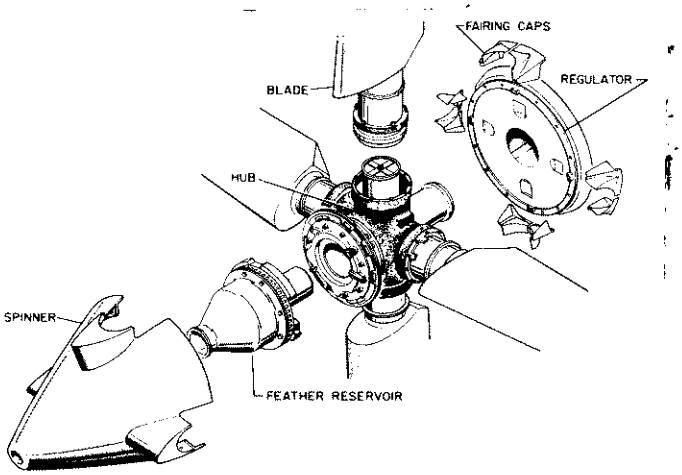
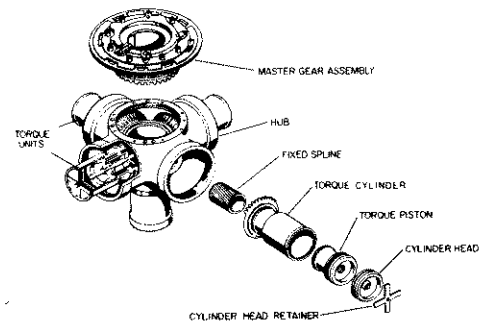
POWER PLANT

PROPELLER COMPONENTS





PROPELLERS

GENERAL

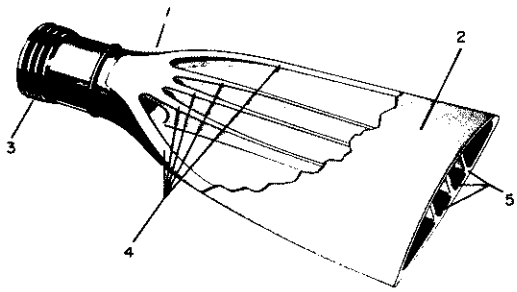
The Aeroproducts No. A6441FN-606 propeller is a single rotation, hydraulically controlled, constant speed type, incorporating an integral hydraulic governing system operating independently to maintain precise control during all operating conditions. The diameter is 13 ft. 6 in. and total installed weight is approximately 1030 lbs. The complete assembly is provided with spinner, feathering and reversing features, selective pitch control, negative torque control, synchronizing, phase-synchronizing, and electrical icing control.

The propeller has four blades. The propeller converts engine torque to thrust and regulates this torque to absorb engine power under varying conditions. The integral hydraulic system of the propeller supplies the power required to change propeller blade angle, or pitch to compensate for variations in blade loading and maintain a constant RPM. The hydraulic system is controlled by a mechanical linkage from the cockpit, with an electronic system providing a vernier or trimmer to hydraulic governing for synchronizing and phase-synchronizing with a master propeller.

HUB ASSEMBLY

The hub assembly consists of four torque units, one mounted in each hub socket. The conversion of hydraulic energy to mechanical turning action is the purpose of these units. This is accomplished by having two oil passages, one to the outboard side of the torque piston and the other to inboard side of the torque piston. The helical spline machined on the torque unit components convert linear piston movement to blade rotation movement. A master gear meshes with the blade gear, which is a machined part of the torque cylinder, to coordinate blade angle change and is located on the face of the hub body. The master gear assembly includes the mechanical pitch lock and low pitch stop. The pitch lock is a ring with ratchet type teeth spring loaded into engagement with teeth on the master gear to prevent rotation of the master gear in a decrease pitch direction. This will occur with a loss of hydraulic pressure as CTM (Centrifugal Twisting Moment) will tend to decrease blade angle without assistance from hydraulic pressure. The lock will also engage if an overspeed beyond a pre-determined setting occurs and will hold the existing blade angle. The pitch lock will operate in the governing range only. The mechanical low pitch stop consists of two members, one splined to the hub and the other to the master gear. Each has four lugs equally spaced circumferentially on engaging faces. The two members are spring loaded into engagement, and the lugs are so designed that the member splined to the master gear is prevented from further rotation in the decrease pitch direction. When reverse pitch is desired, the member splined to the hub is hydraulically positioned to permit scheduled blade angle changes. Through the feedback drive gear machined on the pitch stop member, which rotates with the master gear blade angle, intelligence is relayed through a shaft which in turn positions a part of the regulator mechanical control linkage. By scheduling blade angle with fuel flow, a blade angle can be selected by the power setting in the beta ranges, and a variable minimum blade angle can be established in the governing range.

PROPELLER COMPONENTS



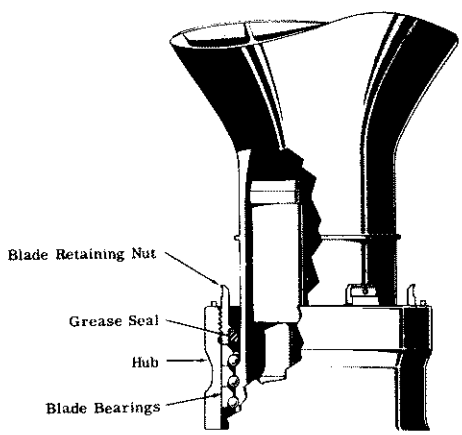
1. THRUST MEMBER
2. CAMBER SHEET
3. INTEGRAL BEARING RACES
4. CAMBER SHEET BRAZED TO THRUST MEMBER ALONG THESE SURFACES
5. STRENGTHENING RIBS

Blade Structure

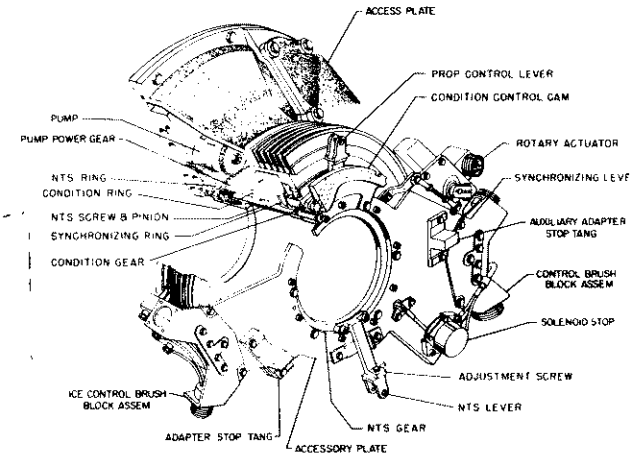
BLADE AND RETENTION ASSEMBLY

The blades are of hollow steel construction incorporating three longitudinal strengthening ribs and are composed of a thrust member and a camber sheet which are joined together by a brazing process and roll welded from the 54" station on lead and trail edge outboard to blade tip. The blade is equipped with a de-iced plastic cuff. The internal parts of the blades are treated with an iron oxide rust preventive paint and the cavities are purged with nitrogen at atmospheric pressure to prevent corrosion of the internal surfaces. The nitrogen is sealed in the blade cavities by a cup seal. This cup also has a stud located in the center for placing of balance washers to obtain horizontal propeller balance. The blades are retained in the hub by a blade retaining nut and an integral race retention assembly. The three inner races of the retention assembly are machined on the blade root and flame hardened. The retention assembly consists of three sets of balls, a nylon cage, ground matched set of three outer races, a metal seal spacer, seal back-up snap ring, a grease seal and blade retaining nut.

