 Probe
13. Compressor Turbine Disk Assembly
14. Compressor Turbine Guide Vane Assembly
15. Fire Seal Mount Ring
16. Gas Generator Case
17. Inlet Screen Support
18. Inlet Screen
19. Lifting Bracket
20. Oil-To-Fuel Heater
21. Ignition Exciter Box
22. Oil Filler
23. Oil Level Indicator
24. Fire Seal Mount Ring
25. Compressor Inlet Case
26. Compressor Assembly
27. Compressor Bleed Valve
28. Fuel Manifold
29. Spark Igniter Plug
30. Combustion Chamber Liner

Figure 1-1. Major Sections of Engine

stage compressor air (P2.5) is bled from the main flow of compressor air to the area between the inner and outer cases. This air is relieved to atmosphere by the compressor bleed valve to facilitate acceleration in the low speed ranges. The bleed valve is governed by a predetermined ratio of P3/P2.5 which begins to close the valve at approximately 86% Ng and fully closes it by 91% Ng. Valve operation is altitude compensated.

(5) The combustion chamber liner consists of an annular reverse-flow weldment, with varying sized perforations to allow entry of compressed air from the diffuser tubes. Air is mixed with fuel and ignited within the combustion chamber liner. Approximately 25% of the available air is required for combustion. The remainder is used for engine cooling, seal pressurization and engine bleed. Airflows to and from the liner are in opposite directions and this reversal, together with a second airflow reversal beyond the combustion chamber liner, eliminates the need for a long shaft between compressor and compressor turbine. Engine weight and overall length are thus reduced.

(6) Fuel is injected into the combustion chamber liner by 14 simplex nozzles supplied by a dual manifold. Air-fuel mixture is ignited by two spark igniter plugs which protrude into the liner. Resultant gases expand from the liner through compressor turbine nozzle guide vanes to the compressor turbine. Nozzle guide vanes insure that expanding gases impinge on the turbine blades at the optimum angle and velocity for minimum energy loss throughout the operating speed range. Expanding gases from the compressor turbine pass rearward through a second set of nozzle guide vanes to drive the power turbine. Exhaust gas from the power turbine is directed through an exhaust plenum to atmosphere, via an exhaust duct and port.

(7) A combustion chamber drain valve is located at 6 o'clock positions of each gas generator case. Function is to drain unused fuel from combustion chamber after power section shutdown.

(8) The engine has an accessory gearbox located forward of the inlet plenum. Power to drive engine accessories is provided by a coupling shaft from the compressor. Accessories thus driven are: engine oil pump, starter-generator, Ng governor (located in AFCU), Ng tach-generator, engine fuel pump, and engine oil system contrifugal breather. (See figure 1-2.)

(9) The power turbine in each engine drives the reduction gearbox output shaft through a three-stage reduction gear train. An integral torque-meter device, an Nf governor, Nf tach-generator and sprag clutch (free-wheeling) are incorporated in each gear train to monitor engine torque and Nf speed and to isolate an inoperative engine.

d. Combining Gearbox:

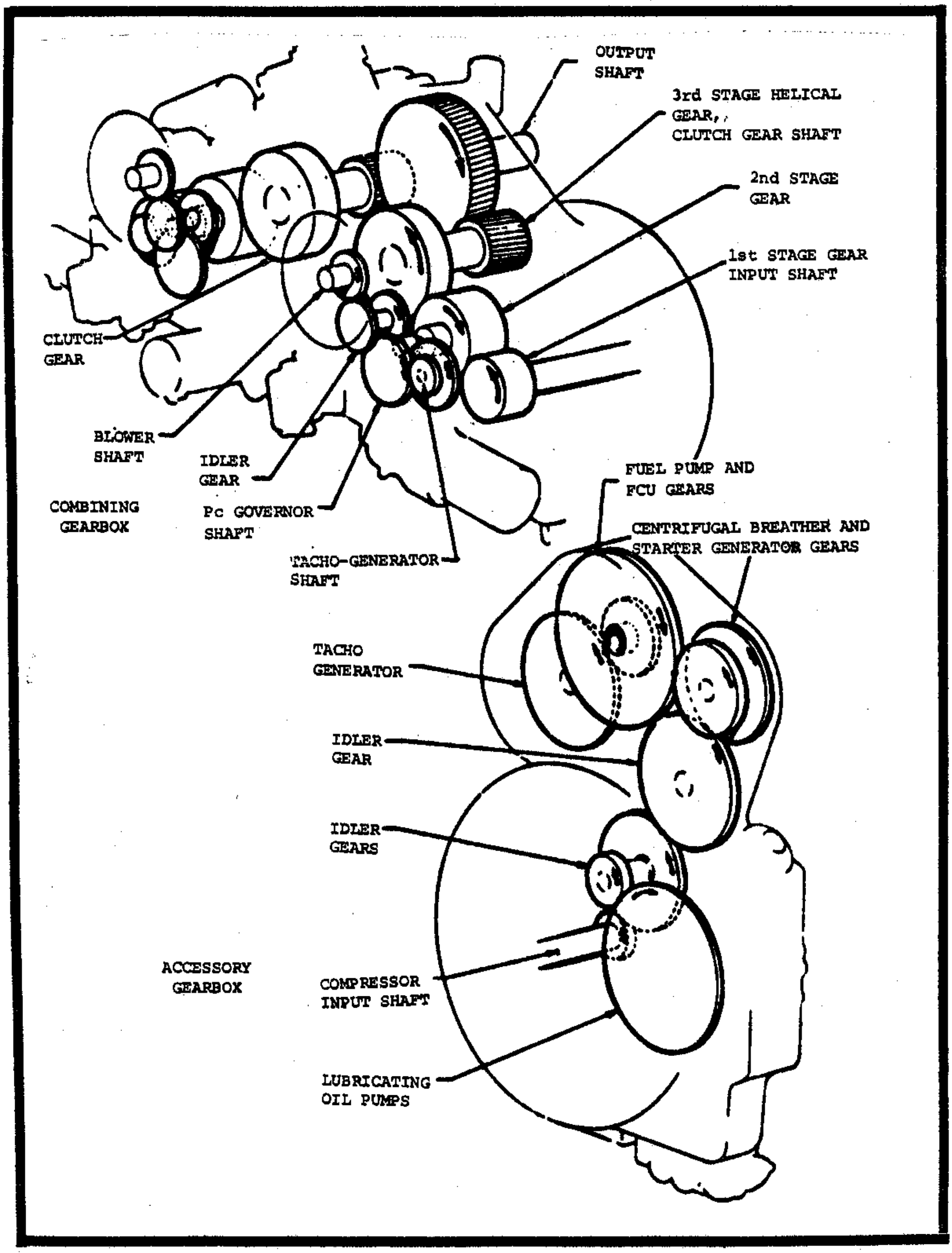


Figure 1-2. Combining Gearbox and Accessory Gearbox

(1) Overall reduction through the combining gearbox is 5:1 (power turbine speed is 33,000 at 100%; output shaft speed is 6600).

