Theory of Operations

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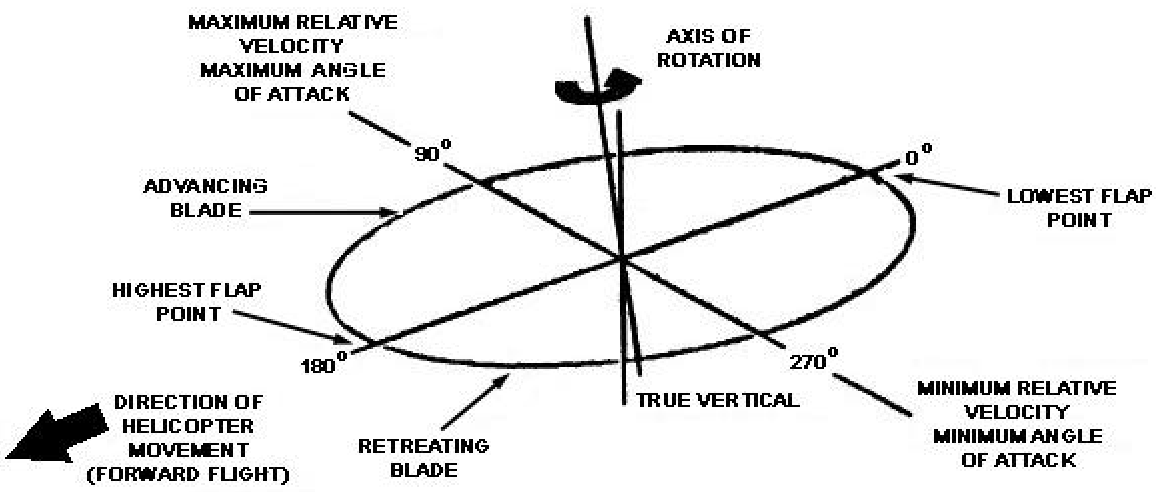
SECTION I
PRINCIPLES OF FLIGHT

The helicopter differs from the fixed-wing aircraft in that its lifting surfaces rotate. This allows the surfaces to move to generate lift while the helicopter remains Stationary. In the Chinook, lift and propulsion are derived from two sets of three rotor blades. Each set of blades is mounted on a rotor head: one forward and the other aft. Since these heads rotate in opposite directions, torque is canceled, and anti-torque rotor is required.

In forward flight dissymmetry of lift is caused by the relative wind, which acts as a head wind on the advancing blade and increases the lift, while it acts as a tail wind on a retreating blade and decreases the lift. The blade cycle shown below illustrates how the rotor system maintains symmetric lift through full articulation of the blades.

To equalize lift throughout the cycle, the blades are permitted to move up and down (flap). The advancing blade flaps upward because of increased lift: the retreating blade flaps downward because of decreased lift. The result is a reduction in angle of attack of the advancing blade and an increase in angle of attack of the retreating blade. In this way, lift is equalized across the rotary-wing disk.

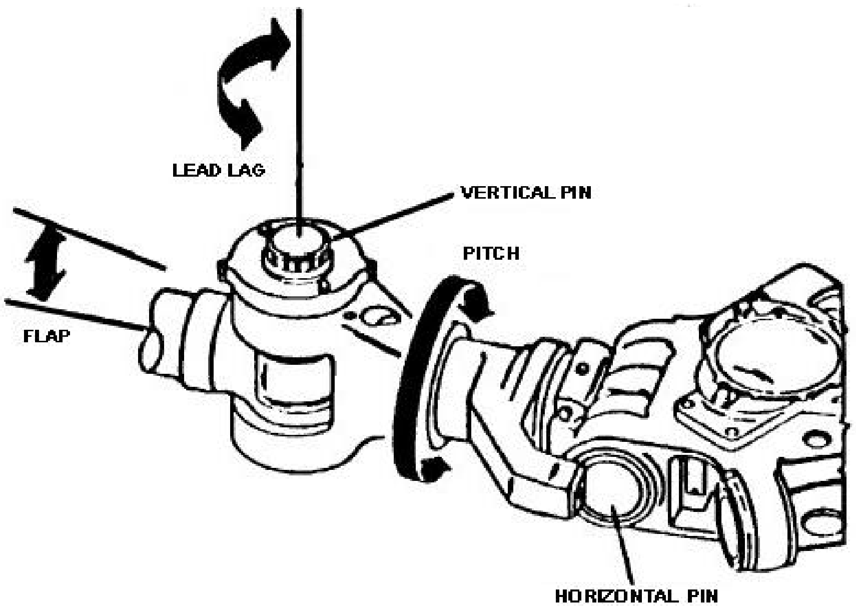
The cycle of a single forward blade with counterclockwise rotation is illustrated. The same cycle occurs with the aft blade, except that rotation is clockwise, which reverses the 90° and 270° positions in the cycle.



Hinge Points

A fully articulated blade assembly is capable of movement in three directions about its attachment to the rotor head. It moves up and down (flaps) around a horizontal hinge pin, fore and aft (leads and lags) around a vertical hinge pin, and rotates (increases or decreases pitch) by twisting the laminated tie bars within the pitch-varying housing to which the blade assembly is attached.

Lead-lag movements and flapping are caused by external aerodynamic forces prevailing in the blades plane of rotation and are beyond the



pilot's control. Pitch changes are controlled by the pilot, either collectively, to vary the lift, or cyclically, to vary the flight direction.

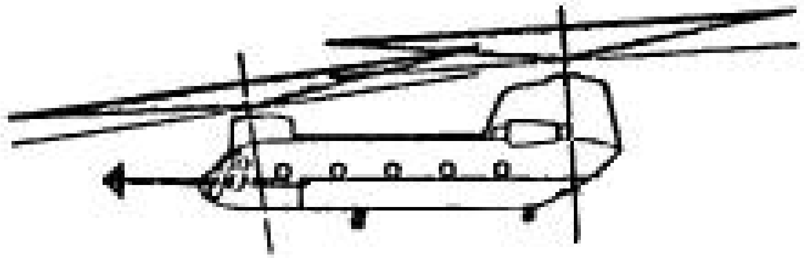
Control Actions

The Chinook has three basic pilot flight controls: yaw pedals, pitch and roll control stick, and thrust control. The first two controls are positioned similarly to those in fixed-wing aircraft, while the latter is located to the left of each pilot's seat. A brief explanation of the helicopter control actions follows:

Flight control movements are transmitted through a system of bell cranks and push-pull tubes to a mixing unit. Control movements are mixed there to become lateral cyclic and collective pitch inputs to the hydraulic actuators in the upper controls.

The upper controls lift and tilt swash plates which, in turn, raise or lower pitch links. The pitch links are connected to pitch-varying housings on the blade arms and vary the pitch of the blades during the rotation cycle.

Control motions must be coordinated to produce various flight maneuvers, as in fixed-wing aircraft. In addition, helicopter control actions have their own characteristic effects on aircraft attitude, and an additional control, the thrust control, must be coordinated for certain maneuvers. A climbing turn, for instance, is accomplished by using a combination of directional pedal, aft control stick, and increased thrust.

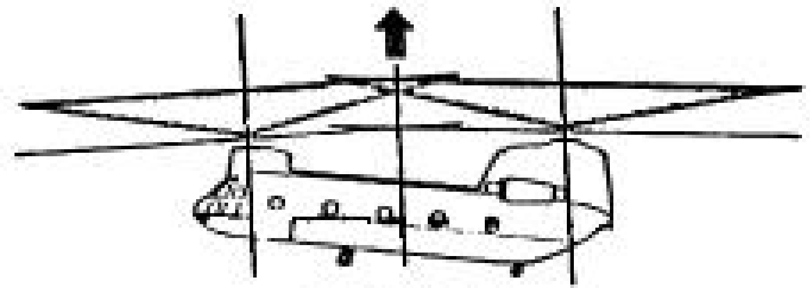


CYCLIC CONTROL
FORWARD / AFT
MOVEMENT

Control Stick

For forward flight, the pilot moves the control stick forward. This increases the thrust of the aft blades and decreases the thrust of the forward blades, causing the helicopter to rotate nose downward and move forward as show in the illustration. Since there is a large range of longitudinal control, a capacity for high forward speed and extremes in center-of-gravity accommodation are inherent.

When the pilot wants the helicopter to move laterally or to roll to the left or right, he moves the control stick in the desired direction. This action tilts the plane of rotation of both sets of rotor blades in the same direction, causing a corresponding movement of the helicopter.