The blade root is hollow to receive the torque unit cylinders. Splines are machined on the inside diameter of the blade root which mate with the indexing ring on the torque cylinder. This provides a torque drive to turn the blades and a means of indexing blade angle.



Blade Retention

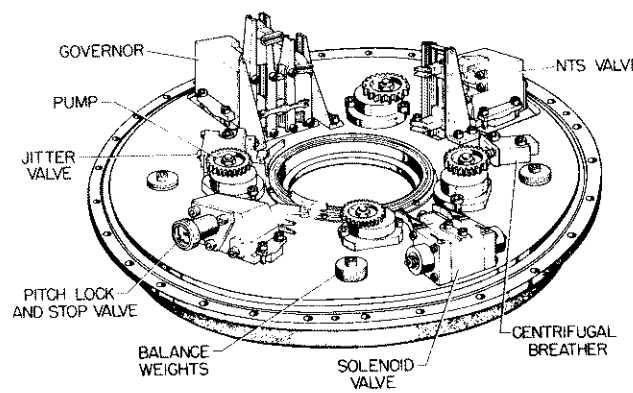


REGULATOR ASSEMBLY

THE REGULATOR ASSEMBLY

The regulator provides selective propeller pitch from full reverse to the flight idle range. It schedules blade angle in accordance with throttle position. In the flight range it provides speed governing along with protective and emergency features, such as pitch lock, increase pitch for NTS, feathering, and auto-feathering. It is the brains and heart of the propeller in that it normally governs engine speeds and also senses abnormalities of operation, reacts accordingly, and controls the system as required for the compensation of error.

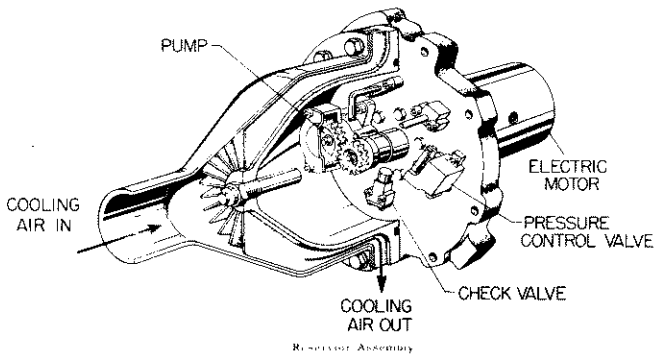
The regulator assembly is doughnut-shaped, mounted on the rear of the hub and consists of a housing and cover, adapter assembly, accessory mounting plate, pumps and hydraulic components.



Regulator Housing and Components

The Housing and Cover, when combined, make up the hollow doughnut-shaped reservoir that stores the necessary reserve of hydraulic fluid. The housing contains hydraulic passages and provides a mounting surface for the hydraulic components. The cover provides mounting provisions for the electrical slip ring assembly. The adapter assembly is the non-rotating portion

of the regulator and is held stationary by an adapter stop fitting mounted to the front of the gear box. The adapter assembly consists mainly of the pump power gear and the mechanical control mechanisms. The accessory mounting plate is attached to the stationary adapter assembly and mounts the electrical brush block assemblies, and external electrical and mechanical controls. The gear driven hydraulic pumps are mounted to the rotating regulator housing and driven by the pump power gear mounted to the stationary adapter assembly. They supply hydraulic flow automatically, continuously, and in proportion to the rotation of the propeller to satisfy the hydraulic pressure system demands of the propeller. The remaining hydraulic control valve assemblies in the regulator are mounted on the regulator housing.

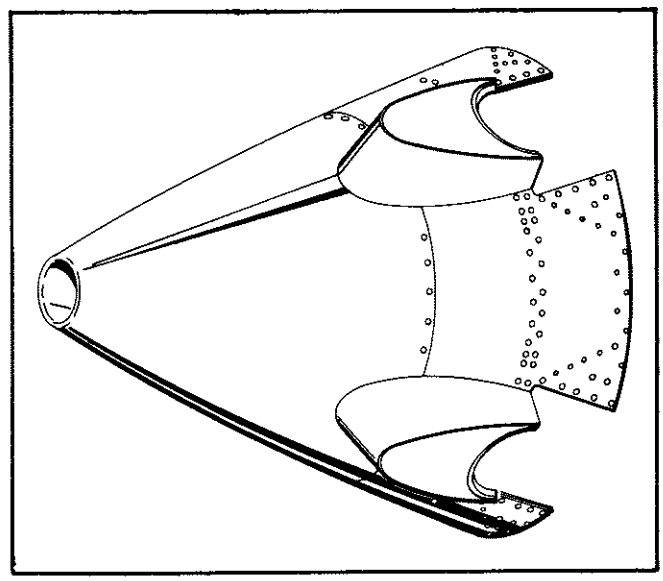


Reservoir Assembly

THE FEATHER MOTOR RESERVOIR ASSEMBLY

The feather motor reservoir assembly is mounted to the hub face and supplies the necessary hydraulic pressure to complete the feather operation, initiate the unfeather operation, and operate the propeller in a static condition. The propeller is initially serviced hydraulically through a filler assembly in the front of the reservoir. The reservoir consists of a housing, cover, motor, pump, hydraulic valves, and shield.

The reservoir housing is a machined casting incorporating its own hydraulic transfer tubes and mounts the other major components. The cover is a finned machined casting. It encloses the components mounted on the housing and forms the reservoir cavity. The cover fins aid in cooling the hydraulic fluid by airflow through the spinner nose. The electric pump drive motor is mounted on the external rear face of the housing and extends into the hub bore. The pump is mounted on the internal front face of the housing and is driven by the electric motor. The other hydraulic control valves are mounted on the housing and control the flow and pressure output of the pump. The shield is a spun aluminum baffle mounted to the housing over the cover to route airflow.



THE SPINNER ASSEMBLY

The spinner assembly is an aluminum one piece cone shaped, spun and riveted assembly. It mounts to a metal ring retained to the periphery of the regulator and piloted by the air shut-off plate on face of hub. The spinner is dynamically balanced independently of the propeller assembly to insure interchangeability between propellers. It is equipped with an anti-icing and de-icing system.

PROPELLER PHASE AND SPEED CONTROL

The hydraulic governor which provides constant speed operation of each propeller is supplemented by an external electrical control system which makes it possible to synchronize the rotational speed of all four propellers (synchronizing) and to maintain a predetermined angular relationship between all propellers (phase synchronizing). Synchronizing and phase synchronizing are accomplished by trimming the primary hydraulic governor.

Synchronizing and phase synchronizing function as independent systems. Either type of operation may be selected, or both may be turned off. The speed correcting signals from each system are independent and control the propeller by separate means. A common method of error sensing is used for both synchronizing and phase synchronizing. Synchronizing has the ability to correct speed errors provided they do not exceed ±276 RPM of normal onspeed condition when selected.

PROPELLER PHASE AND SPEED CONTROL (Continued)

Its primary purpose is to correct large speed errors in preparation for phase synchronizing. The phase synchronizing system has the ability to correct phase relationship of the propellers provided the speed error does not exceed ±107 RPM when selected. Either No. 2 or No. 3 propeller may be selected as Master propeller and all other propellers are slaved to the one selected. The Master propeller operates at its nominal hydraulic governing setting.

