Systems Lesson 6.0

ROTOR REVIEW

Main Rotor System
Diameter 46ft (14.0m)
Chord 1ft 2in (0.37m)
Engine-to-rotor gear ratio 20.38:1
Tip speed 780 ft/sec (240m/s)
Rotor RPM 324rpm

Tail Rotor System
Diameter 8ft 7in (2.6m)
Chord 11.5 in (0.30m)
Tip speed 745 ft/sec (230m/s)
Rotor RPM 1,660rpm

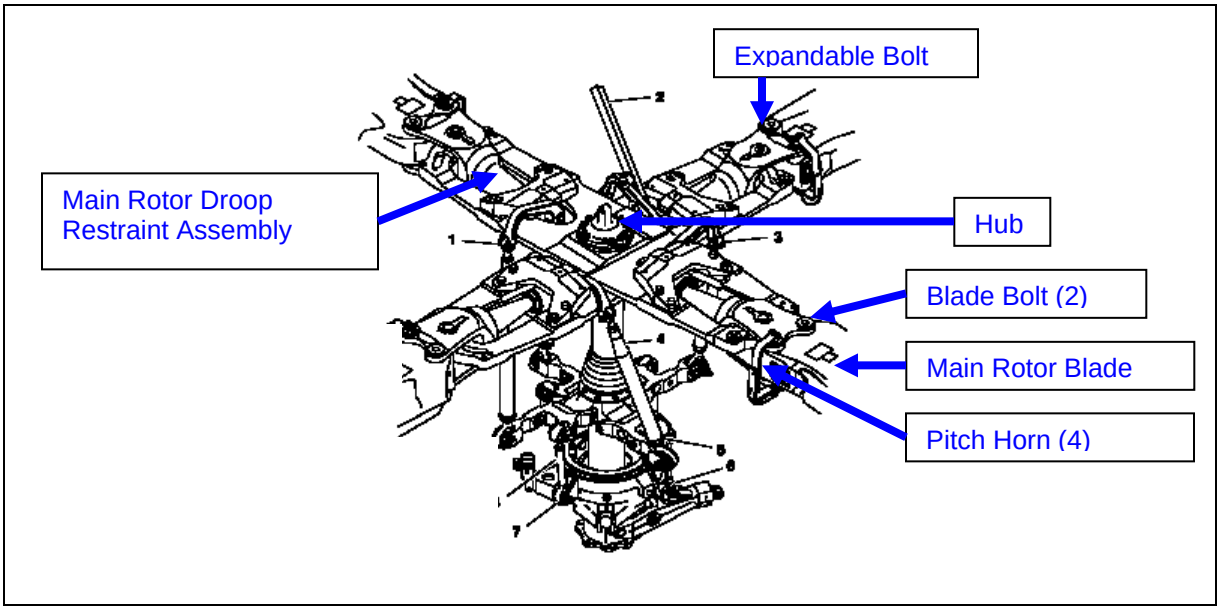
Main and Tail Rotor Systems Overview

The Bell 412 has a rigid, soft-in-plane, flex-beam **MAIN ROTOR SYSTEM**. Its four rotor blades give a softer, more comfortable ride with reduced vibration levels when compared to a two bladed system. The main rotor consists of four composite blades mounted to flex-beam type yokes to provide a soft - in-plane arrangement. Elastomeric bearings help dampen vibration and provide lead-lag action for the blades.

The blades are made of composite material with a stainless steel/titanium leading edge abrasion strip. The main rotor hub is made from solid titanium providing immense strength and flexibility without metal fatigue.

The **TAIL ROTOR SYSTEM** is used to counteract main rotor torque and provide heading control when hovering. The two blades are attached to a hub that is mounted on the tail rotor gearbox. A pitch change mechanism connects the tail rotor flight controls to the tail rotor blades to provide a change in tail rotor thrust.

The tail rotor is a two-bladed, semi-rigid rotor system mounted on the right side of the vertical fin. Rotor flapping is provided by a delta hinge arrangement to provide stability during hovering turns and forward flight.

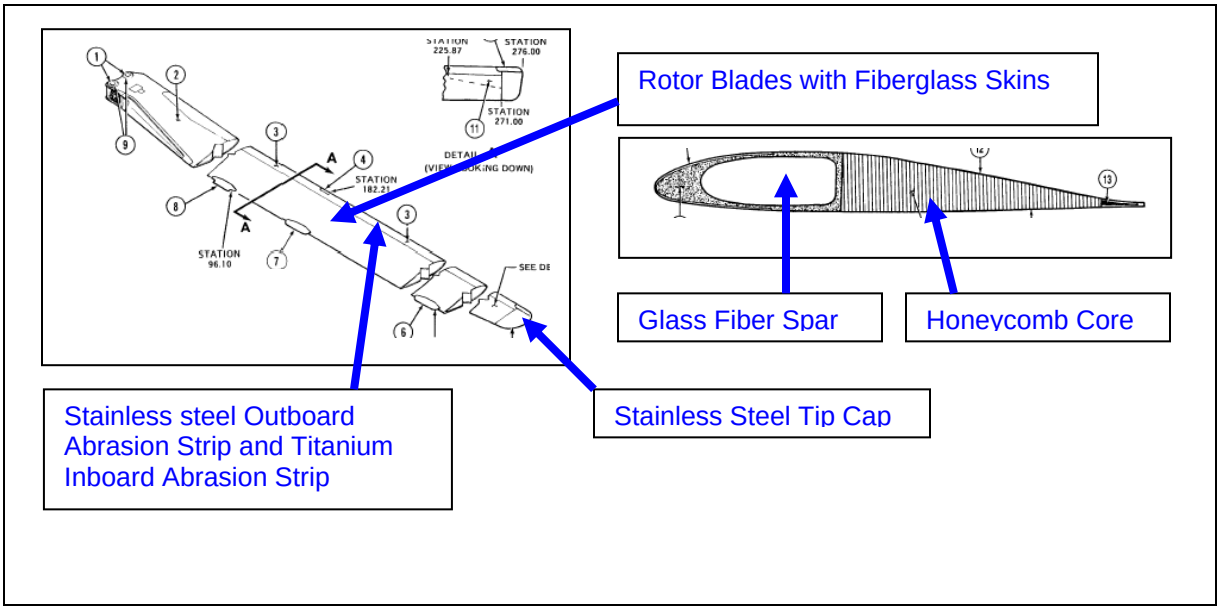


Main Rotor Hub and Blades

The main rotor hub and blade consists of the **HUB**, **FOUR MAIN ROTOR BLADES**, and **FOUR PITCH HORNS.**

Each main rotor blade is connected to hub by either **TWO FIXED DIAMETER BOLTS** or one fixed diameter bolt on the leading edge side of rotor blade and an **EXPANDABLE BOLT** on the trailing edge side of rotor blade.

The **MAIN ROTOR DROOP RESTRAINT ASSEMBLY** minimizes yoke flexing during static rotor blade droop.

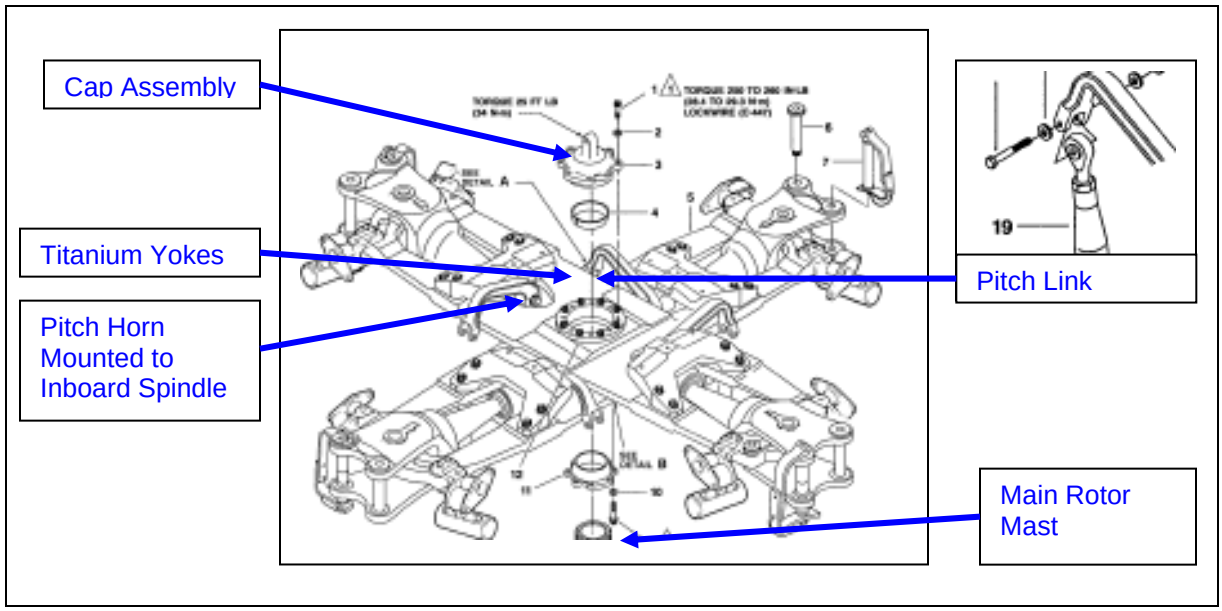


Main Rotor Blades

The main rotor blades are constructed of fiberglass with a **HONEYCOMB CORE, STAINLESS STEEL TIP CAP and OUTBOARD ABRASION STRIP and a TITANIUM INBOARD ABRASION STRIP.**

The **GLASS FIBER SPAR** is made up of four spar caps and a nose block, constructed of spanwise oriented unidirectional glass fibers, all bonded between inner and outer glass fiber torque wraps.