(2) Each engine input section consists of the first and second stage reduction gears, idler gears, and oil cooler blower drive. (See figure 1-2.)

(3) The output section consists of the output gear and shaft, the third stage reduction gears, the torque sensing devices, the sprag clutches and the combining gearbox oil pump. The combining gearbox oil pump is driven by gears at the rear of the output shaft to supply pressure oil through an independent lubrication system to components of the output section.

(4) The function of power turbine governors is to regulate fuel flow, in conjunction with automatic fuel control units, to maintain rpm of power turbines at desired value in fuel system automatic mode.

(5) Torque control unit. The function of this unit is to regulate fuel flow, in conjunction with automatic fuel control units, to maintain power section output torques equal within maximum limit. The maximum allowable torque split is 4%.

5. REQUIRED EQUIPMENT/MATERIALS. None.

6. GENERAL INSTRUCTIONS AND PROCEDURES. Complete classroom handouts.

CHAPTER 2

FLIGHT CONTROLS AND ROTOR SYSTEMS

1. OBJECTIVE. The student should be able to describe the operation of:

   a. Main and tail rotor systems.

   b. Hydraulic system.

   c. Vibrations.

   d. Flight controls.

   e. Force trim.

2. REQUIREMENTS. See assignment sheet.

3. SOURCE REFERENCES:

   a. TO 1H-1(U)N-1, Flight Manual.

   b. TO 1H-1(U)N-2-1, Organizational Maintenance.

   c. TO 1H-1(U)N-3, Structural Repair.

4. SUPPLEMENTAL INFORMATION:

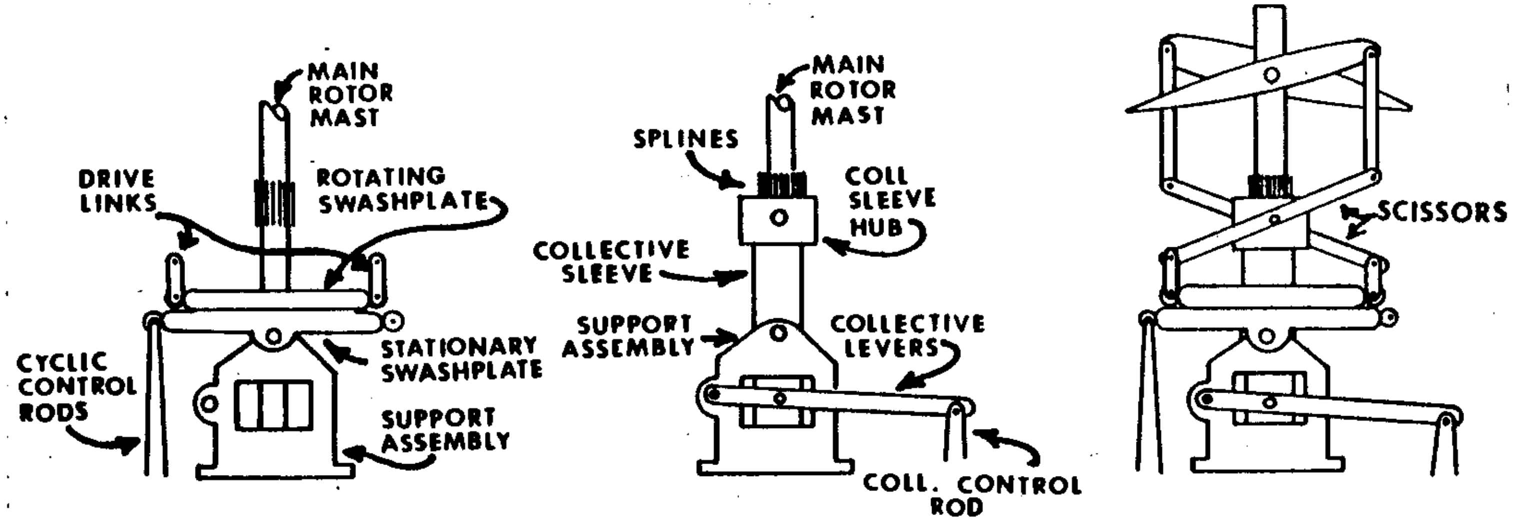
a. Main Rotor System. The main rotor system consists of a preconed, underslung, semirigid hub, two all metal blades, a stabilizer bar, swashplate, collective sleeve and associated linkage.

(1) The pilot requires two modes of control over the main rotor; collective and cyclic. Cyclic pitch control is accomplished by changing blade pitch equally, simultaneously and in opposite directions. Collective changes pitch equally, simultaneously and in the same direction.

(2) We must be able to apply cyclic and collective in varying degrees to each blade. These inputs must be mixed to give each blade a single pitch change at any given instant.

(3) The two bladed, controllable pitch tail rotor is composed of the blades and hub and is driven by the tail rotor gearbox. It is hinge mounted to provide automatic equalization of thrust on advancing and retreating blades. Control links provide collective pitch to the rotor.

(4) The main rotor system transmits inputs from collective and cyclic flight controls to the blades. Since it must transmit two separate inputs (collective and cyclic) to perform a single task (pitch change), it is essentially a mixing unit. (See figure 2-1.)



CYCLIC + COLLECTIVE = MIXED

Cyclic inputs are fed to the stationary swashplate (S.P.) which is gimballed to the support assembly. Cyclic inputs will tilt the stationary S.P. in any direction.

Mounted to the stationary S.P. through a bearing is the rotating swashplate. Cyclic movement will tilt the rotating S.P. and transmit this tilt through the drive links.

Collective inputs are fed from the control rod to the collective levers. The levers are pivoted on the support assembly. Pins on the levers attach to the coll. sleeve.

The coll. sleeve hub rotates and is pushed up or down by the sleeve. A bearing between the hub and sleeve allows mating of the rotating hub to the non-rotating sleeve. Splines on the mast mate with splines in the hub to allow vertical movement.

To mix the two inputs the scissors attach to the end points of the cyclic and collective systems (drive links, and coll. sleeve hub) and to the blades themselves.

To add "up" collective we move the hub and the scissors open, giving equal, simultaneous, same direction pitch change.

Tilting the swashplates with cyclic, blade pitch change is equal, simultaneous and in opposite directions.