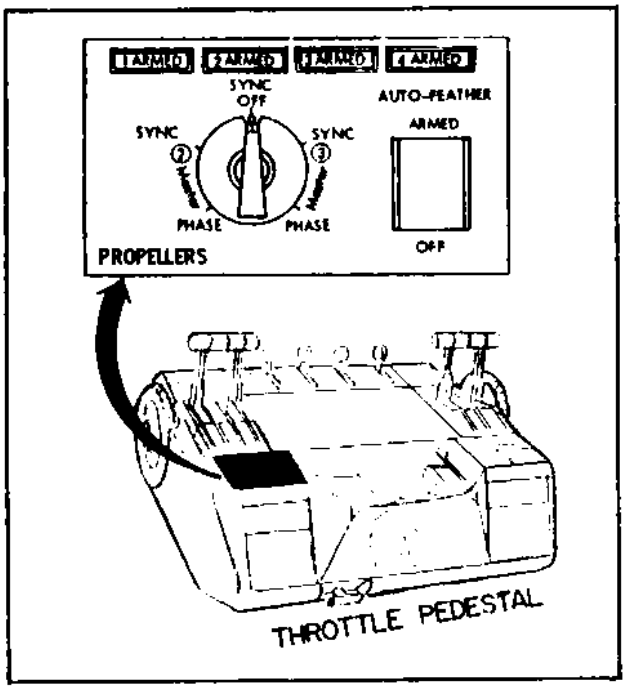
Operating characteristics in the "PHASE SYNC" mode are somewhat better with #2 engine selected as master than with #3 selected, due to the method of preselecting the desired blade angle phase relationships. With #2 selected as master, all propellers will hold within ±6° of the relationships selected for minimum noise. With #3 engine selected as master, the #1 and #2 propellers can be as much as 12° from the optimum phase. Therefore, #2 should be used as master unless some malfunction makes the use of #3 preferable.

When the synchronizing switch is in the PHASE position, the electro-mechanical synchronizer is deactivated at the speed it last held and turns on the phase synchronizing. Should the nominal speed error of the slave propellers subsequently exceed the correction range of the phase synchronizer, a momentary return to SYNC will again bring them within the phase synchronizing range.

With switch in SYNC OFF position, during all constant speed governing operation, an acceleration-sensitive loop of the electrical control system is active to stabilize short term variations in propeller speed.

Synchronizing and phase synchronizing are automatically removed from any propeller during feathering, unfeathering or beta range operation. These functions are also automatically removed from all slave propellers when the Master propeller is feathered.

Five switches, consisting of one synchronizing switch and four fuel governor check switches, are used for complete control of the propeller phase and speed control circuit.



The synchronizing switch is a five-position rotary selector switch with the following positions:

PHASE WITH NO. 2 ENGINE MASTER

SYNC WITH NO. 2 ENGINE MASTER

SYNC OFF

SYNC WITH NO. 3 ENGINE MASTER

PHASE WITH NO. 3 ENGINE MASTER

Fuel Governor Check: With switch in SYNC OFF position, the electro-mechanical system provides a propeller overspeed setting which permits a check on the engine fuel governor and propeller pitch lock.

POWER PLANT

INDICATORS-INSTRUMENTS

INDICATOR	INDICATES	LOCATION
T.I.T. GAGE (4) (Turbine Inlet Temp.)	Temperature at turbine inlet.	Center Instrument Panel
TACHOMETER (4)	Speed of engine rotor.	Center Instrument Panel
TORQUEMETER GAGE (4)	Shaft Horsepower delivered to reduction gearing. (At 13,820 engine RPM)	Center Instrument Panel
ENGINE OIL PRESSURE GAGE (4)	Main engine oil pressure.	Center Instrument Panel
REDUCTION GEAR OIL PRESSURE GAGE (4)	Main reduction gear oil pressure.	Center Instrument Panel
OIL TEMPERATURE GAGE (4)	Temperature of oil at inlets to engine and reduction gear.	Center Instrument Panel
OIL PRESSURE WARNING LIGHTS (4)	Engine oil pressure less than 50 PSI and reduction gear oil pressure less than 130 PSI, or either. Low oil pressure from either system illuminates same indicator light.	Center Instrument Panel over respective oil gages
OIL COOLER FLAP POSITION INDICATOR (2 DUAL)	Position of oil cooler flaps.	Center Instrument Panel
FUEL FLOW METERS (4)	Fuel flow to engine.	Center Instrument Panel
TEMPERATURE TRIM LIGHTS (4)	When "OFF" indicates trim system making fuel flow correction. When "ON" indicates no correction being made, or that there has been an over-temperature condition.	Lower Left-hand Corner of Pedestal
FUEL PUMP LIGHTS (4)	Light indicates failure of primary fuel pump. Light during start is normal.	Center Overhead Starting Panel
BOOST PUMP PRESSURE WARNING LIGHTS (4)	Less than minimum pressure differential across the engine driven boost pump.	Fuel Control Panel on Throttle Pedestal
AUTO-FEATHER ARMING LIGHTS (4)	Auto-feathering arming switch is in "ON" position and auto-feathering circuit is armed for operation.	Lower Left-Hand Corner of Pedestal
NTS CHECK LIGHTS (4)	During NTS check, comes ON when NTS system begins to function, and remains ON until NTS switch returned to normal position.	Lower Left-Hand Corner of Center Instrument Panel
FEATHER MOTOR INDICATOR LIGHTS (4)	Feather motor is energized.	In feather buttons just below Center Overhead Starting Panel.
TAXI RANGE LIGHTS (BETA RANGE) (4)	Throttle below Flight Idle range.	Center Instrument Panel above T.I.T. gages.
STARTER OVERSPEED WARNING LIGHT (1)	Starter overspeed. Illuminates if starter engaged above overspeed setting.	Center Overhead Starting Panel
ENGINE AIR BLEED VALVE OPEN LIGHTS (4)	Air bleed valves not fully closed.	Engine Start Panel
MANIFOLD PRESSURE INDICATOR	Pressure in air bleed manifold.	Engine Start Panel
LEAKAGE TEST LIGHT	When illuminated during leakage test, indicates that leakage in Bleed Air system is within limits.	Engine Start Panel

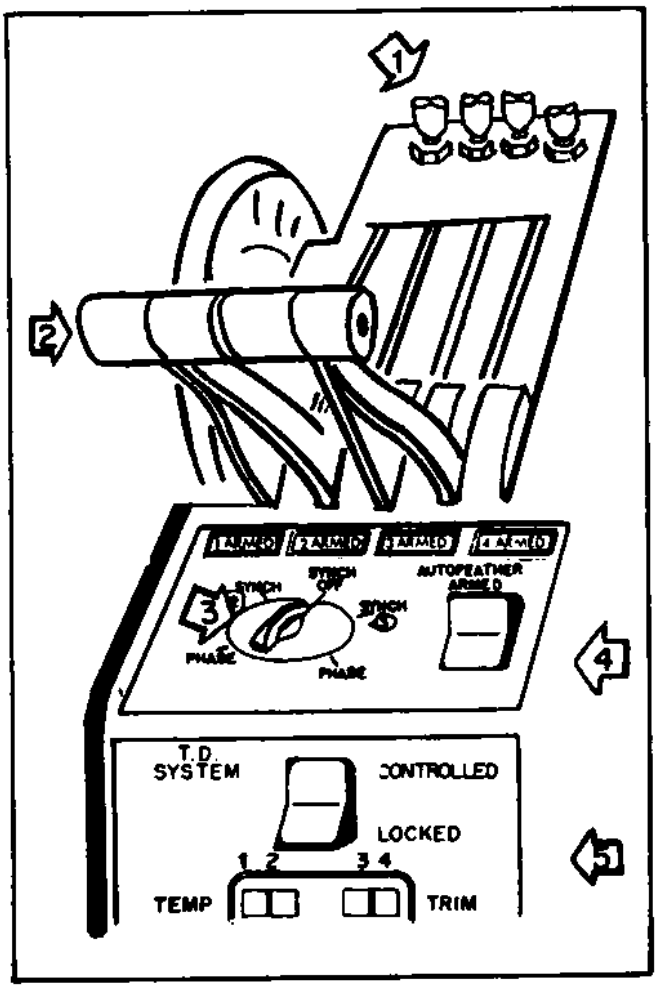
CONTROLS

RPM SWITCH (4)

(1) This switch is provided to select either low (9900-10,300 RPM) or high (13,200-14,000 RPM) engine speed during ground operations. When the throttle is between the 9° and 30° detents and the switch is depressed, the engine speed changes to the low-speed taxi range. The switch will remain in LOW until returned to NORMAL. If high-speed taxi RPM or reverse is desired, the switch should be returned to NORMAL before moving the throttle out of the 9°-30° range. When the d-c bus is de-energized, if the switches are in LOW, they will trip to NORMAL position.