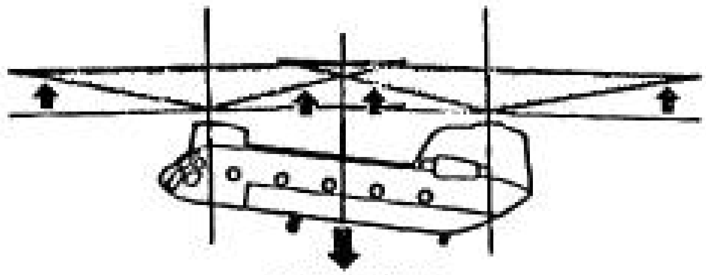


TRUST CONTROL
UPWARD / DOWNWARD
MOVEMENT

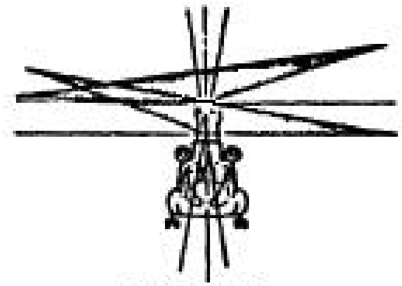
Thrust Control

Lift can be varied to produce climbs or descents by changing the thrust of the blades. When the thrust control in the cockpit is raised, the pitch of all six blades is increased simultaneously, causing the helicopter to ascend as shown in the illustration. Lowering the thrust control decreases the pitch of all six blades, causing the helicopter to descend. An intermediate setting of the thrust control permits a desired altitude to be maintained.

Auto-rotation (descent without engine power) is accomplished by lowering the thrust control and maintaining slight forward motion down to the landing site. See the following paragraph.



AUTOROTATION



YAW CONTROL

Autorotation

Autorotation is the flight condition in which no engine power is applied and the rotor blades are driven only by the relative wind. It is used to safely land a helicopter after engine failure.

In powered flight, airflow over the blades is downward. During autorotation, the airflow changes to upward. This upward flow causes the blades to continue rotating but, left unchecked, will also cause the blade angle of attack to increase to the point where aerodynamic drag will cause a loss of rotor rpm.

To prevent this, on entering autorotation, the collective control is lowered to decrease blade pitch. This counters the airflow-induced increase in angle of attack and allow lift and rpm to be maintained. Lift is maintained throughout the helicopter's descent by balancing collective pitch against airflow through the blades until a landing is made.

Overrunning clutches in the drive system allow the rotor to turn faster than the engine during autorotation.

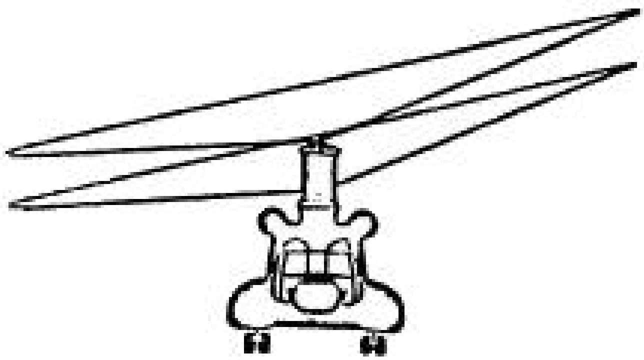
Yaw Control

Yaw is controlled by tilting the plane of rotation of the rotor blades. Control motions to accomplish this are achieved through the yaw pedals.

The plane of rotation is tilted by increasing blade lift through part of the cycle and decreasing it through another part of the cycle. As the plane tilts, the helicopter moves in the direction of the downward side of the tilt.

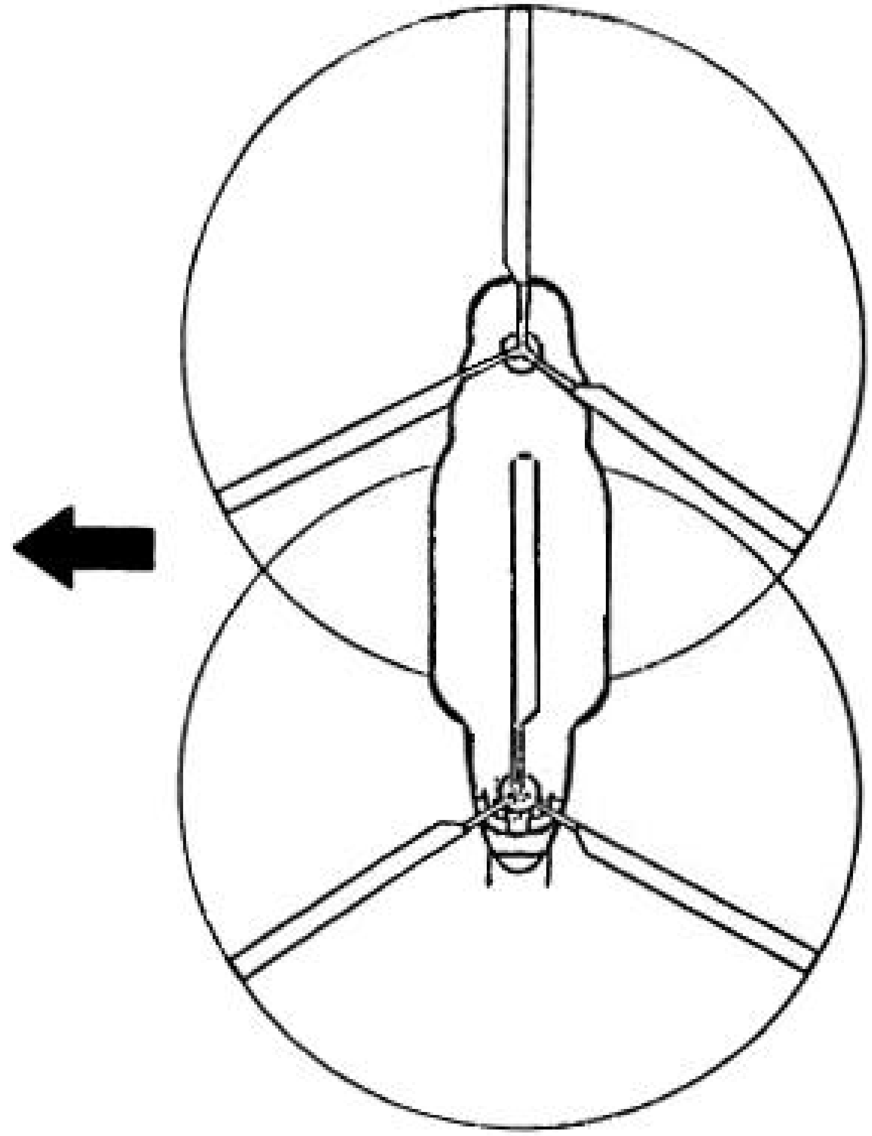
When the pilot applies left or right yaw pedal movement, the plane of rotation of the forward rotor blades is tilted in the same direction; simultaneously, the plane of rotation of the aft rotor blades is tilted in the opposite direction. The result is a hovering turn around the vertical axis. A left pedal application is illustrated.

