POLITÉCNICA

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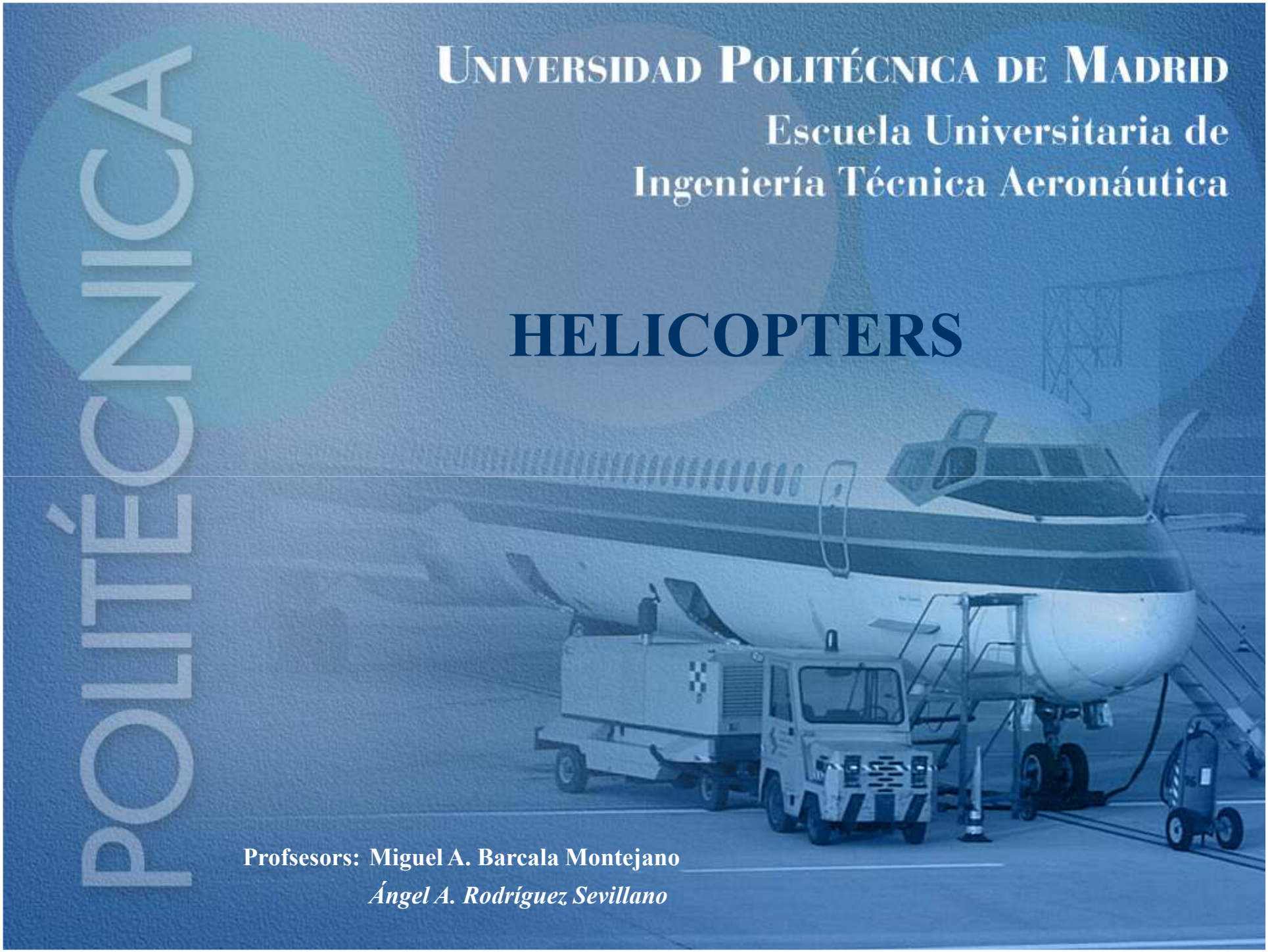
Escuela Universitaria de
Ingeniería Técnica Aeronáutica

HELICOPTERS



Profsesors: Miguel A. Barcala Montejano

Ángel A. Rodríguez Sevillano

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POWER TRANSMISSION SYSTEM

INTRODUCTION

- There are many possible configurations.
- Only 5 of these configurations have been important and 2 of them are very rare.
  - Monorrotor Helicopter.
  - Birotor in tandem (***twin tandem).***
  - Birotor side by side (***twin side-by-side*).**
  - Birotor with two crossing axes (***twin intermeshing*).**
  - Birotor coaxial **(*twin coaxial*).**

INTRODUCTION

- The monorotor helicopter, in which the reaction torque generated in the fuselage, by the main rotor, is offset by the tail rotor or by another device.

INTRODUCTION

- Birotor in tandem (***twin tandem***)**:** The rotors are positioned symmetrically about the transversal axis of the vehicle. The rotors intersecting blades and rotating in opposite directions. Both rotors inclined axis to cancel out any torque transmitted to the fuselage.

INTRODUCTION

- The birotor side by side helicopter (***twin side-by-side***) has never been popular, even though it was used in one of the largest helicopters built, the Mil V-12.

INTRODUCTION

- The type of birotor (***twin intermeshing***) is made of two rotors rotating in opposite directions on two inclined axis and are located close together.

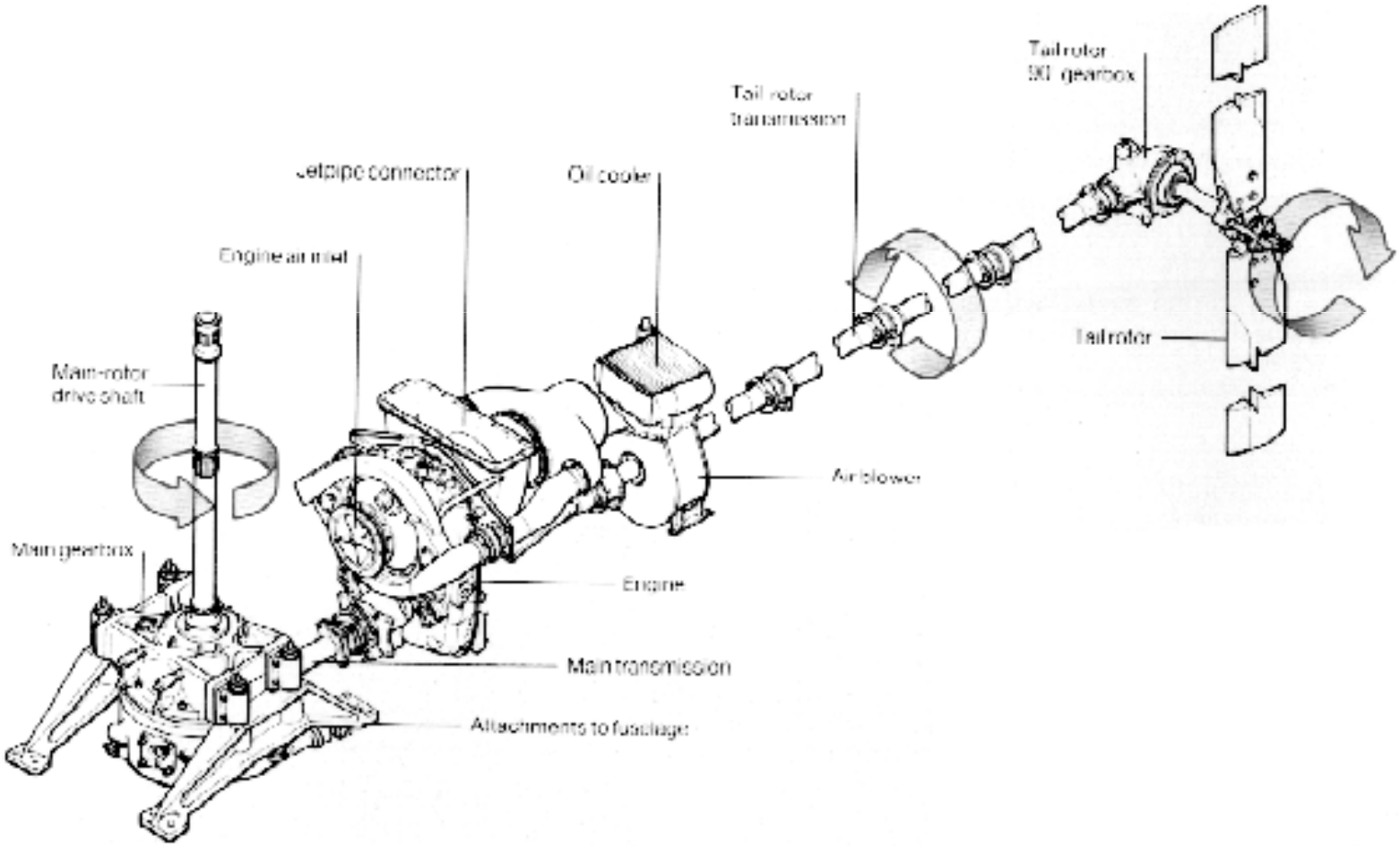
INTRODUCTION

- The last mentioned configuration is the birotor coaxial helicopter ***(twin coaxial)*** in which the rotors are on top of each other rotating in opposite directions. It is quite a compact layout.

Photo courtesy www.egroups.com/group/recognition


Photo courtesy www.egroups.com/group/recognition

MOVING PARTS



MOVING PARTS

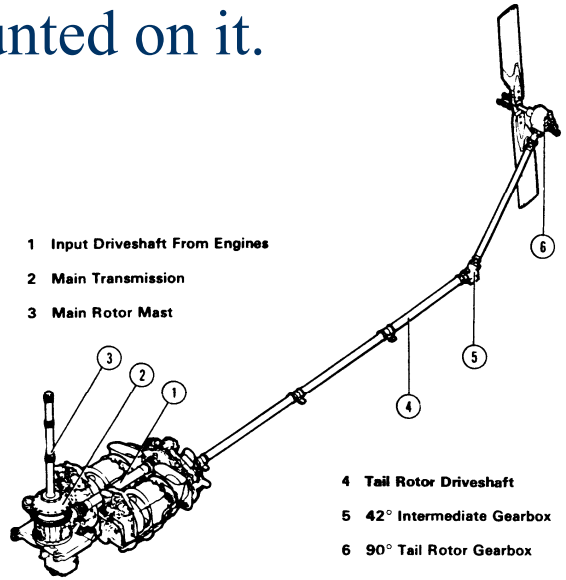
- Gearboxes, transmission shafts/drive shafts and control systems (cap 10).
- There will be one or more gearboxes that connect the engine/s whose output shaft is rotating at an angular velocity between 6000 and 50000 R.P.M.
- The main rotor rotates about 300 R.P.M.
- The design is fundamental, not only for its function of transmitting power and reducing angular speed, but because it can seriously penalise the total weight of the vehicle.

SYSTEM DESCRIPTION

- System is made of:
  - Assembly of shafts and reduction boxes of R.P.M.
  - Set of elements, components, and systems are moved due to the engine.

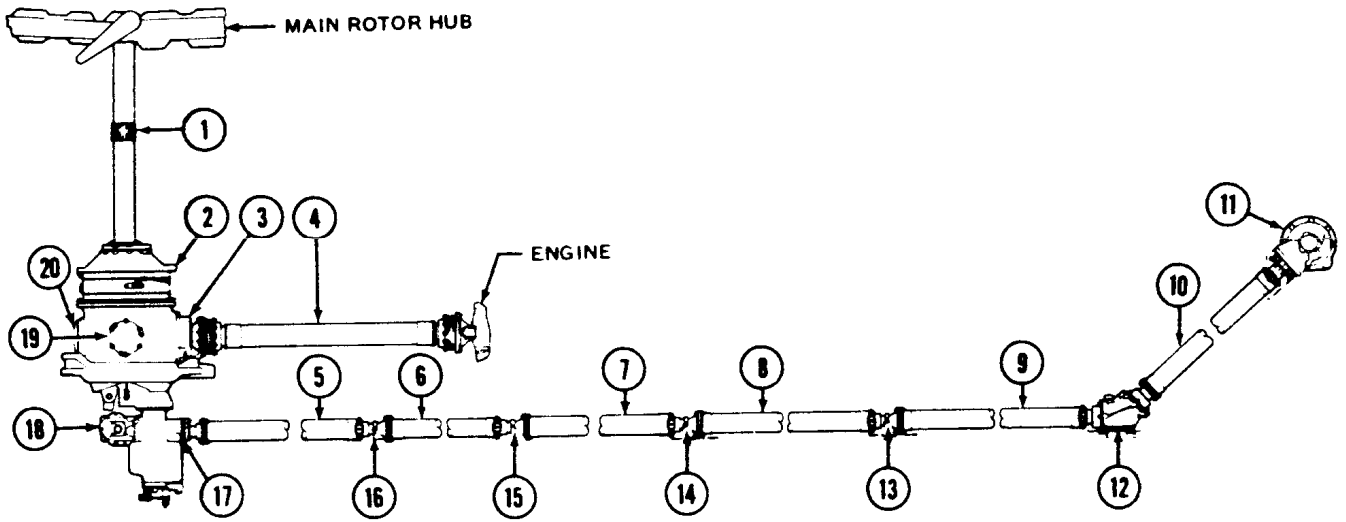
SYSTEM DESCRIPTION

- Power Transmission of the **Agusta AB412**.
  - The power from the engine/s is transmitted through a shaft/s, to the main gearbox and hence the main rotor and to the tail rotor through one or two gearboxes (42 º and 90º).
  - Also, a set of accessories that are mounted on it.



SYSTEM DESCRIPTION

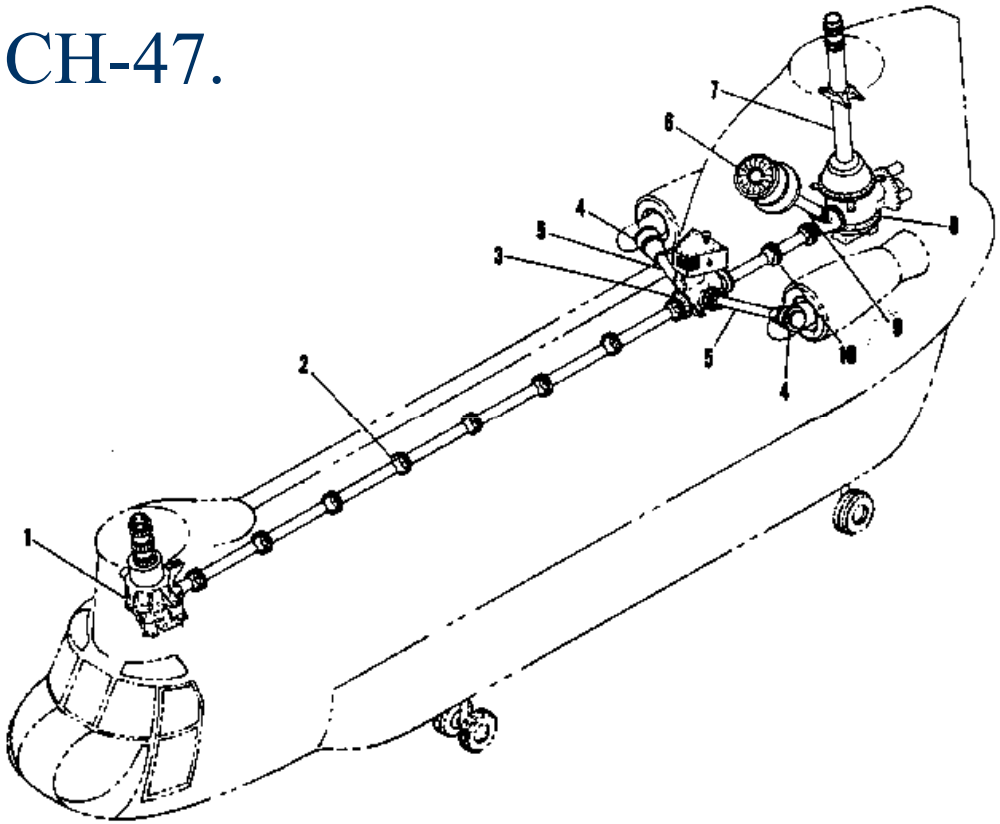
- Other transmission systems.