THROTTLE (4)

(2) The throttle directs a signal from the cockpit to the engine control system calling for the propeller blade angle, fuel flow, and consequently the turbine inlet temperature which will deliver the amount of power required. Once the throttle has been positioned, the control system will maintain the desired setting automatically. There is a set of four throttles on either side of the pedestal.



PROPELLER SYNCHRONIZER SWITCH

(3) This is a five-position switch to select one or other of two propellers as a master for synchronizing or phase-synchronizing and a neutral position when hydraulic governing only is desired. Synchronizing functions are inoperative when the throttle is in the Beta range.

AUTO FEATHER ARMING SWITCH

(4) When the switch is moved from OFF to ARMED it provides electrical power to the throttle quadrant auto feather arming switch. Both the arming switch and the throttle quadrant switch (actuated at 75°) must be closed before the Thrust Sensitive Signal device in the reduction gear can cause feathering of the propeller.

TEMPERATURE TRIM SWITCH

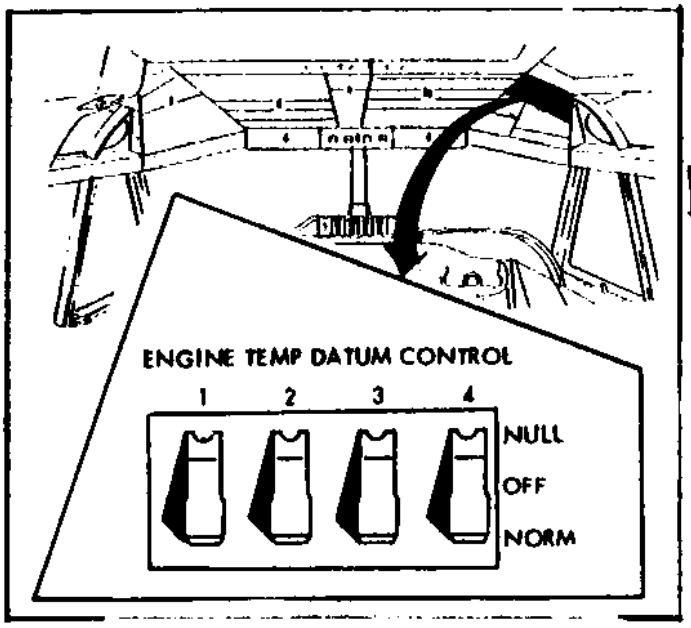
(5) At FLIGHT IDLE, fuel flow is scheduled so that optimum drag conditions exist for approach and landing. However, due to differences in fuel density and other variables which a hydro-mechanical fuel control cannot compensate for, it is possible to have more or less than the power needed for the required drag condition during landing. By use of the temperature trim switch, the percentage correction in fuel flow applied by the trim system in the 65°-90° throttle range is locked in so that it is available at FLIGHT IDLE (34°) and thereby minimizes variations in flight idle horsepower.

The temperature trim switch controls the brake on the temperature datum valve actuator motor. In CONTROLLED, the engine operates to a prescribed turbine inlet temperature schedule in the 65°-90° throttle range. In LOCKED, and with the throttle in the 65°-90° range, the temperature datum valve will supply a constant percentage fuel flow correction which is then available from 65° down to 0° throttle position.

If an over-temperature condition occurs when the switch is in LOCKED, the control system automatically unlocks the valve brake, more fuel is by-passed, and the turbine inlet temperature is reduced. The switch remains in LOCKED but there is no longer a fixed correction locked in (indicated by the temperature trim light being lit). The switch must then be reset (after throttle is placed above 65°) if it is desired to again lock in a trim correction.

POWER PLANT

CONTROLS



TEMPERATURE DATUM CONTROL SWITCH

This switch is provided to control the electronic fuel trimming system. With the switch in NORMAL, electrical power is supplied to the Temperature Datum Control so it may function to trim the output of the Fuel Control. With the switch positioned to NULL, power is cut off from the Temperature Datum Control and the Temperature Datum Valve returns to the NULL position, bypassing 20% of the fuel metered by the Fuel Control unit. The electronic overtemperature protection is lost and turbine inlet temperature must be kept within limits by adjustment of the throttle, and temperature trim light indications should be disregarded.

The switch also has an OFF position. Modifications to the original configuration have been made which results in the NULL configuration being obtained if the switch is in either NULL or OFF position.

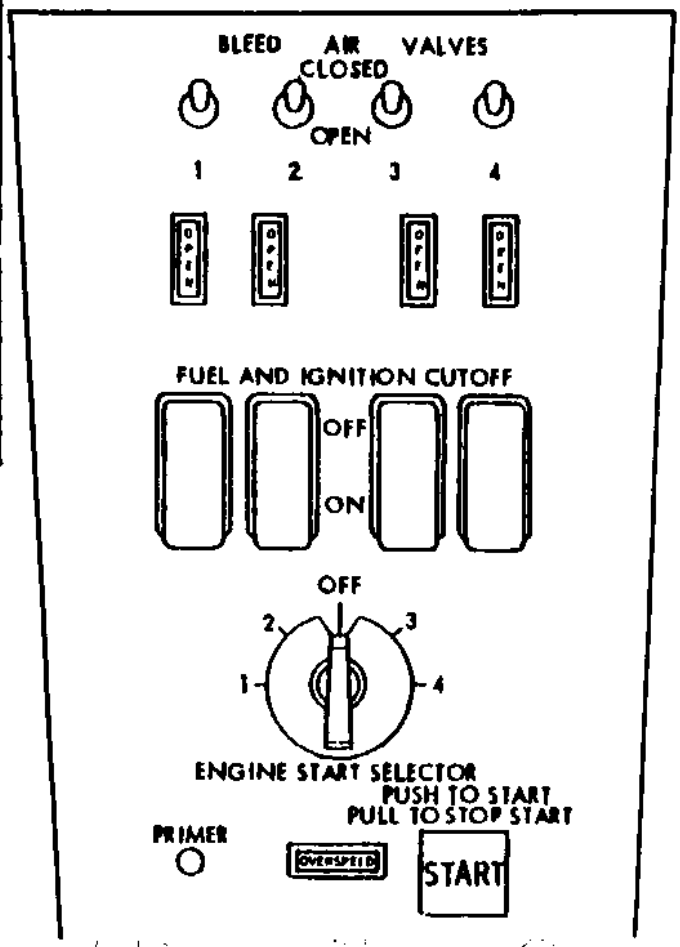
ENGINE START SELECTOR SWITCH

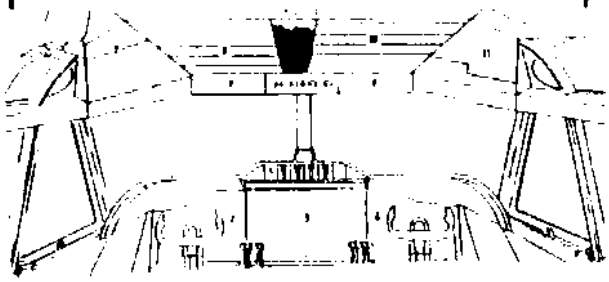
This switch is located on the center overhead Engine Starting Panel. It must be positioned to the engine to be started.