The rotor blades are covered with **FIBERGLASS SKINS.**

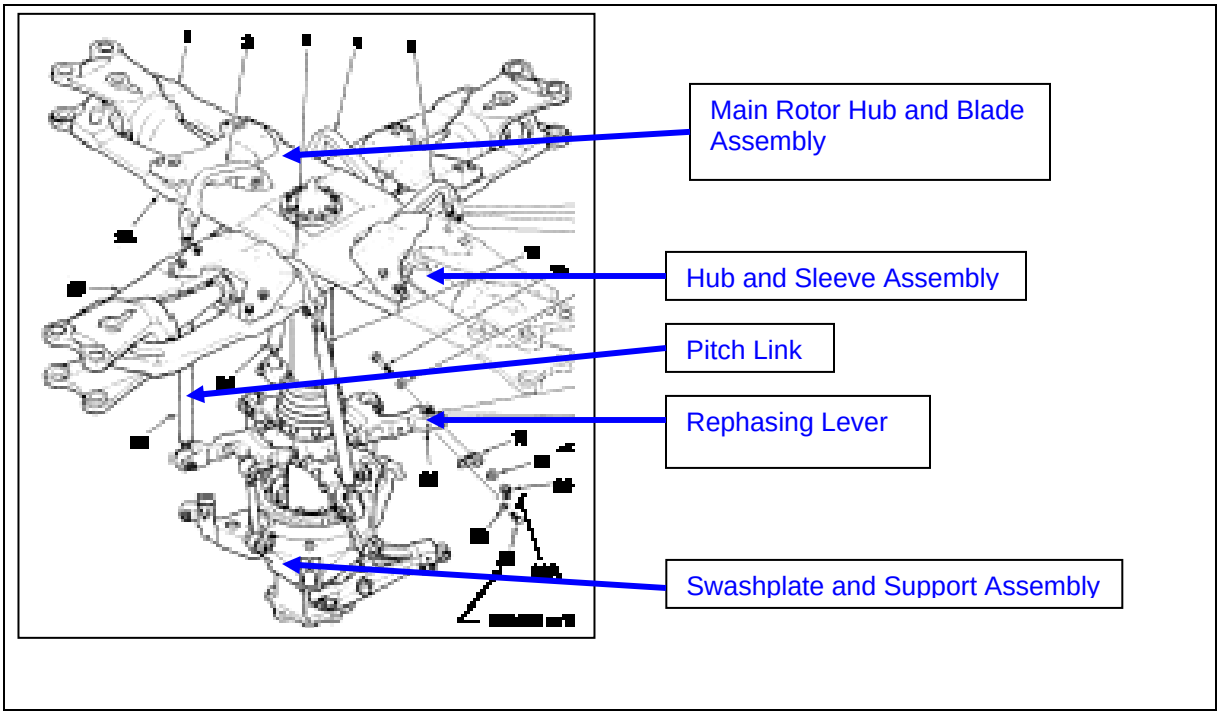


Main Rotor Hub

The main rotor hub consists of **TWO TITANIUM YOKES**, each of which mounts two steel spindles in elastomeric bearings and elastomeric dampers. Each spindle has two spindle lugs for mounting a rotor blade.

Rotor blade pitch control is achieved by means of a **PITCH HORN ATTACHED TO INBOARD END OF EACH SPINDLE**. The opposite end of each pitch horn is attached to a **PITCH LINK**. **The pitch links are attached to the rotating controls.**

The main rotor hub is attached to the **MAIN ROTOR MAST** by a procedure which does not require application of large torque values to hub retaining nut. The **CAP ASSEMBLY**, which secures the main rotor hub to the mast, is threaded on to the mast and is also bolted to hub with eight bolts.

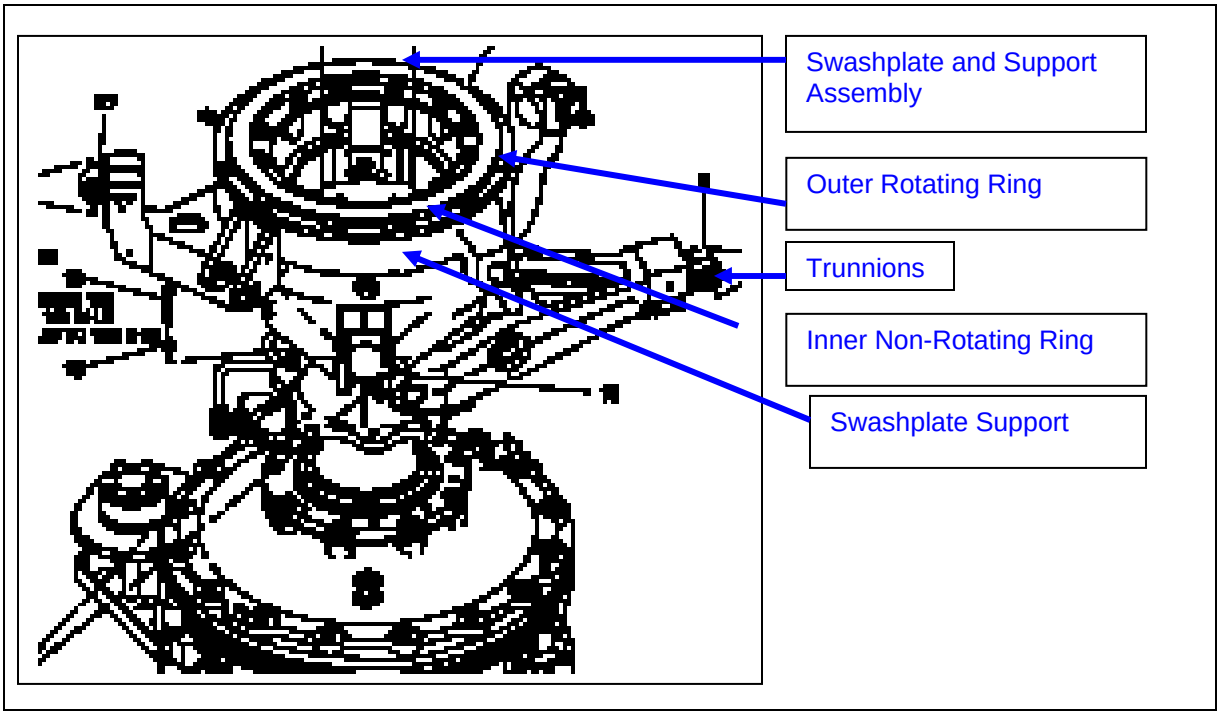


Main Rotor Controls

The function of main rotor controls is to transmit cyclic and collective input forces to the **MAIN ROTOR HUB AND BLADE ASSEMBLY** by means of the hub and sleeve, swashplate and support assembly, and interconnecting links and tubes.

The two major assemblies of main rotor controls are the **HUB AND SLEEVE ASSEMBLY** and the **SWASHPLATE AND SUPPORT ASSEMBLY**.

The **FOUR PITCH LINKS, FOUR REPHASING LEVERS**, one drive link, three swashplate links and collective lever, are also included in main rotor control installation.

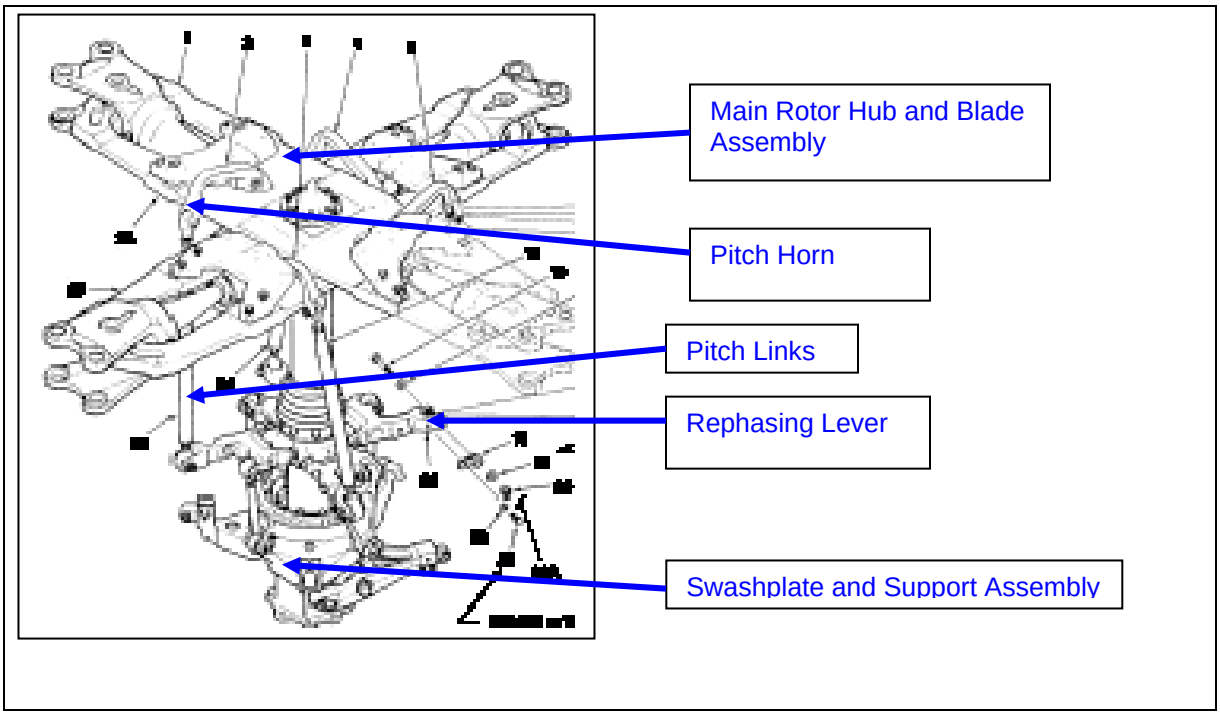


Swashplate and Support Assembly

The **SWASHPLATE AND SUPPORT ASSEMBLY** consists of the **OUTER ROTATING RING** mounted through a duplex bearing set on the **INNER NON-ROTATING RING.**

The inner ring is connected to the **SWASHPLATE SUPPORT** by a gimbal ring assembly. Servo actuator control tubes connect to two **TRUNNIONS** on the inner ring assembly to tilt the ring in the desired direction.