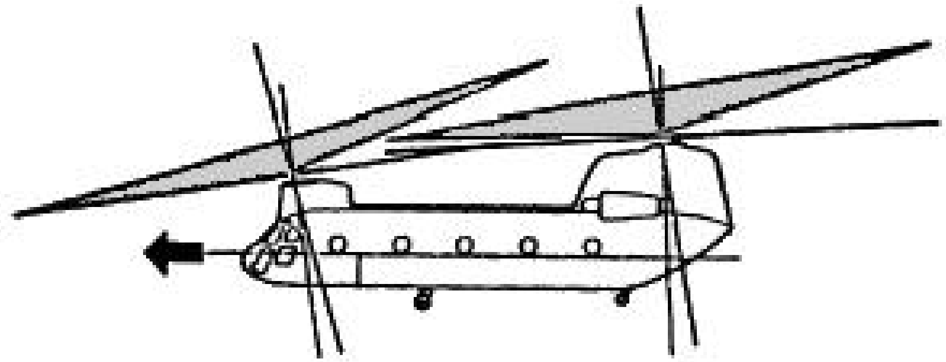
RIGHT CYCLIC INPUT



RIGHT CYCLIC

FORWARD AND AFT ROTOR DISKS
TILT RIGHT.
AIRCRAFT MOVESTO THE RIGHT





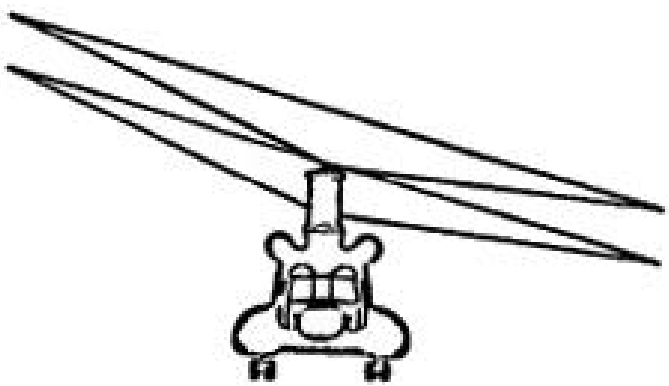
AUTOMATIC SPEED TRIM

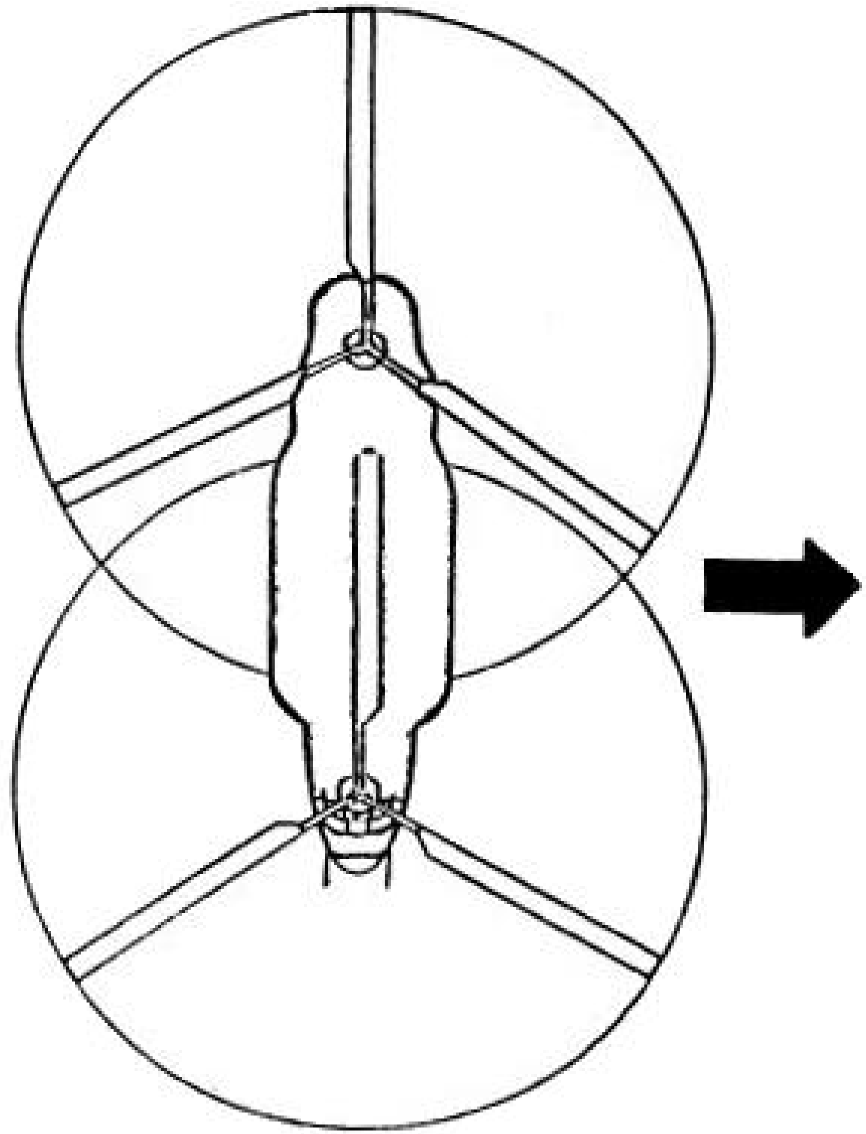
Automatic Speed Trim

An automatic speed trim system provides longitudinal cyclic tilt of the rotor blades proportional to airspeed. This system automatically adjusts the tilt of both sets of rotor blades to provide and essential level fuselage attitude at high speed. Increasing airspeed also induces programmed removal of some of the differential collective pitch generated through the control stick, thereby providing a positive stick gradient.

If airspeed is constant and the helicopter is momentarily displaced longitudinally by gusty winds, causing an airspeed change, the speed trim system will tend to return the helicopter to the selected speed.