Figure 2-1. Cyclic and Collective Controls

(5) Main Rotor Control. Mixing of collective and cyclic inputs is achieved through a rotating scissors assembly. This assembly consists of two scissors levers and a rotating hub. Each lever has three attachment points. The center point attaches to the collective sleeve hub and moves up and down as the sleeve moves up and down. One end of each lever is attached to a pitch control rod; therefore, collective sleeve movement will change the pitch of the blades equally, simultaneously and in the same direction. (See figure 2-2.)

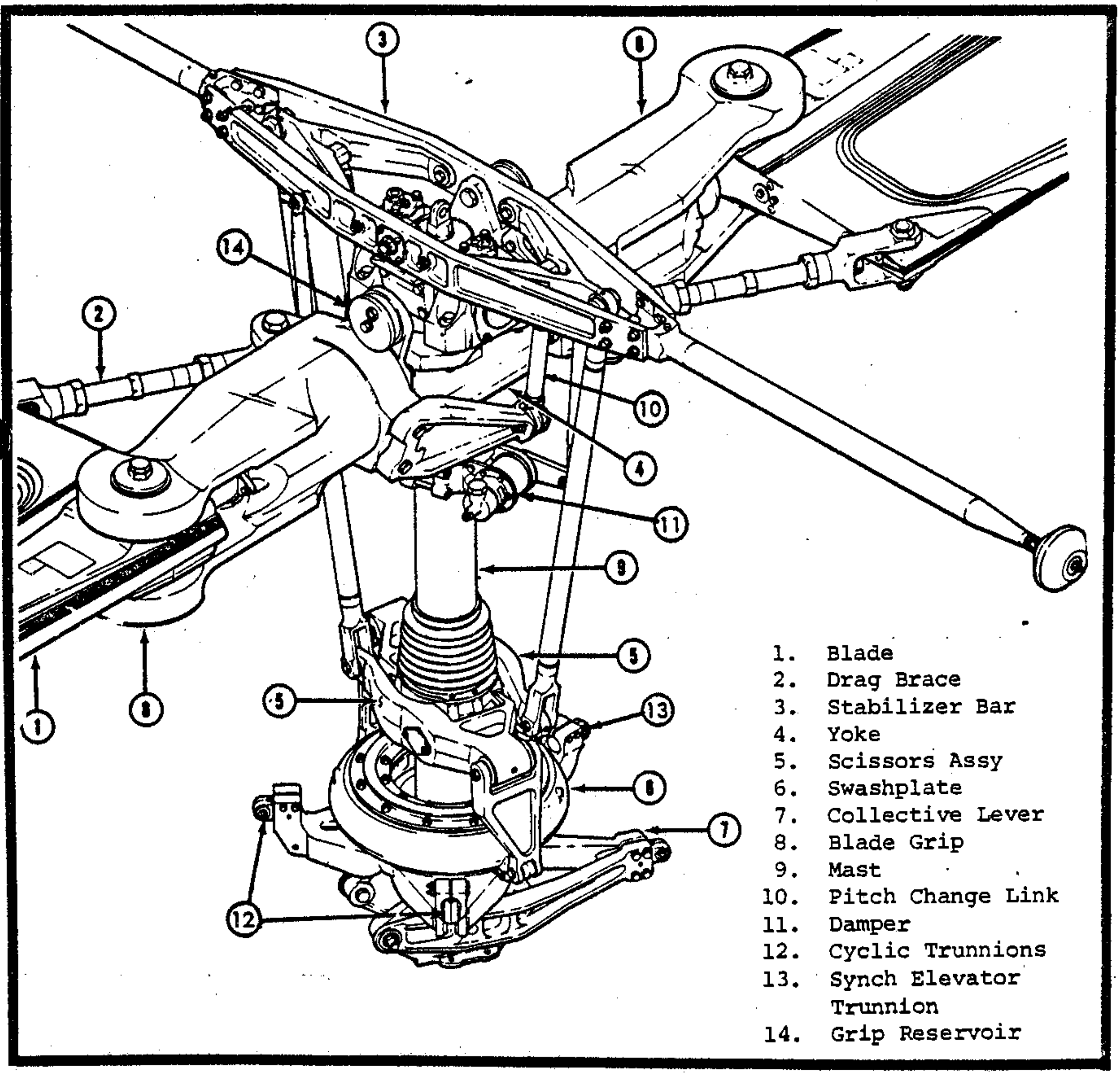


Figure 2-2. Main Rotor Control

(a) The third attachment point is connected to the rotating swashplate by a drive link. The scissors lever must follow or describe a path parallel to the swashplates. If the swashplate is tipped forward, the path of the scissors will tip forward.

(b) Nomenclature of the swashplate is confusing unless its operation is understood. The nonrotating inner ring mounts the inner race of the swashplate bearing. It has trunnions for the cyclic and synchronized elevator control rod ends and is mounted to the gimbal ring to allow tilting. The rotating outer ring contains the bearing outer race and trunnions for attachment to the drive links.

(c) The collective sleeve is nonrotating and is moved up and down inside the swashplate and outside the mast by the collective levers. Movement of the collective levers is controlled by the collective control rod.

(6) Stabilizer Bar Assembly. Control inputs are fed from the scissors levers to the stabilizer bar and thence to the blades. The stabilizer bar is placed in the control system so its gyroscopic properties provide stability in all flight conditions. If while hovering the helicopter is disturbed, the stabilizer bar will tend to remain in its original plane, causing a relative displacement of the mast to the bar. Since pitch change forces travel through the bar to the blades, this relative displacement causes the blades to feather and return the rotor to near its original position. If the bar were completely unrestrained, it would remain in its original plane of rotation and induce stability almost to the point of removing control from the pilot. Therefore, a compromise is reached by partially restraining and dampening the bar to give it "mast following" characteristics.

(a) The rate of mast following is regulated by two hydraulic dampers which tend to displace the bar as the mast is displaced. The dampers are double acting and are attached to the mast by a split-splined clamp. A sight gage on the damper provides a visual check on damper timing. The dampers are set to return from full displacement to neutral within 5 seconds, plus or minus one second.

(b) The stabilizer bar is bolted to the main rotor hub trunnion and has connections for the control rods, pitch change links and damper control tubes. It is statically balanced by adjusting the weights at each end.

(7) Main Rotor Hub. The main rotor hub is made up of the trunnion, pillow blocks, yoke and blade grips. It provides rotor flapping or teetering, blade feathering, and connects the blades to the mast. (See figure 2-3.)