1. Mast assembly
2. Transmission
3. Input quill
4. Engine to transmission driveshaft
5. Tail rotor driveshaft
6. Tail rotor driveshaft (short section)
7. Tail rotor driveshaft
8. Tail rotor driveshaft
9. Tail rotor driveshaft
10. Tail rotor driveshaft
11. Tail rotor gearbox
12. Intermediate gearbox
13. Hanger assembly
14. Hanger assembly
15. Hanger assembly
16. Hanger assembly
17. Tail rotor drive quill
18. Hydraulic pump and tachometer (system 1)
19. Cover
20. Hydraulic pump drive quill (system 2)

SYSTEM DESCRIPTION

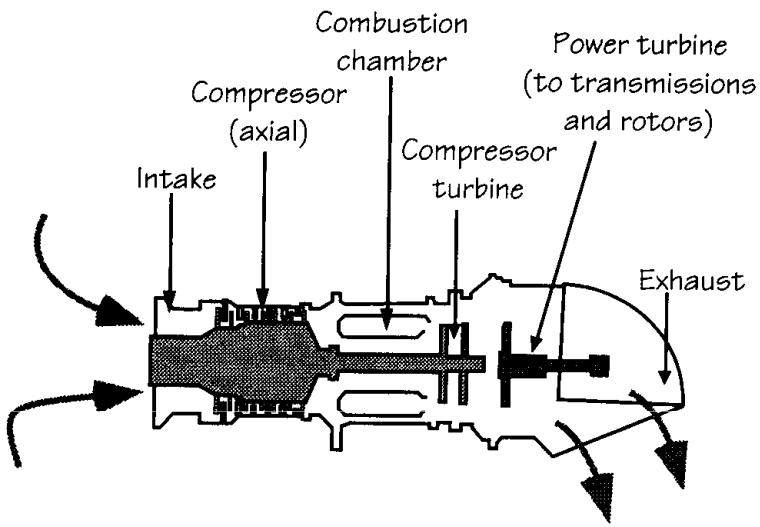
- Power transmission CH-47.

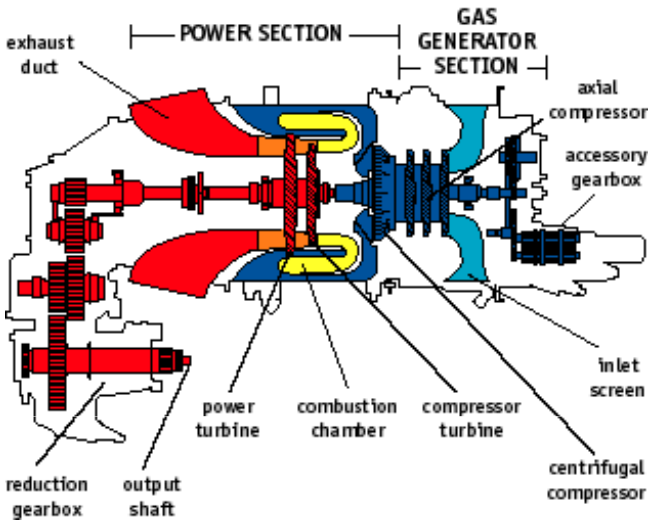


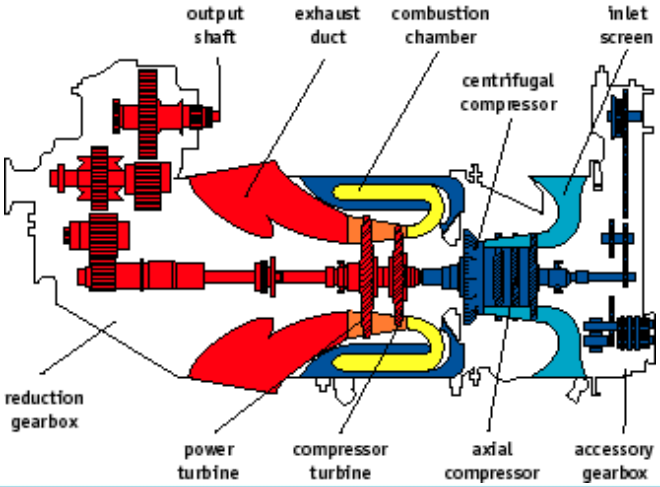
1. Forward rotary-wing drive transmission
2. Forward sync shaft
3. Engine combining transmission
4. Engine transmission
5. Engine shaft
6. Transmission oil cooling fan
7. Aft rotary-wing drive shaft
8. Aft rotary-wing drive transmission
9. Transmission oil cooling fan drive shaft
10. Aft synchronizing shaft

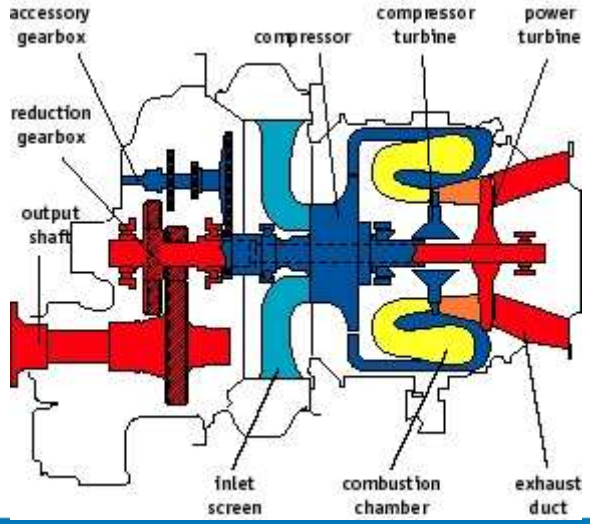
Figure 6-1. Drive Train System

Engine

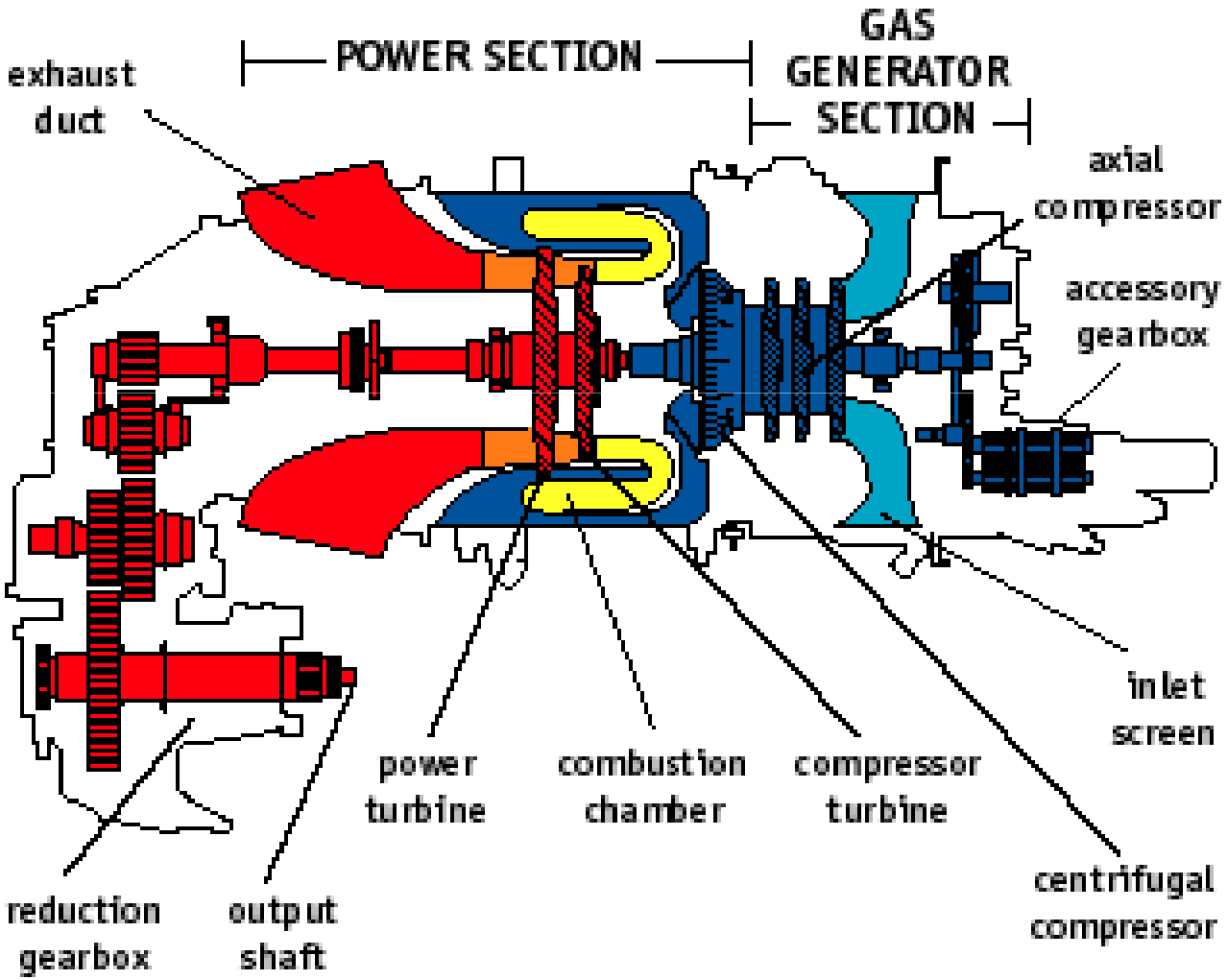

Combustion chamber
Compressor (axial)
Power turbine (to transmissions and rotors)
Compressor turbine
Intake
Exhaust


exhaust duct
POWER SECTION
GAS GENERATOR SECTION
axial compressor
accessory gearbox
inlet screen
power turbine
combustion chamber
compressor turbine
centrifugal compressor
reduction gearbox
output shaft


output shaft
exhaust duct
combustion chamber
inlet screen
centrifugal compressor
reduction gearbox
power turbine
compressor turbine
axial compressor
accessory gearbox


accessory gearbox
compressor
compressor turbine
power turbine
reduction gearbox
output shaft
inlet screen
combustion chamber
exhaust duct

Engine

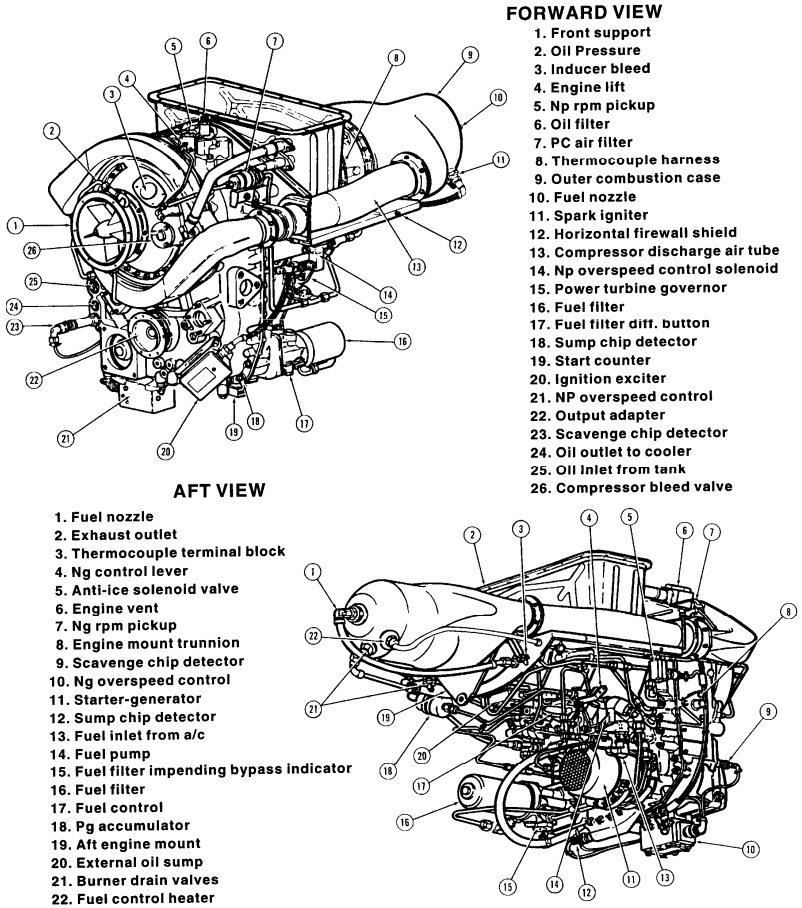

POWER SECTION
GAS GENERATOR SECTION
exhaust duct
axial compressor
accessory gearbox
inlet screen
power turbine
combustion chamber
compressor turbine
centrifugal compressor
reduction gearbox
output shaft

Engine

- Reasons to use turbines are:
  - Smoother operation with a significant reduction in vibrations.
  - The helicopter is quieter, or at least has a different kind of noise.
  - Lighter for the same power output.
  - The rotation velocities are typically between 6000-50000 R.P.M. in the majority of engines.