LEFT CYCLIC INPUT

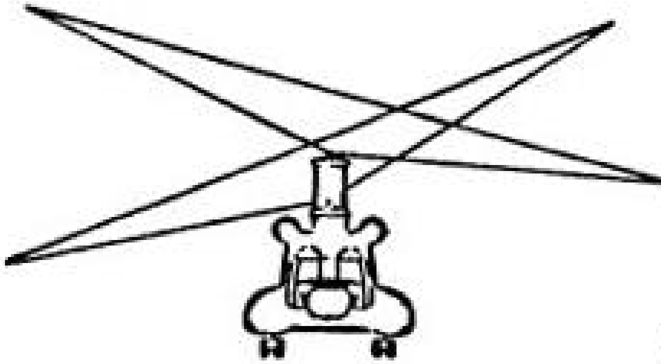


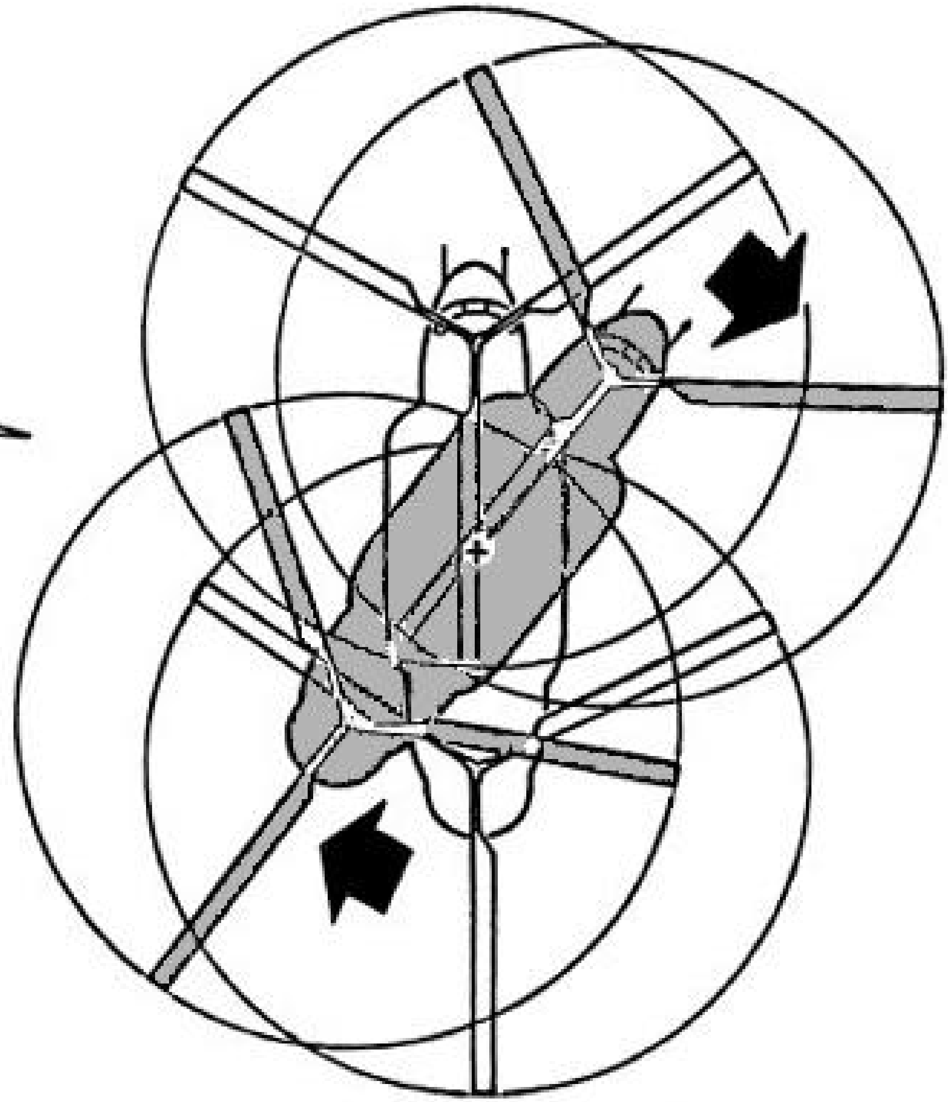


LEFT CYCLIC

FORWARD AND AFT ROTOR DISKS
TILT LEFT.
AIRCRAFT MOVES TO THE LEFT

RIGHT PEDAL INPUT

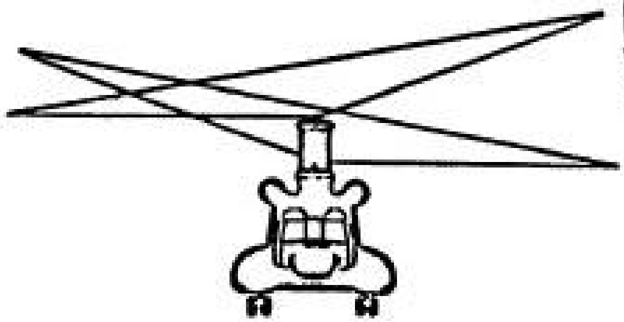


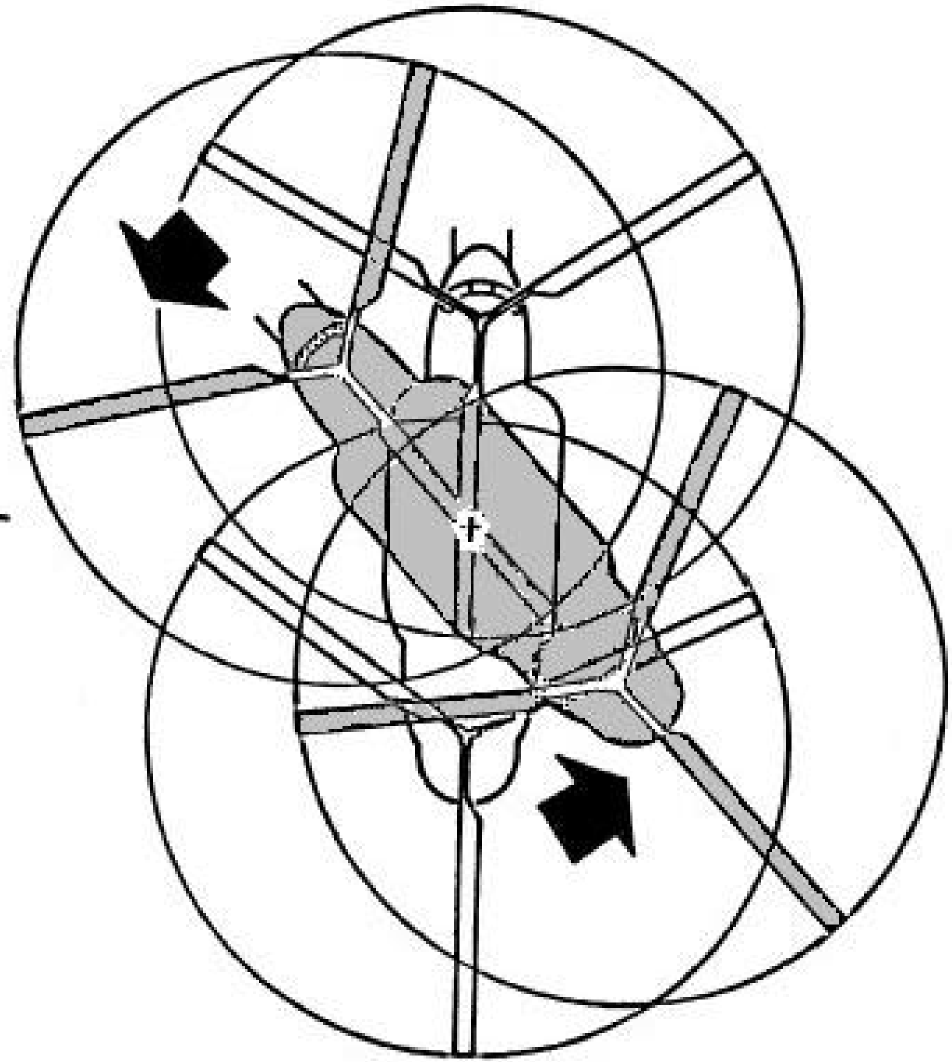


RIGHT PEDAL

FORWARD ROTOR DISK TILTS RIGHT.
AFT ROTOR DISK TILTS LEFT.
AIRCRAFT ROTATES CLOCKWISE ABOUT
A CENTER FUSELAGE PIVOT.

LEFT PEDAL INPUT

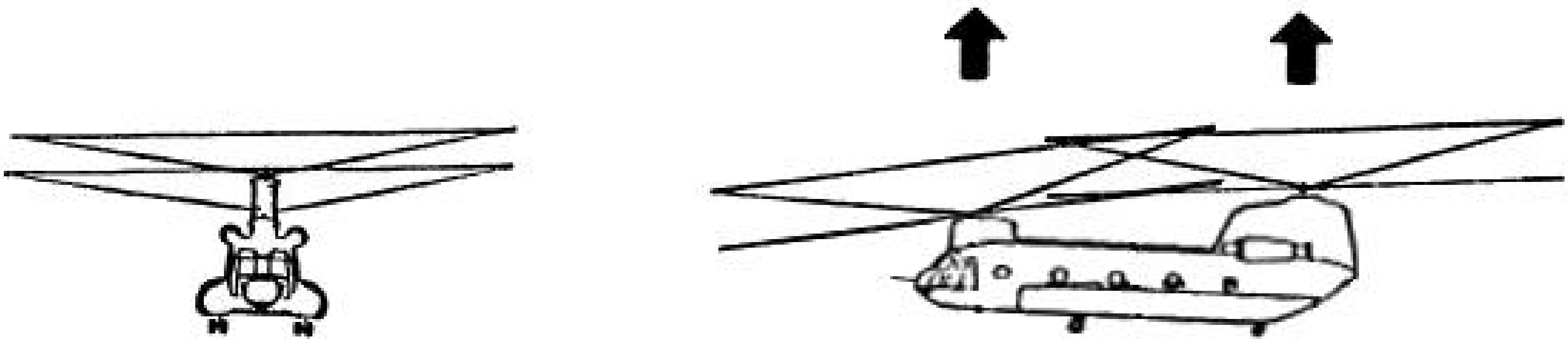




LEFT PEDAL

FORWARD ROTOR DISK TILTS LEFT.
AFT ROTOR DISK TILTS RIGHT.
AIRCRAFT ROTATES COUNTER
CLOCKWISE ABOUT A CENTER
FUSELAGE PIVOT.