(a) The yoke, trunnion, and pillow blocks may best be considered as a single unit since they are bolted together when installed. The trunnion is splined to mate with the mast and is retained on the mast with a split-cone bushing and a screw-cap retaining nut. The trunnion is allowed to pivot on roller bearings within the pillow blocks to provide flapping of the rotor system. The yoke provides mounting for the blade grips and mounts the grip feathering bearings. Blade grip reservoirs provide lubrication to the feathering bearings inside the blade grips.

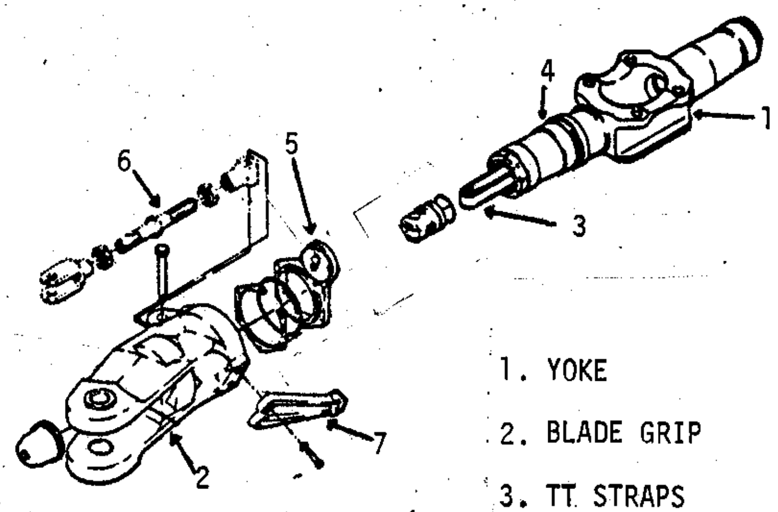


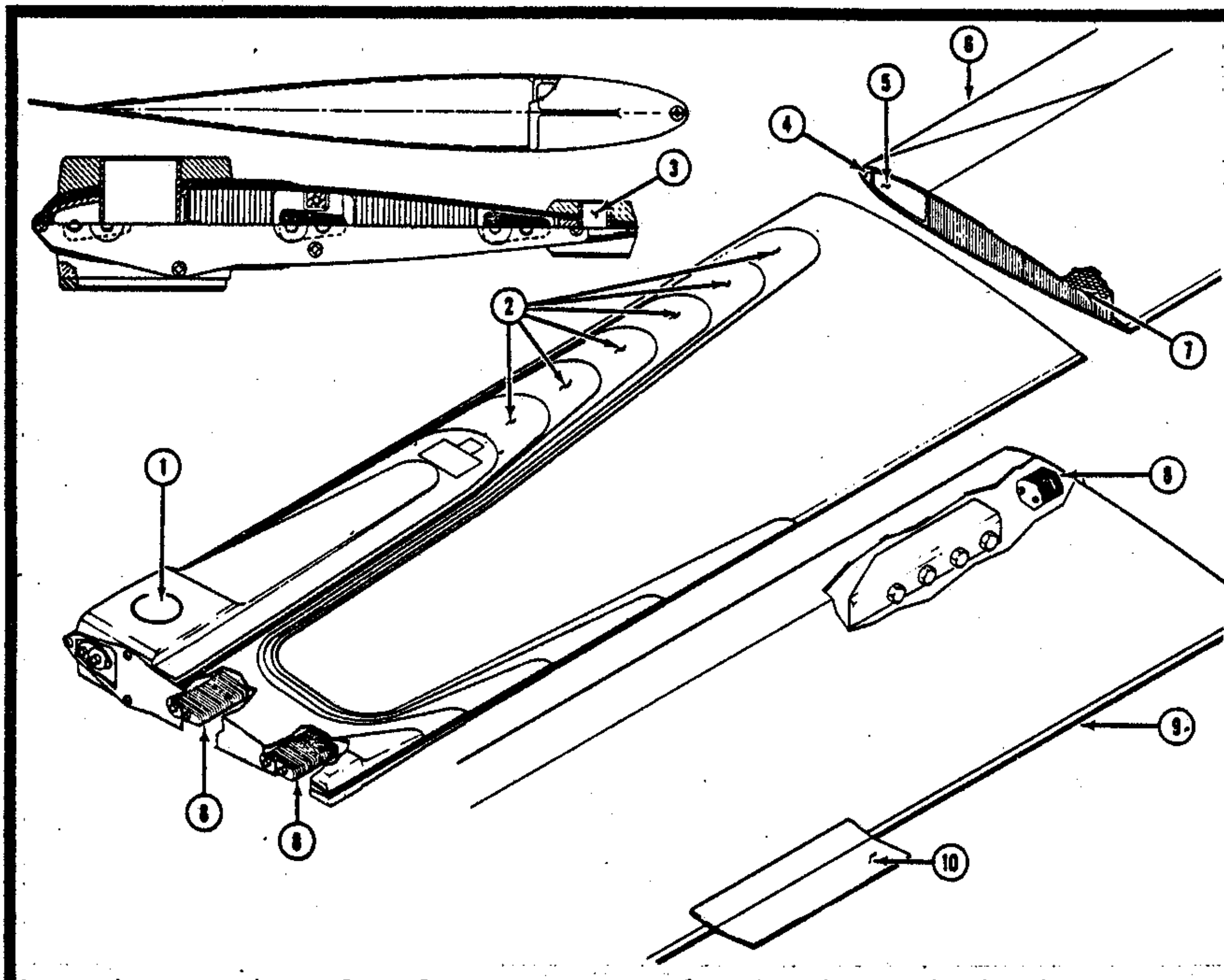
Figure 2-3. Main Rotor Hub

(b) Attachment of the blade grips to the yoke is provided by the tension-torsion (TT) straps. These straps absorb centrifugal loads (tension) and feathering loads (torsion). The TT straps are located inside the yoke spindle and are not lubricated.

(8) Main Rotor Blades. Each blade is attached to its grip by a single bolt and a drag brace. The hollow blade bolts may be weighted with lead wool for spanwise balancing. The adjustable drag links allow alignment of the blades. The rotor blades have a brass and aluminum nose block, main spar, honeycomb core, and trailing edge. The sections are bonded to the metal skin with an adhesive applied under head and pressure. (See figure 2-4.)

(9) Tail Rotor System. The tail rotor is driven by the output shaft of the 90^{o} gearbox.

(10) Tail Rotor Control. Changes in pitch occur equally, simultaneously, and in the same direction. Pitch changes are accomplished by movement of the pitch change rod and transmitted by the crosshead assembly through the pitch change links to the blades. Feathering and centrifugal loads are absorbed by ballbearings between the blade grip and yoke. A unique feature of the hub is the offset hinge or trunnion, which restrains flapping.