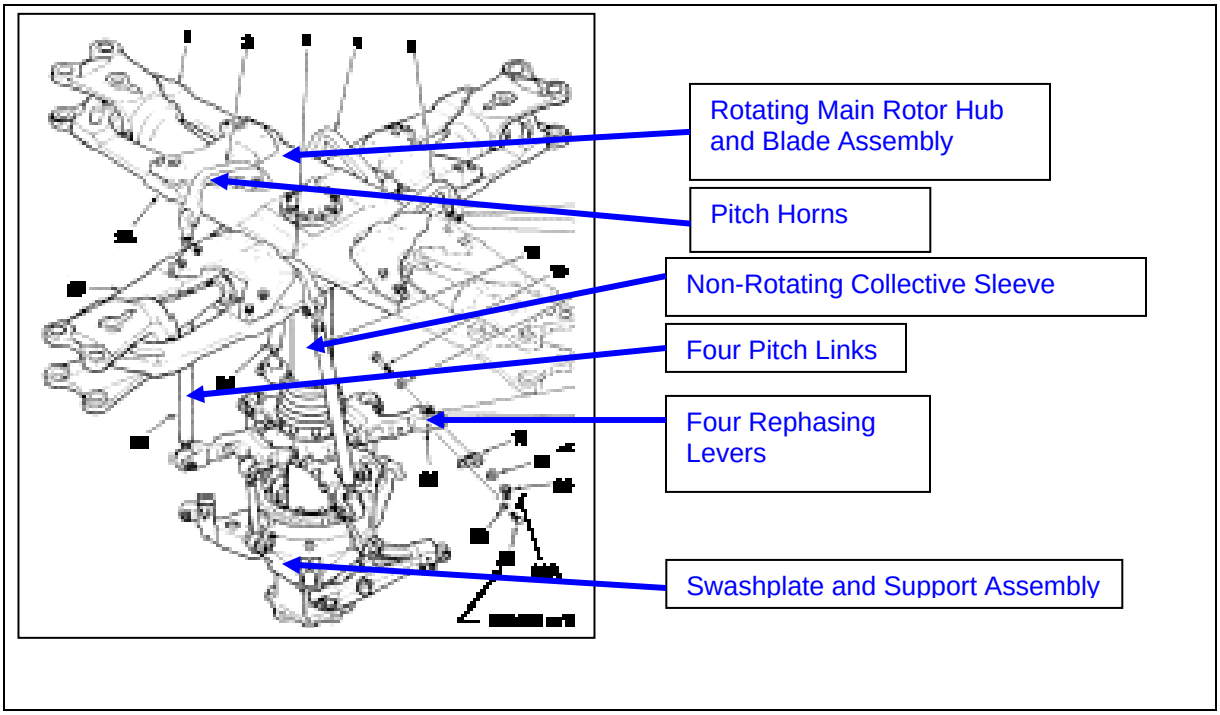
The outer ring assembly tilts with the inner ring assembly, but rotates independently with the rotating controls.



Main Rotor Pitch Link Assemblies

The **PITCH LINKS** are composed of a tube, two swaged inserts, two adjustable rod end bearings with lock nuts, a nameplate, and a decal.

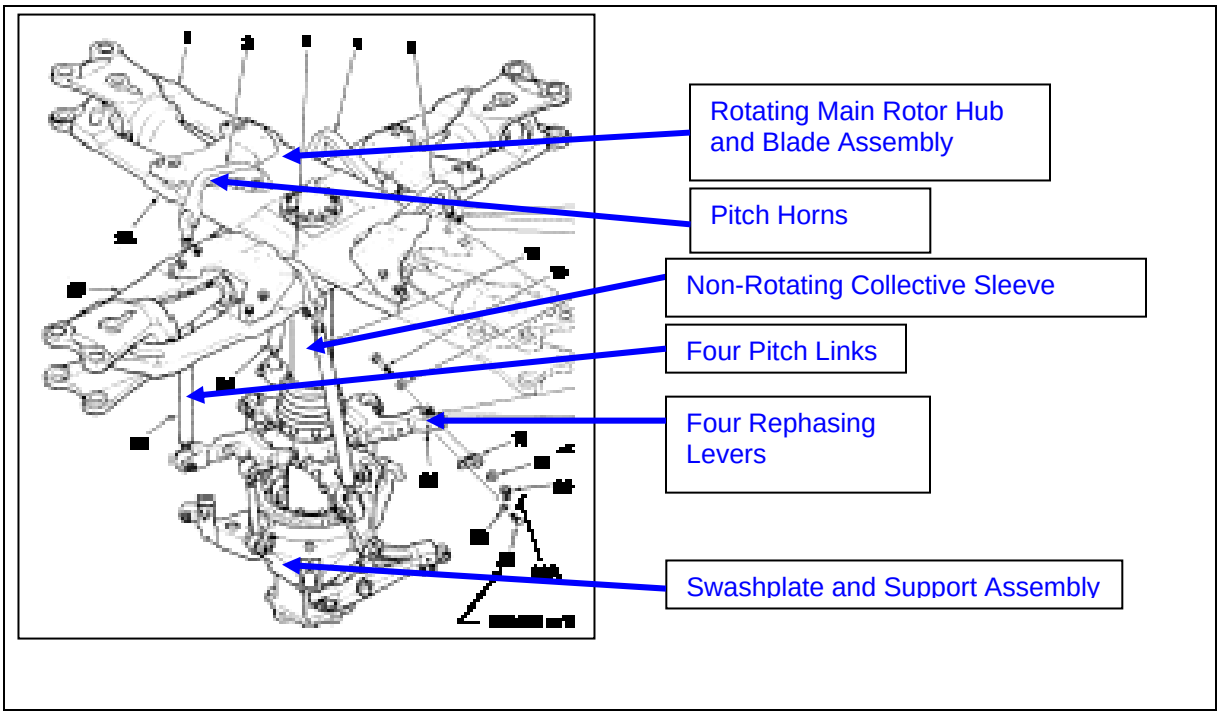
The pitch link assemblies connect the semi-circular **PITCH HORN** on the blade spindle to the **REPHASING LEVERS** on the hub and sleeve.



Hub and Sleeve Assembly

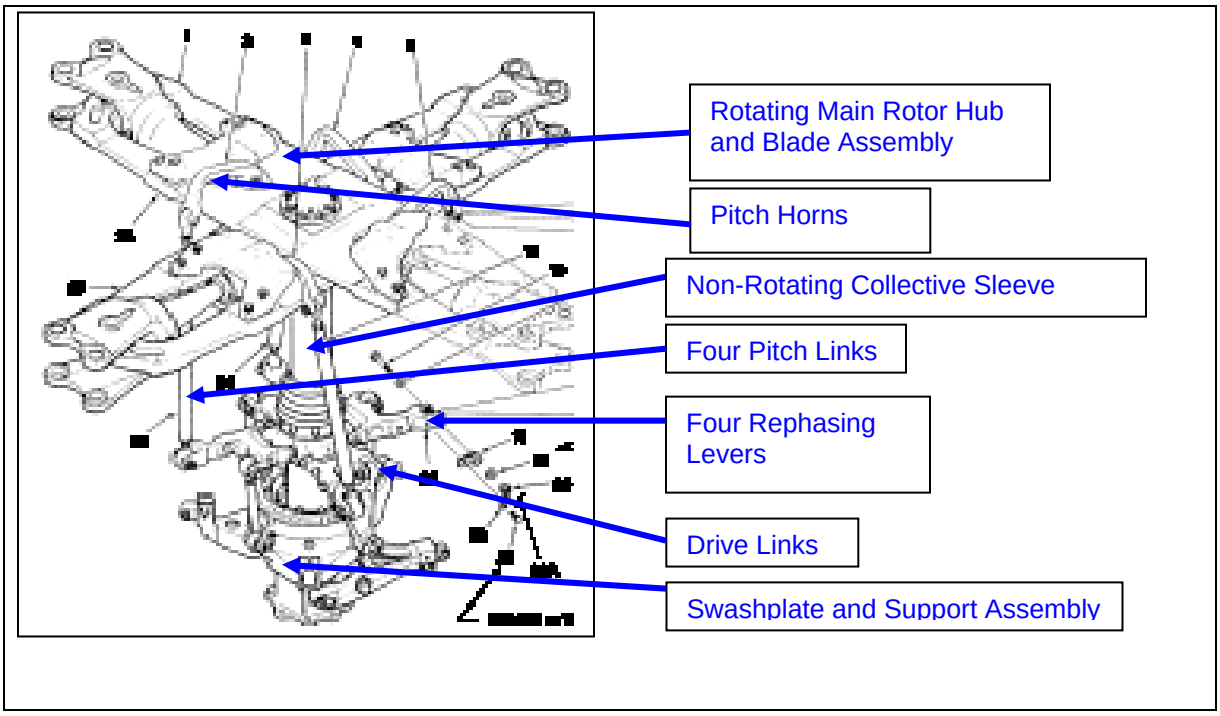
The hub and sleeve assembly consists of **FOUR REPHASING LEVERS** and a **ROTATING MAIN ROTOR HUB AND BLADE ASSEMBLY** splined to the mast and mounted through ball bearings on upper end of **NON-ROTATING COLLECTIVE SLEEVE**. The collective hub and sleeve operates between the **SWASHPLATE AND SUPPORT ASSEMBLY** and mast, and is actuated by collective lever attached to lower end. The inboard ends of rephasing levers are connected to the hub.