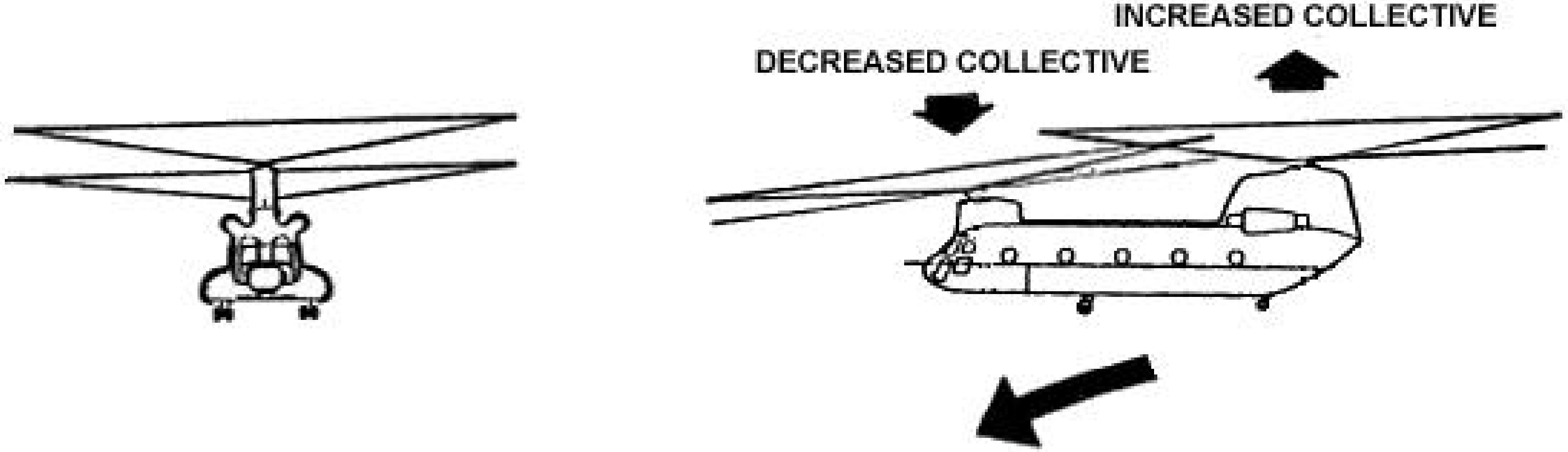
COLLECTIVE INPUTS



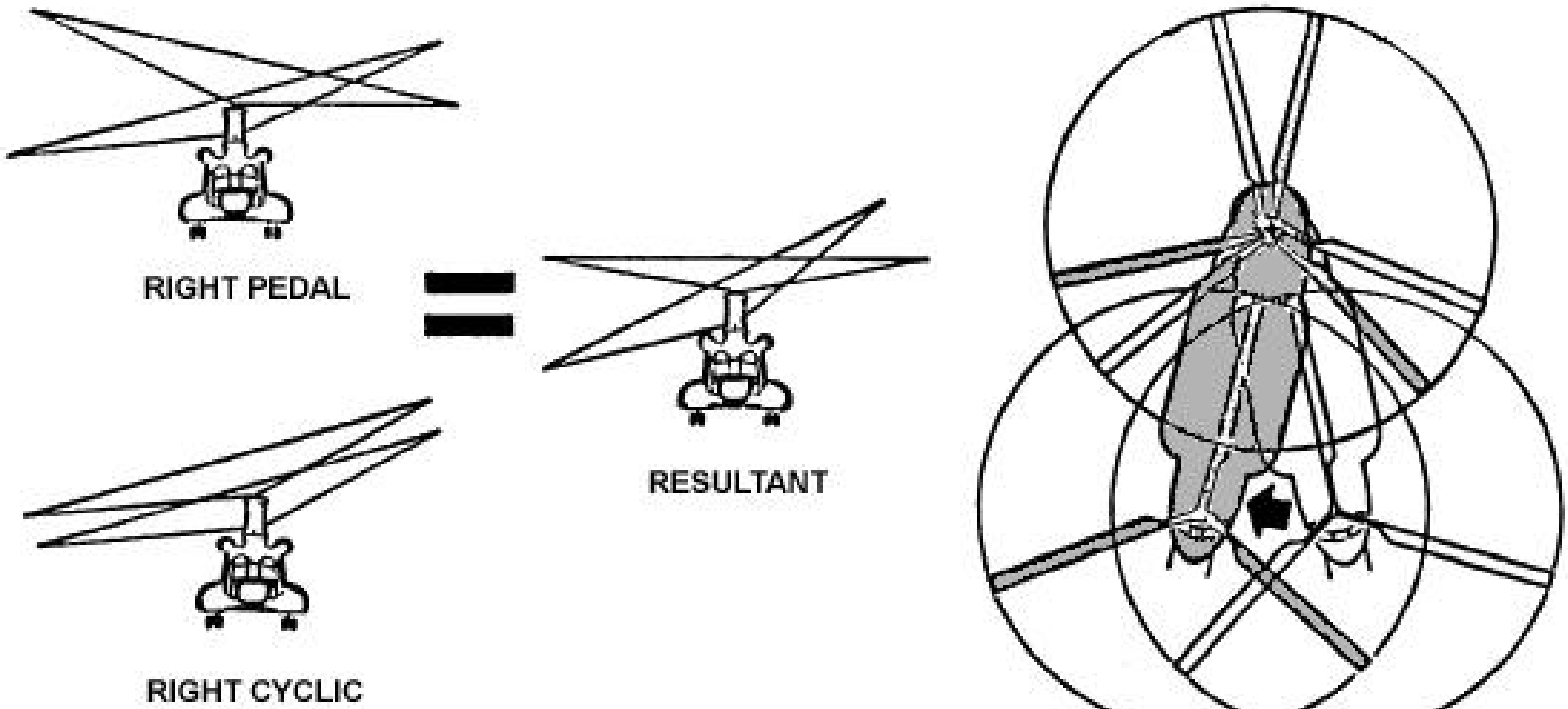
INCREASED COLLECTIVE

DECREASED COLLECTIVE

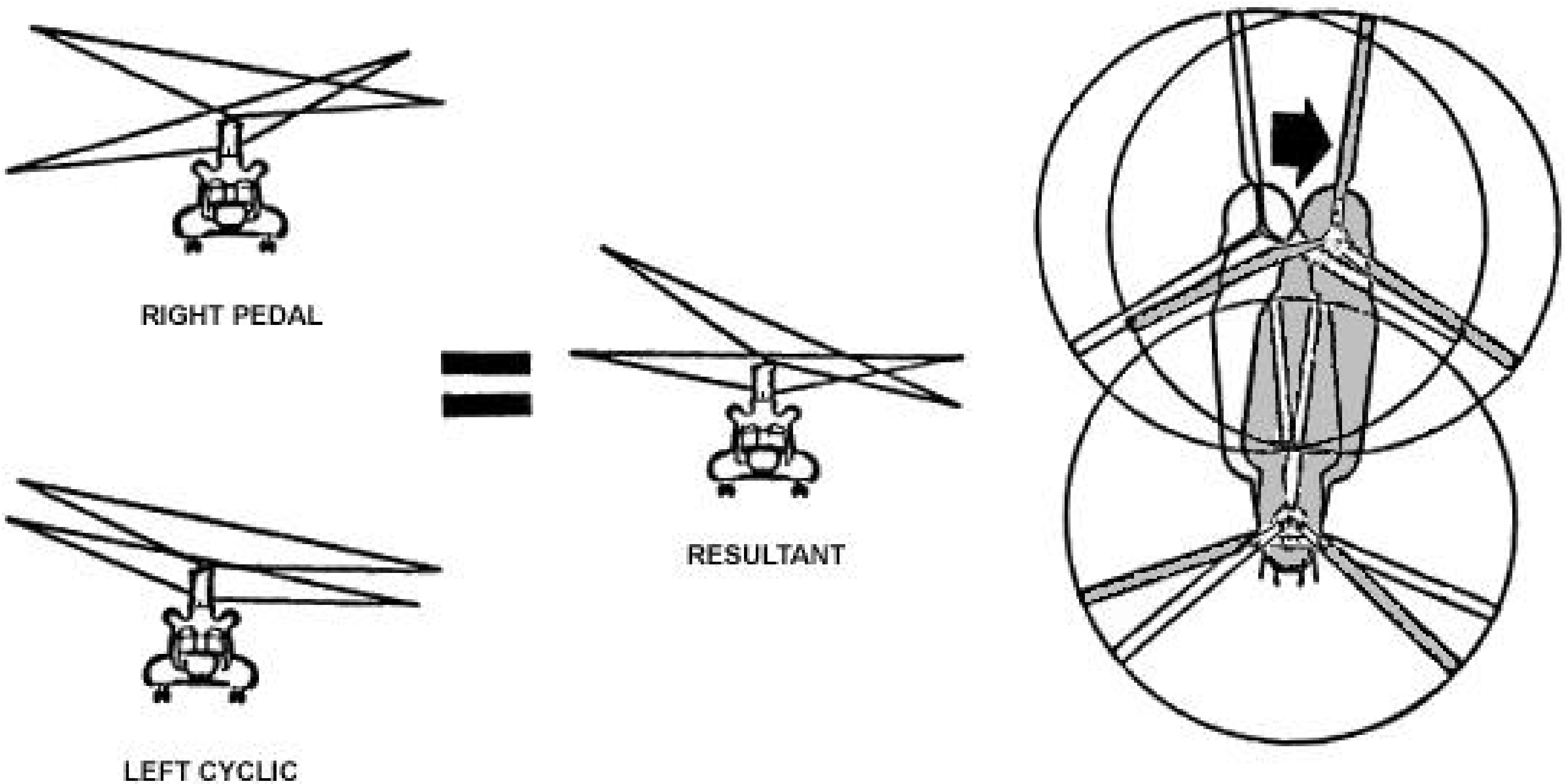
FORWARD PITCH STICK INPUT



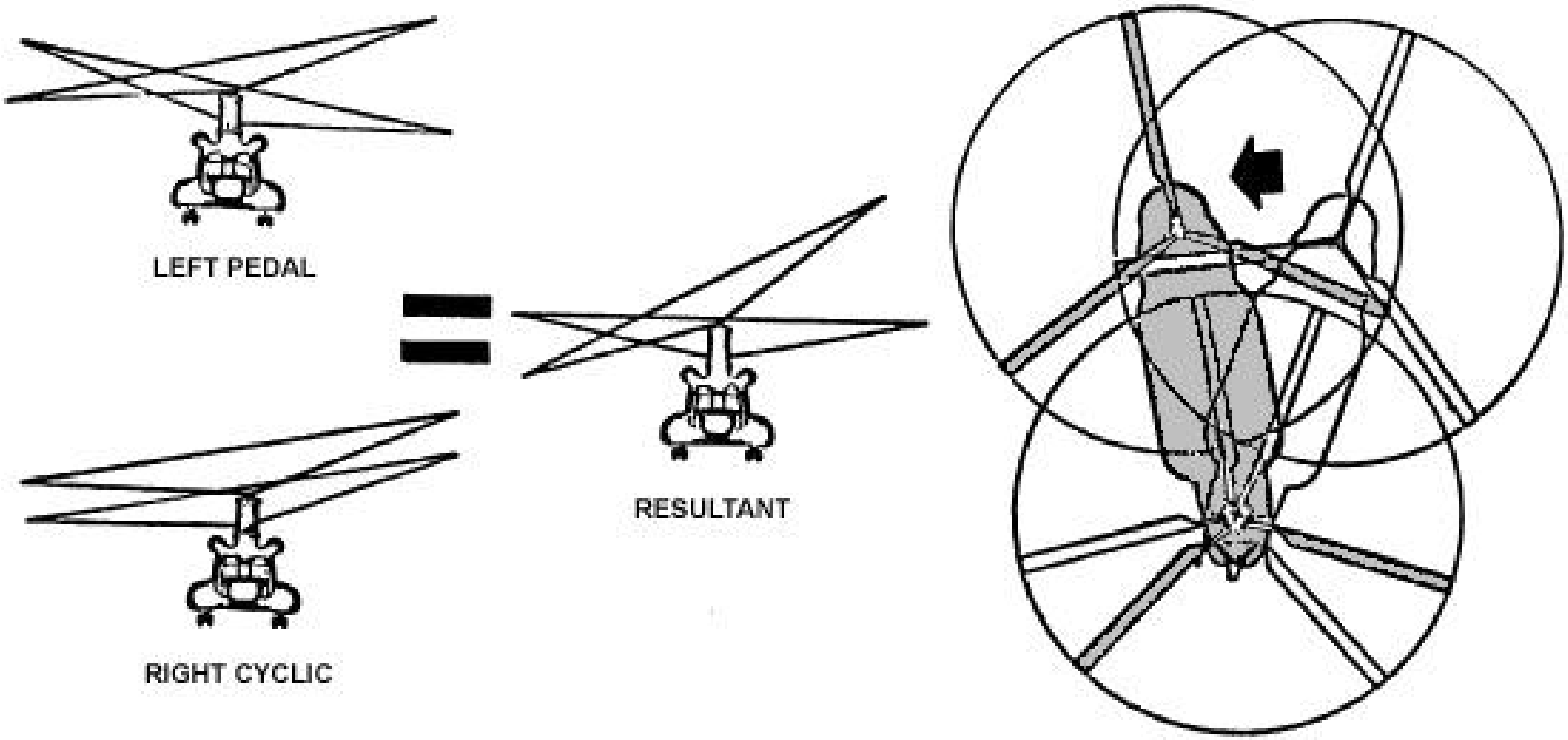
RIGHT PEDAL AND RIGHT STICK INPUTS



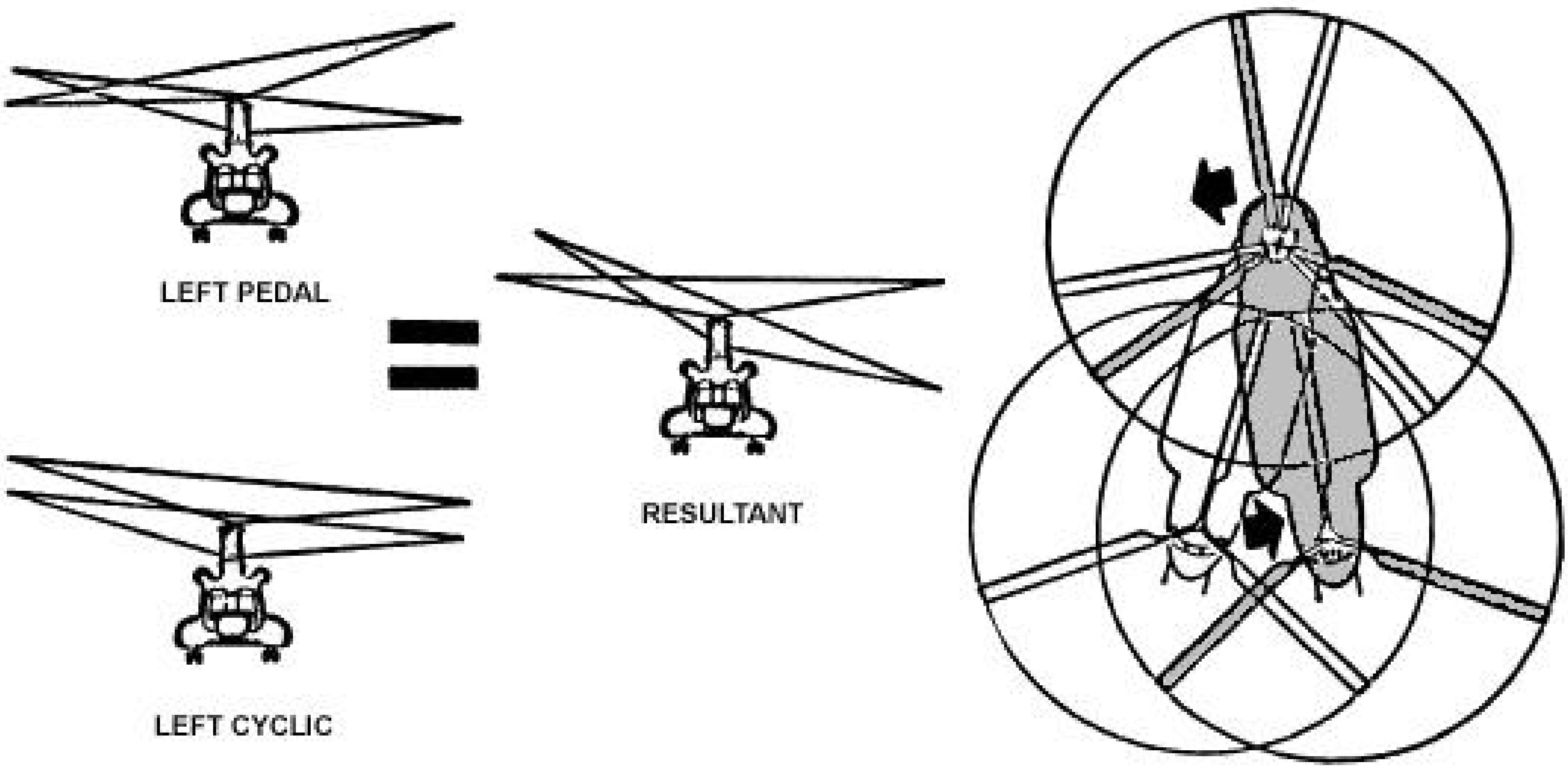
RIGHT PEDAL AND LEFT STICK INPUTS



LEFT PEDAL AND RIGHT STICK INPUTS



LEFT PEDAL AND LEFT STICK INPUTS



GLOSSARY

acc	accumulator
ACD	Automatic Chart Display
act	Actuator
AFT	Aft Gearbox Transmission
AGB	Accessory Gearbox
agb	accessory gearbox
AM	Amplitude Modulation
ant	antenna
APU	Auxiliary Power Unit
aux	auxiliary
bcn	beacon
bfo	beat-frequency oscillator
BP	Booster Pump
brt	bright
BTU	British Thermal Unit
CAP	Caution Advisory Panel
$CBrF_3$	bromotrifluoromethane
CCDA	Cockpit Controlled Driver Actuator
CCS	Crew Communication System
CCT	Circuit
cg or CG	Center of Gravity
CGI	Cruise Guide Indicator
Chip Det	Chip Detector
Combining	Combining Gearbox Transmission
comp't	compartment
cont	control
CP Grip	Collective Pitch Grip
cps	cycles per second
CPT	Control Position Transducer
cs1	Console
DASH	Differential Air Speed Hold
DCP	Differential Collective Pitch
DPFU	Dectrac Position Fixing Unit
ECL	Engine Condition Lever
EDP	Engine Driven Pump
EGT	Exhaust Gas Temp
EMC	Electro-magnetic Compatibility
Engine	Engine Gearbox Transmission
Engine Beep	Engine RPM Trim Trim