1. Main Retention Bolt Hole
2. Doublers (Aluminum Alclad)
3. Drag Brace Bolt Hole
4. Nose Block (Brass)
5. Spar (Aluminum Alclad Extrusion)
6. Abrasion Strip (Stainless Steel)
7. Core (Aluminum Honeycomb)
8. Balance Weights
9. Trailing Edge Strip (Aluminum Alclad Extrusion)
10. Trim Tab (Alumunum Alclad)

Figure 2-4. Main Rotor Blade

(11) Tail Rotor Blades. The tail blades have phenolic spar, a honeycomb core and a trailing edge. The metal skin is bonded to these components by the same process used in main rotor blade construction (See figure 2-5.)

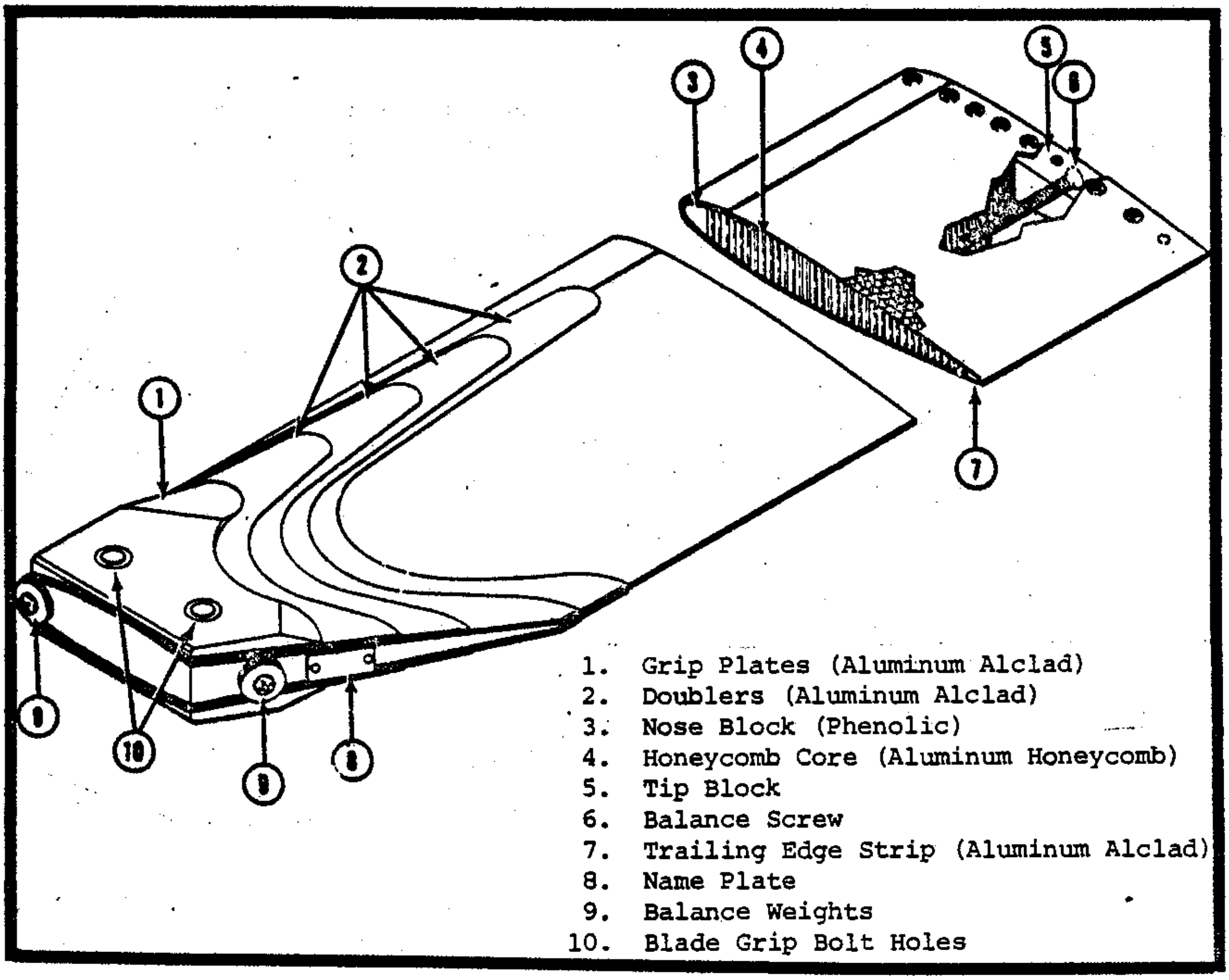


Figure 2-5. Tail Rotor Blade

b. Vibrations. Some low magnitude vibrations are always present in the helicopter. It is when the magnitude of any vibration increases that it becomes important. The main problem is deciding when a vibration level has reached the point of being unacceptable. The only sources of vibrations of any frequency are the rotating or moving parts on the helicopter, other parts vibrate only in sympathy with an existing vibration. Extreme low frequency and most medium frequency vibrations are caused by the rotor or dynamic controls. Various malfunctions in stationary components can affect the absorption or damping of the existing vibrations and increase the overall level felt by the pilot. A number of vibrations are present which are considered a normal characteristic of the machine. Two per revolution (2/rev) vibration is the most prominent of these, with 4/rev or 6/rev the next most prominent. There is always a small amount of high frequency present. Flight experience is necessary to learn the normal vibration levels. Even experienced pilots sometimes make the mistake of concentrating on one specific vibration and conclude that the vibration level is higher than normal when actually it isn't. It just seems so because the pilot is concentrating on it. For simplicity and standardization, vibrations are arbitrarily divided in general frequencies as follows:

Extreme low frequency -	Less than 1/rev pylon rock
Low frequency -	1/rev or 2/rev type vibration
Med frequency -	Generally, 4, 5 or 6/rev
High frequency -	Tail rotor or faster

(1) Extreme Low Frequency Vibration. Extreme low frequency vibration is limited to pylon rock. Pylon rocking two or three cycles per second is inherent with the rotor, mast, and transmission system. To keep the vibration from reaching noticeable levels, transmission mount dampening is incorporated to absorb the rocking. Malfunctions in the dampening system will allow rocking to start and continue until it can be felt by the pilot. A quick check of the dampening system may be made by the pilot while in a hover. Moving the cyclic fore and aft at about one movement per second will start the pylon rocking. The length of time it takes for the rocking to die out after the motion of the cyclic is stopped is indicative of the quality of the dampening. An abnormal continuation of rock during the check or a continued presence of rock during normal flight is an indication that something is wrong with the transmission mounts or dampers. This may be due to wear, parts loosening up, breakage, incorrect installations, or the wrong type parts installed.