The outboard ends of rephasing levers are connected to **PITCH HORNS** by **FOUR PITCH LINKS** that **transmit collective and cyclic control motions to the main rotor hub and blade assembly.**



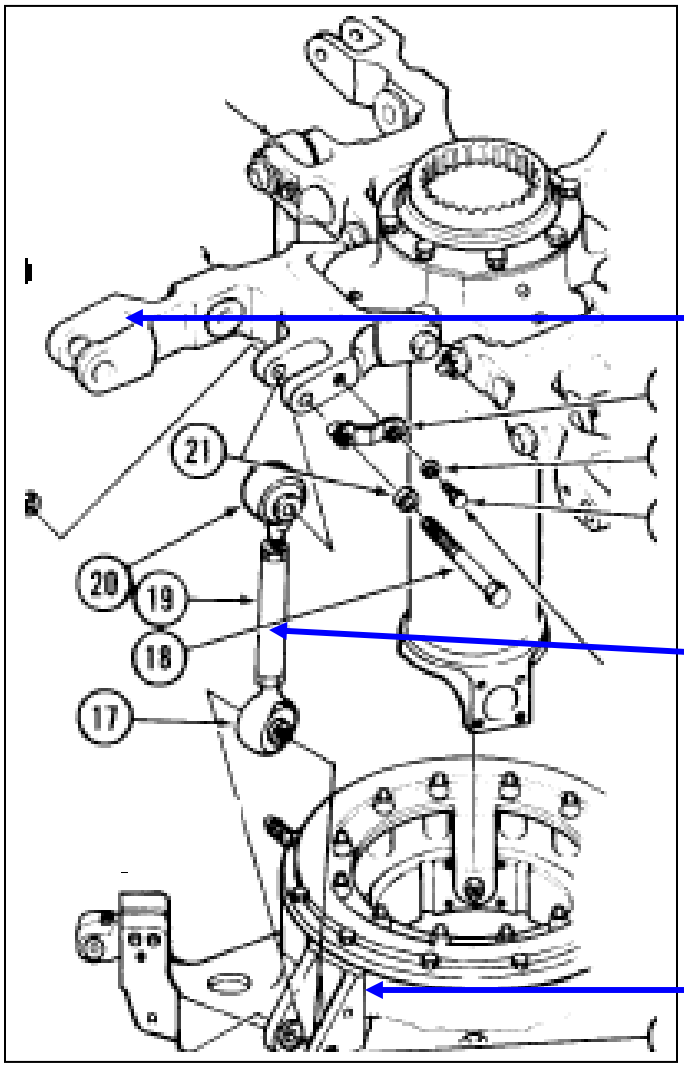
Rephasing Levers

The outboard ends of the **FOUR REPHASING LEVERS** are connected to **PITCH HORNS** by **FOUR PITCH LINKS** that **transmit collective and cyclic control motions to the main rotor hub and blade assembly.**



Drive Link Asssembly

The **REPHASING LEVERS** are connected to two **DRIVE LINKS** and two swashplate links. The outboard ends of rephasing levers are connected to **PITCH HORNS** by **FOUR PITCH LINKS** that transmit collective and cyclic control motions to the main rotor hub and blade assembly.



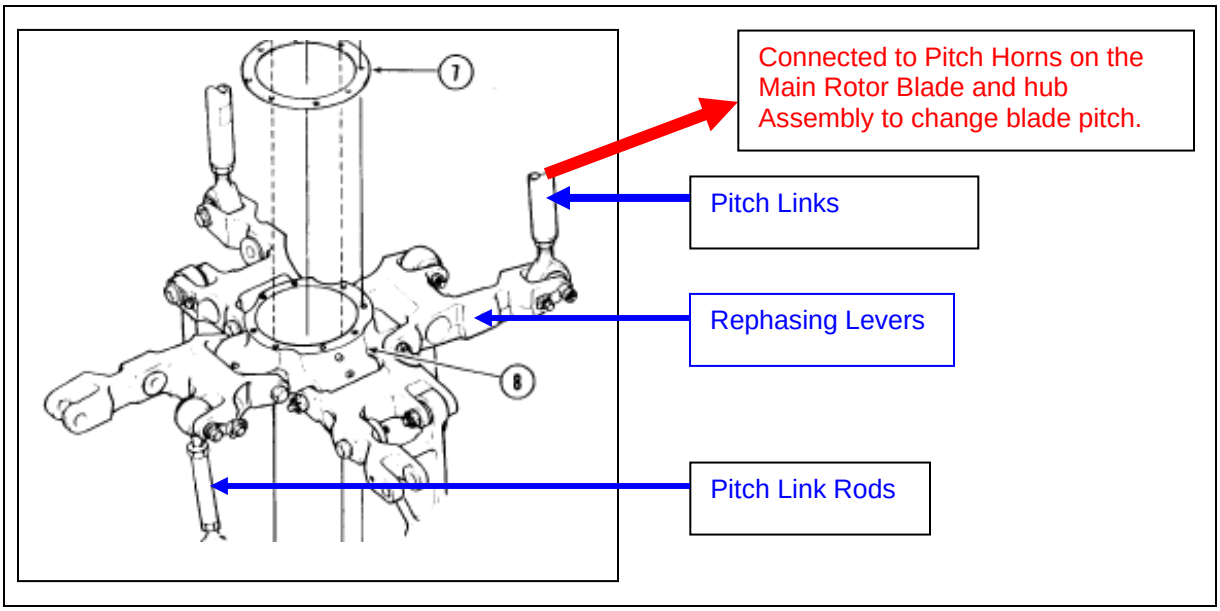
Swashplate Link Assembly

The **SWASHPLATE LINK ASSEMBLY** connects the **OUTER RING OF THE SWASHPLATE** to the **REPHASING LEVER DRIVER.**

Rephasing Lever Driver

Swashplate Link Assembly

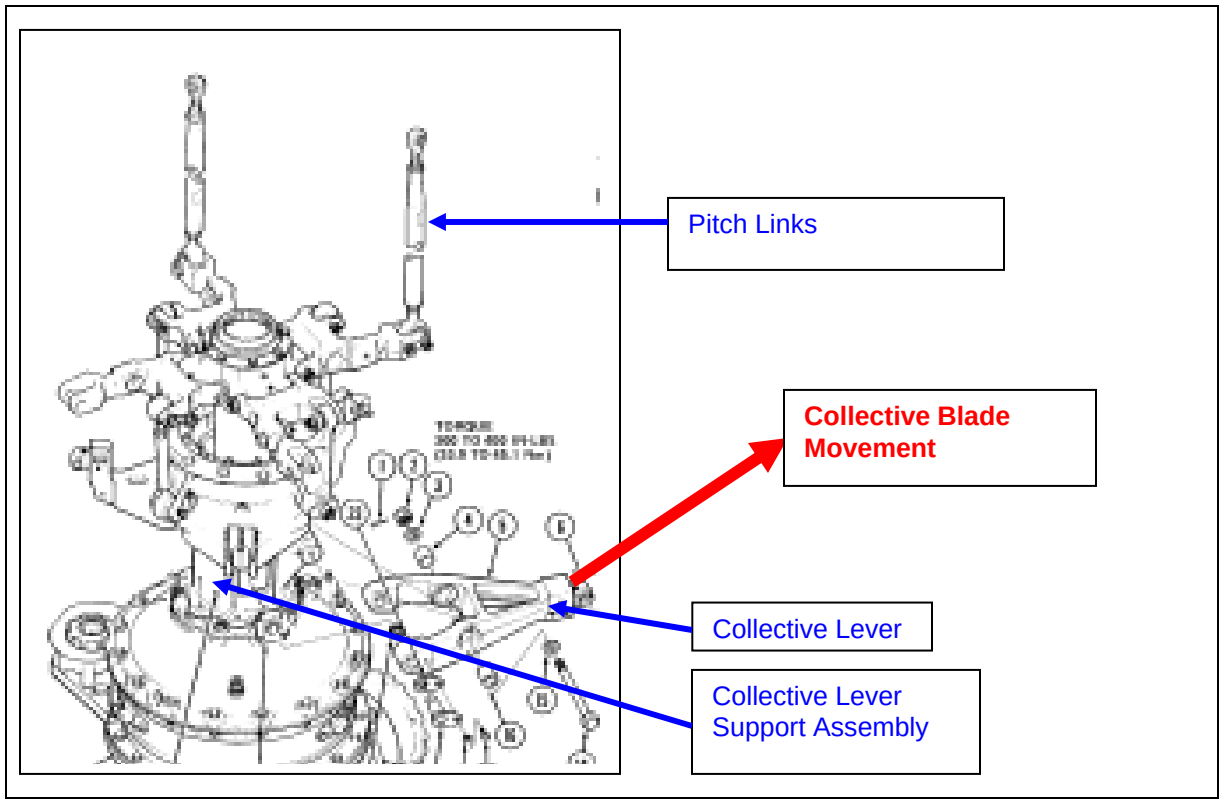
Outer Ring of the Swashplate



Collective Pitch Drive Plate Set

The **PITCH LINK RODS** are connected to the **REPHASING LEVERS**, which in turn are connected to the **PITCH LINKS**.

The Pitch Links connect to the Pitch Horns on the Main Rotor Hub and Blade Assembly and change the pitch of the Main Rotor Blades.



