CHAPTER 7A

POWERPLANT

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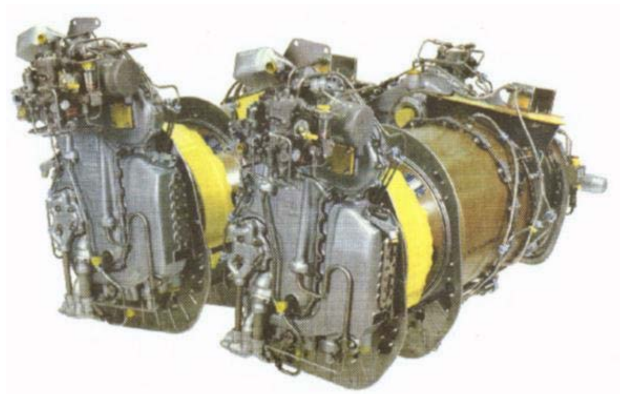


INTRODUCTION

The powerplant in the Model 212 helicopter is a twin-pack installation, designed by Pratt & Whitnet Canada (a.k.a. United Aircraft of Canada Limited (UACL)) and is designated the PT6T-3, PT6T-3B or PT6T-3DF rated at 1800, 2,052 or 2,260 shaft horsepower (shp) respectively (Note: Source of Hp ratings unknown. Pratt and Whitney advertise the PT6T Twin Pac as an 1800 Shaft Horsepower Class power pack which is available in the range 1800-2000 shp0. The Twin Pac consists of two identical free-turbine turbo shaft engines which drive a common reduction gearbox, commonly referred to as the "combining gearbox" or "C-box." Each engine is totally separate and independent in operation except for the attachment to the C-box, thus providing true twin-engine reliability. Other features of the engines include noise suppression, easy starting, and a large number of parts common with the commercial Pratt and Whitney PT6 series turboprop engines and the military T400 engines.

Note:

Campbell helicopters currently operates with PT6T-3 & PT6T-3B Twin-pacs only. Any data provided here-in for the PT6T-3DF is for information only.

GENERAL

The identical engines are mounted side by side on the engine deck with the left engine designated as No. 1 and the right engine as No. 2. Each engine has an accessory gearbox (N1 accessory section), a gas producer (or N1) section, a power turbine (or N2) section, and an exhaust section (Figure 7-1).

Each engine is attached to and outputs power to the combining gearbox at the rear of its N2 section. The C-box has two internal sections: a gear reduction section for each engine, and a combining section driving a single output shaft. The C-box contains two clutch assemblies which provide positive drive from each engine yet allow for free-wheeling if one or both engines become inoperative. N2 accessories for each engine are mounted on the rear of the associated engine gear reduction section of the C-box.

Each engine is equipped with its own air management, fuel, starting, ignition, lubrication, and fire protection systems. The combining section of the C-box has its own lubrication system.

Operationally, the engines may be started using either airframe battery power or external power. After one engine is started on battery power, the associated generator may be used to assist the battery in starting the second engine.

PERTINENT DATA

Dimensions

The approximate dimensions of the powerplant are:

- Width - 44.3"
- Length - 65.3"
- Height - 32.6"
- Weight - 617No.(dry) (without accessories)

Oil Systems

The oil used in the PT6T-3B & -3DF powerplants is oil conforming to PWA specification No.521 and SBNo.1. It can be either MIL-L-7808E or subsequent (3 centistoke, Type I) for all ambient temperatures or MIL-L-23699 (5 centistoke, Type II) may be used when ambient temperatures are above -40 deg. F (-40 deg. C).

The accessory gearbox pressures are 40 PSI minimum with 115 PSI maximum. The reduction gearbox pressures are 40 PSI minimum with 80 PSI maximum.

The oil temperature for both accessory gearboxes and the combining gearbox are 5 deg.C minimum and 107 deg.C maximum.

Fuel System

The fuel used in the Model 212 is ASTM Type B (JP-4) for all temperatures or ASTM Type A or A-1 (JP-5) with ambient temperatures above -22 deg. F (-30 deg. C). The fuel must have an anti-icing additive when ambient or fuel temperatures are below 0 deg. F, conforming to Spec. PFA-55MB. Blending instructions usually on the anti-icing container.

SHP Ratings

The following are for Standard Day, Sea Level, Static Conditions with no installation losses and no air bleed or airframe accessory power absorption.