FCU	Fuel Control Unit
FDIC	Flight Display Interface Control
FM	Frequency modulation
Fwd	Forward Gearbox Transmission
GSDI	Ground Speed Drift Angle Indicator
HIGE	Hover in ground Effect
HOGE	Hover out of ground Effect
HSI	Horizontal Situation Indicator
htr	heater
IFF	Identification Friend or Foe
ign	ignition
ISIS	Integral Spar Inspection System
LCTA	Longitudinal Cyclic Trim Actuator
LCPA	Longitudinal Cyclic Pitch Actuator
LVDT	Linear Variable Differential Transducer
mkr bcn	marker beacon
mom	moment

nac	nacelle
N1	Gas Generator Speed
N2	Power Turbine Speed
ovhd	overhead
ovsp	over-speed
ph	phase
pn1	panel
pri	primary
psf	pounds per square foot
psi	pounds per square inch
PTIT	Power Turbine Inlet Temperature
ptt	press-to-talk
pwr	power
rect	rectifier
rel	release
ret	retract
retr	retract
rf	radio frequency
RMI	radio magnetic indicator
sec	secondary
shp	shaft horsepower
SIF	Selective Identification Feature
sq ft	square feet
Sta..	Station
Sta.. No	Station Number
STVA	Self Tuning Vibration Absorber
TACAN	Tactical Air Navigation
TANS	Tactical Air Navigation System
Thrust Rod	Collective Grip
TRU	Transformer Rectifier Unit
Transmission	Gearbox
wshld	windshield
w/s	windscreen
wt	weight
ut	utility
util	utility
VAC	Volts Alternating Current
VDC	Volts Direct Current
vent	ventilate
vgi	vertical gyro indicator
VOR	very high frequency omni-directional range
x-feed	
X-Feed	Cross-feed
XMSN	transmission
ZI	Zone Identification