Collective Lever Assembly

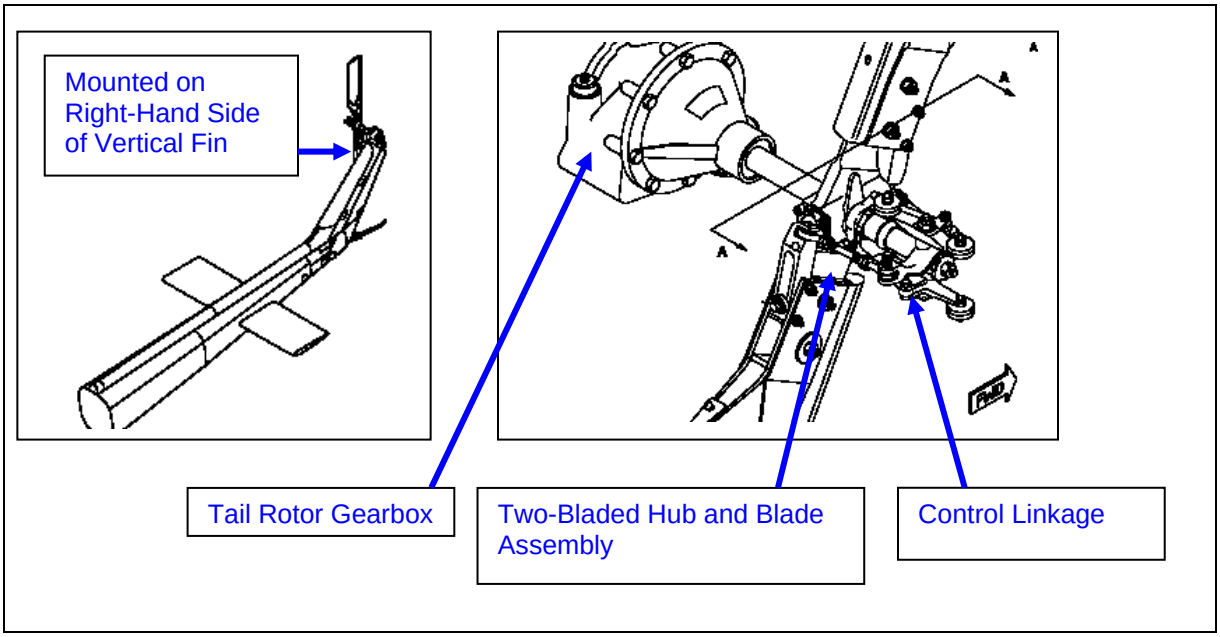
The **COLLECTIVE LEVER** is attached to the **COLLECTIVE LEVER SUPPORT ASSEMBLY**. Movement of the Collective Lever up or down causes all of the **PITCH LINKS** to move the same distance collectively. This movement causes all of the Main Rotor Blades to increase or decrease movement collectively. This is called **COLLECTIVE BLADE MOVEMENT.**

Tail Rotor System
Diameter 8ft 7in (2.6m)
Chord 11.5 in (0.30m)
Tip speed 745 ft/sec (230m/s)
Rotor RPM 1,660rpm

Tail Rotor System Overview

The **TAIL ROTOR SYSTEM** is used to counteract main rotor torque and provide heading control when hovering. The two blades are attached to a hub that is mounted on the tail rotor gearbox. A pitch change mechanism connects the tail rotor flight controls to the tail rotor blades to provide a change in tail rotor thrust.

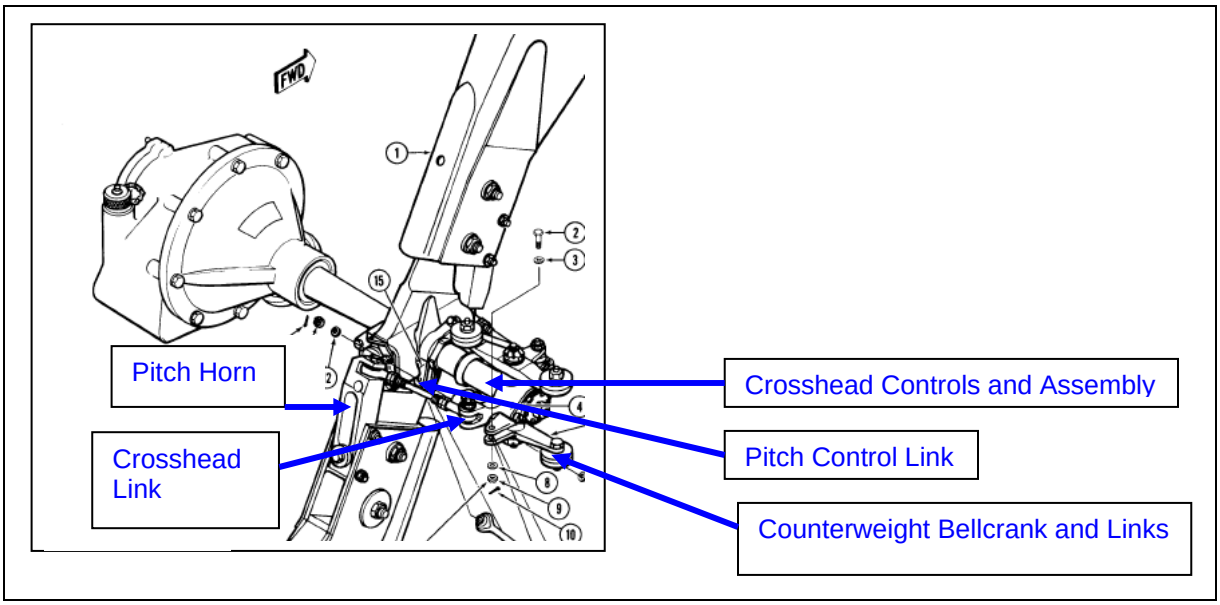
The tail rotor is a two-bladed, semi-rigid rotor system mounted on the right side of the vertical fin. Rotor flapping is provided by a delta hinge arrangement to provide stability during hovering turns and forward flight.



Tail Rotor Hub and Blades

The tail rotor installation consists of the **TWO-BLADED TAIL ROTOR HUB AND BLADE ASSEMBLY** and **CONTROL LINKAGE** and mounted on the **RIGHT-HAND SIDE of the VERTICAL FIN.**

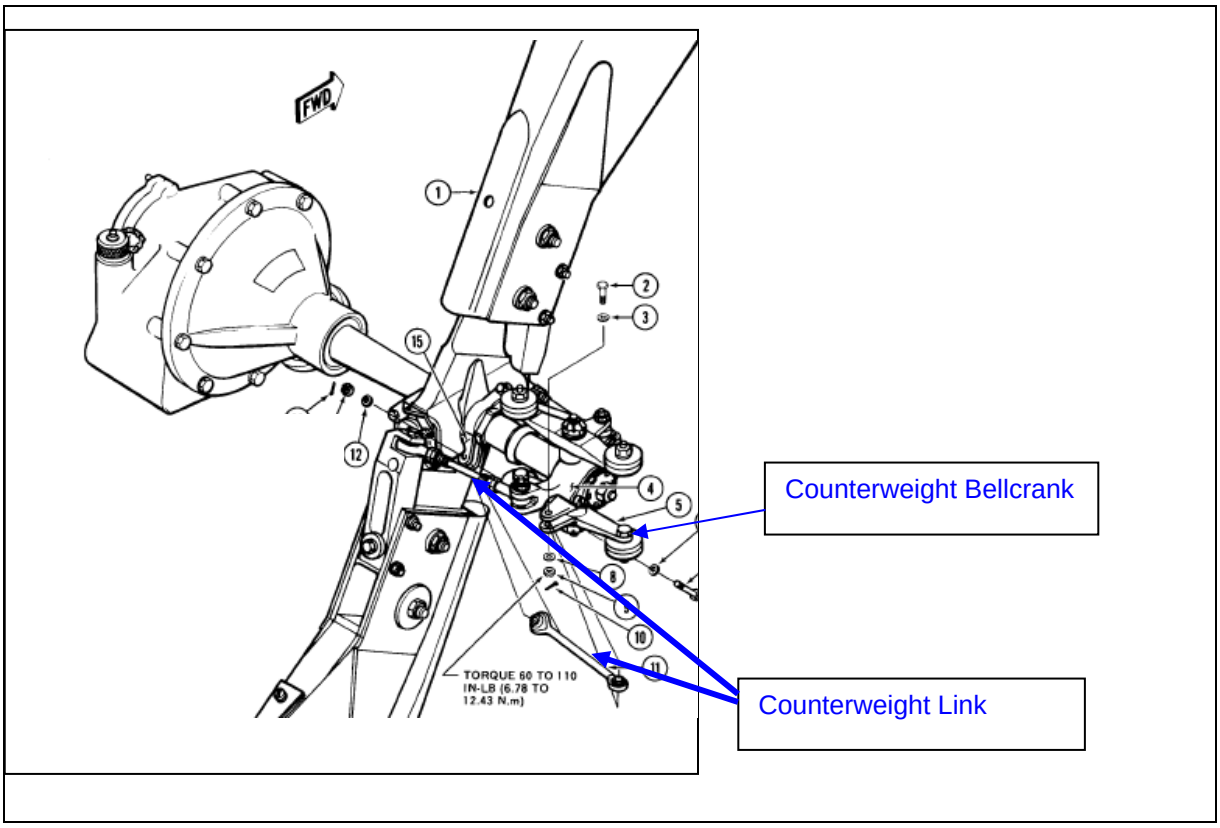
The rotor turns **clockwise,** as viewed from the **TAIL ROTOR GEARBOX**, and counteracts main rotor torque to provide directional control.