(2) Low Frequency Vibration. Low frequency vibrations, 1/rev and 2/rev are caused by the rotor itself. 1/rev vibrations 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 a spanwise unbalance of the rotor due to a difference of weight between blades, the alignment of the CG of the blades with respect to the spanwise axis which affects chordwise balance, or unbalance of the hub or stabilizer bar. Rigidly controlled manufacturing processes and techniques eliminate all but minor differences between blades, resulting in blades which are virtually identical. The minor differences which remain will affect flight but are compensated for by adjustments of trim tabs and pitch settings. Generally, verticals felt predominantly in low power descent at

moderate airspeeds (60-70 knots) are caused by a basic difference in blade lift and can be corrected by rolling the grip slightly out of track. Verticals felt mostly in forward flight, that get worse as airspeed increases, are usually due to one blade developing more lift with increased speed than the other (a climbing blade). This condition is corrected by adjustment of the trim tabs.

(a) Associated with the 1/rev vertical is the intermittent 1/rev vertical. Essentially, this is a vibration initiated by a gust effect causing a momentary increase of lift in one blade giving a 1/rev vibration. 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).

(b) Should a rotor or rotor component be 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 aircraft, causing the pilot's seats to bounce up and down. It should be noted that the seats bounce up and down out of phase; that is, the pilot goes up while the copilot goes down. An unusually severe lateral can be felt as a definite sideward motion as well as a vertical motion. Laterals existing due to an unbalance in the rotor are of two types; spanwise and chordwise. Spanwise unbalance is caused simply by one blade and hub being heavier than the other (i.e., an unbalance along the rotor span). A chordwise unbalance means there is more weight toward the trailing edge of one blade than the other. Both types of unbalance can be caused by the hub as well as the blades. Another occasional source of a lateral is the stabilizer bar. Improper balancing of the bar prior to installation is the main reason for this problem. Lateral vibrations are usually felt in a hover and in descending moderate airspeed turns and tend to disappear in forward flight. An out-of-ground effect hover is usually the best place to feel a lateral and reducing the rpm to 91% will often make the lateral more prominent.

(c) Two per rev (2/rev) vibrations are inherent with two bladed rotor systems 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 dampening or absorption capability or an actual increase in the 1/rev vibration level of the rotor itself. The loss of dampening can be caused by such factors as deteriorated transmission mounts or lift link bushing, or an airframe component loosening up and vibrating in sympathy with the inherent 2/rev. An increase in the 2/rev level of the rotor itself can be caused by worn or loose parts in the rotor hub or looseness in the rotating controls.

(3) Medium Frequency Vibrations. Medium frequency vibrations at frequencies of 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 vibrations, or a loose airframe component, such as the 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 of this range are nearly always caused by something loose; either a regular part of the aircraft or part of the cargo or external stores. The vibration is felt as a rattling in the aircraft structure. The most common cause is loose skids caused by worn, loose, or improper skid retaining straps. Loose skids can be discovered by shaking the ship with cyclic and feeling if they vibrate or looking out the door at the skids while shaking the aircraft. (Excessive or severe shaking is undesirable and will make even tight skids vibrate.) Many times skids will cause considerable vibration during turns and maneuvers if they are extremely loose. Loose skids are not a serious condition but can cause annoyance to flight crews and passengers. Other sources of medium frequency vibrations are the elevator, access doors, cargo hook, electronic gear, safety belt out the door, and engine/transmission cowling. Sometimes air loads will cause the small fire extinguisher doors and the step doors to vibrate. 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.

(4) 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. This includes many unusual situations such as hydraulic line buzzing, or starter relay buzzing. Most common and obvious causes are loose elevator linkage at swashplate horn, loose elevator, or tail rotor balance and track. Pilot experience can help greatly in trouble-shooting the cause of a high frequency vibration, since a pilot who has experienced a vibration can often identify the cause the next time he feels it.

c. Flight Controls. The flight control system of the UH-1N is straight forward and rugged. All linkages are direct mechanical connections between the pilot and the rotor system. All control inputs are boosted and isolated from feedback during normal operation by the hydraulic power cylinders. In addition, the force trim units provide artificial "feel" and positioning the cyclic and tail rotor controls.

(1) Cyclic Controls. Lateral cyclic movements are fed from either stick directly to a bellcrank between the sticks. This bellcrank translates lateral motion into a push-pull motion which is transmitted to the mixing bellcrank. This force is then translated into a force on each of the servos equally, simultaneously, and in opposite directions. (See figure 2-6.)

(a) Thus, for a right cyclic movement, the control linkage is "pushed" (forward to aft). This rotates the bellcrank in the mixing unit, pushes the left cyclic control rod up and pulls the right cyclic control rod down. Since these control rods are fixed to the swashplate, the swashplate tilts to the right.

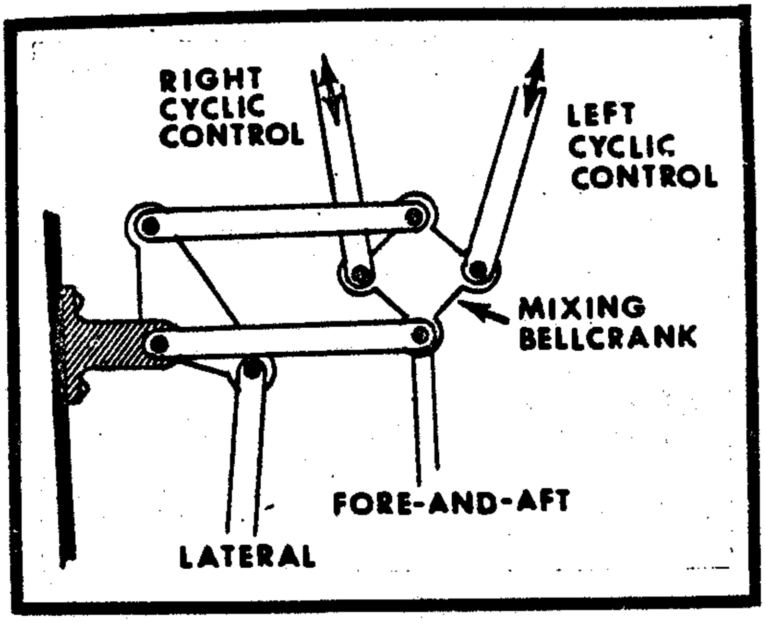


Figure 2-6. Cyclic Mixing Unit

(b) To avoid feedback in the controls from this "equal and opposite" force distribution, a spring is installed between the transmission and the right cyclic trunnion. This spring tends to balance out any slop or play between the two power cylinders.