Engine

- Figure 9-18 (Bell 230). Accessories and engine controls



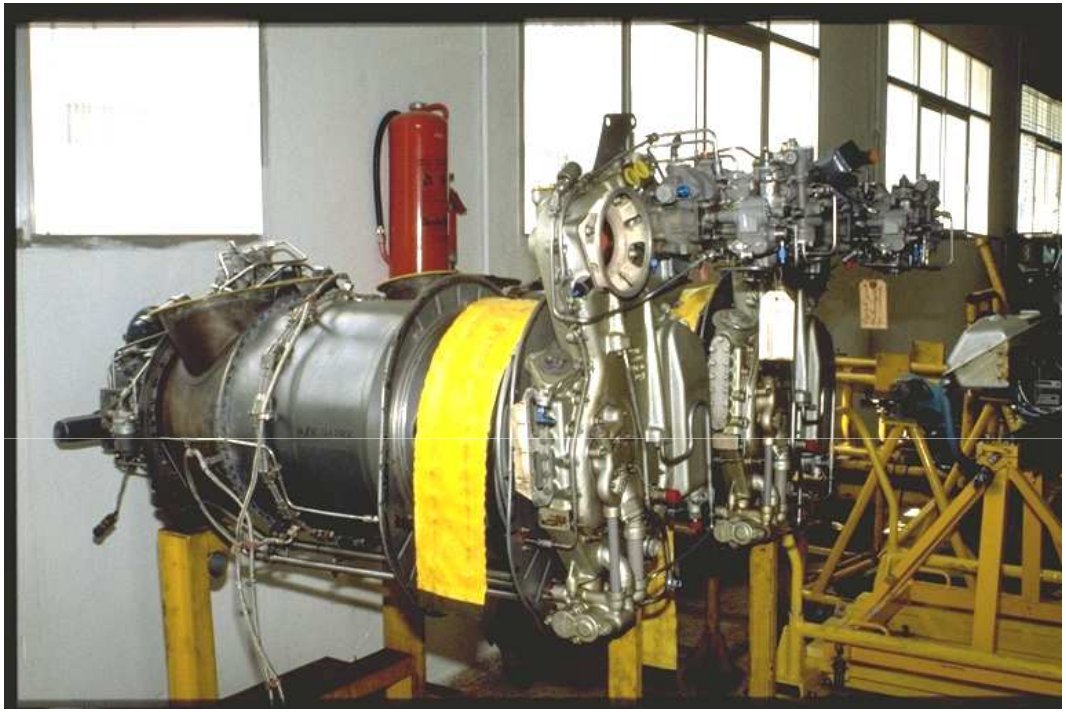
FORWARD VIEW

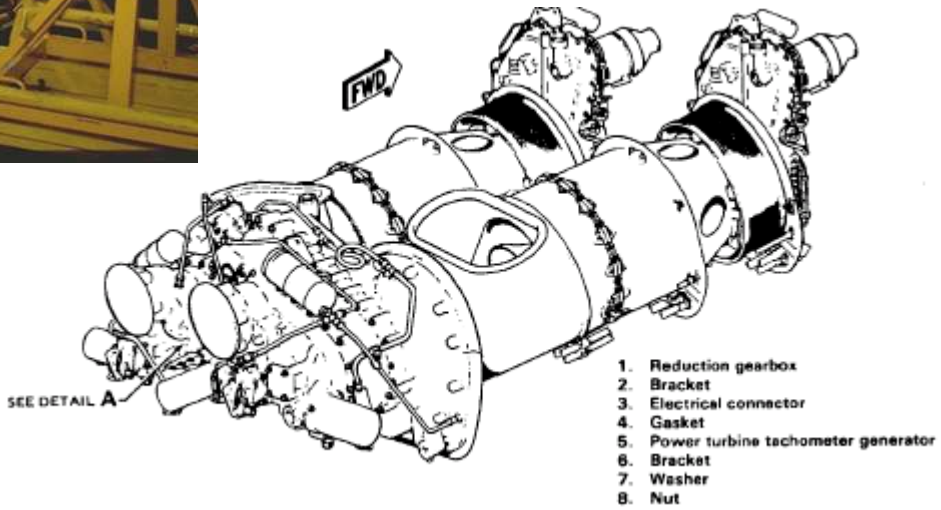
1. Front support
2. Oil Pressure
3. Inducer bleed
4. Engine lift
5. Np rpm pickup
6. Oil filter
7. PC air filter
8. Thermocouple harness
9. Outer combustion case
10. Fuel nozzle
11. Spark igniter
12. Horizontal firewall shield
13. Compressor discharge air tube
14. Np overspeed control solenoid
15. Power turbine governor
16. Fuel filter
17. Fuel filter diff. button
18. Sump chip detector
19. Start counter
20. Ignition exciter
21. NP overspeed control
22. Output adapter
23. Scavenge chip detector
24. Oil outlet to cooler
25. Oil inlet from tank
26. Compressor bleed valve

AFT VIEW

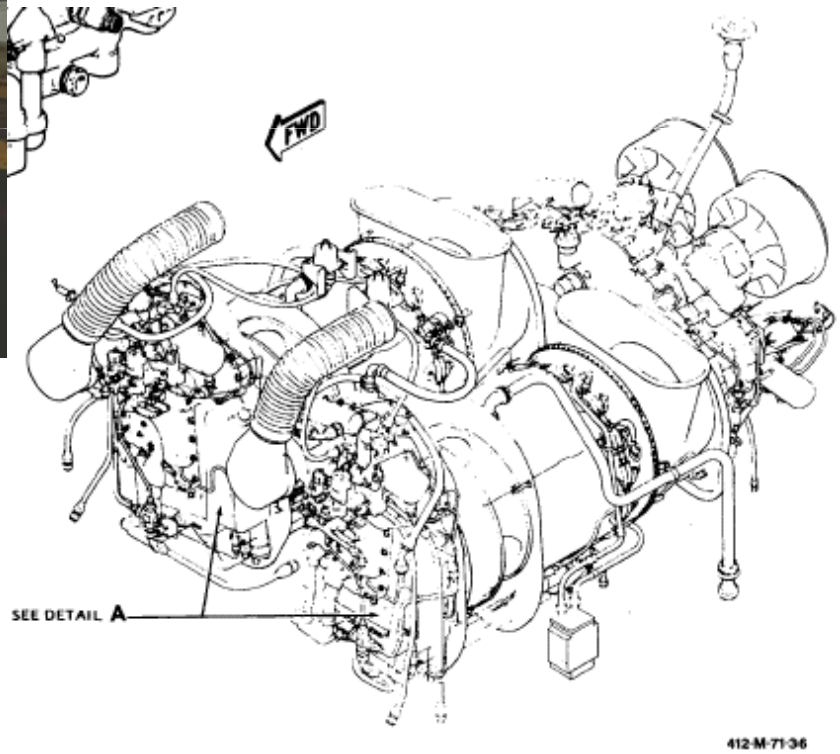
1. Fuel nozzle
2. Exhaust outlet
3. Thermocouple terminal block
4. Ng control lever
5. Anti-ice solenoid valve
6. Engine vent
7. Ng rpm pickup
8. Engine mount trunnion
9. Scavenge chip detector
10. Ng overspeed control
11. Starter-generator
12. Sump chip detector
13. Fuel inlet from a/c
14. Fuel pump
15. Fuel filter impending bypass indicator
16. Fuel filter
17. Fuel control
18. Pg accumulator
19. Aft engine mount
20. External oil sump
21. Burner drain valves
22. Fuel control heater

Engine




FWD
SEE DETAIL A
1. Reduction gearbox
2. Bracket
3. Electrical connector
4. Gasket
5. Power turbine tachometer generator
6. Bracket
7. Washer
8. Nut

Engine

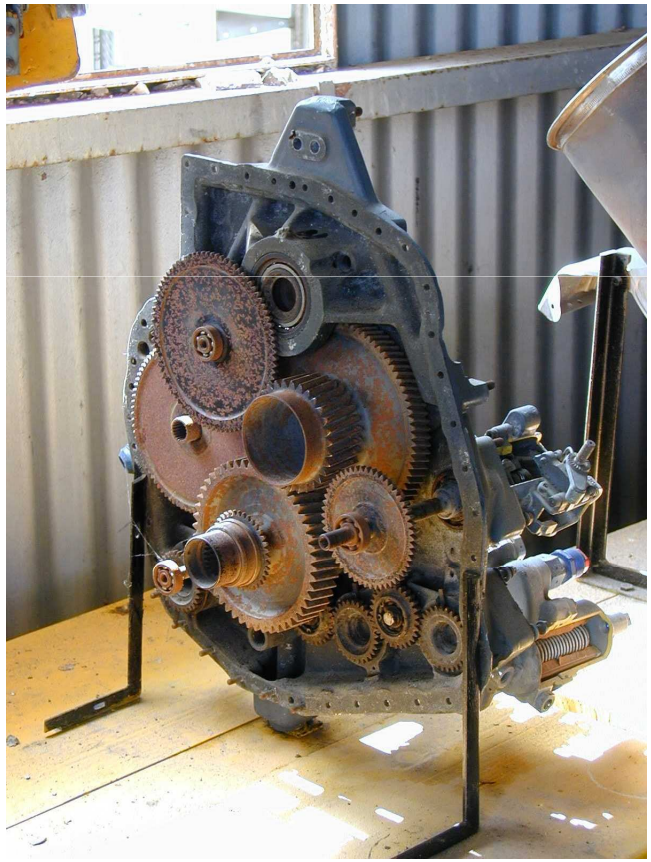


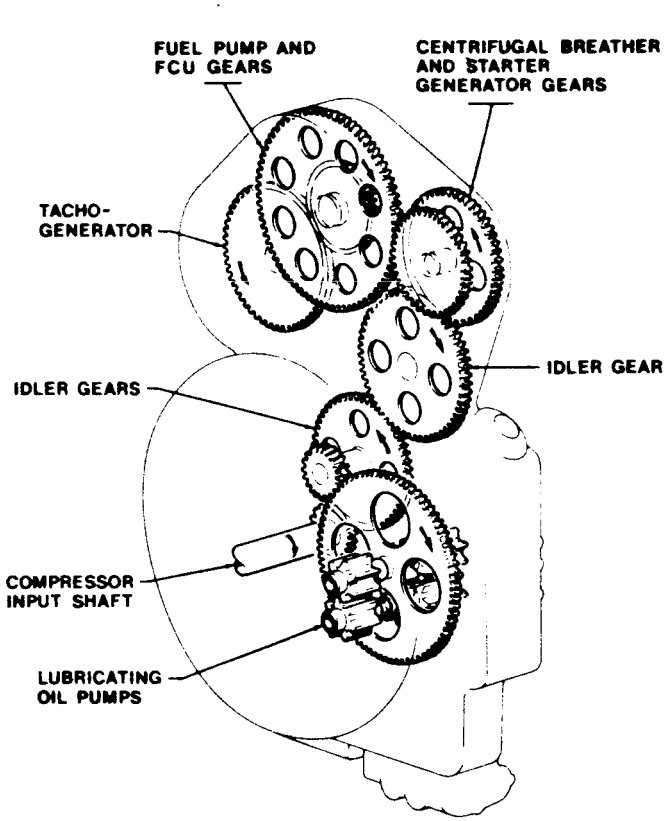
Engine

- Within the power plant, the gearboxes are generally installed at the output shaft.
  - Provide a first reduction of the R.P.M. (around 5:1).
  - Supply power to the auxiliary systems and accessories: torque wrench, oil pump, start up system (input/output), fuel control system.

Engine

- The gearbox of the Agusta AB412.





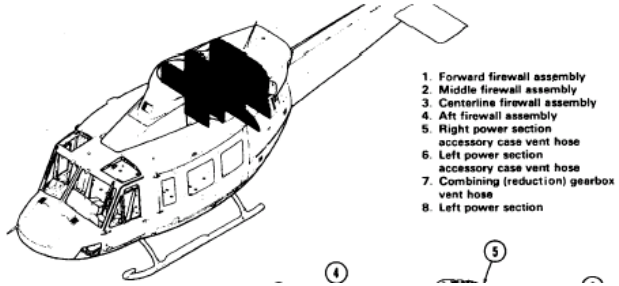
Engine

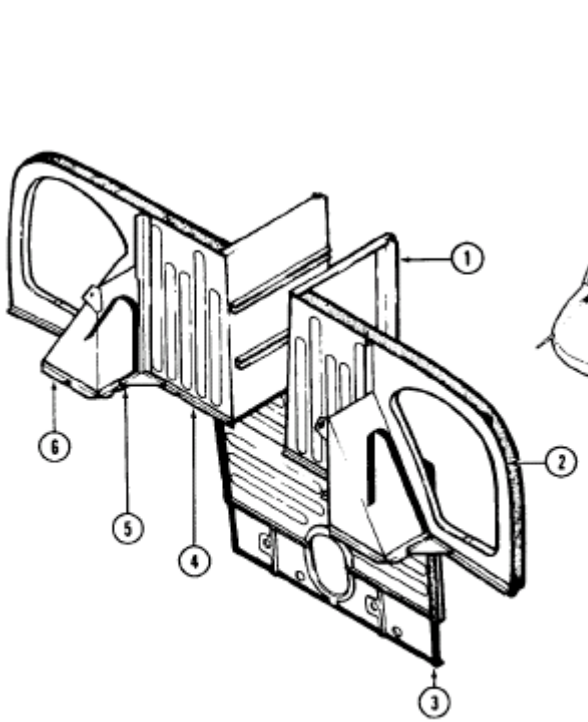
- They also can have the function of combining the power output when the helicopter has two engines.
- In recent decades: new generation of gearboxes with significant reductions in the weight of the transmission.
- Numerous improvements: gearboxes of light material with 3 steps of reduction with a ratio velocity of 12:1 and even greater improvements which:
  - reduce the forces on the teeth/grooves of the boxes,
  - reduce the number of parts,
  - reduce the noise,
  - facilitate the installation of MMS devices (*mast-mounted sight*) and,
  - other minor advantages.

Engine

Engine

- Firewall.





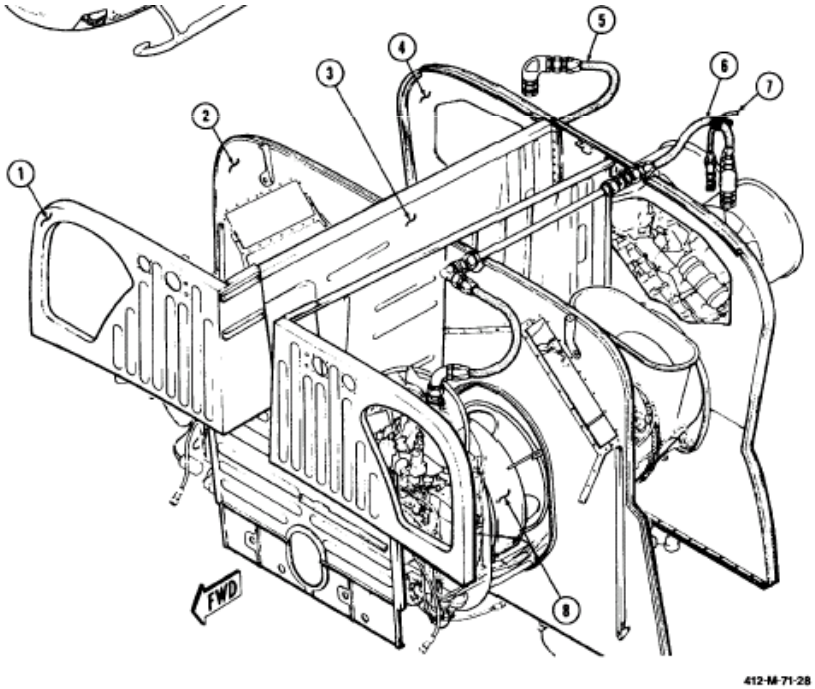
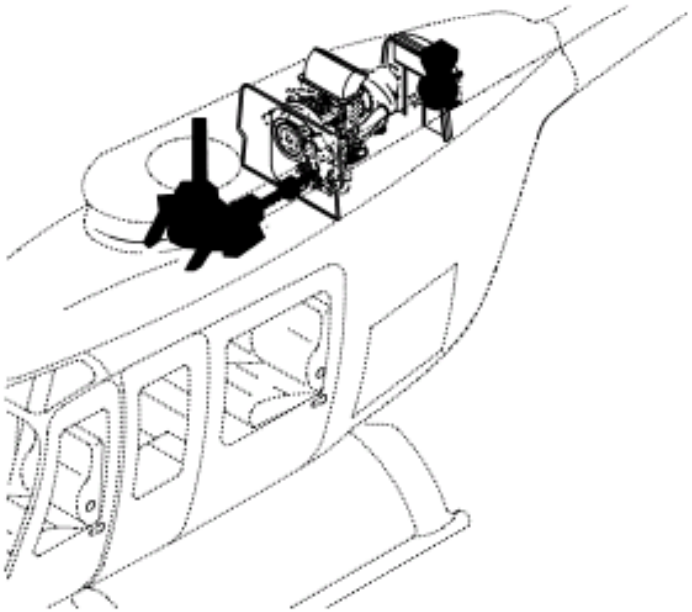