Tail Rotor Controls

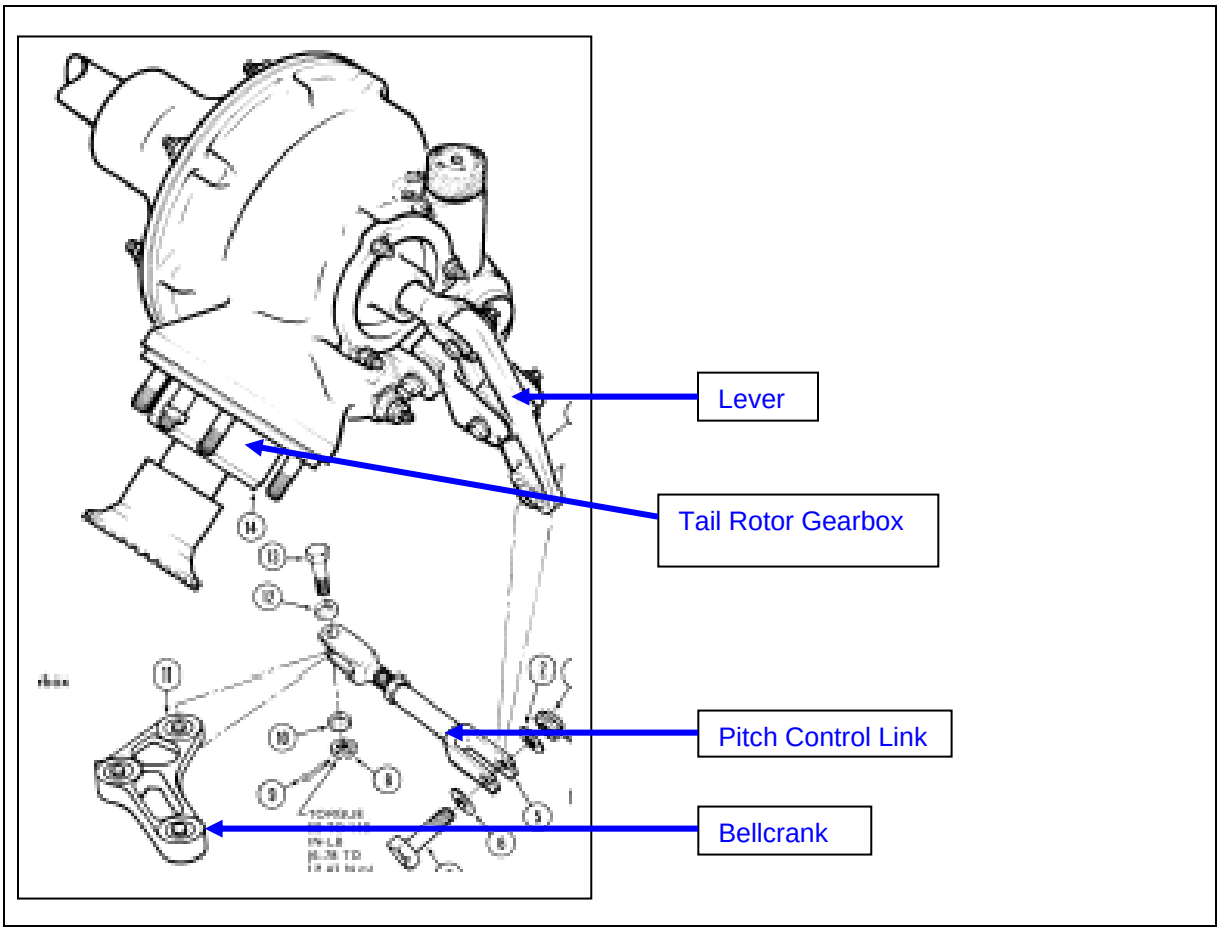
Some of the main tail rotor controls are the following:

COUNTERWEIGHT BELLCRANK AND LINKS
PITCH CONTROL LINK
PITCH HORN
CROSSHEAD LINK
CROSSHEAD CONTROLS AND ASSEMBLY



Counterweight Link

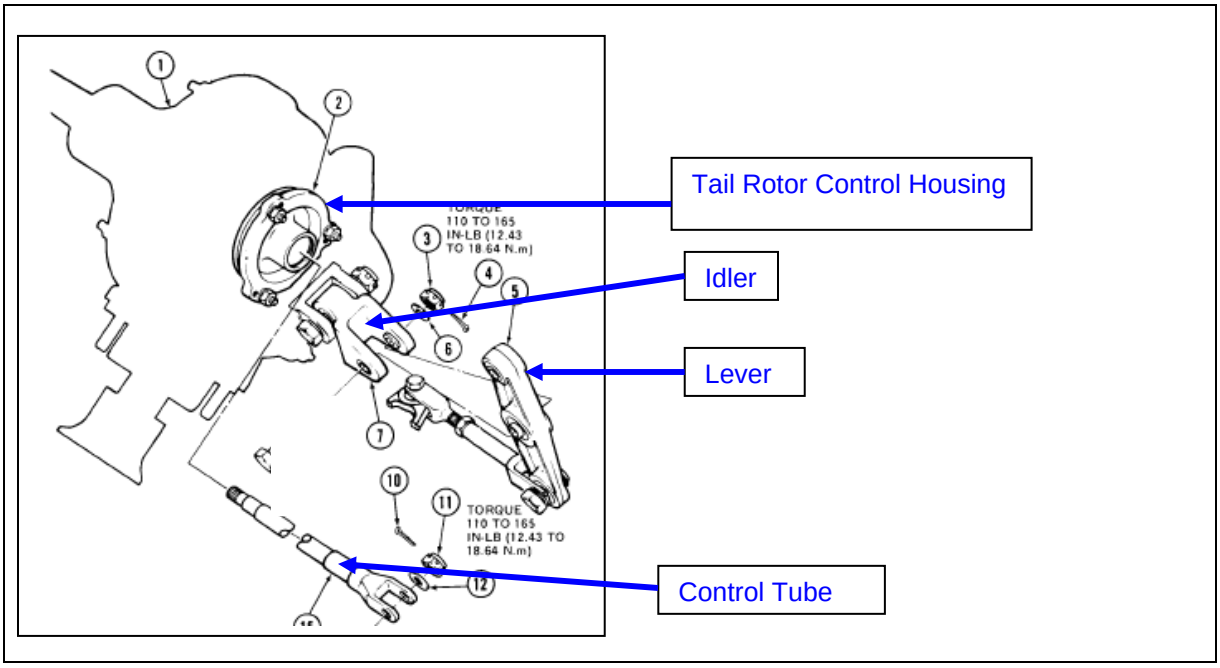
The **COUNTERWEIGHT LINK** **is attached to the** **COUNTERWEIGHT BELLCRANK.**



Pitch Control Link

The **PITCH CONTROL LINK** changes the tail rotor pitch based on rudder control inputs.

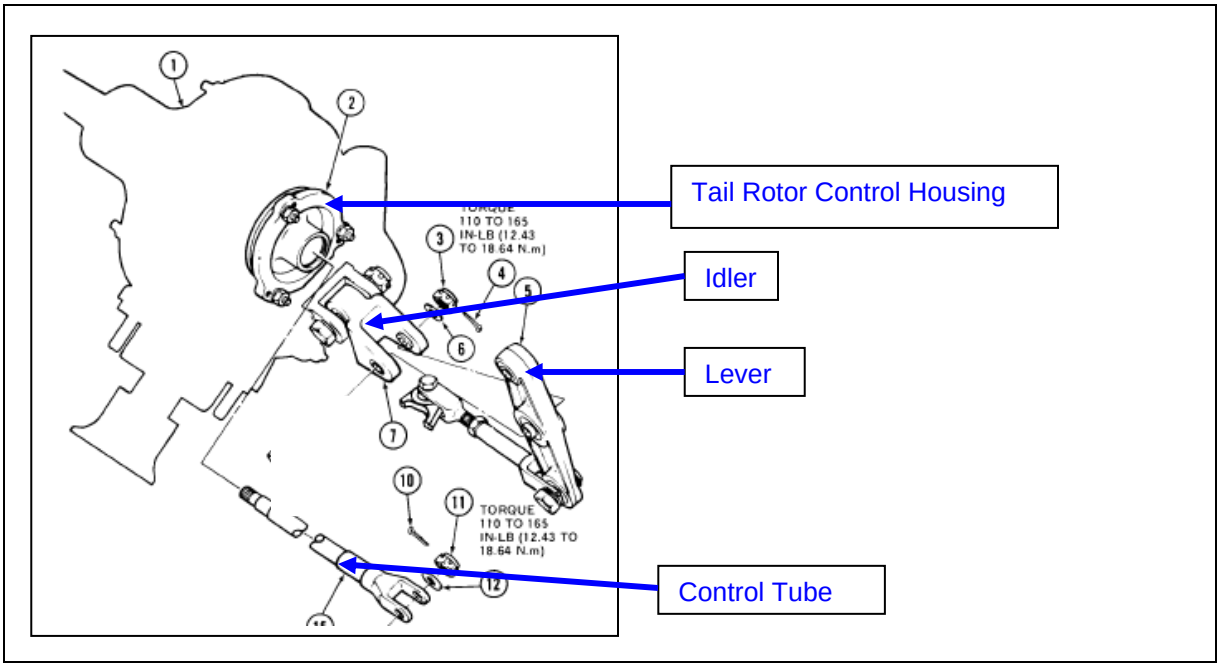
Other related components include the **LEVER**, the **BELLCRANK**, and the **TAIL ROTOR GEARBOX**.