The PT6T-3B = Each Power Section 1025 SHP 2½ minute rating, 970 SHP 30 minute rating; 900 SHP Takeoff rating and 800 SHP Maximum Continuous rating.

Powerplant - takeoff ratings. PT6T3DF = Each Power Section 900 SHP Takeoff rating, and 1,130 hp each engine OEI operations.

Complete Powerplant

PT6T-3B
1800 SHP - 5 minute rating - Takeoff rating
1600 SHP - Max Continuous power

PT6T-3DF
1800 SHP - 5 minute rating - Takeoff
1600 SHP - Max. Continuous power.

NOTE: Twin engine powerplant ratings are given for information only as the powerplant has been de-rated for 212 installations.

Dual Torque Indicator Limits

PT6T-3DF, PT6T-3B and PT6T-3
Twin Operation:
5 Minute Takeoff range 87.5% to 100%

PT6T-3 Single (OEI) Operation:
30 minute operation 63.9%to 71.8% tq.

PT6T-3B Single (OEI) Operation:
30 minute operation 63.9%to 79.4% tq.

PT6T-3DF Single Operation:
2 ½ minute range 83.6% to 87.5%
Continuous operation 5% to 83.6% tq.

ITT Limits

PT6T-3B
Takeoff, twin engine operation - 810°C, 5 minute max. with a maximum transient of 850° not to exceed 5 seconds.

Single engine - 822°C, 30 minutes max.
Single engine - 850°C, 2½ minute max.
Maximum OEI - 850°. C.
Starting transient limit - 1090°. C, not to exceed 2 seconds above 960° C.

PT6T-3DF
Takeoff, twin engine operation - 810°C,
Single engine operation - 810°C to 885°C, 30 minutes max.
Max OEI - 940°C
Max starting above 960°C ------1090°C, not to exceed 2 seconds above 960°C

Speeds

N1 = Gas Produce

PT6T-3B
Maximum Continuous Operation = 100.8%
Transient Limit - 102.6% not to exceed 30 seconds

PT6T-3DF

Maximum Continuous Operation = 103.2%
Transient Limit – 103.2% not to exceed 10 seconds

N2 = Power Turbine

Maximum Continuous Operation = 100% = 33,000 RPM.
Transient Limit = 101.5% N2. Not to exceed 10 seconds.
Normal Operating Range = 97 to 100% N2.

Direction and Rotations

All terms relating to the powerplant; such as front, rear, right, left, up, down, clockwise and counter clockwise, will apply when the engine is in the horizontal position as viewed from the reduction gearbox end, or those directions as if seated in the pilot's seat.

Air Management System

Each air management system is a system of ducts and a particle separator door (valve) to provide inlet air to the power section and to the ejector. It provides inlet air to the power section, inertial particle separation, and cools and carries off exhaust gases.

Each system is composed of: Air inlet section, forward duct, engine induction baffle, particle separator door, transition duct, power section exhaust duct, and ejector.

Each particle separator door is controlled by a 28V DC operated actuator. The particle separator door is open under normal conditions of engine operation to provide inertia separation. The door is closed automatically when the Engine Low RPM Warning Light illuminates as a result of N1 speed at or below 52.5% ± 2%, or when the fire extinguisher pull "T" handle is OUT.

When the particle separator door closes, the caution light segment "Particle Separator" will illuminate.

The engine air management, and engine fire protection systems are covered in this chapter.

ENGINE OPERATION

Air, drawn in through the engine air inlet, is compressed and directed to the combustor. Fuel is added and ignited to produce hot exhaust gas, which is directed against the single N1 turbine wheel. The N1 turbine wheel is connected to the compressor, thus ensuring self-sustaining operation of the gas producer section (Figure 7-2).