FUEL AND IGNITION CUT-OFF SWITCH (4)

Placing this switch ON arms the fuel and ignition circuits for starting. (Actuation of these circuits is made by the Speed Sensitive Control.) It is also used for normal engine shut-down. Placing the switch in OFF shuts off fuel electrically and prevents ignition from occurring. The switch may be used to prevent fuel flow and ignition when motoring the engine.

CAUTION: When the Engine Shutdown Circuit Breakers, on the Forward Load Center Circuit Breaker Panel, are pulled, it is equivalent to turning ON the Fuel and Ignition Cut-off switch.





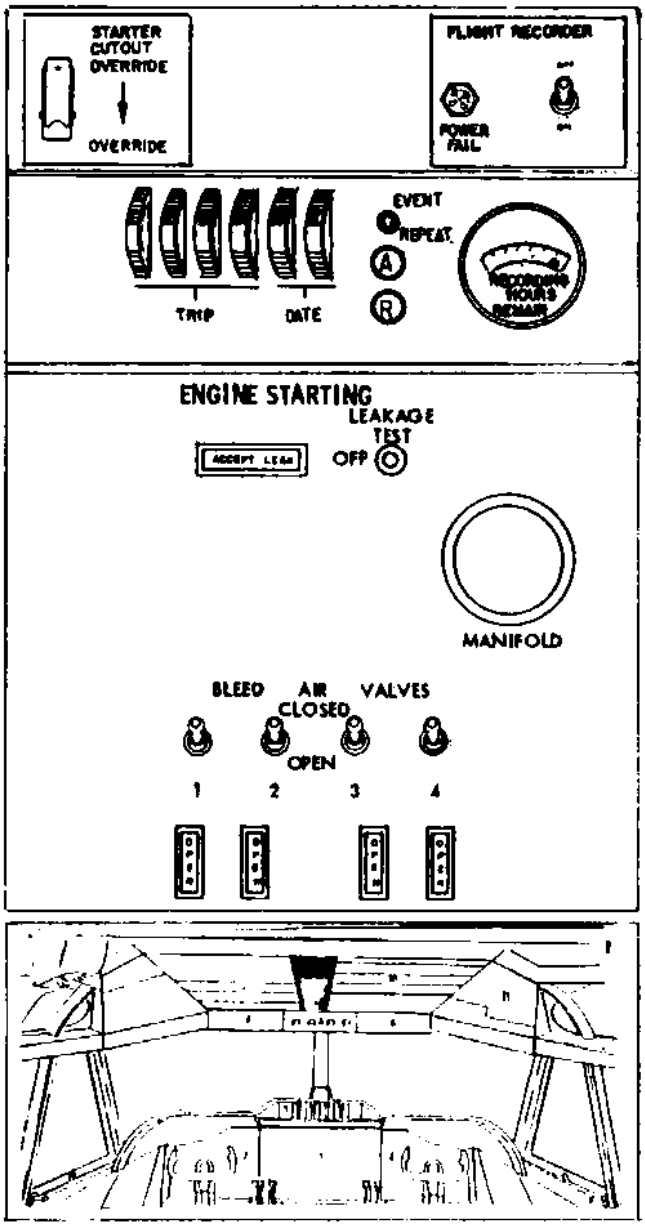
PRIMER BUTTON

The primer button, when depressed, provides power to the primer system. When used, it is depressed during starting and released after light-off (when T.I.T. begins to rise). The primer system can be cut off at any time during the primer cycle by releasing the button, which is spring loaded.

CONTROLS

STARTER BUTTON

This button, when depressed, provides a circuit that energizes the engine starter. The button remains in until engine speed reaches approximately 8240-8650 rpm when it should "pop out" and starter be disengaged. Starter may be disengaged at any time by manually pulling the button out.



BLEED AIR VALVE SWITCHES

The engine air bleed shut-off switches are located on the Engine Starting Panel. These switches provide for the manual control of the air bleed valves. These valves are always closed except during engine starting and bleed air anti-icing or de-icing.

STARTER CUTOUT OVERRIDE SWITCH

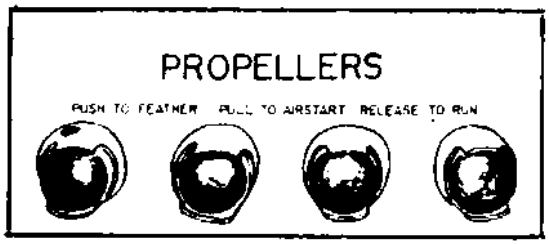
A momentary-contact switch, placarded "STARTER CUTOUT OVERRIDE", is located above the engine starting panel. The momentary position, "OVERRIDE", provides a circuit to bypass the Starter Cutout Switch and may be used (as a method) for starting an engine on which the Starter Cutout Switch has failed in an open circuit condition. When necessary to use the Starter Cutout Override Switch for starting, the Starter Button must also be held "IN" manually and the engine rpm monitored. To prevent overspeeding and disintegration of starter turbine, both the override switch and Starter Button must be released when the engine reaches 8250 rpm.

CAUTION: DO NOT HOLD OVERRIDE SWITCH IN "OVERRIDE" OR STARTER BUTTON "IN" AFTER 8250 ENGINE RPM HAS BEEN REACHED.

DO NOT ACTUATE EITHER THE STARTER BUTTON OR OVERRIDE SWITCH WHEN START SELECTOR SWITCH IS SELECTED TO AN ENGINE WHICH IS TURNING.

LEAKAGE TEST SWITCH

A leakage test switch is located on the Engine Starting Panel. It energizes the leakage test circuits, used for testing acceptable amount of leakage permissible in starter bleed air system. (Normally used by Maintenance.)

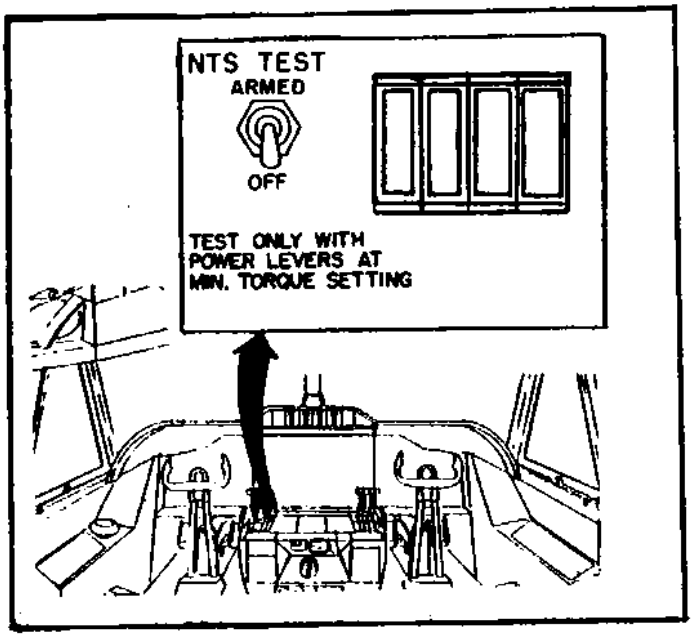


PROPELLER FEATHER BUTTON (4)

Depressing the button feathers the propeller and electrically cuts off fuel at the fuel control. The button remains in feather position unless manually repositioned. (Timer shuts off feather motor after approximately 60 seconds even though the button remains in.) Pulling the button outward to the extreme position operates the feather pump motor to unfeather the propeller. The center position is NORMAL. A light in the feather button comes on when there is power sent to the feather motor. The feather button cannot be used to feather the propeller when the throttle is in the 0-24" range due to the disarming of the NTS lever inside the propeller regulator. (Feathering in this range with the engine running can be accomplished only with the emergency handle.