Control Tube

The **CONTROL TUBE** for tail rotor blade pitch fits into the **TAIL ROTOR CONTROL HOUSING.**

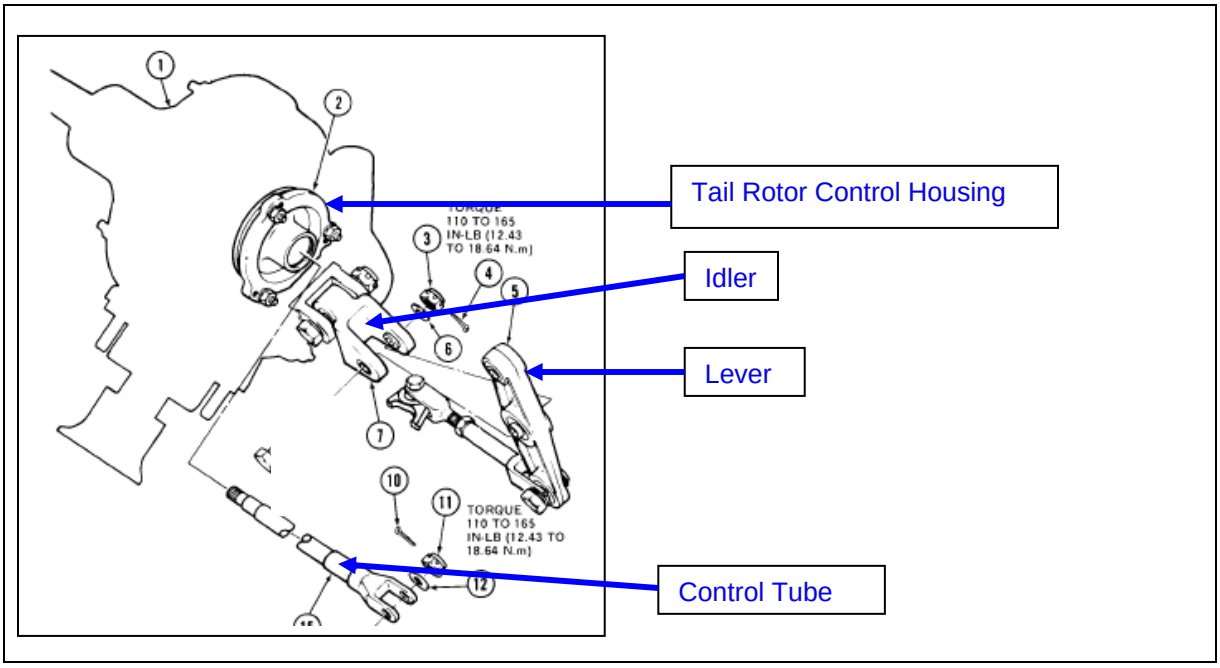
Other related components include the **LEVER** and the **IDLER.**



Control Housing

The **CONTROL TUBE** for tail rotor blade pitch fits into the **TAIL ROTOR CONTROL HOUSING.**

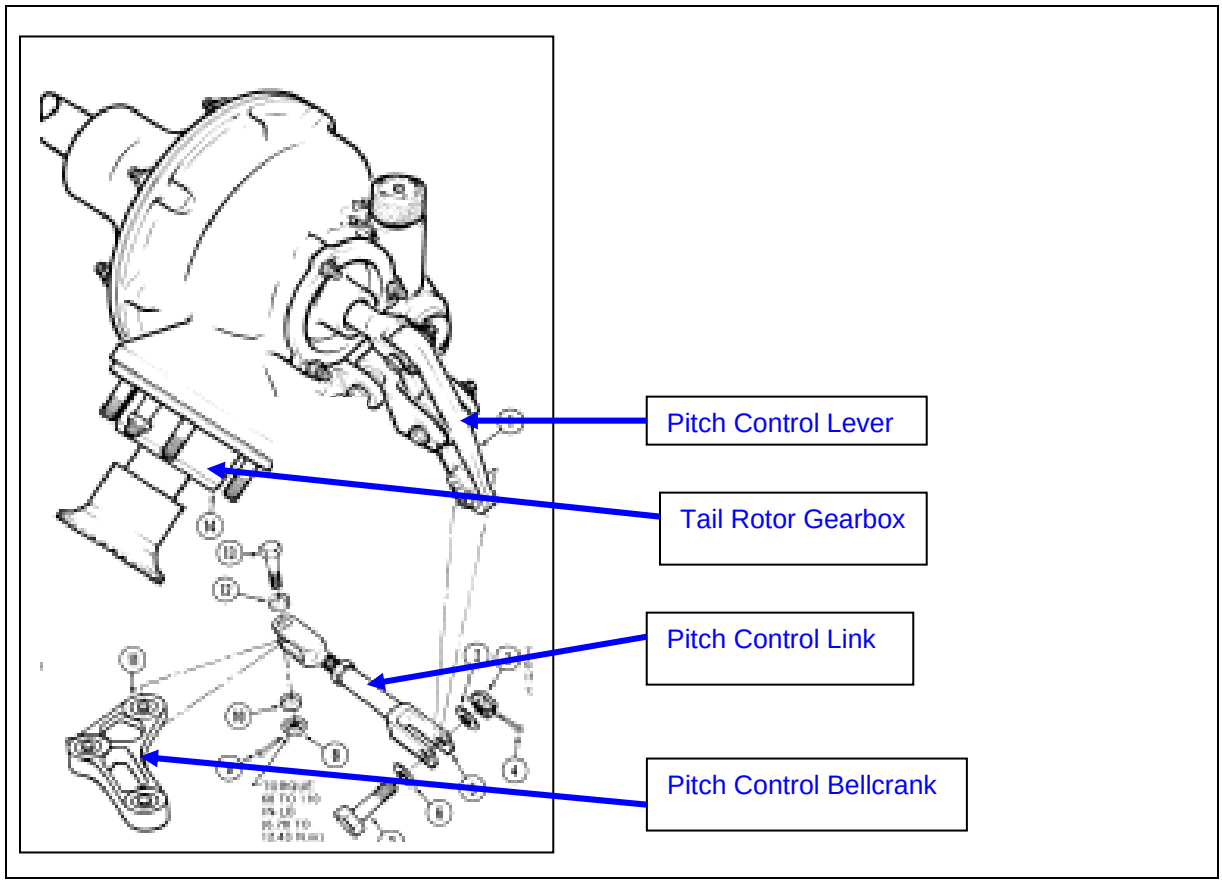
Other related components include the **LEVER** and the **IDLER.**



Tail Rotor Lever

The **TAIL ROTOR LEVER** positions the **CONTROL TUBE.**

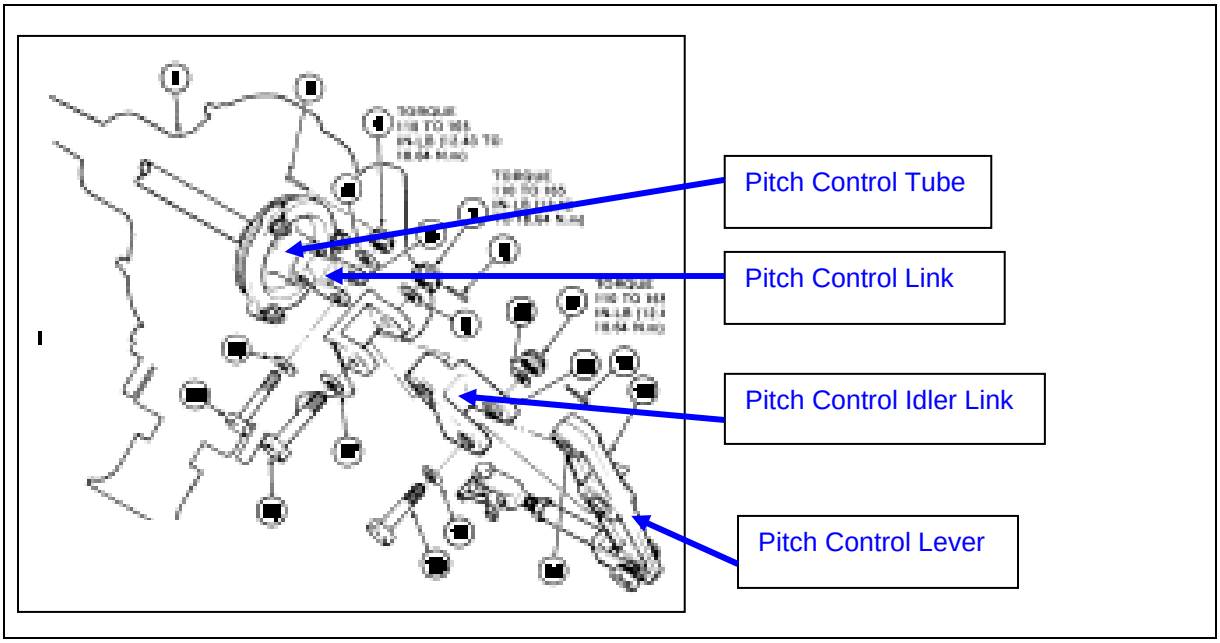
Other related components include the **TAIL ROTOR CONTROL HOUSING** and the **IDLER.**



Control Link

Key components of the Control Link are the **PITCH CONTROL LEVER,** the **PITCH CONTROL LINK,** the **PITCH CONTROL BELLCRANK,** and the **TAIL ROTOR GEARBOX.**