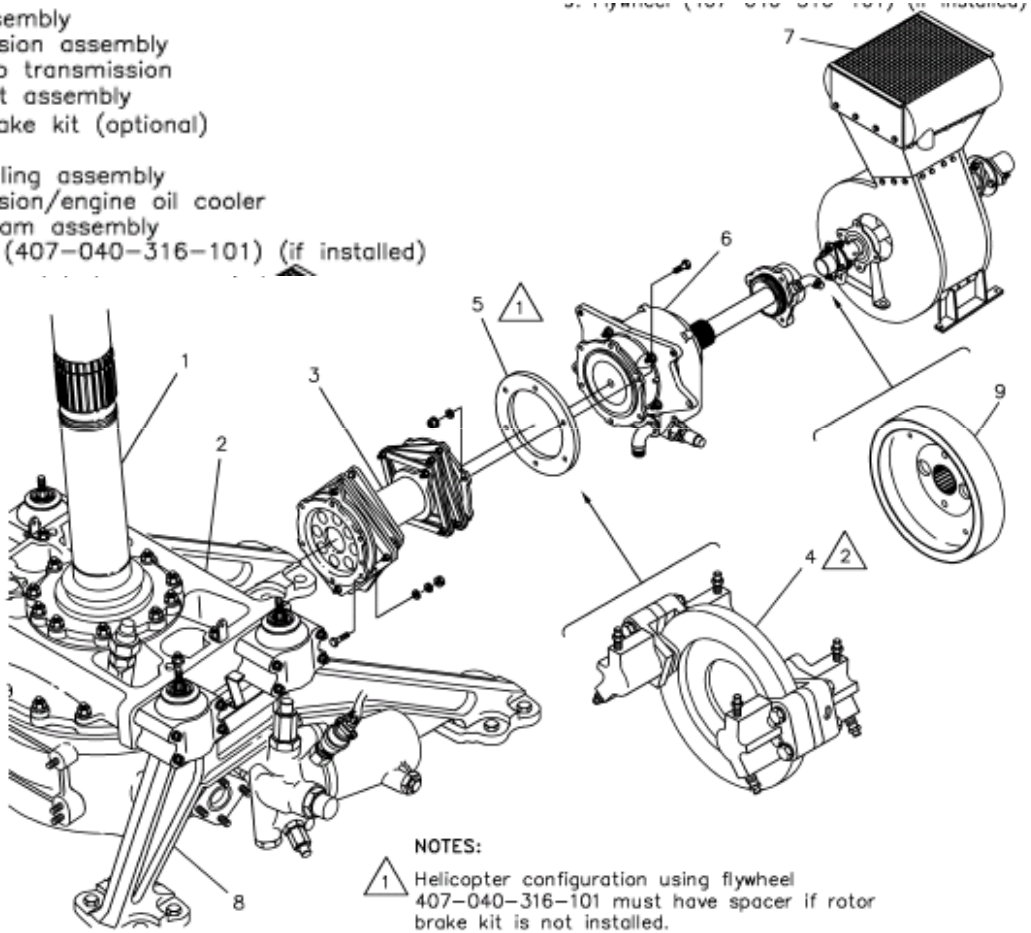
Figure 71-28. Engine Firewalls

Engine

- Bell 407.



1. Mast assembly
2. Transmission assembly
3. Engine to transmission driveshaft assembly
4. Rotor brake kit (optional)
5. Spacer
6. Freewheeling assembly
7. Transmission/engine oil cooler
8. Pylon beam assembly
9. Flywheel (407-040-316-101) (if installed)



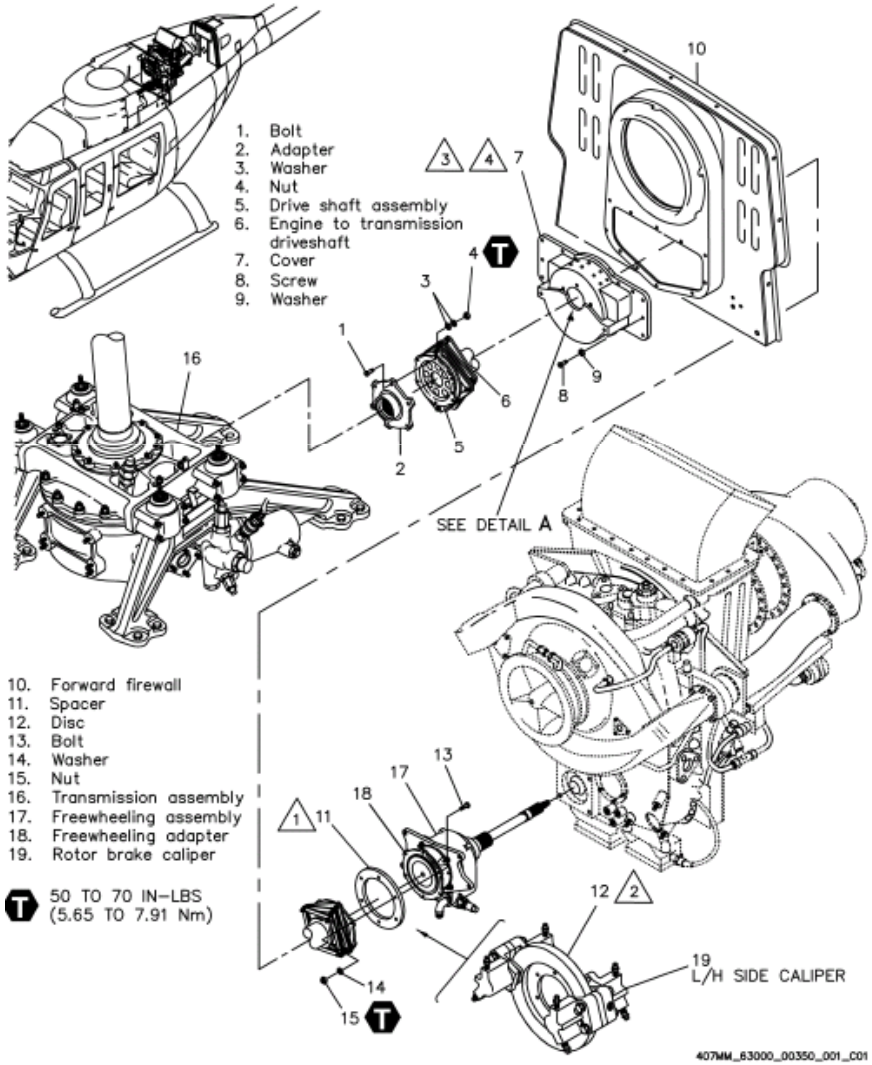
NOTES:

1. Helicopter configuration using flywheel 407-040-316-101 must have spacer if rotor brake kit is not installed.
2. Helicopter configuration with no flywheel 407-040-316-101 must have rotor brake disc 407-340-318-101 installed at all times.

407MM_63000_00010_001_C01

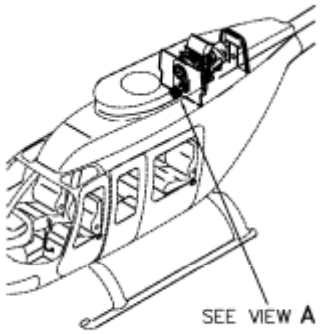
Engine

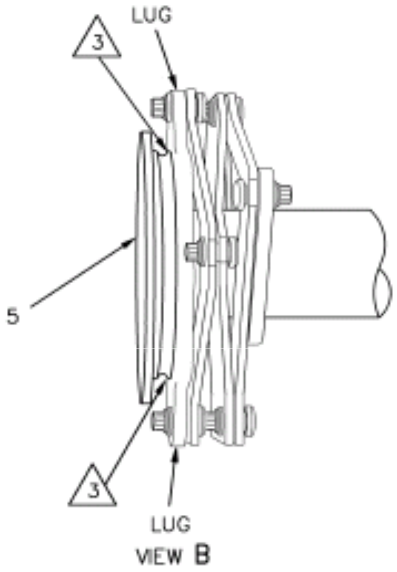
- Bell 407.

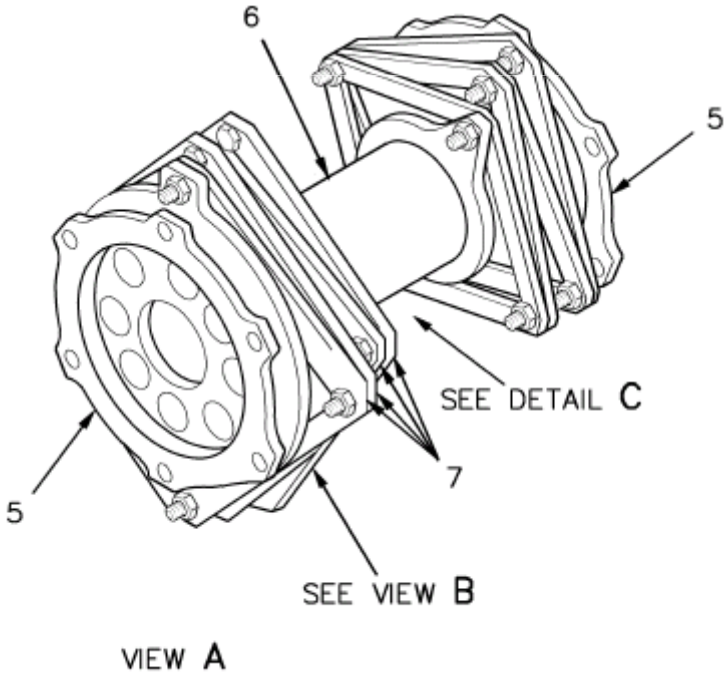


Engine

- Bell 407.





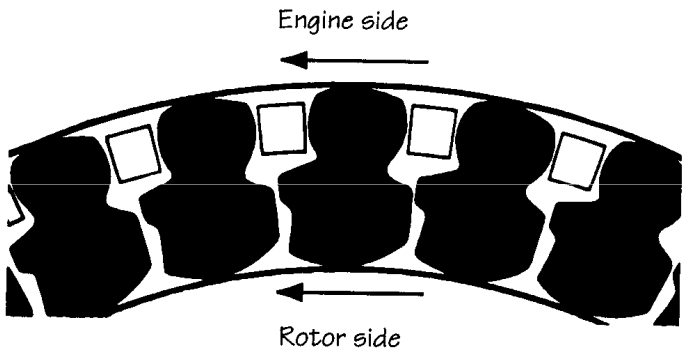


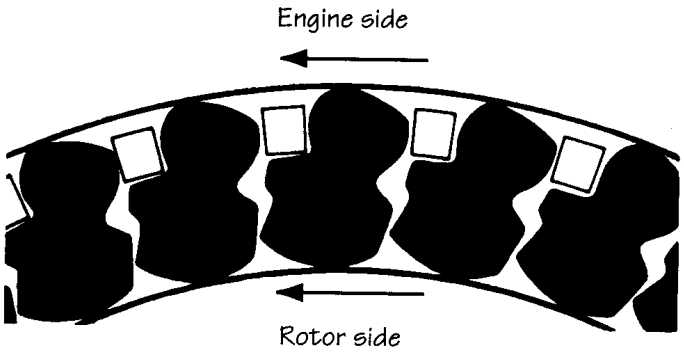
Freewheel

- For both piston and turbine helicopters.
- A gear is necessary to disengage the rotor engine in case of engine failure or in case of functioning in idle.
- This mechanism is called *freewheel*.

Freewheel

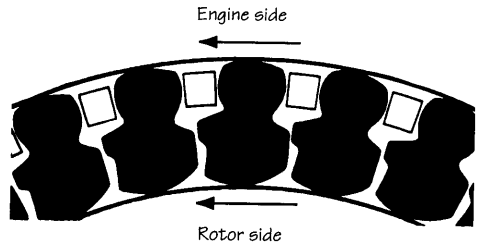
- The *freewheel* is composed of 2 tracks, the inner track and the outer one, plus a screen in which a series of links is mounted.

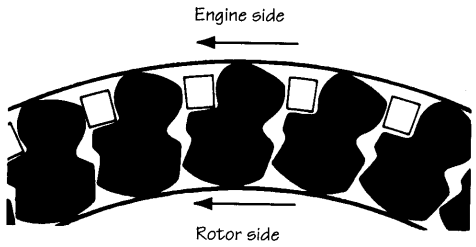




Freewheel

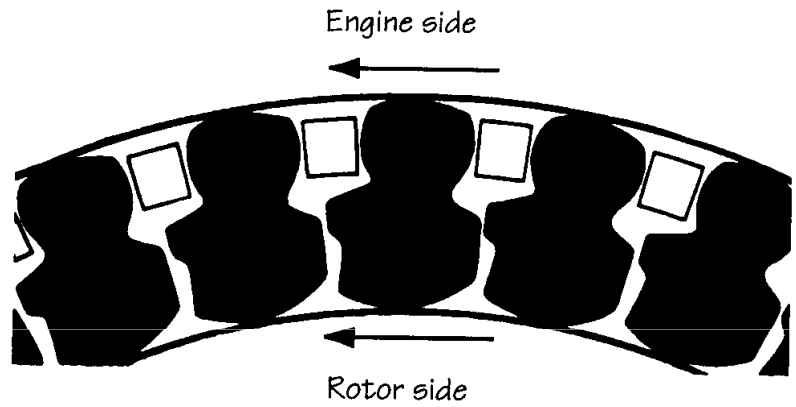
- Each link has 2 diametres, one of them being longer than the other.
  - If the movement comes from the outer track (engine side), it tilts the link with the greatest diametre making it jam through the tracks, turning jointed, as a whole.

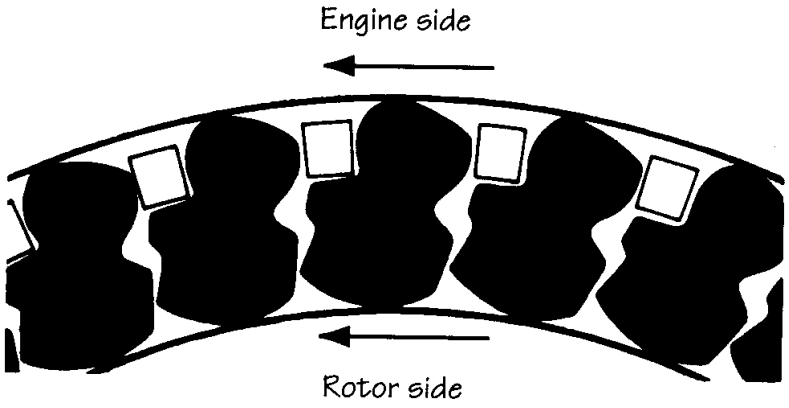




Freewheel

- If the movement comes from the interior track (rotor side), it tilts the links with the smallest diametre, thus disengaging both tracks, rotating the interior track and leaving the exterior track free (stopped, or rotating at lower R.P.M./revolutions than the interior).