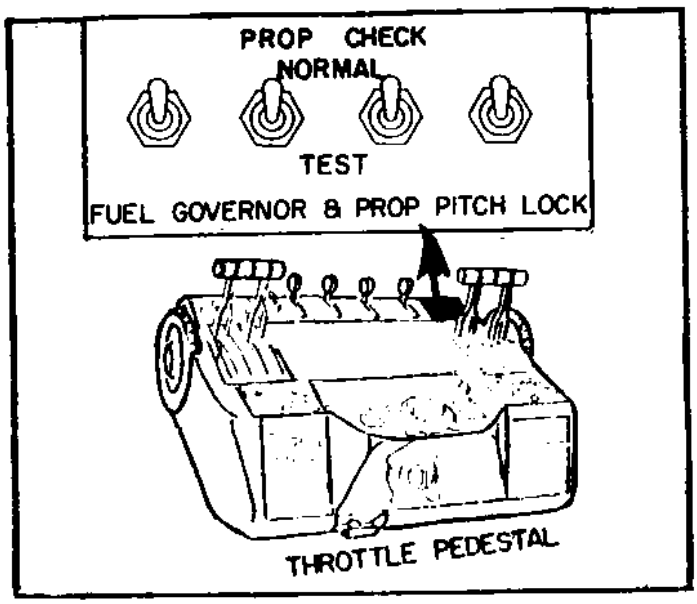
POWER PLANT

CONTROLS



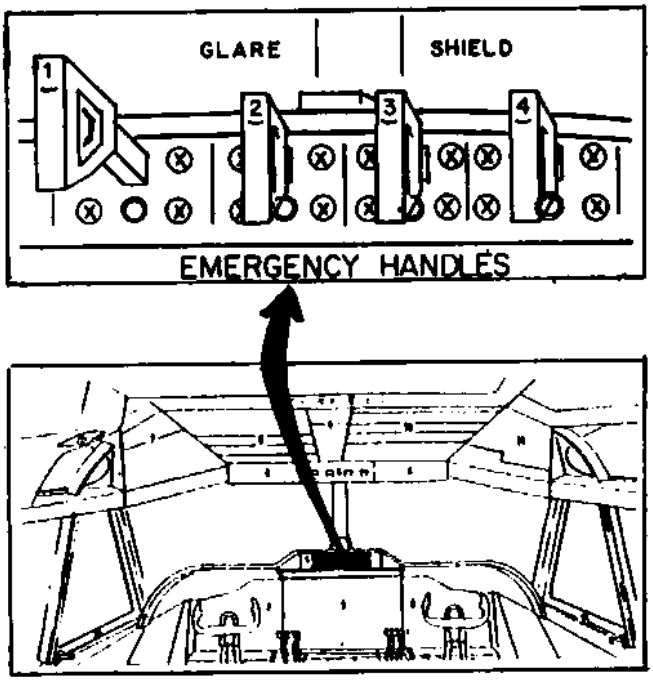
NTS TEST SWITCH

The NTS Test Switch is a two-position, OFF-ARMED, switch. When the switch is moved from OFF to ARMED, it provides power to a switch in the feather solenoid for each engine. When an engine is shut down, propeller inertia produces a momentary negative torque as rpm decays. If the NTS system is functioning properly, the switch in the feather solenoid is closed by NTS linkage action, and the cockpit NTS Test Light comes on. The Test Light remains on until the switch is moved to the OFF position. This test is performed with the throttle at minimum torque (start) position; propeller blade angle does not change because NTS is blocked out in the propeller regulator.



FUEL GOVERNOR CHECK SWITCH

This switch has two positions--NORMAL and TEST. TEST position causes the propeller actuator to adjust the propeller governor to a speed which is above the fuel control governing speed, thus allowing a check to be made on the operation of the engine fuel governor and the pitch lock. The synchronizing switch must be in the SYNCH OFF position for the fuel governor check procedure.



EMERGENCY SHUTDOWN HANDLE (4)

The Emergency Handle, one for each engine, is provided for emergency shutdown of engine. When pulled completely out, it accomplishes the following:

- Shuts off fuel at:
  Fuel emergency shut-off valve
  Fuel control shut-off valve
- Shuts off engine oil
- Shuts off alternator cooling air
- Shuts off bleed air at firewall
- Arms fire extinguishing system
- Feathers propeller
- Shuts off propeller oil reservoir cooling air
- Locks out ignition

ON INBOARDS

- Shuts off output duct of cabin compressors

ON OUTBOARDS

- Shuts off nacelle zone 3 cooling air

When the Emergency Handle is pulled out or pushed in, it should not be moved back to original position for at least 10 seconds to allow electrical actuators to run full travel before reversing.

OPERATION

CONDITION	CONTROL OR INDICATOR	ACTION	REMARKS
ENGINE STARTS	RPM SWITCHES	LOW	Engines may be started with these switches in either position, but will usually be started in LOW to reduce noise level in terminal area.
	THROTTLE	START POSITION	If the throttle had to be moved to the start position, pull out the feather button and hold until blade stops moving. Thereafter, DO NOT MOVE THE THROTTLE FROM ACTUATION OF STARTER UNTIL START IS COMPLETELY ACCOMPLISHED.
	The above items are accomplished during the pre-engine starting period and thus are check list items. Upon receiving signal from the ground, engines will be started in the following manner.		
	FREON OR FAN SWITCH	OFF	The Electra ground power unit is not capable of delivering full electrical output at the same time it is delivering air for an engine start. Therefore, it is necessary to minimize electrical demands by turning off Freon or heat, whichever may be in use, before starting engines.
	AIR BLEED VALVES	OPEN	When aft air connection is to be used, FUSELAGE switches on the AIR FOIL ICE panel also must be put to the OPEN position.
	FUEL & IGNITION SWITCH	ON	ARMS CIRCUITS. During start keep finger on this switch to enable quick turn OFF if rate of rise of T.I.T. is excessive, or if start T.I.T. limit of 877°C is exceeded, or if hung start is indicated. In case of no-light-off, turn OFF before releasing starter button. Once Fuel and Ignition switch is turned OFF, do not turn back on until RPM has decayed to zero.
	ENGINE STARTER SELECTOR	ENGINE TO BE STARTED	Starting sequence is normally 4,3,2,1, when aft air and AC electrical connections are to be used. If forward air and electrical connections are to be used, starting sequence is 4,1,2,3; in this case AC ground unit will be disconnected after 4 is started and AIR will be disconnected after 1 is started; this permits ground personnel and equipment removal from the propeller area before starting inboard engines.
	When ready to start the first engine (4), the Captain will advise the ground crew via interphone "Turn on air".		
	FUEL PUMP	ON	Turn on before starting engine and leave on for all engine operation.
	PRIMER BUTTON	DEPRESS-HOLD	To use primer, hold on, then release as soon as there is indication of light-off. Prime normally used on all starts. EXCEPTION: Do not use prime if engine has been shut down less than 15 minutes when start being made from low energy (less than 50 psi) air supply. If first start is unsuccessful, prime should be used on second attempt after purging the engine by motoring with the starter.
	STARTER BUTTON	DEPRESS	Energizes starter, and is held in by a solenoid. The starter button should pop out automatically as the starter declutches from the engine drive at 8240-8650 RPM. If it does not pop out at this point, it should be pulled out manually. If the starter overspeed warning light comes on, it indicates starter has not declutched, and engine should be shut down immediately.
	Check the following items closely during all engine starts in the manner outlined in Section 4-3, pages 7 and 9.		
	FUEL PUMP LIGHTS	CHECK	0-2200 RPM - OFF 2200-9000 RPM - ON Above 9000 RPM - OFF.