(c) Fore and aft cyclic is transmitted from the cyclic stick to an interconnecting tube and lever assembly. This assembly pushes or pulls a rod to the mixing bellcrank and moves both right and left cyclic controls forward or aft. This force is transmitted equally, simultaneously and in the same direction through both power cylinders to the swashplate.

(d) If the stick is pushed forward, the mixing bellcrank and both cyclic control rods pull forward. The control rods operate the power cylinders to tilt the swashplate forward.

(e) Note that fore and aft control is independent of lateral control. Regardless of the position of the lateral controls the two control rods are pulled or pushed equally in the same direction.

(2) Collective Control. Collective pitch stick movement is transmitted through the interconnecting jackshaft tube and a series of control rods to the power cylinder. The power cylinder has a spring installed at the spool valve actuating arm to help prevent collective creep. The top end of the power cylinder is connected to the collective lever, which moves the collective sleeve up or down as required. The collective sleeve changes the pitch of the blades equally, simultaneously and in the same direction.

(3) Tail Rotor Controls. Tail rotor control is transmitted by a series of bellcranks and push-pull rods to the power cylinder and then to the 90° gearbox. The hydraulic boost cylinder is mounted in the fuselage under the engine deck, immediately forward of the tail boom. The cylinder reduces the effort required for control and reduces feedback forces from the tail rotor. Pedal movements are translated mechanically to a push or pull on the pitch change control rod, which runs in and out inside the hollow 90° gearbox driveshaft. The control rod moves the crosshead in or out changing the pitch of

both blades. (See figure 2-7.) The pitch change mechanism consists of a link, lever and idler mounted on the left side of 90° gearbox, attached to a control tube which extends through hollow output shaft of gearbox and connects to pitch control crosshead, which is linked to tail rotor. Movement of pedals is transmitted through linkage to lever which control tube back and forth in output shaft to change pitch of blades.

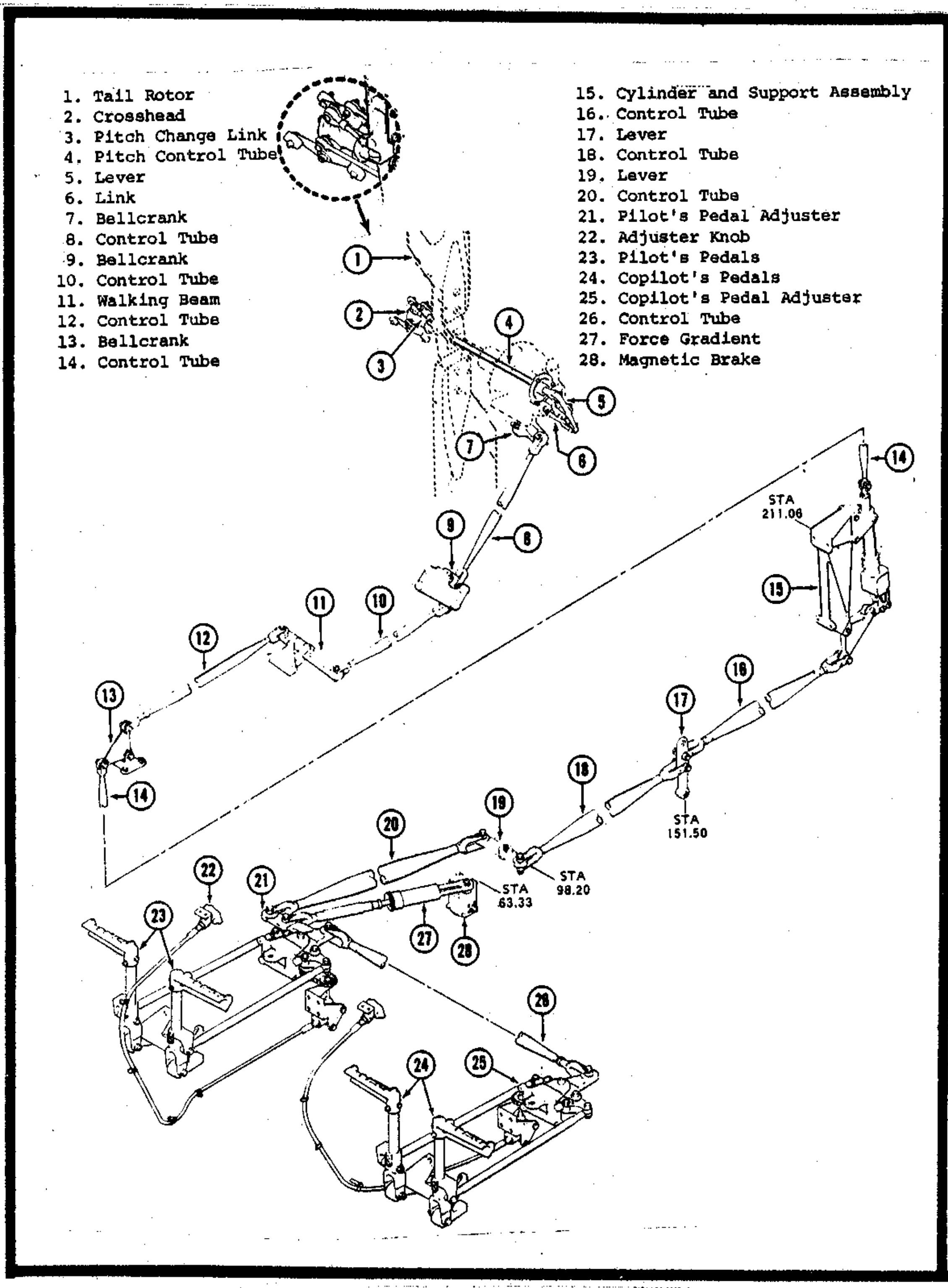


Figure 2-7. Tail Rotor Control System

(4) Synchronized Elevator Control. The synch elevator trunnion is located at the aft portion of the swashplate. Fore and aft cyclic movement changes the pitch of the synch elevator. Cyclic movement in either direction from center results in the leading edge of the synch elevator moving up. This is accomplished through an off-center bellcrank.

(5) Force Trim. The force centering devices consist of spring assemblies and magnetic brakes. Two such devices are installed on the cyclic controls and one of the tail rotor controls. The spring assemblies are merely cylinders which mount a floating spring to an arm. Spring pressure is obtained if this arm is pushed in (compression) or pulled out (tension). The arm of each spring assembly is fixed to an arm of the affected control. The other end of the assembly is attached to the moveable arm of a magnetic brake, which is rigidly mounted to the airframe. (See figure 2-8.)