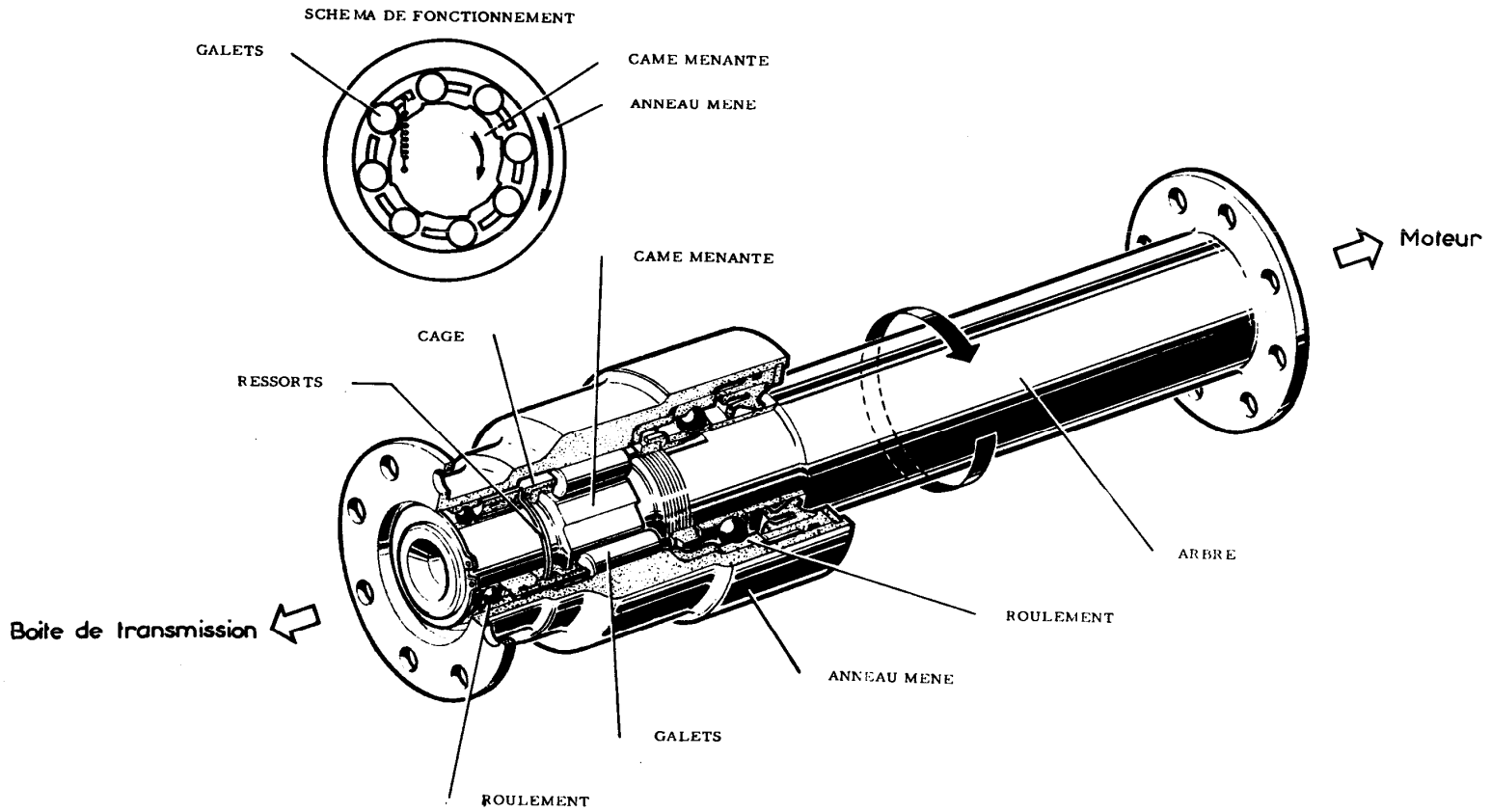




Freewheel

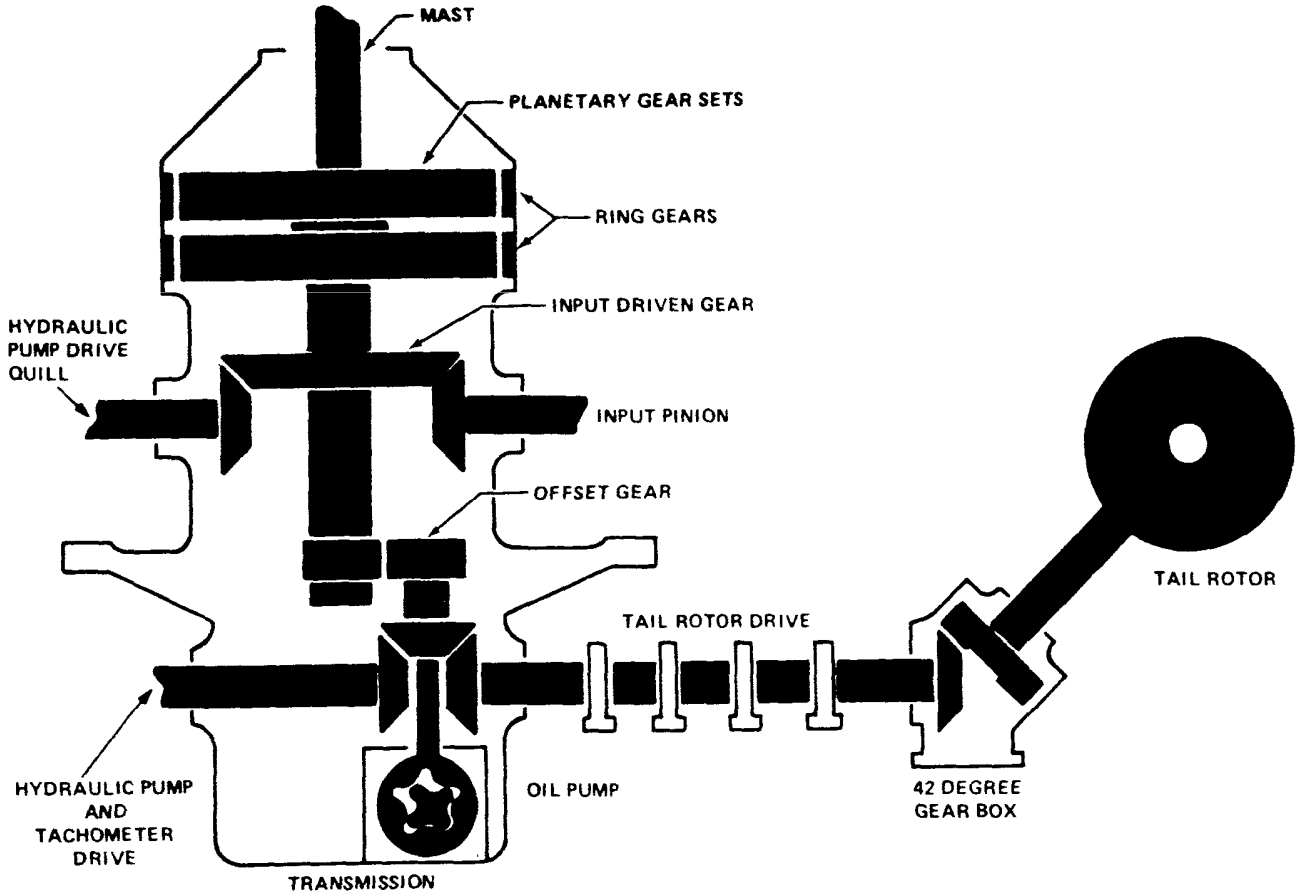
Freewheel

- Another freewheel design.



Main Transmission

- Main gearbox. MGB.

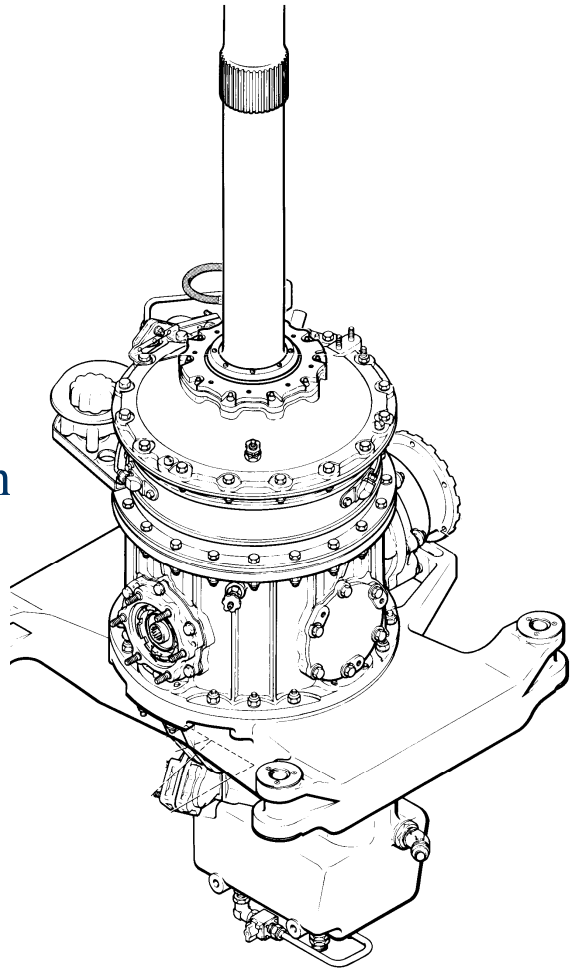


Main Transmission

- Main Gearbox: The universal type is usually situated in front of the engine and suspended by struts on structural supports on the roof of the cockpit.
- Engage the engine or engines by the driving shaft or shafts.
- The function of the main transmission is twofold:
  - To reduce the movement of the rotor,
  - To change the direction of the shaft of rotation (by) 90º.

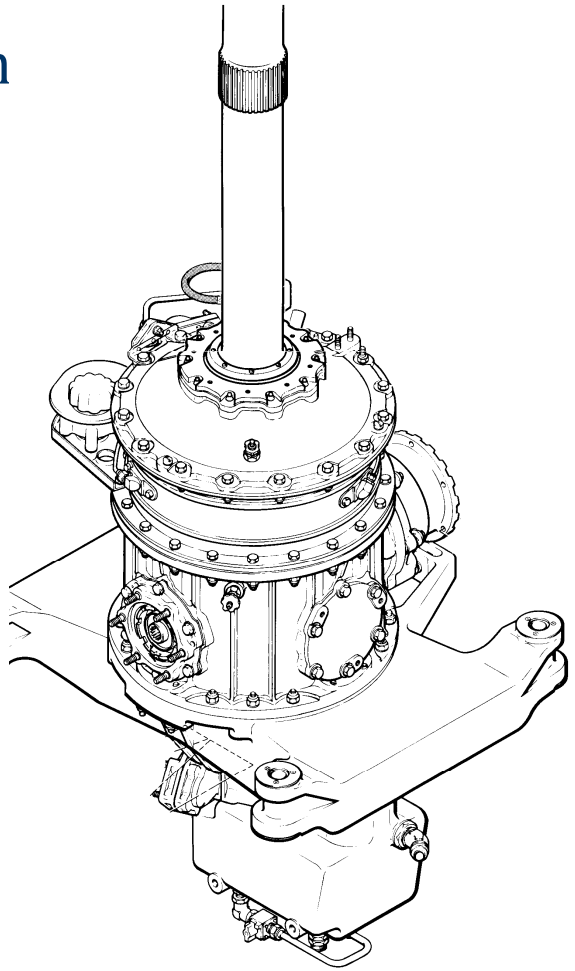
Main Transmission

- It generally consists of 3 sections:
  - *Intermediate section*: a casing on which the following are mounted
    - the engine input pinion gear at the rear ,
    - the gearbox of the main generator on the front
    - an optional power output on the left side
  - *Upper section* is composed of a casing which is mounted on the intermediate section and screwed in.
    - Inside there will be one (or more) toothed ring/s that form the planetary system that produce one of the reductions of R.P.M.



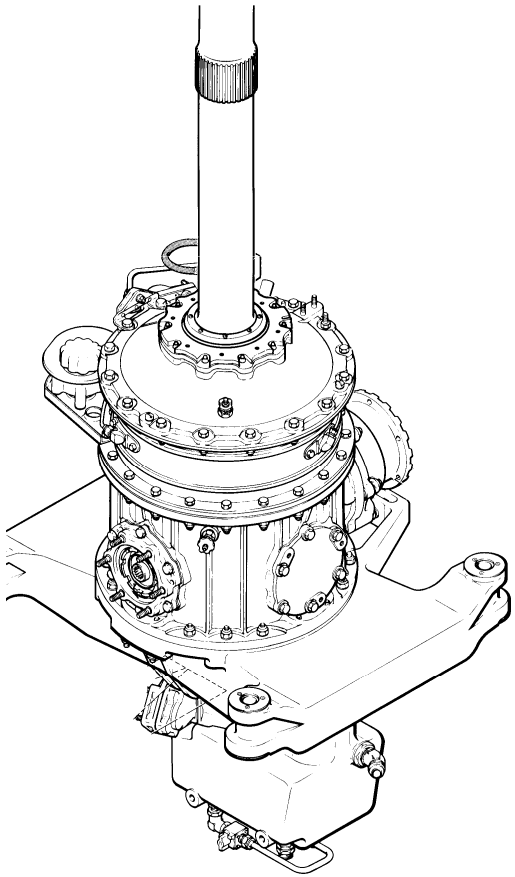
Main Transmission

- *Lower section* consists of a casing that serves as an oil sump of the main transmission.
  - A series of motion output shafts for accessories are mounted on this section.
  - The lower section takes its movement from the intermediate section through a shaft.