AIRCRAFT GENERAL

Introduction

1. The CH-47D helicopter is an improved configuration of the CH-47A, B, and C Model.

2. The objective for the design was to modernize the CH-47 to a configuration to improve operation, reliability, maintainability, vulnerability/survivability and safety.

3. Structural changes were made to support system changes.

4. Improved system areas are:

   a. Fiberglass rotor blades

   b. Integrally cooled transmission systems

   c. Advanced Flight Control System

   d. Improved Avionics/Instrumentation

   e. Separated electrical systems

   f. Battery charger

   g. Multi-Cargo Hook System

   h. Improved hydraulic systems

      (1) Separate drive for boost pumps

      (2) Modular components, permaswage and rusan

      (3) Overall reduction of leak points from approximately 1040 in the CH-47C to 220 in the CH-47D.

      (4) Addition of a maintenance panel for hydraulic and drive systems.

      (5) Improved hydraulic pumps

      (6) Improved flight control actuators with jam indicators.

   i. T-62T-2B APU with third generator.

   j. Oil cooled main generators.

   k. T55-L-712 engines.

   l. Improved transmissions and lubrication systems.

   m. Single-point pressure refueling.

B. Presentation

1. General Specification Data

   a. Empty Weight - approximately 23,000 lbs.

   b. Maximum Gross Weight - 50,000 lbs.

   c. Engine Rating Limits

      (1) Continuous - 3000 HP

      (2) Maximum - 3750 HP

      (3) Emergency - 4500 HP

   d. Fuel Capacity - Total

      (1) U.S. Gal. - 1030

      (2) Lbs. (JP-4 at 59 degrees F.) - 6693

   e. Center-of-gravity-limits TM55-1520-240-20

      (1) Std. 310-349 Empty

      (2) Std. 310-346 Oper TM55-1520-240-10

      (3) Std. 322-331 Max Gross

   f. Dimensions - External/Internal

2. Airframe Sections

   a. Cockpit

   b. Cabin

   c. Aft Fuselage

   d. Aft Pylon

3. Fuselage Sections

   a. The cockpit fuselage is completely fabricated and assembled prior to splicing to the cabin structure.

   b. The cabin fuselage is composed of four panels; the crown, left-hand and right-hand side, and bottom. When covered by the cargo floor, the lower section forms a watertight compartment.

   c. The aft fuselage contains the cargo ramp and door is spliced to the cabin fuselage at Station 440.

   d. The aft pylon is attached to the aft fuselage structure at field splice. To permit transportation of the helicopter within a limited space, the aft pylon can be removed.

4. Operating Limitations

a. Cover the following items from Operators Manual, Chapter 5 and Chapter 6.

(1) Rotor

(2) Airspeed

(3) Torque

(4) Cruise Guide

(5) PTIT

(6) N-1 Tach

(7) Engine Oil Pressure

(8) Engine Oil Temperature

(9) Transmission Oil Pressure

(10) Transmission Oil Temperature

(11) Hydraulic Systems

(a) Pressure

(b) Temperature

(12) Center of Gravity

(13) Cargo Hook

(14) Rescue Hoist

(15) Cyclic Trim

(16) AFCS

(17) Landing

(18) Ground Taxiing

(19) Water Operation

(20) APU Operation

(21) Pilot Tube Anti-Ice

5. Cockpit Arrangement

a. Overhead Panel - Describe function of each panel/switches

(1) Lighting

(a) Pilot's Flt Inst

(b) Anti-Coll Lights

(c) Ctr Sect Inst Lights

(d) Flood Lights

(e) Plt Slt Cont

(f) Dome Lights

(g) Overhead Panel Lights

(h) Console Lights

(i) Co-Plt Cont

(j) Co-Pilot Flt Inst Lights

(k) Formation Lights

(l) Emer Exit Lights

(2) Anti-Ice

(a) Eng

(b) Pitot

(c) Windshield

(3) Hoist

(a) Hoist Master

(b) Hoist In-Out

(c) Cable Cutter

(4) Cargo Hook

(a) Emerg

(b) Select

(c) Hook Loaded Lights

(d) Master

(5) Hydraulic

(a) Flt

(b) Contr

(c) Pwr XFR No. 2

(d) Pwr XFR No. 1

(e) Ramp

(f) Brake Steer

(6) Fuel Control

(a) Pump Switches (6 ea.)

(b) Aux Press Lights

(c) Cross-feed Fuel Valves

(d) Refuel Station

(7) Start

(a) Switches

(b) Lights

(8) Engine Condition

(a) No. 1

(b) No. 2

(9) Emergency Power

(a) Flag

(b) Timer

(10) Compass

(a) Set Knob

(b) Slave Switch

(c) Indicator

(11) Troop Warning

(a) Troop Alarm

(b) Troop Jump Lights Switch

(c) Troop Jump Lights

(12) Heating/Windshield Wipers

(a) Windshield Wipers Switch

(b) Vent Blower Switch

(c) Start Switch

(d) Cabin Temp Selector

(13) Electric

(a) APU Switch

(b) BATT Switch

(c) Generator Switches

1 No. 1

2 No. 2

3 APU

b. Pilots Instrument Panel -

Describe each item and its function.

(1) Cruise guide test switch

(2) Cruise guide indicator

(3) Radio call plate

(4) Master caution light

(5) Airspeed indicator

(6) Attitude indicator

(7) AIMS altimeter

(8) Vertical velocity indicator

(9) Radar altimeter display dimmer

(10) Cockpit air knob turn & slip indicator

(11) Attitude indicator (VGI) switch

(12) Horizontal situation indicator

(13) HSI mode select panel

(14) Radar altimeter

(15) Clock

(16) Rotor tachometer

(17) Torque-meter

(18) Emergency power caution light

c. Copilot's Instrument Panel

(1) Torque-meter

(2) Airspeed indicator

(3) Attitude indicator

(4) Altimeter

(5) Master caution light

(6) Radio call plate

(7) Radar altimeter display dimmer

(8) Vertical velocity indicator

(9) Turn and slip indicator

(10) Attitude indicator (VGI) switch

(11) HSI mode select panel

(12) Horizontal situation indicator

(13) Clock

(14) Radar altimeter

(15) Cockpit air knob

(16) Rotor tachometer

(17) Emergency power caution light

d. Center Instrument Panel

(1) Missile alert display

(2) Fire control handles

(3) Fire detector test switch

(4) Fire extinguisher agent switch

(5) Gas producer tachometers

(6) Power turbine inlet temperature indicators

(7) Transmission oil pressure indicator

(8) Transmission oil pressure

(9) Longitudinal cyclic trim indicators

(10) Transmission oil temperature selector switch

(11) Fuel flow indicator

(12) Transmission oil temperature selector switch

(13) Fuel quantity indicator

(14) Fuel quantity selector switch

(15) Caution lights and VHF antenna select panel

(16) Engine oil pressure indicators

(17) Engine oil temperature indicators

(18) Master caution panel

(19) KY-28 indicator light

(20) IFF caution light

e. Canted Console

(1) AFCS Panel

(a) System Select Switch

(b) Cyclic Trim Switches

(c) HDG Switch

(d) BARO Alt Switch

(e) RAD Alt Switch

(f) Stick Position Indicator

f. Flat Console

(1) Emerg Eng Trim Panel

(a) Auto/Manual Switches

(b) Inc/Dec Switches

(2) Steering Control

(a) Swivel Switch

(b) Control Knob

g. Pitch and roll grip

(1) Centering device release switch

(2) Pitch and roll trim control

(3) Inter-phone/radio switch

h. Thrust grip

(1) RPM increase/decrease switches

(2) Search light switches

(3) Thrust control brake trigger

i. Power distribution panels

(1) No. 1 AC and DC

(2) No. 2 AC and DC

6. Compartments

a. Nose compartment

(1) General component locations

(a) Relays

(b) Comm/Nav components

(c) Hydraulic components

b. L.H. electrical compartment

(1) Electrical external power connection

(2) Component locations inside pod

(a) Electrical power components

(b) Engine control components

c. R.H. electrical compartment

(1) Electrical power components

(2) Engine control components

d. Pressure refueling Station

(1) Panel location

(2) Switch description and functions

(a) Power switch

(b) Panel light switch

(c) Valve test switches (seven (7) each)