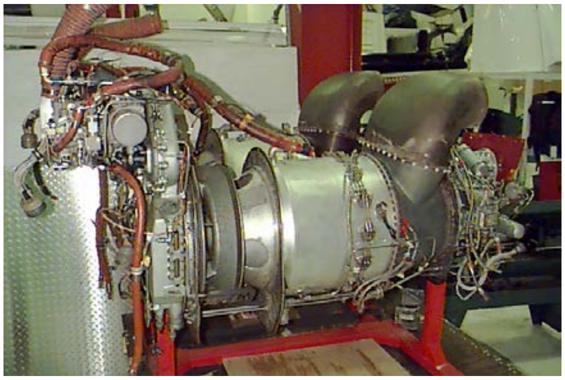


Figure 7-1a PT6T-3B Twin Pack

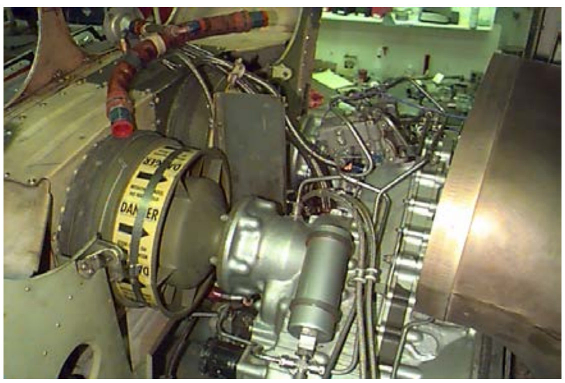


Figure 7-1b Combining Gearbox

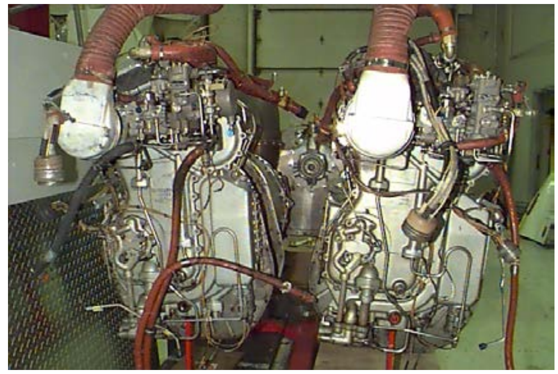


Figure 7-1c PT6T-3B Twin Pack

Exhaust gas exiting the N1 turbine wheel is directed against the N2 turbine wheel, which is connected by shafting to the gear reduction section of the combining gearbox.

The high-speed rotation of the N2 is reduced through three stages of gear reduction, which convert the high rpm to increase power output. The second stage of gear reduction drives the third stage of gear reduction through a Sprag clutch, often referred to as a "free-wheeling unit."

The single combining gear, which is normally driven by both of the engine's third-stage reduction gears, drives the main drive shaft, which, in turn, drives the main transmission and rotor systems.

Each engine is started and operated separately, connected together only through the combining gear, which allows both engines to share the power load. The free-wheeling units, in the input section of the Combining gearbox, allow either or both engines to be disengaged from the combining gear in the event of an engine failure or an autorotation.