POWER PLANT

OPERATION

CONDITION	CONTROL OR INDICATOR	ACTION	REMARKS
ENGINE STARTS (Cont.)	T.I.T. & TACHOMETER	CHECK T.I.T. & RPM	Monitor these instruments continually from starter engagement until stabilized start is established. SHUT DOWN IMMEDIATELY and record in log book if T.I.T. exceeds 965°C momentarily, or 877°C for 8 seconds. If engine does not accelerate after 5 seconds with T.I.T. at 800-877°C, or if rate of temperature rise indicates limit will be exceeded, make precautionary shut-down. Keep finger on Fuel and Ignition Switch during entire start so it may be quickly turned off to effect a shut-down. Engine should stabilize out on a good start at 9900-10,300 RPM in LOW, 13,200-14,000 RPM in NORMAL, with throttle in start position, T.I.T. should stabilize at 380-700 in LOW, 395-625 in NORMAL.
	OIL	CHECK	Pressure: Discontinue start if no engine or reduction gear pressure indicated on reaching 5000 RPM during start. After start: Engine Pressure..... 50-75 PSI Red. Gear Pressure..... 50 PSI MIN. Temp..... 40°-100° NORMAL NOTE: Keep throttle in start position until oil temperature has reached 0°C. Between 0°C and 40°C, torquemeter reading must not exceed 1000 IHP.
	TEMP. TRIM LIGHT	CHECK	Should be ON.
	Turn External Power Switch OFF if #4 generator voltage is normal (115V) and start second engine (#3 if using aft air connection, #1 if using forward connection).		
	After second engine is started, Captain will use interphone to advise ground crew to "Disconnect air". Thereafter, upon signal from the ground crew, the remaining engines will be started.		
TAXIING	THROTTLES	USE OF	Use throttles judiciously to control taxi speeds, sparing the brakes as much as possible. As most taxiing will be in LOW RPM to reduce noise level and conserve fuel, care must be exercised not to move the throttles into the range (below 9°, above 30°) which will trip engines out of LOW RPM operation.
TAKE-OFF	RPM SWITCHES	NORMAL	Switch 1, 2, and 3 engines to NORMAL and observe Generator advisory lights to determine that each generator picks up its respective electrical bus, then shift 4 to NORMAL.
	AUTO FEATHER SWITCH	ARMED	This partially arms the auto feathering (TSS) system. It will be completely armed when the throttles are advanced to 75° or more. Auto feather indicator light is ON.
	THROTTLES	ADVANCE TO TAKE-OFF	T.I.T. of 971° or 4000 HP, whichever comes first. A too rapid throttle movement may arm the auto feather circuit before 500 pounds thrust is developed, which might cause a propeller to auto feather.
	During take-off, the Beta lights should go out as throttle is moved into the flight range and the Temperature Trim lights should go out as the throttle is moved past 65°. The following should be monitored:		
	T.I.T. & TORQUEMETER	MONITOR	965°-977°C. If in excess of 977°C, reduce to 971°C by retarding throttle. Temperatures may be less than this if 4000 IHP is developed. Whichever limit is reached first will be the governing limit.

OPERATION

CONDITION	CONTROL OR INDICATOR	ACTION	REMARKS
TAKE-OFF (Cont.)	TACHOMETER	MONITOR	13,820 RPM desired. Normal range 13,680-13,960 RPM. Feather propeller and record if RPM drops below 13,400 or exceeds 16,000 momentarily or 14,900 for a sustained period.
	OIL	CHECK	Engine Pressure..... 50-75 PSI Red. Gear Pressure... 150-240 PSI Temperature..... 40-85°C (100°C Max. for 5 minutes)
For other flight regimes, the auto feather switch will be off and the auto feather light will be OFF. Power will be set as desired with the throttle in conjunction with T.I.T. and Torquemeter readings. The following tabulation should be helpful.			
NORMAL FLIGHT			METO / CLIMB / CRUISE / DESCENT
	T.I.T.	(MAX.)	932°C / 895°C / 847°C / 847°C
	TORQUEMETER	(MAX.)	3400 IHP / 3400 IHP / 3200 IHP / 3200 IHP
	OIL PRES.	ENG.	- - - - - - - - - 50-75 PSI - - - - - - - - -
		RED. GEAR	- - - - - - - - 130-240 PSI - - - - - - - -
	OIL TEMP.		60-85°C (100°C for 5 minutes and 90°C for 5 minutes)
HOLDING AND APPROACH	THROTTLES	SET	Setting throttle so torquemeter gage reads 1000 HP, plus or minus a hundred or so, will maintain altitude at an airspeed of 190 knots with flaps up, or 150 knots with flaps set to take-off. With wheels extended, a slight reduction from this setting will permit normal descent for approach to the airport for a landing.
LANDING AND TAXIING	THROTTLES	SET	On touchdown, lift back over ramp into taxi range and retard as required toward maximum reverse. Reversing should be used at as high a speed as possible for maximum effectiveness. CAUTION: DECOUPLING MAY OCCUR IF THROTTLES ARE MOVED BELOW FLIGHT IDLE ON THE GROUND AT SPEEDS ABOVE 130 KNOTS.
	RPM SWITCHES	LOW	With throttles near start position, place #4 RPM switch to LOW, check to see that its generator is developing 115V, then move 1, 2 and 3 RPM switches to LOW, checking to see that buses transfer to #4. Check T.I.T. during downshift to guard against overtemperature. Do not downshift at taxi speeds above 50 knots or while engines are in reverse.
NORMAL SHUTDOWN AND NTS CHECK	THROTTLES	START POSITION	This places the blades at minimum torque position for succeeding starts. (See CAUTION at bottom of next page.)
	NTS TEST SWITCH	ARMED	An NTS check will be made at each engine shut-down to assure that NTS linkage is functioning properly to close the switch in the feather solenoid. With the system functioning properly, an NTS LIGHT will glow in the cockpit when NTS check is made. The Captain places the NTS TEST SWITCH in the ARMED position and notes that the NTS TEST LIGHT comes on when the Flight Engineer cuts off the fuel and ignition switches. Both Captain and Engineer watch decay of T.I.T. and RPM until engines have stopped turning. If either does not decelerate at a steady rate, it is an indication of incomplete fuel shut-off and the Captain should pull the emergency handle at once if either indication is noticed as hanging at an intermediate point. #4 engine is the last to be shut down as its generator is carrying the electrical loads until a ground electrical source is plugged in. At the conclusion of each flight, a notation will be made in the Airplane Log indicating that the required NTS checks have been made, and whether or not they gave satisfactory NTS indication. If Log inspection reveals an unsatisfactory check when engine shut down in low rpm, next shutdown should be made with high rpm and result of check noted in Log.
	FUEL & IGNITION SWITCHES #1, #2 & #3	OFF	
	FUEL & IGNITION SWITCH #4	OFF	
	NTS TEST SWITCH	OFF	