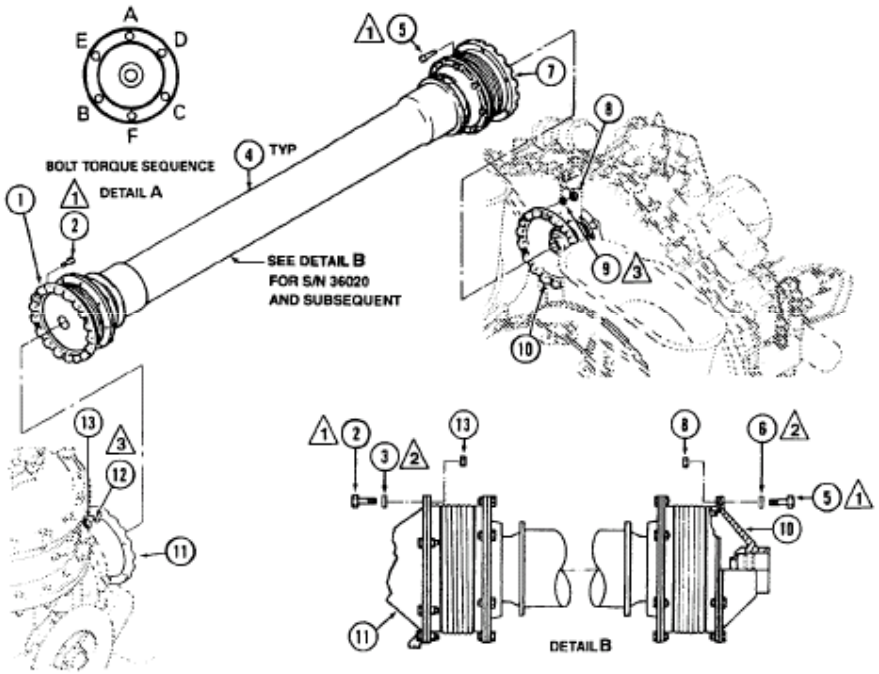
Main Transmission

- Main Transmission Bell 412

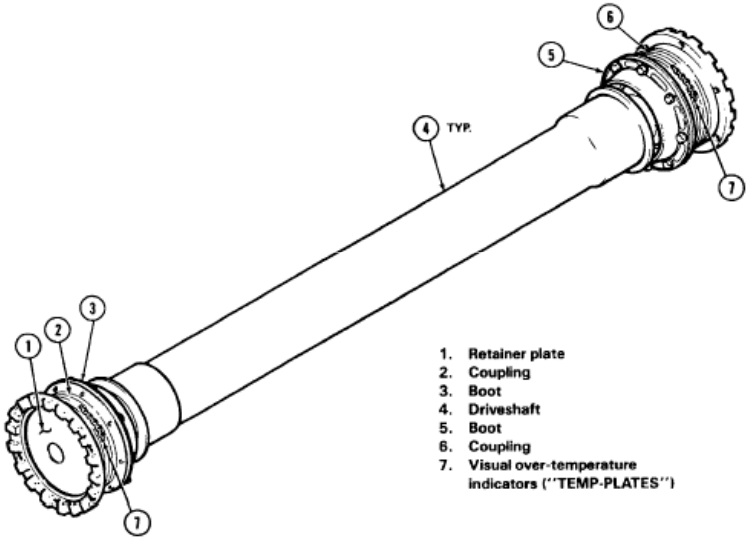


Main Transmission

- Main Transmission Bell 412



1. Flexible coupling (forward)
2. Bolt
3. Steel washers
4. Driveshaft
5. Bolt
6. Steel washers
7. Flexible coupling (aft)
8. Nut
9. Steel washer
10. Engine-to-driveshaft curvic coupling adapter
11. Main input quill curvic coupling adapter
12. Steel washer
13. Nut



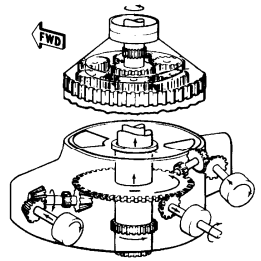
1. Retainer plate
2. Coupling
3. Boot
4. Driveshaft
5. Boot
6. Coupling
7. Visual over-temperature indicators (''TEMP-PLATES'')

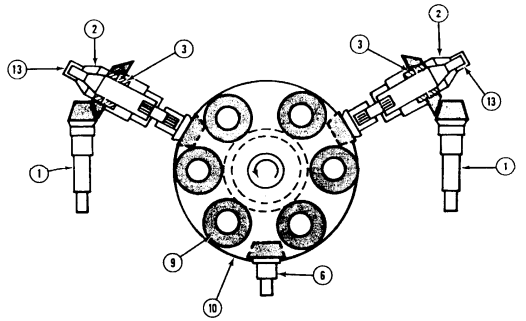
MGB OPERATION

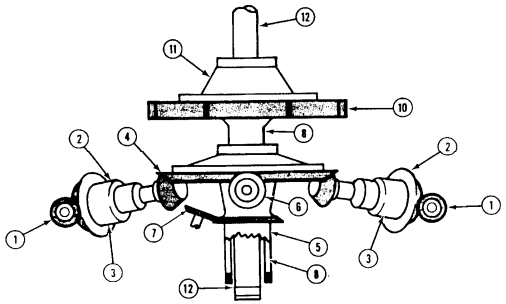
- Example (twin engine helicopter, Bell 230).

TRANSMISSION SCHEMATIC

1. Input pinion gear (2)
2. Outboard gear assembly (2)
3. Freewheeling clutch (2)
4. Spiral bevel collector gear
5. Collector gear shaft
6. Tail rotor drive gear
7. Oil pump drive gear
8. Sun gear
9. Pinion gear (6)
10. Ring gear
11. Planetary carrier
12. Main rotor mast
13. Hydraulic pump drive (2)





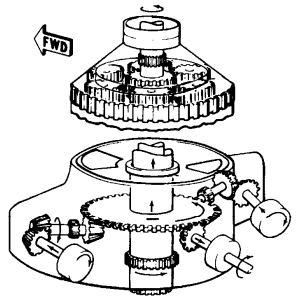


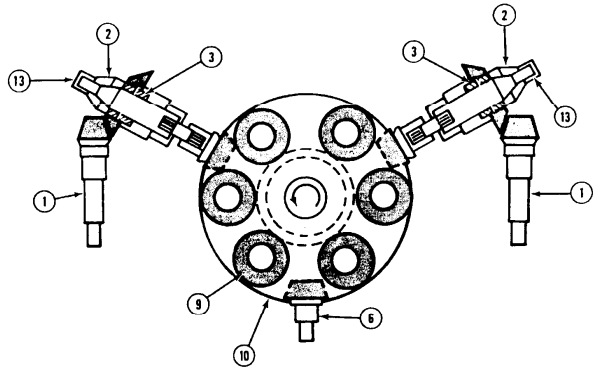
MGB OPERATION

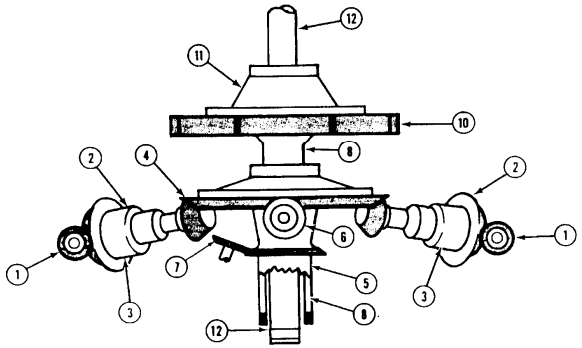
- The movement is transmitted from each power shaft to the first reduction gear with its corresponding freewheel.
- From the gear, on one side comes the movement for the hydraulic system, and from the other to the main collector gear that combines the outputs of both turbines.

TRANSMISSION SCHEMATIC

1. Input pinion gear (2)
2. Outboard gear assembly (2)
3. Freewheeling clutch (2)
4. Spiral bevel collector gear
5. Collector gear shaft
6. Tail rotor drive gear
7. Oil pump drive gear
8. Sun gear
9. Pinion gear (6)
10. Ring gear
11. Planetary carrier
12. Main rotor mast
13. Hydraulic pump drive (2)





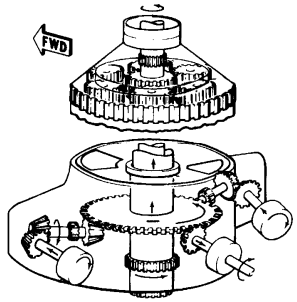


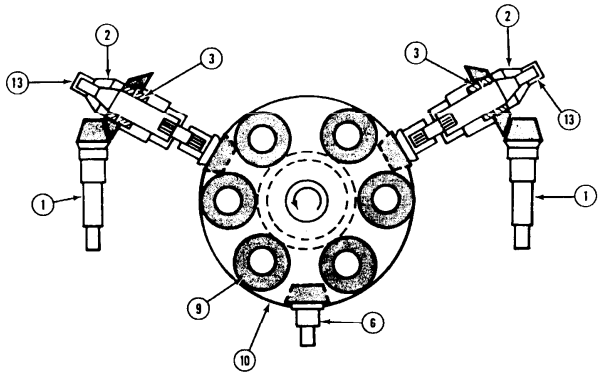
MGB OPERATION

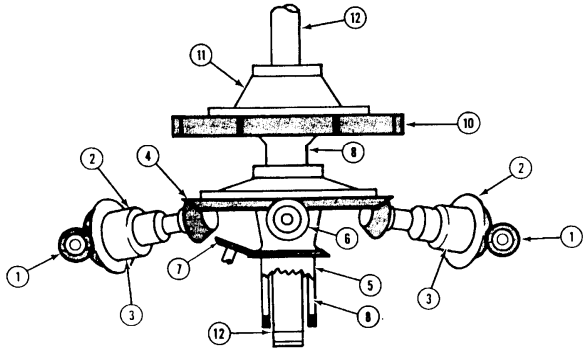
- Through the vertical shafts, it is transmitted to the sun gear of the planetary gear sets, which rotate constrained in a translation motion because they are geared in a fixed ring.
- The planetary gears are joined by a support box that rotates around them, and gives motion to the main rotor mast. The tail rotor obtain the movement from the lower output gear.

TRANSMISSION SCHEMATIC

1. Input pinion gear (2)
2. Outboard gear assembly (2)
3. Freewheeling clutch (2)
4. Spiral bevel collector gear
5. Collector gear shaft
6. Tail rotor drive gear
7. Oil pump drive gear
8. Sun gear
9. Pinion gear (6)
10. Ring gear
11. Planetary carrier
12. Main rotor mast
13. Hydraulic pump drive (2)





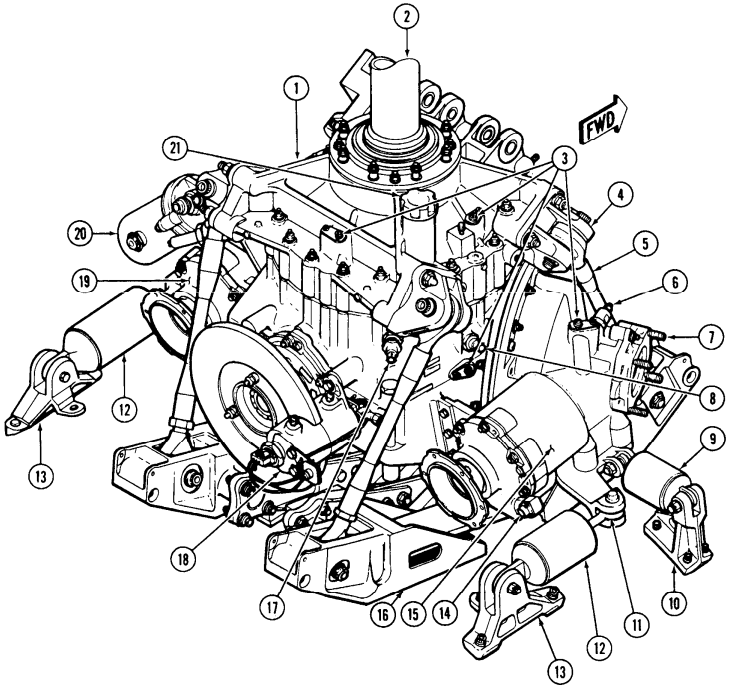


MGB OPERATION

- In this way three reductions can be achieved for the main rotor:
  - The first one is achieved in the exterior gear (turboshaft – freewheel),
  - The second in the main collector gear, and
  - The third in the planetary gear set.

MGB OPERATION

- Main Gearbox (Bell 230).



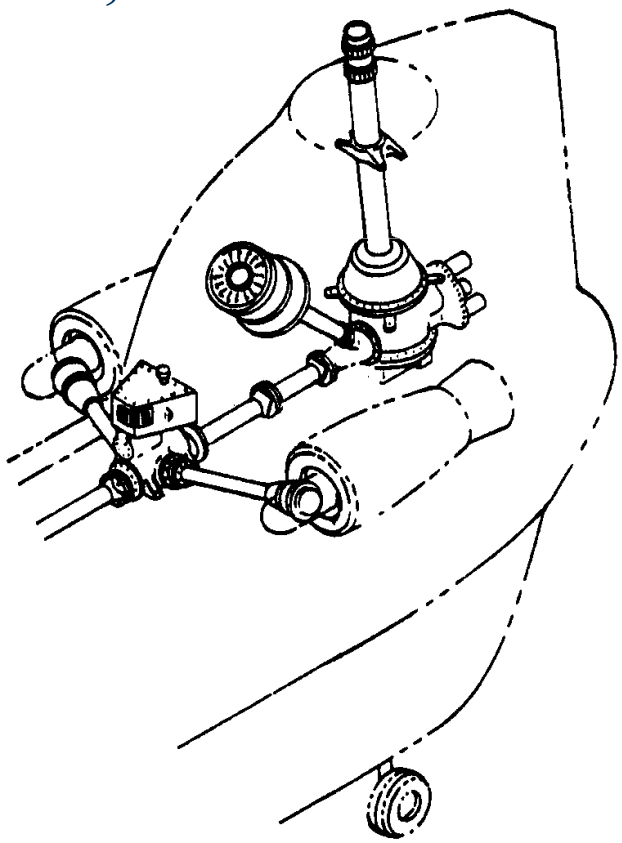
1. Transmission
2. Mast
3. Oil jet
4. Lift fitting
5. Lift link
6. Low pressure switch
7. Hydraulic pump adapter
8. Tachometer sensor
9. Lateral isolation mount
10. Isolation mount support
11. Isolation mount fitting
12. Longitudinal isolation mount
13. Isolation mount support
14. Chip detector
15. Outboard quill
16. Nodal beam assembly
17. Chip detector
18. Rotor brake
19. Input quill
20. Oil filter
21. Filler cap

MGB OPERATION

- In other helicopter configurations the combination of the 2 engine outputs produces an additional gearbox.
- There are other cases where there are two systems of sun-planetary gears which produce a necessary reduction: in these cases there is usually no exterior gear system.

MGB OPERATION

- **Rear rotor transmission details CH-47.**
  Detail of the rear rotor transmission, birotor helicopter in tandem.