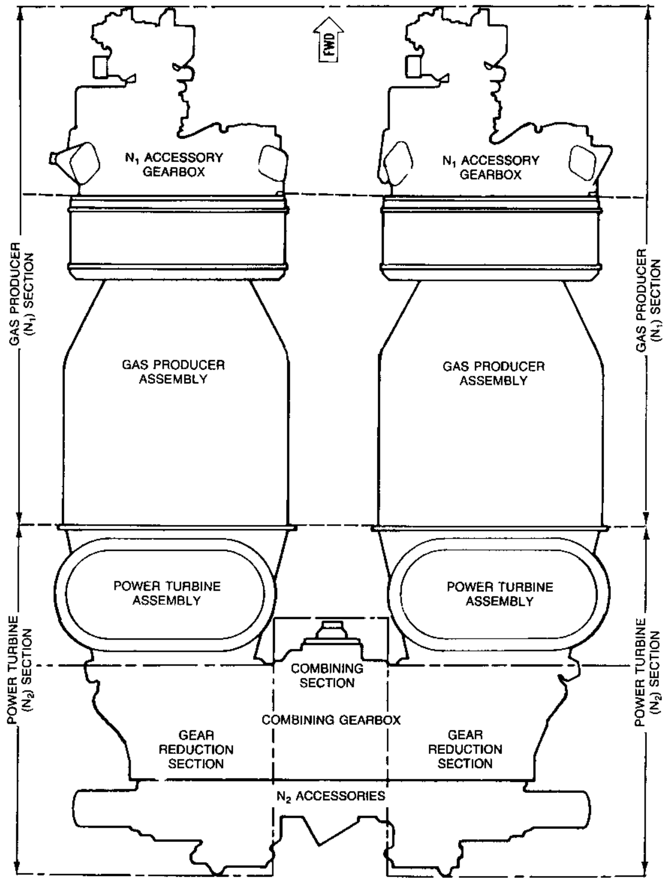


Figure 7-2 Twin Pack Major Sections Diagram

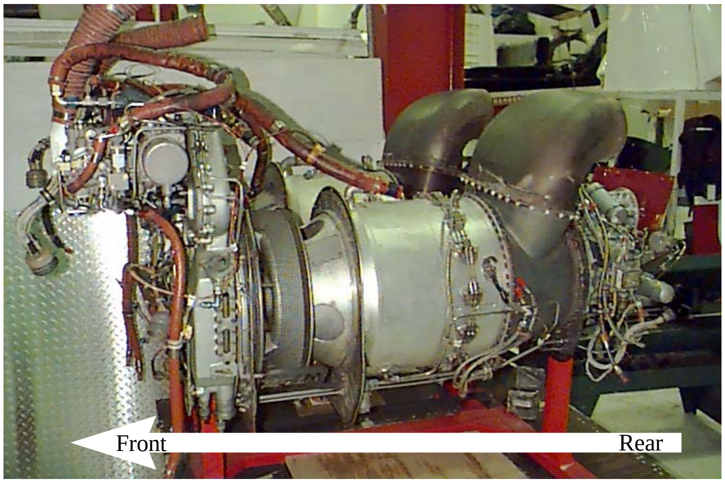


Figure 7-3 PT6T-3B Side View Photo

ENGINE SECTIONS

GENERAL

There are three major divisions of the PT6T powerplant (Figure 7-2); two power sections, left and right; and the single reduction gearbox section.

The left hand power section and accessory gearbox is designated the No.1 engine and the right hand power section and accessory gearbox is designated the No.2 engine.

Power Section

The two power sections of the PT6T are identical free-power turbine turbo-shaft engines. Each power section is composed of the accessory gearbox, gas generator section and power turbine-exhaust section.

Each power section uses two separate turbines, gas producer turbine (N1), to drive the compressor and accessory gearbox, and a power turbine (N2) to drive the turbine shaft that is coupled to the power output shaft to drive the reduction gearbox.

Compressor Inlet Case

Air entering the airframe air management system forward duct is routed into the induction baffle assembly that encircles the inlet section. The air then enters the compressor inlet case through wire mesh screen that covers the entire inlet. The compressor inlet case forms a circular plenum through which the air is directed into the compressor.

Compressor Assembly

The compressor assembly consists of three axial stages and a single centrifugal stage of compression. It rotates clockwise and provides a 7:1 compression ratio at 100% N1 or 38,100 RPM rotational speed. The airflow from the compressor is provided to the diffuser portion of the gas generator case.

Gas Generator Case

The gas generator case houses the compressor assembly, gas producer turbine guide vane assembly, the gas producer turbine (N1), and the combustible chamber liner. It acts as a diffuser for the air by decreasing the velocity and increasing the static pressure of the air.

A boss on the gas generator case at the 11 o'clock position, center, provides a tap for customer bleed air. The rear section forms the outer housing for the combustion liner and has mounting bosses for the 14 simplex fuel nozzles and two bosses for the ignitor plugs at the 4 and 11 o'clock positions. A terminal block for the ITT system is mounted at the 10 o'clock position.

Combustion Section

The combustion chamber liner is open at one end and domed at the other. It contains various types of perforations to permit air to enter the liner for optimum fuel-air ratios, even temperature distribution, and to provide insulating air for the steel liner. Fuel through the fourteen fuel nozzles mixes with the compressed air, is ignited and expands to drive the two turbines.

The expanding gases move forward into the exit ducts where the direction is reversed and the gases enter the gas producer turbine guide vane ring assembly. The vane directs the gases onto the gas producer turbine at the optimum angle. The power turbine nozzle guide vane ring assembly directs gas flow onto the power turbine. The power turbine is splined to the turbine shaft and drives the appropriate power section reduction gear train in the reduction gearbox by means of a coupling shaft. The power turbine rotates at

approximately 33,000 RPM at 100% N2 speed, in a counterclockwise direction.

Exhaust Duct Assembly

The gases leaving the power turbine exit at a single outlet port on the top of the exhaust duct, mix with the bypassed air, enters the ejector duct and goes overboard.