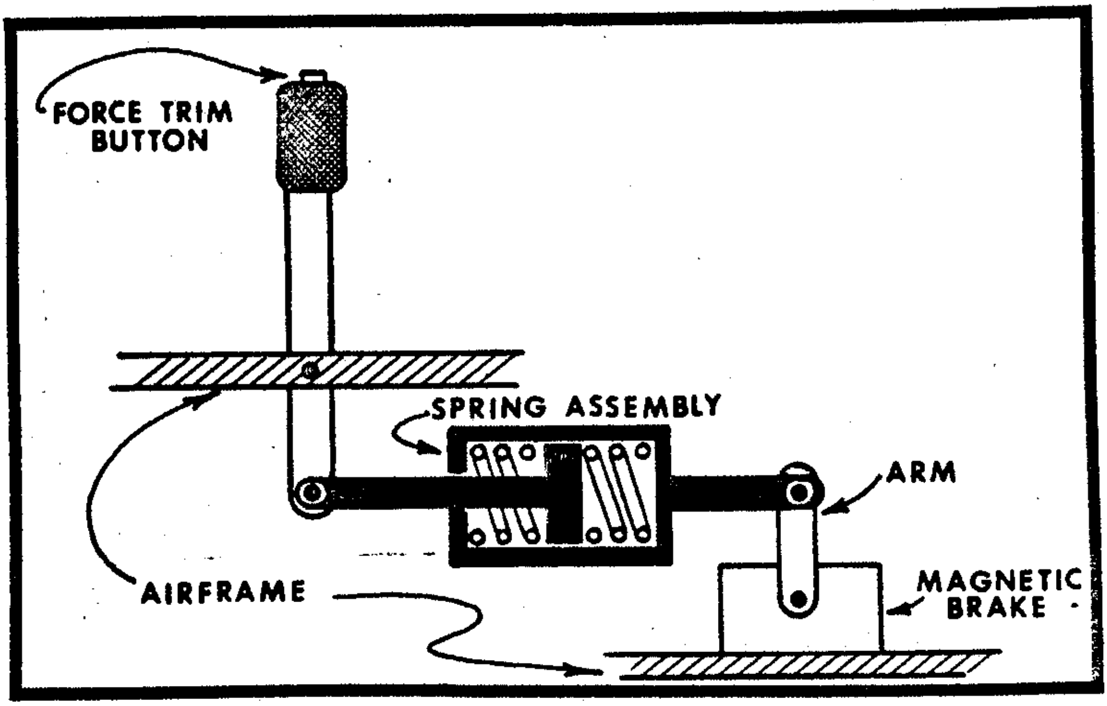


Figure 2-8. Force Trim/Gradient Assembly

(a) Depressing the force trim button interrupts current to the brake and allows the brake arm and the spring assembly to move freely to a new position. If the button is released, current flows to the magnetic brake, and holds the arm and spring assembly in position. Control movements then must work against spring pressure until the button is again depressed.

(b) Note that when the trim button is depressed, the spring assembly repositions the brake arm. The sole function of the brake is to establish a new neutral position (trim) for the control. The spring assembly provides "feel" or artificial control pressure for any given control position. These assemblies are identical and may be interchanged.

CHAPTER 3

MALFUNCTION ANALYSIS

1. OBJECTIVE. The student should be able to answer the following questions and understand the reasons for the correct answers.

2. REQUIREMENTS. See assignment sheet.

3. SUPPLEMENTAL INFORMATION. Provided in lessons EN-1 through EN-6.

4. EXERCISE:

a. After starting the number two engine, you notice it is reading near zero torque, higher Nf, and much cooler ITT compared to the number one.

What has happened?____

____.

What should you do?____

____.

b. On engine start the ITT rapidly rises to 1090^{o} on light off.

You should____

____.

You have____

____.

c. During a power check in the remote area, you hear a rumble. The ITT on number one quickly increases. Ng, Nf, and N_r fall off and the low RPM audio and light come on.

What has happened?____

____.

What would you do?____

____.

d. The RIGHT FUEL BOOST caution light illuminates. The number two engine will flame out. True________. False________.

You should____.

e. The fuel pressure gage suddenly drops to zero and two caution lights illuminate. The engine will quit. True______. False______.

You should____.

f. In the event of a complete electrical failure, you should anticipate a hydraulic failure. True_______. False_______.

g. You are flying along and notice a noxious odor (smells like sulfur and clears up your insidious nasal congestion). You have

______________________________________, and__________

______________________________may happen. You should_________

____.

h. The combining gearbox (CGB) oil pressure starts fluctuating at about plus or minus 10. You should anticipate________________

You should____.

i. You are enroute, flying at Vne; all of a sudden the aircraft begins to shake violently. The nose then pitches down and the vibration stops.

You should____.

What has happened?_______________________________________

____.

j. You are enroute at cruise airspeed and all of a sudden the nose swings to the right and pitches down. You should_______________

______________________________. You have_________________

____.

k. Enroute to Las Vegas the engine oil pressure starts to wiggle a little. You check the oil temperature and it's OK. The oil pressure starts to wiggle a little more, and the temperature is now about 10°C warmer. What are you going to do? What do you have?______________

____

____.

l. You are the pilot on a local 60-1 flight. While flying, you notice that the tail rotor pedals slowly get sluggish and stiff, then they feel like they grind and become very difficult to move. You should____

____.

m. You are flying along and notice a high-pitched "buzz" throughout the entire airframe. You should____________________

____.

n. After shutting down for a passenger drop-off, you attempt to start, using the asterisk items on the checklist. After energizing the starter for 15 seconds, you don't get a light. You should

____

____.

o. While on an unauthorized flight across the Gulf of Mexico you suddenly experience a complete engine failure. How are you going to get it down safely?______________________________________

____.

p. Just after passing Grants enroute to Nellis the cabin starts to fill with electrical fumes. What should you do?__________________

____.

q. After passing Sandia Crest enroute to the base the number one engine fails because you reached up to turn off the force trim switch and inadvertently turned the main fuel switch off. What are you going to do?____

____.

r. While flying to the auxiliary field, the fire warning light comes on. What should you do immediately?____________________

____.

s. While flying along at 700 ft AGL, the pilot reaches across and picks up the checklist which is lying on the center console. You hear a loud muffled pop and an engine wind down and grind to a stop. You also observe the following caution lights on the number one engine: oil press, particle sep off, DC generator, and gov manual.

What happened?____.

What caused it?____.

What should you do?____.