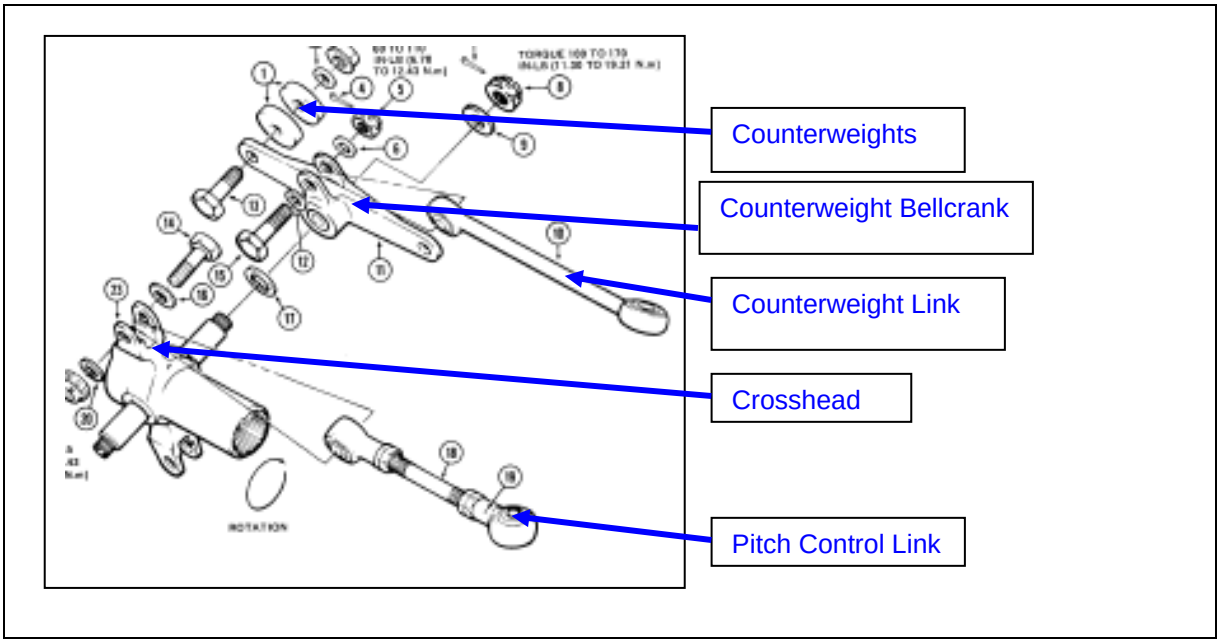
The Pitch Control Link changes the pitch of the tail rotor blades based on rudder control inputs.



Idler

Key Components of the **Tail Rotor Pitch Contols** also include the **PITCH CONTROL IDLER LINK** that connects to the **PITCH CONTROL LEVER** and to the **PITCH CONTROL LINK** in the **PITCH CONTROL TUBE.**

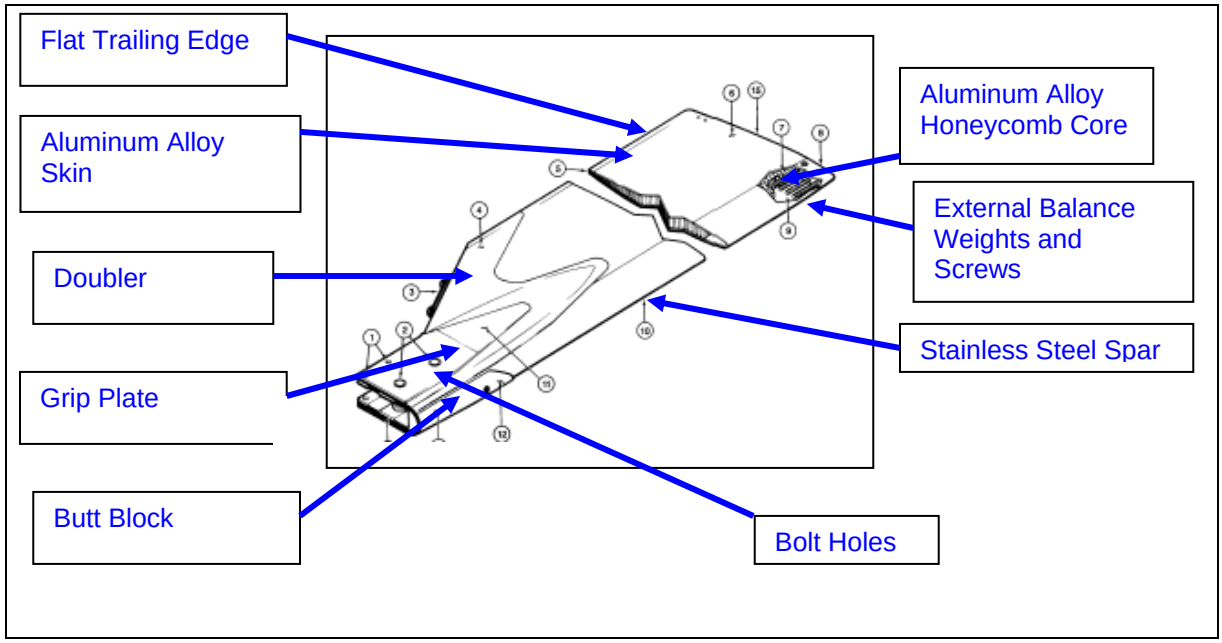
The Pitch Control Link changes the pitch of the tail rotor blades based on rudder control inputs.



Crosshead Controls

Key Components of the **Tail Rotor Pitch Contols** also include the **Crosshead Controls.**

The key components of the **Crosshead Controls** include the **CROSSHEAD** that is attached to the **PITCH CONTROL LINK**, and the **COUNTERWEIGHT LINK** that is attached to the **COUNTERWEIGHT BELLCRANK** with its **COUNTERWEIGHTS**.



Tail Rotor Blades

Each tail rotor blade is a bonded assembly consisting of a **SHAPED STAINLESS STEEL SPAR** forming the leading edge, an **ALUMINIMUM ALLOY HONEYCOMB CORE**, and **ALUMINIMUM ALLOY SKINS**.

A **FLAT TRAILING EDGE** is formed by the extension of skins over a narrow aluminum strip. Aluminum alloy **DOUBLERS, GRIP PLATES** and **BUTT BLOCKS** reinforce the root end of blade. This section extends inboard to form a “box” open toward hub and trailing edge. Two **BOLT HOLES** through the upper and lower surfaces provide for attachment of blade to hub. **EXTERNALLY ATTACHED BALANCE WEIGHTS AND BALANCE SCREWS** inside the blade tip facilitate blade balancing.

TRIPLE TACHOMETER

ROTOR RPM (N_R)

26 to 77%	Transient ground operation
80%	Minimum for autorotation below 8000 Lb (3629 kg) gross weight
80 to 91%	Power off operation below 8000 Lb (3629 kg) gross weight
91 to 104.5%	Continuous operation (91% minimum power off)
104.5%	Maximum

ENGINE RPM (N_E)

97%	Minimum
97 to 100%	Continuous operation
100 to 104.5%	Operation at or below 30% engine torque
104.5%	Maximum at or below 30% engine torque

Rotor RPM (N_r) Limits – Power On

- **MINIMUM 97%**
- **CONTINUOUS OPERATION 97 TO 100%**
- **MAXIMUM CONTINUOUS 100%**
- **OPERATION WITH ENG TORQUE AT OR BELOW 30% 100 TO 104.5%**
- **MAXIMUM WITH ENG TORQUE AT OR BELOW 30% 104.5%**

TRIPLE TACHOMETER

ROTOR RPM (N_R)

26 to 77%	Transient ground operation
80%	Minimum for autorotation below 8000 Lb (3629 kg) gross weight
80 to 91%	Power off operation below 8000 Lb (3629 kg) gross weight
91 to 104.5%	Continuous operation (91% minimum power off)
104.5%	Maximum

ENGINE RPM (N_R)

97%	Minimum
97 to 100%	Continuous operation
100 to 104.5%	Operation at or below 30% engine torque
104.5%	Maximum at or below 30% engine torque

Rotor RPM (N_r) Limits – Power Off

- **MINIMUM FOR AUTOROTATION WITH GROSS WEIGHT BELOW 8,000 POUNDS (3629 KG) 80%**
- **POWER OFF OPERATION WITH GROSS WEIGHT BELOW 8,000 POUNDS (3629 KG) 80 TO 104.5%**
- **MINIMUM FOR AUTOROTATION WITH GROSS WEIGHT AT OR ABOVE 8000 POUNDS (3629KG) 91%**
- **MAXIMUM 104.5%**

TRIPLE TACHOMETER

ROTOR RPM (N_R)

26 to 77%	Transient ground operation
80%	Minimum for autorotation below 8000 Lb (3629 kg) gross weight
80 to 91%	Power off operation below 8000 Lb (3629 kg) gross weight
91 to 104.5%	Continuous operation (91% minimum power off)
104.5%	Maximum

ENGINE RPM (N_E)

97%	Minimum
97 to 100%	Continuous operation
100 to 104.5%	Operation at or below 30% engine torque
104.5%	Maximum at or below 30% engine torque

Rotor RPM (N_r) Limits – Ground Operation

- **MINIMUM 77%**
- **MINIMUM WITH STICK CENTERING INDICATOR SYSTEM INOPERATIVE 97%**
- **TRANSIENT (AVOID STEADY STATE OPERATIONS) 26 TO 77%**

TRIPLE TACHOMETER

ROTOR RPM (N_R)

26 to 77%	Transient ground operation
80%	Minimum for autorotation below 8000 Lb (3629 kg) gross weight
80 to 91%	Power off operation below 8000 Lb (3629 kg) gross weight
91 to 104.5%	Continuous operation (91% minimum power off)
104.5%	Maximum

ENGINE RPM (N_G)

97%	Minimum
97 to 100%	Continuous operation
100 to 104.5%	Operation at or below 30% engine torque
104.5%	Maximum at or below 30% engine torque

Rotor Brake Limitations

- Engine starts with rotor brake engaged are prohibited.
- Rotor brake application is limited to ground operation and shall not be applied until both engines are shut down and rotor rpm has decreased to 40% NR or below.
- **ROTOR BRAKE OPERATION 40% (N_r) OR BELOW**