GAS PRODUCER SECTION

The gas producer section is commonly referred to as the "N1 section." The primary function of the N1 section is generating hot exhaust gas to drive the power turbine (N2). In order to do this, a majority of the gas output is used to drive the compressor and accessories, thus making the engine self-sustaining.

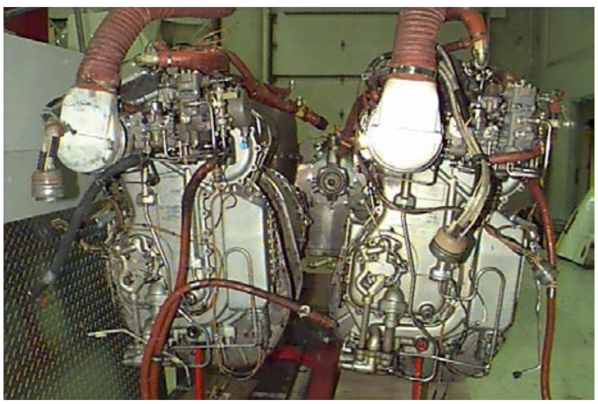


Figure 7-4A N1 Accessory Drive

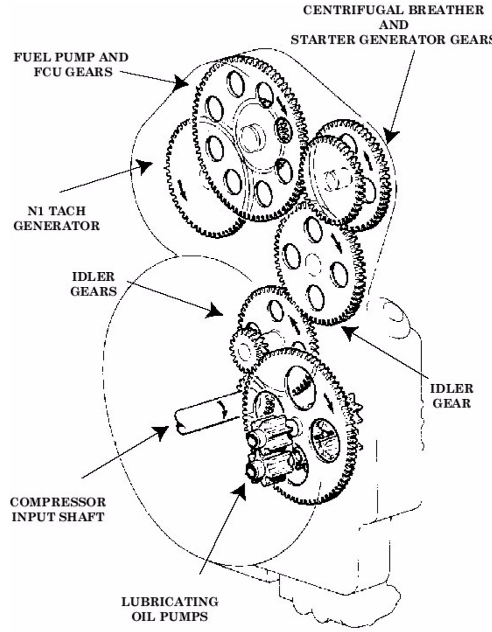


Figure 7-4B N1 Accessory Drive

The N1 section includes the N1 accessory gearbox section, engine air inlet, N1 compressor, annular combustor ring, N1 turbine, and interturbine temperature (ITT) thermocouples.

The N1 accessory gearbox section mounts the starter generator, engine fuel pump, fuel filter, fuel heater, engine fuel control unit (FCU), N1 tach generator, and engine lubrication oil pumps (Figure 7-4).

The screened engine air inlet is located directly behind the N1 accessory section and is enclosed in the particle separator plenum of the air management system (Figure 7-5).

Figure 7-5 Engine Air Inlet

The N1 compressor, which provides compressed ambient air for combustion and cooling, has four stages of compression, three stages of axial compression, and one stage of centrifugal compression (Figure 7-3).

The annular combustor ring provides controlled burning of fuel, introduced by 14 fuel nozzles mounted on the N1 section case, and directs the flow of hot gas to the N1 turbine wheel and the ITT thermocouples.

POWER TURBINE SECTION

The single-stage N1 turbine wheel, driven by the hot exhaust gas, is splined to and drives the compressor and the N1 accessories. The ITT thermocouples provide the raw temperature data, which is corrected and displayed by the cockpit ITT gauge.

The single N2 power turbine is driven by the remaining hot exhaust gas coming through the N1 turbine. A shaft connects the N2 turbine wheel of the gear reduction train in the C-box, where the high rpm of the N2 turbine converts to a usable rpm, torque, and shaft horsepower to drive the main transmission and rotor systems.