POWER PLANT

OPERATION

CONDITION	CONTROL OR INDICATOR	ACTION	REMARKS
EMERGENCY SHUT DOWN (GROUND OR AIR)	EMERGENCY HANDLE	PULL OUT LEAVE OUT	This shuts off fuel valves in the engine and at the fuel tank as well as feathering the propeller and arming the fire extinguishers and accomplishing other items as described on page 4, Section 6-2.
	CHECK LIST	USE	Use Check List in flight, to clean up secondary items involved in an emergency shut-down. NOTE: The feathering button will be held in by solenoid action after Emergency Handle has been pulled. Do not return Feather Button to Neutral. If light does not go out in Feather Button after one minute, pull PROP FEATHER PUMP CONTROL CB for appropriate engine.
STATIC AUTO FEATHER CHECK			An autofeather check will be made once each day and its accomplishment will be marked in the appropriate box on page 1 of the Airplane Log. Crews on subsequent flights need not make this check if examination of the Airplane's Log shows that it has been made.
	THROTTLES (ALL 4)	TAKE-OFF	This closes the 75° throttle auto-feather switches.
	AUTO FEATHER ARMING SWITCH	ARMED	This completes the auto-feather circuit and #4 feathering button will be drawn in by solenoid action; the feather pump will be energized, and the blades will move toward feathered position. The Captain will monitor the Beta light. When it goes out, the blades have moved out of the Beta range, and he will retard throttle to flight idle position.
	THROTTLE #4	*FLIGHT IDLE	The pilot will visually inspect propeller blades to see that they are still moving toward feather after the throttle has been set to flight idle. He audibly reports to the Captain that the blades are still moving toward feather.
	THROTTLE #4	START POSITION	The blades will now move to assume the position called for by the throttle. The Beta light will come ON as the blades pass into the Beta range. A time lapse of 4 seconds is allowed for them to be positioned to "START" then the Captain stops the feather pump by pulling feather button to neutral position.
	FEATHER BUTTON #4	NEUTRAL (NORMAL)	As the Captain moves this switch to Neutral, #1 propeller will start to feather.
	The same procedures are followed on the remaining propellers, except that the Captain, rather than the Pilot, must visually check that the blades are continuing toward the feathered position on engines #1 and #2 after the throttle has been placed in the Flight Idle position. Propeller sequence of feathering in this procedure is 4, 1, 3, 2. After the last propeller has been checked, the blades are in "Start" position.		
	AUTO FEATHER ARMING SW.	OFF	At completion of check.
	FEATHER BUTTONS	CHECK	All neutral. Engine(s) will not start if Feather Button has not been returned to the normal position.

*CAUTION: With electrical power on airplane, and throttle(s) positioned above Beta range with engine(s) not running, the propeller solenoid valve will chatter, which could cause damage to this mechanism. Consequently, throttles should be left in Beta range when engines are stopped.

Should it be necessary to have the throttle(s) in Flight Idle for an appreciable time the respective Prop Solenoid (RPM Control) C.B.'s should be pulled. The throttle(s) should be returned to Beta range and circuit breaker(s) re-engaged before starting engine(s). This precaution is not necessary for the short time necessary to perform the Static Auto-Feather Check.

OPERATION

CONDITION	CONTROL OR INDICATION	ACTION	REMARKS
AIR START	DO NOT ATTEMPT TO RESTART THE ENGINE DURING THE PERIOD FROM ONE AND ONE HALF TO FIFTEEN MINUTES FOLLOWING AN INFLIGHT SHUT-DOWN, EXCEPT IN CASE OF EMERGENCY.		
	EMERGENCY HANDLE MAIN FUEL VALVE FUEL BOOST PUMP THROTTLE FUEL & IGNITION SWITCH	FULL IN ON ON FLIGHT IDLE +1" ON	There is no restriction on airspeed at which an air start can be made; however, it is recommended that airspeeds be held to 160 knots or below during this operation. T.I.T. should be below 200°C before making an air start. A momentary overspeed to the vicinity of 14,100 RPM may be expected during this operation.
	PRIMER BUTTON	DEPRESS	Release at indication of light-off.
	FEATHER BUTTON	HOLD OUT	Release at 1000-1400 RPM. NOTE: If the propeller does not begin to rotate after the feather button is pulled out, use the engine starter and cross bleed until rotation starts. This will overcome the propeller brake which has been in a locked position during shut-down.
OVERTEMPERATURE OPERATION DURING START	If T.I.T.	EXCEEDS 965°C MOMENTARILY	Discontinue start immediately and record in airplane log. Do not attempt a restart, call for maintenance as an overtemperature inspection is required.
	If T.I.T.	EXCEEDS 877°C LONGER THAN 8 SECONDS, BUT DOES NOT EXCEED 965°C	Discontinue start immediately and record in airplane log. Cool to below 200°C and attempt a restart. If time or temperature limit is again exceeded, shut down immediately and call for maintenance.
	If T.I.T..... and R.P.M.....	IS IN RANGE OF 800-877°C SLOWS ACCELERATION BETWEEN 5000-7000	A "Hung" or "Stalled" start is indicated. Discontinue start immediately by placing Fuel & Ignition switch to OFF position. Continue to hold Starter Button to motor engine to cool below 200°C and purge fuel, and attempt a restart. Record incident in airplane log.
DURING POWER INCREASE	If T.I.T.	EXCEEDS 1116°C	Reduce power immediately to 895°C or below if in flight. Record and call for maintenance at next stop. Shut down engine immediately if on the ground, record and call for maintenance.
	If T.I.T.	IS IN RANGE OF 977-1050°C EXCEEDING 5 SEC. OR 1050-1116°C EXCEEDING 2 SEC.	If on take-off or in flight: Reduce to 895°C or below and record in log; slowly advance the throttle (not to exceed 977°C) and if limit is again exceeded, record and call for maintenance at the next landing. If on the ground: Reset throttle to FLIGHT IDLE, slowly advance throttle (not to exceed 977°C); if the limit is again exceeded, shut down, record in airplane log, and call for maintenance.

POWER PLANT

OPERATION

CONDITION	CONTROL OR INDICATION	ACTION	REMARKS
FEATHERING SYSTEM CHECK (When Auto-feathering is inoperative)	THROTTLES	FLIGHT IDLE	All 4 throttles to this position.
	FEATHERING BUTTON NO. 1	PUSH TO FEATHER	If feathering circuits are in working order, blades should start toward feathered position.
		CHECK	Feather Light -- ON Prop Blades -- PITCH INCREASING
	THROTTLE #1	START POSITION	Feathering circuit is blocked when throttle is in the Beta Range. Blades should now move to assume position called for by throttle position. The Beta light will go ON as blades pass into Beta Range. Allow four seconds after lights are ON for blades to reach start position, then stop feathering pump.
	FEATHER BUTTON	PULL TO NEUTRAL	This stops feathering pump.
	Repeat above steps for engines 2, 3, and 4.		
ENGINE START WITH STARTER CUTOUT OVERRIDE SWITCH NOTE: Notify Ground Personnel and Record in Log Book when Override used.	STARTER BUTTON	DEPRESS-HOLD	Hold in manually until 8250 rpm is reached, then release.
	STARTER CUTOUT OVERRIDE SWITCH	HOLD IN OVERRIDE POSITION	Hold until 8250 rpm is reached, then release. CAUTION: (1) DO NOT HOLD OVERRIDE SWITCH IN "OVERRIDE" OR STARTER BUTTON "IN" AFTER 8250 ENGINE RPM HAS BEEN REACHED. (2) DO NOT ACTUATE EITHER THE START BUTTON OR OVERRIDE SWITCH WHEN START SELECTOR SWITCH IS SELECTED TO AN ENGINE WHICH IS TURNING.