MGB OPERATION

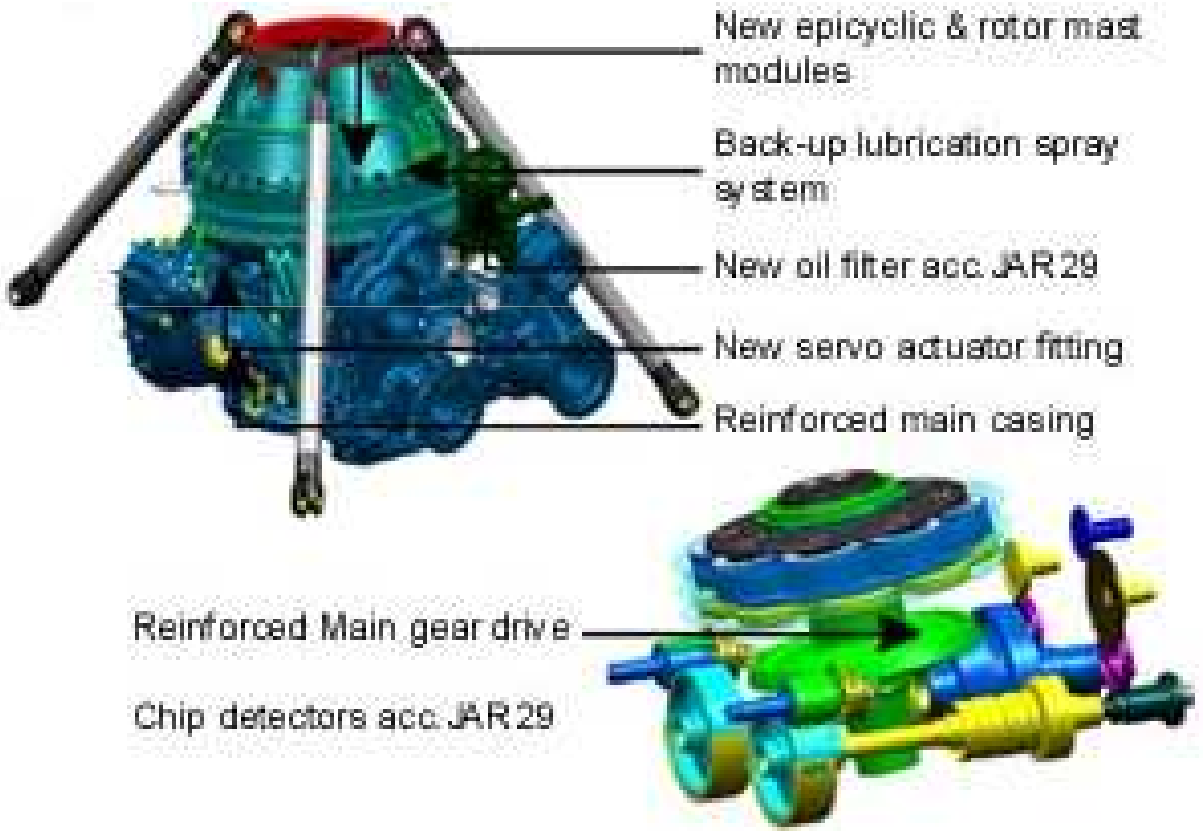
- Main Gearbox **SH60.**

MGB OPERATION

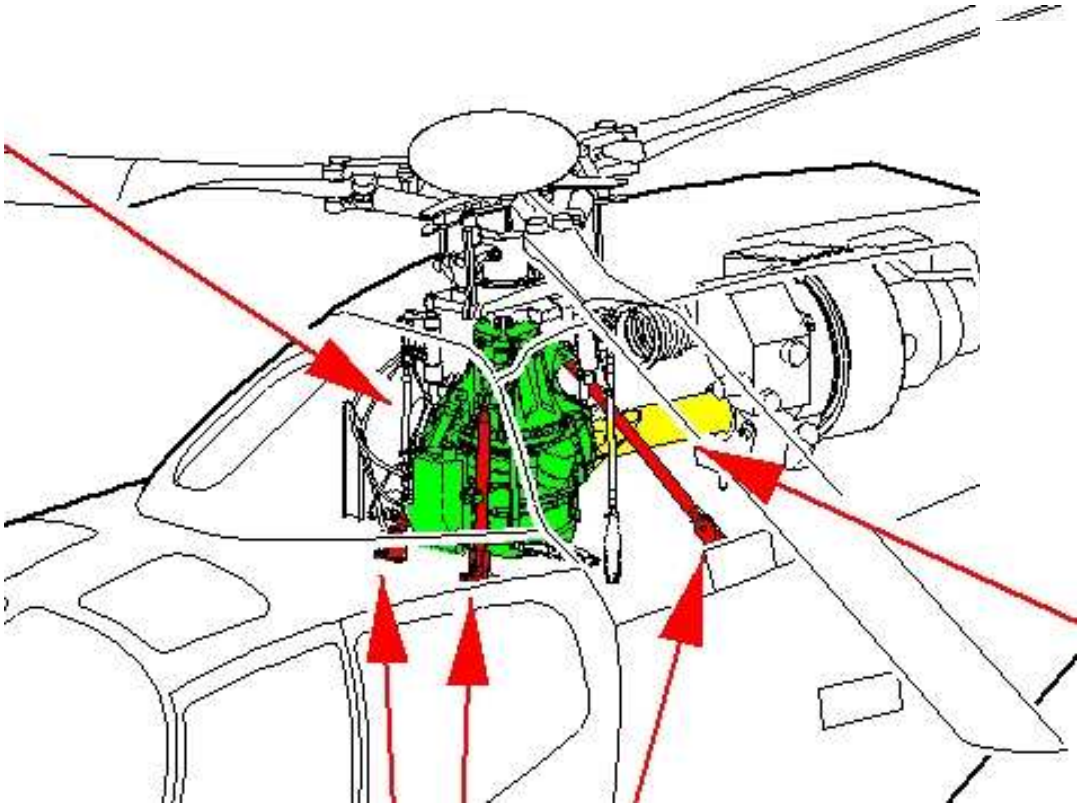
- Main Gearbox **Super Puma.**

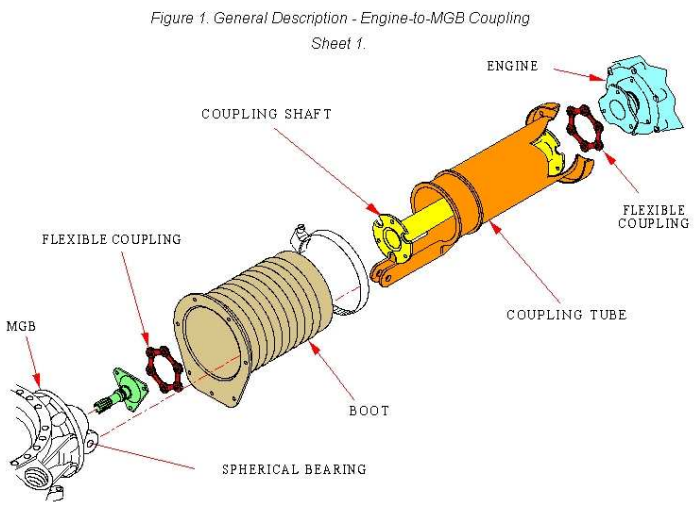
MGB OPERATION

MGB OPERATION



MGB OPERATION





MGB OPERATION

Figure 1. General Description - Main Gearbox
Sheet 1.

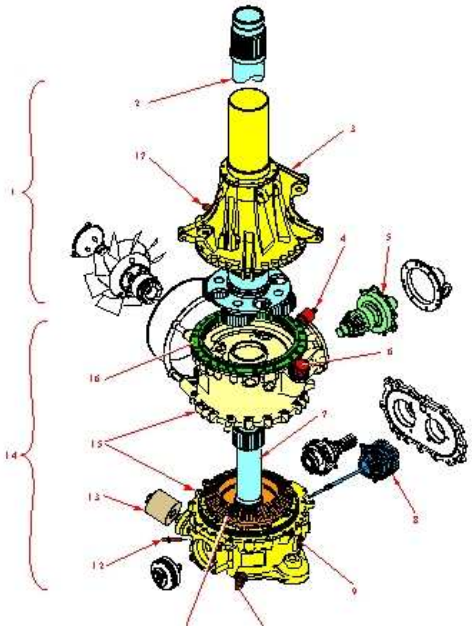


Figure 1. Detailed Description - Main Gearbox
Sheet 1.

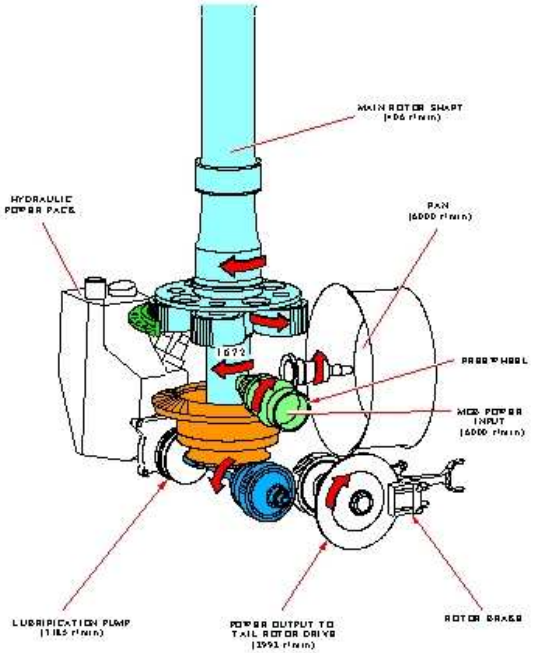
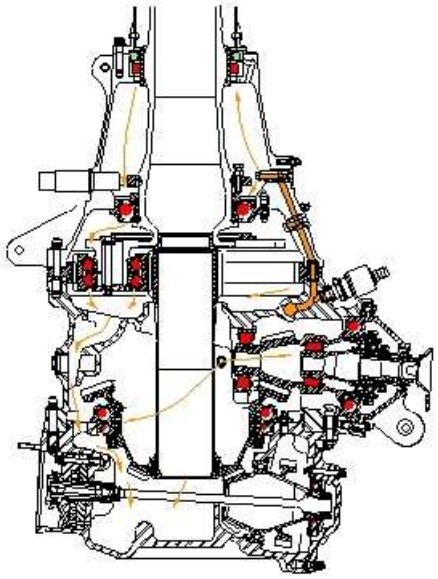
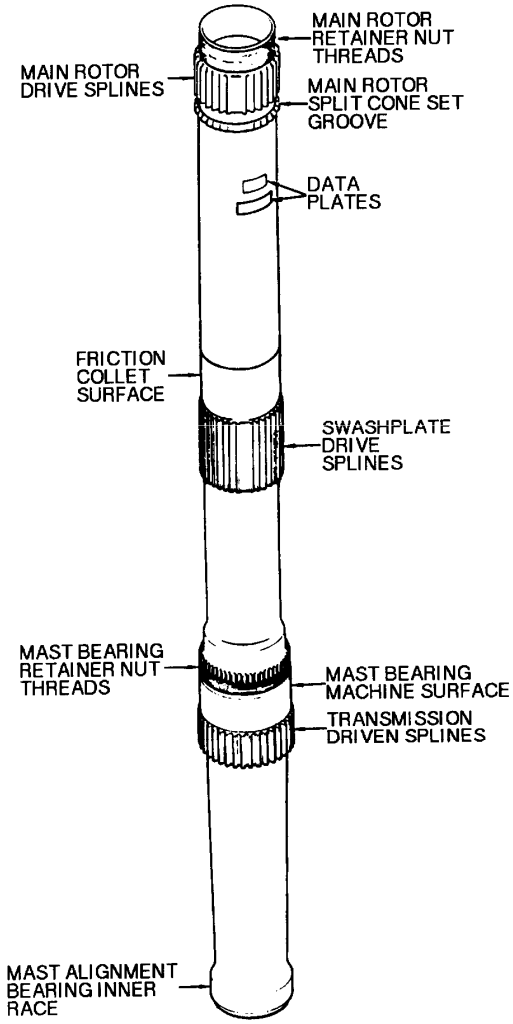


Figure 2. Detailed Description - MGB Lubrication
Sheet 1.



MAST

- Generally, a tubular steel shaft (Bell 230), is aligned with the transmission by a series of bearings.
- It presents a series of grooved and threaded zones.
- In the grooved parts linked together we find: the main rotor, the assembly of controls and the swashplate, the planetary gear sets of the main transmission, which produce the movement.

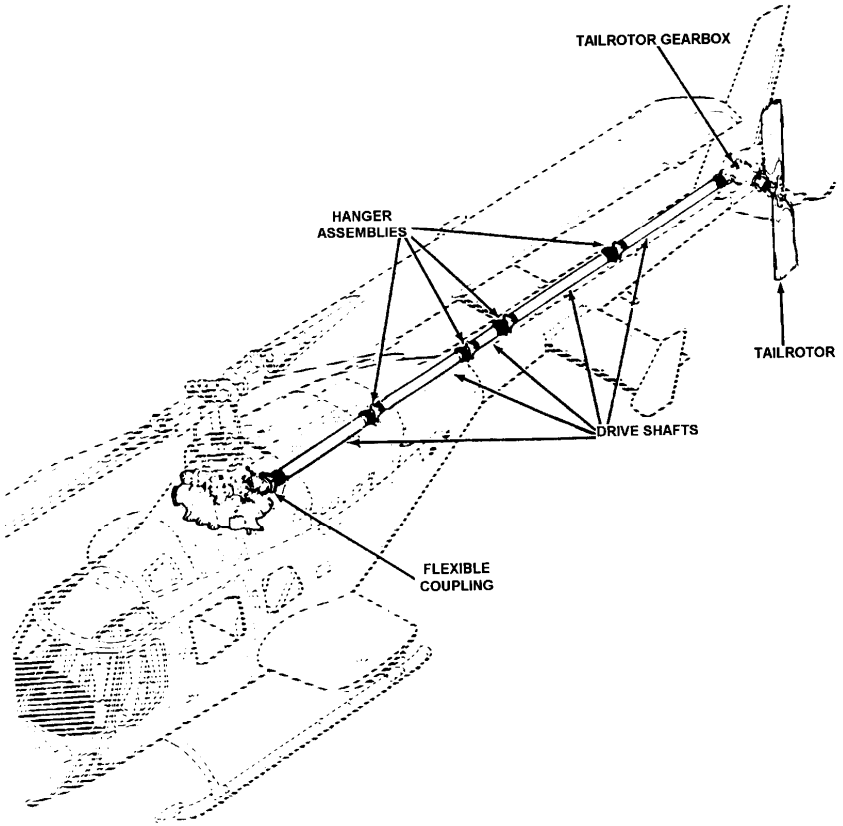


MAST

- (On) the threaded zones there are:
  - The retaining nut of the main rotor,
  - The retaining nut of the upper mast bearing,
  - The retaining nut of the lower mast bearing.

TAIL ROTOR TRANSMISSION

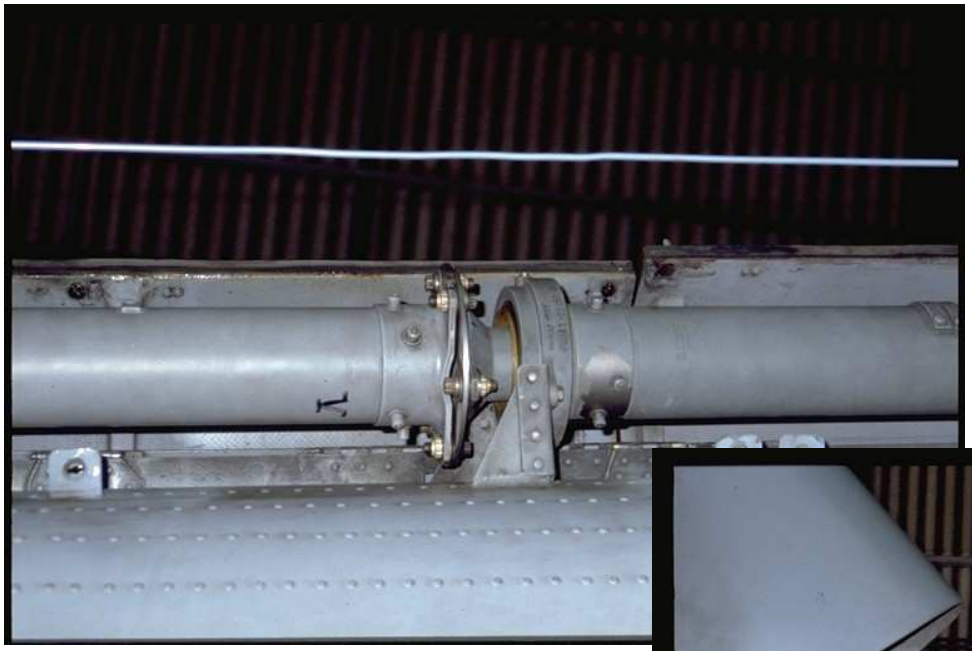
- The assembly of elements transmit the movement from the main gearbox to the tail rotor.