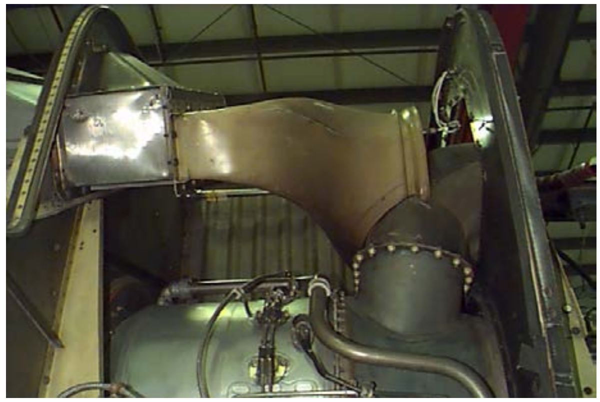
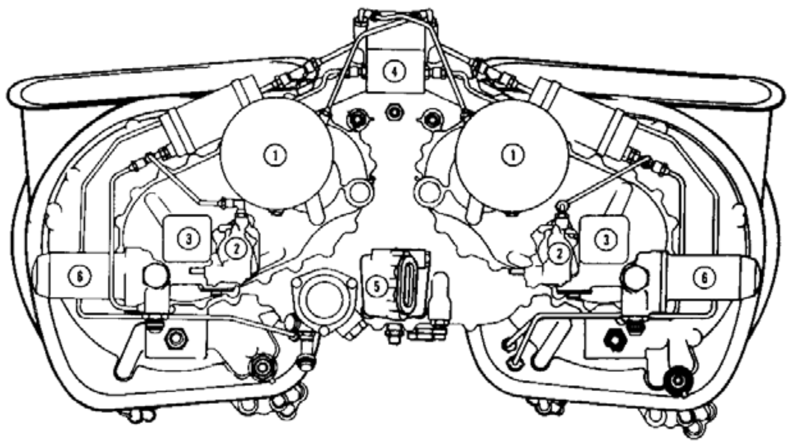


Figure 7-6 Engine Exhaust Ejector

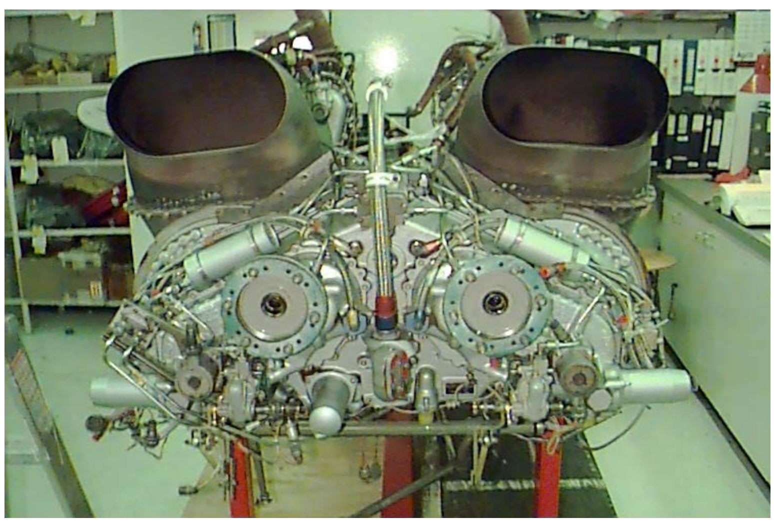
The engine exhaust manifold, which surrounds the N2 section, directs the hot exhaust gas away from the turbine wheel and into the exhaust ejector in the exhaust duct. The ejector assists in operation of the air management system's particle separator (Figure 7-6).

COMBINING GEARBOX

The combining gearbox or C-box has three distinct functions: to provide gear reduction for each engine's N2 rpm, to combine both engines' power into one single output drive to the main transmission, and to mount and drive various engine N2 and C-box accessories (Figure 7-7). The gearbox provides a 5:1 reduction of the power turbine speed (33,000 RPM).to gearbox output shaft speed (6600)



1. Blower; 2. N2 Governor; 3. N2 Tach Generator; 4. Torque Control Unit;
5. C-Box Oil System; 6. Engine Oil Filters



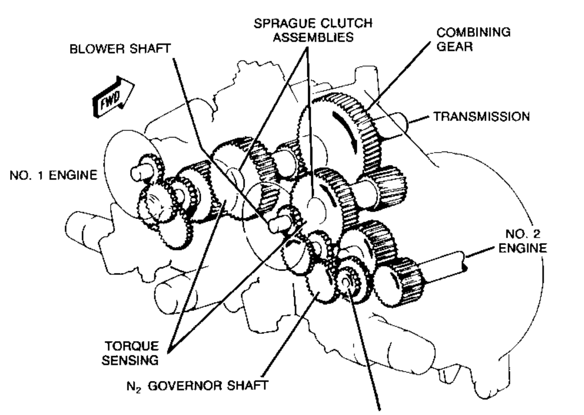


Figure 7-7 Combining Gearbox

The C-box is divided internally into three sections. Each outboard end houses a three-stage gear reduction assembly, used to reduce N2 rpm, and a (Sprag) free-wheeling clutch assembly for use during engine starting or in the event of an engine failure. The separate center combining section contains a single combining gear, which is driven by either or both engines to power the main transmission.