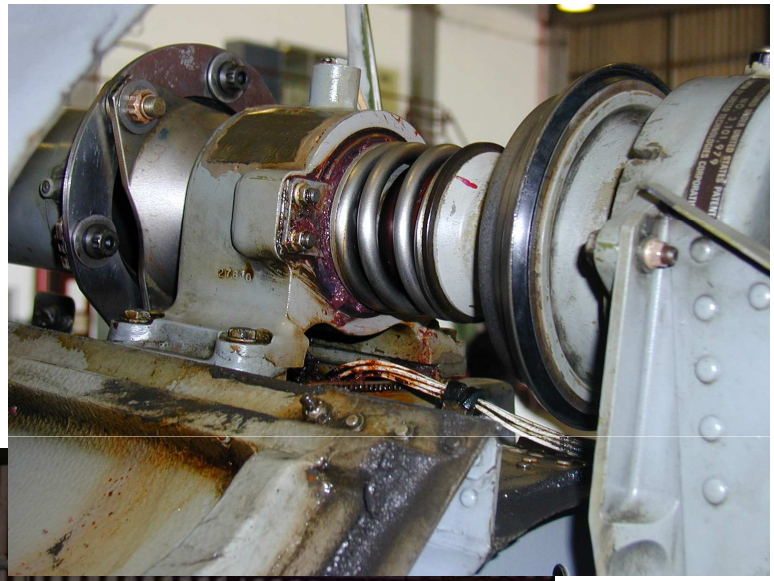


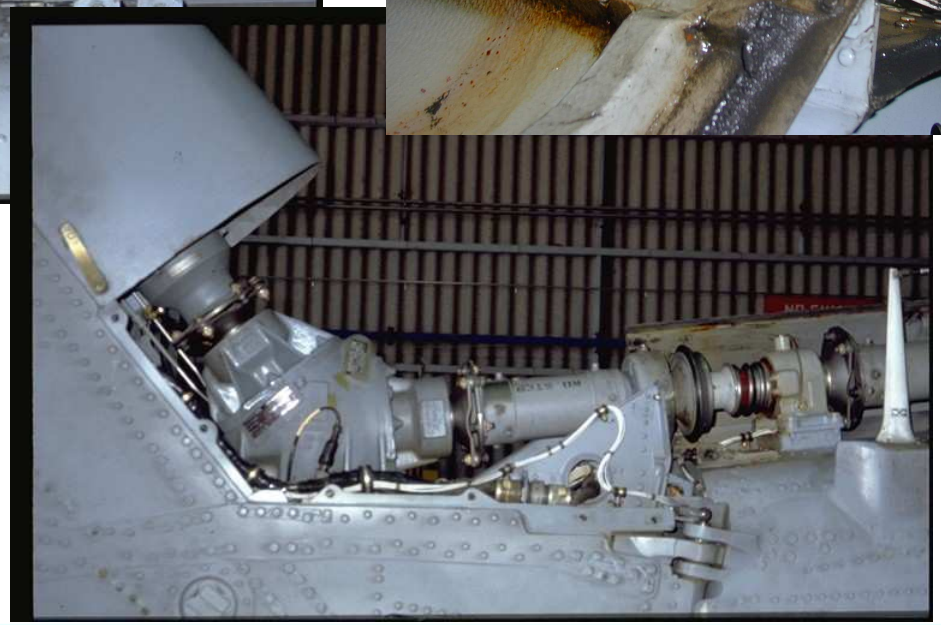
TAIL ROTOR TRANSMISSION

- Movement through the shaft is divided into a series of sections, 1 or 2 gearboxes and links, designed to absorb the system's vibrations (hangers) and mismatches in the alignment of the shafts.

TAIL ROTOR TRANSMISSION

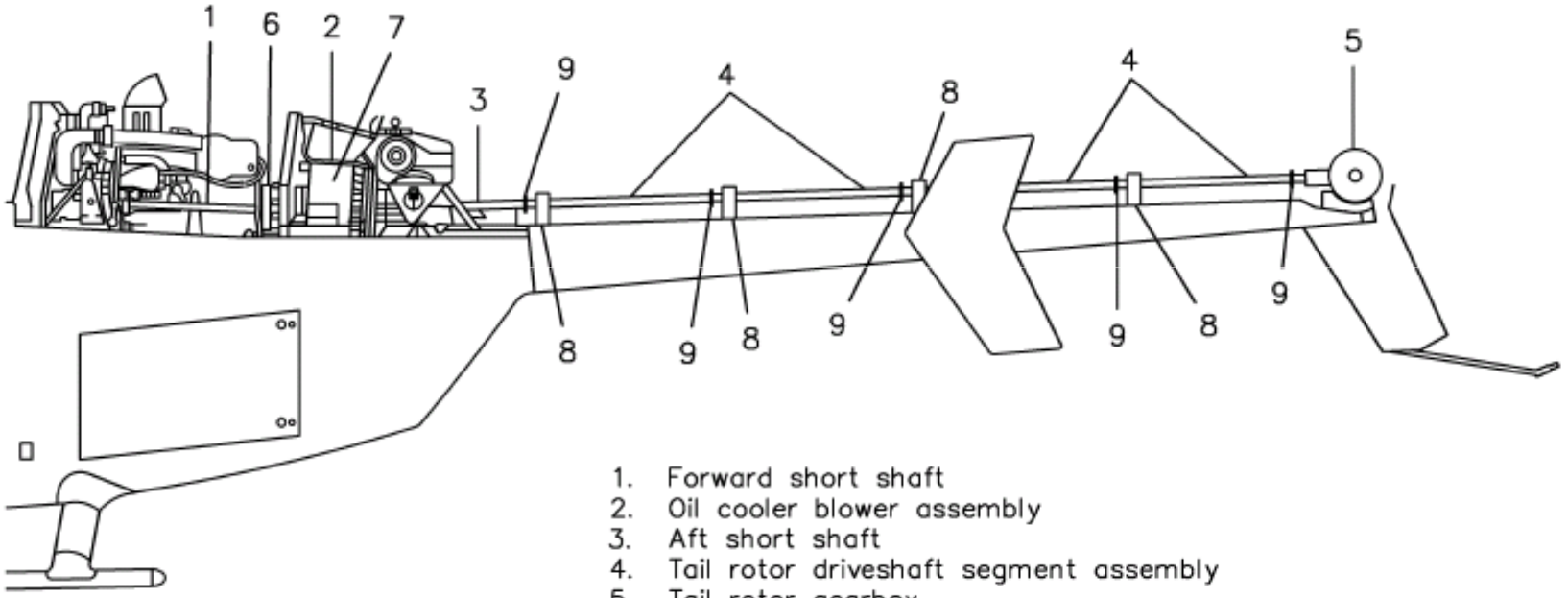






TAIL ROTOR TRANSMISSION

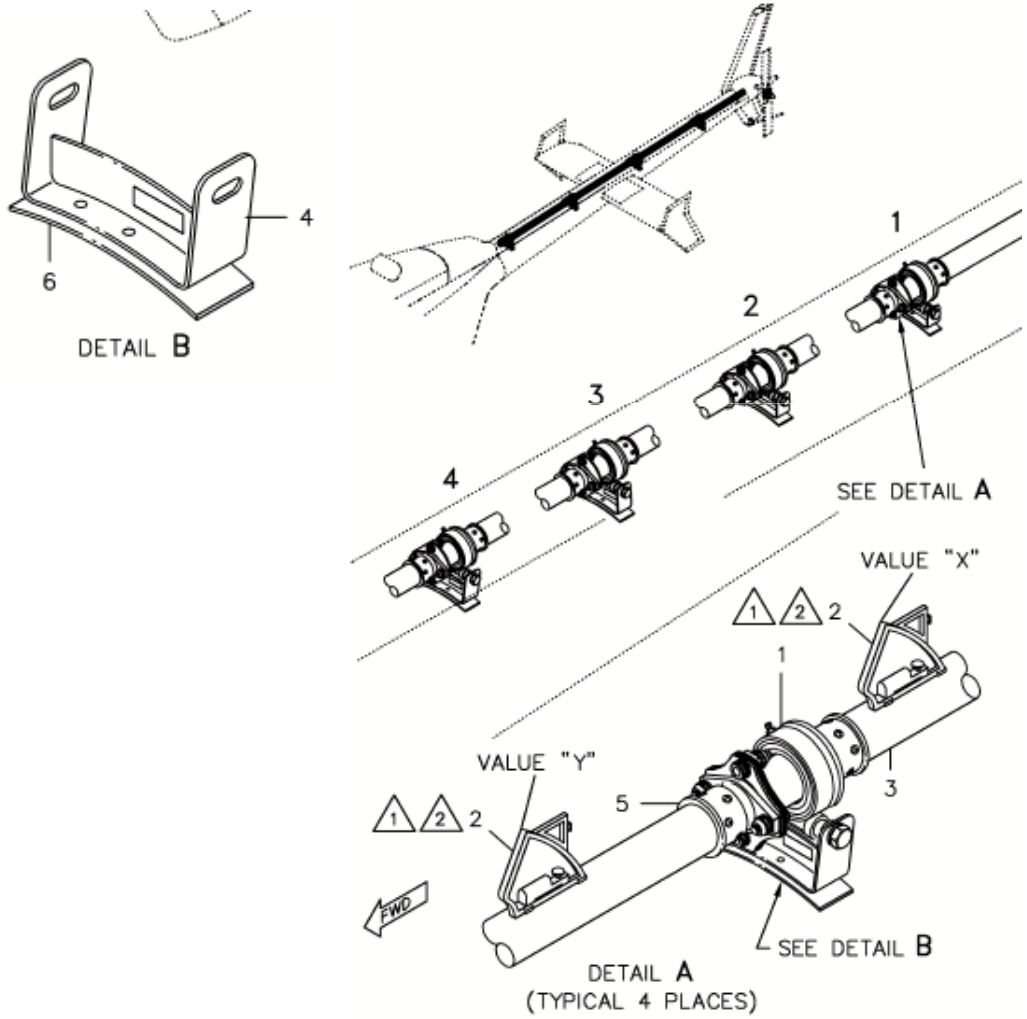
- Bell 407.



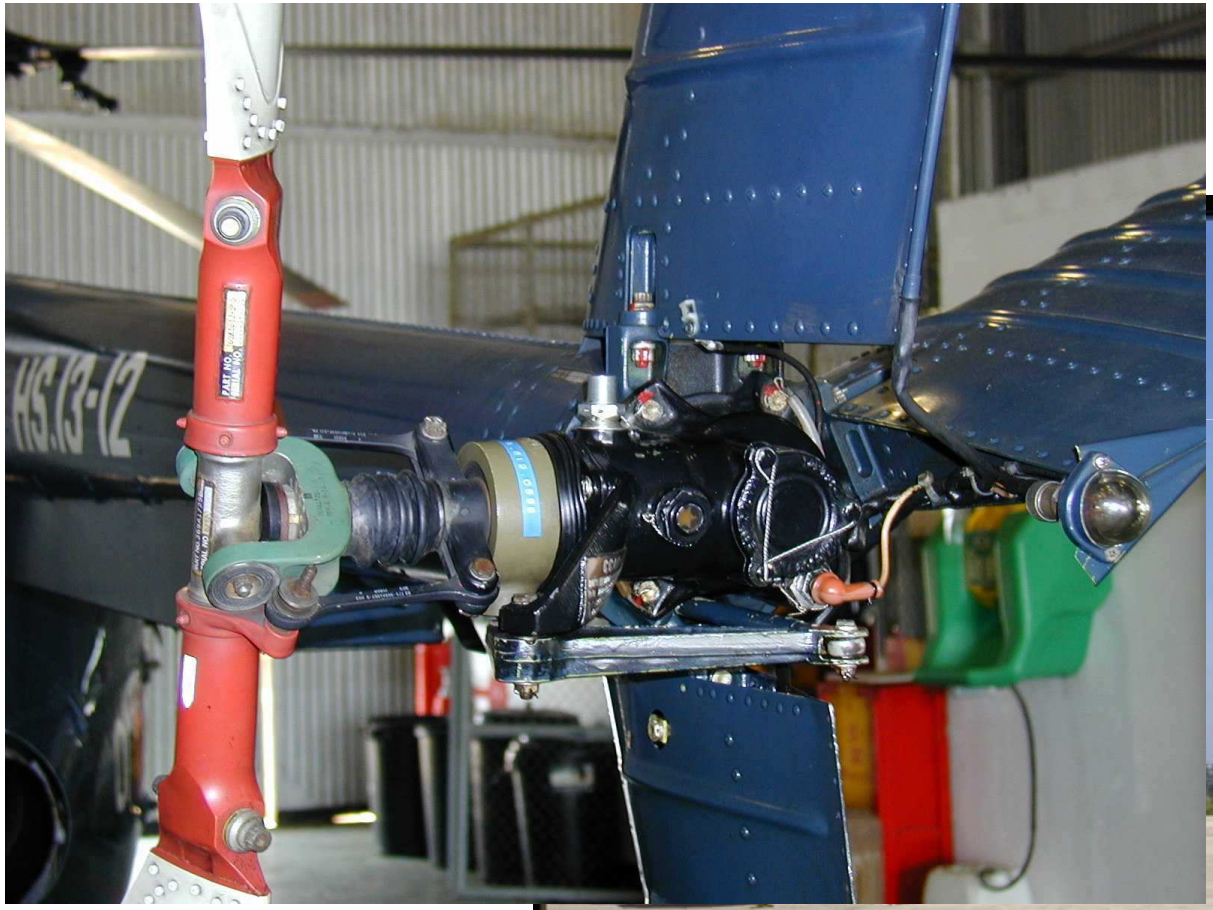
1. Forward short shaft
2. Oil cooler blower assembly
3. Aft short shaft
4. Tail rotor driveshaft segment assembly
5. Tail rotor gearbox
6. Splined flywheel adapter (S/N 53000 thru 53442 pre BHT–407–II–30), splined adapter (S/N 53443 and sub. or S/N 53000 thru 53442 post BHT–407–II–30)
7. Weights (qty–2) (S/N 53443 and sub. or S/N 53000 thru 53442 post BHT–407–II–30)
8. Bearing hanger
9. Coupling disc pack

TAIL ROTOR TRANSMISSION

- Bell 407.



TAIL ROTOR TRANSMISSION



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