N2 accessories for each engine are mounted on the rear of the C-box and include an N2 governor, an N2 tachometer generator, parts of the engine lubrication system, a torquemeter sensing unit, and an oil cooler blower. Mounted on the combining section of the C-box are the torque control unit (TCU) and the C-box lubrication system.

ENGINE INDICATING SYSTEMS

GENERAL

Cockpit indications are provided for the performance of each engine, as well as for overall powerplant operation.

Figure 7-8a N1 and Temperature

Individual engine performance is indicated by a gas producer rpm (N1) and interturbine temperature (ITT) gauge for each engine (Figure 7-8a). Overall powerplant operation is indicated by each engine's N2 rpm displayed on the triple tachometer, and each engine's power output is displayed as torque indicated on the dual torque indicator (Figure 7-8b). On helicopters equipped with dual controls, triple tachometers (Figure 7-8c) and dual torquemeters are provided for both pilots. Warning and caution lights are also provided to advise of engine and engine systems failures and/or malfunctions.

Figure 7-8b Torque Gage

Figure 7-8c N2 and Rotor RPM Instruments

N1 GAUGES

An N1 tachometer generator is mounted on and driven by the N1 accessory section of each engine. Rotation of the N1 tachometer generator develops a frequency signal which is displayed as a percent on the respective engine's N1 gauge. No airframe electrical power is required for N1 gauge operation. Normal and OEI N1 limitations are marked on the face of the gauge and reflect the same limitations found in the manufacturer's approved FM.

RPM WARNING AND CONTROL UNIT

Nl tachometer generator signals from each engine are also sent to the rpm warning and control unit where they activate the ENGINE OUT warning lights and particle separator systems for each engine (Figure 7-9).

As engine N1 rpm increases through 52.5 ±2%, the rpm warning and control unit extinguishes the ENGINE OUT warning light and activates the particle separator system for that engine. If engine N1 rpm falls below 52.5%, the rpm warning and control unit illuminates the ENGINE OUT warning light and shuts off the particle separator system for that engine.

ITT SYSTEM

Aft of the gas producer turbine, and immediately forward of the power turbine nozzle guide vane ring assembly, are mounted the inter-turbine temperature sensing systems. Twin leads and bus bars, with ten Chromel-Alumel probes connected in parallel, provide power section operating temperatures. Shielded leads connect to the terminal block on external portion of the gas generator. Two leads connect from the terminal block on the external portion of the gas generator. Two leads connect from the terminal block to a ITT compensatory unit mounted on the outboard portion of the

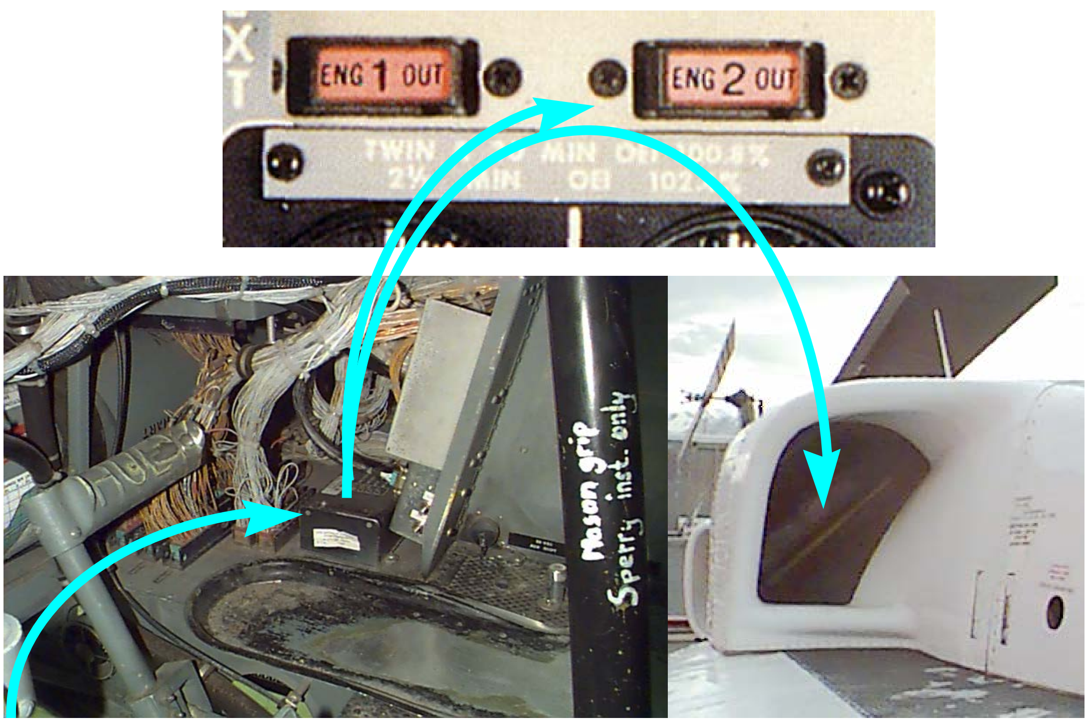


Figure 7-9 RPM Control Unit and Warning System

reduction gearbox. The compensator, mounted on the exterior engine case, is maintenance-adjusted in accordance with engine manufacturer's test data found on the engine data plate and corrects the raw thermocouple signal for variations between power sections. The corrected signal is sent to the engine's ITT gauge and is continuously displayed in degrees centigrade. Normal and OEI ITT limitations are marked on the face of the gauge and reflect the same limitations found in the manufacturer's approved FM.

Loss of DC electrical power to an ITT trim compensator results in a higher-than-normal ITT indication. Loss of DC power to the ITT Gauge results in a loss of gauge indication.

N2 RPM INDICATIONS

Figure 7-10 RPM Indicator

An N2 tachometer generator is mounted on and driven by the N2 accessory section of each engine. Rotation of the N2 tachometer generator develops a frequency signal displayed in percent by the respective engine's N2 needle on the triple tachometer. No airframe electrical power is required for N2 gauge operation. N2 limits are marked on the outer ENG scale of the triple tachometer and reflect the same limitations found in the manufacturer's approved flight manual.

TORQUE INDICATIONS

Torque is the measure of an engine's power output. It should be noted, however, that torque is not actually an engine limitation as N1, N2, and ITT are. The limitations shown on the ENG scale of the dual torquemeter are actually limitations on the components powered by the engines (C-box). The limitations marked on the face of the TRANSMISSION scale reflect the continuous power and takeoff limits for the transmission.

A torque-sensing unit is located at the outboard end of each engine's third-stage clutch gear shaft in the gear reduction section of the combining gearbox. The sensing unit includes a cylinder, with a calibrated leak, filled with pressurized engine oil and a torque oil pressure transmitter. The outboard end of the third-stage clutch gear shaft functions as a piston within the cylinder.

Helical cut gear teeth on both the combining gear and the third-stage clutch gear cause in-out movement of the third-stage clutch gear shaft in response to changes in engine power output. The piston at the end of the shaft acts upon the oil in the torque-sensing cylinder to increase or decrease oil pressure within the cylinder.

Torque-sensing oil pressure is directed through an external oil line to a specially calibrated torque pressure transmitter, which is powered by 26 VAC and protected through the ENG 1 or ENG 2 TORQUE METER circuit breaker. The torque pressure transmitter sends an electrical signal to the appropriate needle in the dual torquemeter to display that engine's power output as a percent on the inner ENG scale.

Figure 7-11 Torque Gage

Each engine's torque sensing and indication is independent of the other engines. However, within the torquemeter itself, the electrical signals from both engines are added and displayed by the white triangle as total torque on the outer TRANSMISSION scale of the torquemeter.

Normal and OEI engine torque limitations are marked on the face of the inner Scale (ENG). Transmission torque and limitations are marked on the face of the outer scale (TRANSMISSION). The markings of both scales reflect the same limitations found in the manufacturer's approved *FM.*

Torquemeter Malfunctions

Torque sensing differs from other pressure sensing systems in two ways: A loss of AC electrical power causes the torquemeter gauge indications to freeze at the indication shown at the time the electrical power failed; also, since torque sensing is a function of engine oil pressure, erroneous torque indications may occur if there is an engine oil pressure malfunction.