(d) Valve lights (two (2) each)

(e) Fuel quantity switch and gage

e. Electronic equipment compartment

(1) Shelf No. 1

(2) Shelf No. 2

(3) Shelf No. 3

(4) Shelf No. 4

(5) Shelf No. 5

f. Heater compartment - identify components

(1) Hydraulic

(2) Heater

(3) Electrical

7. Maintenance panel

   a. Hydraulic indicators

   b. Transmitting indicators

   c. Engine indicator

8. Emergency equipment/exits

   a. Exits

   b. First aid kits

   c. Fire extinguishers

   d. Escape axe

9. Maintenance features

   a. Steps and walkways

   b. Maintenance platforms

   c. Access panels

   d. Fuselage drains

   e. Overboard drains

   f. Air inlet and exhaust openings

10. Protective covers

   a. Engine

   b. APU

   c. Heater

   d. Rotor head

   e. Nose enclosure

   f. Pitot

11. Aircraft physical references

   (Stations, Water Lines, and Butt-lines)

   a. Stations, water lines, and butt-lines are a method for locating components on the aircraft. Station numbers are also used as a means for calculating Weight and Balance.

b. Stations are measured in inches aft from an arbitrary point in space forward of the helicopter (21.5 inches).

c. Water lines are also measured in inches and identify vertical locations. Water line "0" is just above the fuel pods. Below "0" is indicated by negative numbers (-) while those above "0" are positive (+).

d. Butt-lines identify right and left locations and are prefixed with "L" for left and "R" for right of the aircraft centerline. Inches are also the unit of measure.

CHAPTER 2

AIRFRAME

A. Primary Structural Changes to Support System Improvements

1. Fwd fuselage

   a. Reconfigured Fwd Xmsn Support Assy

   b. New supports for pallet mounted controls

   c. New supports for first and second stage mix units

   d. Provisions for wire routing

2. Cabin

   a. Modified structure for updated center hook, including new hook beam.

   b. Support for new tandem hooks. Crown frame changes for wire routing.

3. Aft fuselage and pylon

   a. Pylon changes to accommodate integrally cooled combiner xmsn

   b. Changes to Station 534, WL 72 deck, Station 575 and Station 594 frames to provide passage for cooling air to aft xmsn blower

B. Secondary Structural Changes to Support System Changes and Enhance Accessibility

1. Fwd fuselage

   a. Hydraulic module and blower spts in fwd pylon fairing and cockpit structure

   b. Inlets and exhaust holes for cooling air (xmsn and hyd modules)

   c. PDP supports in cockpit

   d. Avionics shelf supports

   e. Antenna support (IFF, radar-warn, radar alt)

2. Cabin

   a. Tandem hook manual release cable and elect connector spts, without 35. MWO is incorporated to include all three hooks in one manual release handle.

   b. Misc elect and avionics spts

   c. Rescue hatch door change to suit revised hook stowed position

3. Aft fuselage and pylon

   a. Pylon L/E fairing change for cooling air inlets (hyd and xmsn)

   b. Support struct added to WL 72 deck for hydraulic modules

c. Supports Added at Upper Thrust Deck for Hyd Exhaust Blowers

d. New Deck Added above APU (Creates Exhaust Air Plenem to T/E of Pylon from Aft Xmsn Cooler Blower)

e. New Screened Exhaust Hole in T/E and Pylon Crown Fairings

f. Spts for Use of Bomb Hoist for APU Instl or Removal

g. Misc Elect and Hydraulic Component Spts in Aft Fuselage

h. Misc Changes to Formers and Decks to Ensure Adequate Flow of Air to Cooling Units

i. Revised Drainage System in Aft Fuselage

j. Antenna Supports

TEACHING PROCEDURE

C. Cockpit Fuselage Structure

1. Function

   a. Section of aircraft which positions and locates pilot and copilot for operation of aircraft.

   b. Supplies supporting elements for the subsystems to operate the aircraft.

2. Location

   a. Station 21.5 to Station 160.0

3. Nose compartment door

   a. Consists of:

      (1) Spot-welded aluminum alloy assembly

      (2) Hinge

      (3) Latch assy

      (4) Support strut

      (5) Aluminum angles

      (6) IFF antenna

4. Control closet structure

   a. Location

      (1) Station 95 to Station 120

(2) LBL 8 and LBL 18

b. Function

(1) Location for flight control linkage and controls

c. Construction and specifications

(1) Station 95 canted frame assembly

(a) Upper aluminum forged fitting is one of four fwd xmsn mounting points.

(b) Mounting surface for flight control support pallet assembly.

1 Between WL-10 and WL-16

2 1 1/8 inch thick honeycomb core pallet (145S1645)

3 Attached with (8) fasteners

(c) Sheet metal aluminum web assy siding

(2) Sta. 120 frame assy

(a) Upper aluminum forged fitting is one of four fwd xmsn mounting points.

(b) Mounting surface for flight control support pallet assembly.

1 Between WL-8.5 and -15.75

2 1 1/8 inch thick honeycomb core pallet (145S1646)

3 Attached with (6) fasteners

(c) Sheet metal aluminum web assy

(3) LBL 18 beam assy

(a) Upper aluminum forged fitting is one of four fwd xmsn mounting points.

(b) Sheet metal aluminum web assy siding

(4) LBL 8 siding

(a) Picture frame rectangle open to cockpit entryway

(b) Sealed off by attaching acoustic blanket

5. Heater closet structure area

   a. Location

      (1) Station 95 to Station 120

      (2) RBL 18 and right-hand outside structure

   b. Function

      (1) Houses heater assembly

      (2) Houses winch assembly

      (3) Houses absorber control box

   c. Construction

      (1) Fwd side is web assy of Station 95 canted frame assembly.

      (2) Outboard side is outboard fuselage structure

      (3) Inboard boundary is RBL 18 beam assembly.

         (a) Upper aluminum forged fitting of beam assembly is one of four fwd xmsn attach points

      (4) Aft boundary is the Station 120 frame assembly which leave heater closet area open to cabin area

         Sealed off by attaching acoustic blanket

6. Electronic equipment compartment

   a. Location

      (1) Station 95 to Station 120

      (2) LBL 18 and left-hand fuselage structure

   b. Function

      (1) Stowing area for electronic control boxes

   c. Construction

      (1) Fwd boundary is web assembly of Station 95 canted frame assembly

      (2) Inboard boundary is web assembly of LBL 18 beam assembly

      (3) Outboard side is outboard fuselage structure

(4) Aft boundary is the Station 120-frame assembly which leaves compartment open to cabin area

(a) Sealed off by attaching acoustic blanket

(5) Compartment contains five shelves

(a) WL-15.50, WL-3.85, WL+6.23, WL+15.12, and WL+24.88

7. Fwd pylon area

a. Hydraulic module support structure

(1) Location

(a) Between Station 150 and Station 120 above cockpit crown trough (tunnel area)

(2) Function

(a) To support hydraulic oil cooler

(b) To support hydraulic system no. 1 hydraulic module

(3) Construction

(a) Made of aluminum alloy angles in a truss formation

(b) Attached to tunnel decking structure and Sta.. 120 frame assembly structure

b. Fwd pylon fairing structure

(1) Location

(a) Top of cockpit structure aft to Station 160

(2) Function

(a) Supply covering for

1 Upper portion of fwd xmsn

2 Fwd upper flight and rotor controls

3 Hydraulic module support structure

(3) Construction

(a) Fixed fairing assembly

1 Fwd section

a Consists of an inner and outer skin of aluminum alloy and contour maintained by formers between the skins

b Aluminum tubing from upper area to lower area where hinged fairing meets section

c Aluminum channel follows contour of upper rain-shield to aft section

2 Aft section

a Skin is made of laminated, plastic-impregnated glass cloth

b Skin is attached to aluminum stiffeners and formers attached to Station 120 frame assy and tunnel decking

c Top area contains a cooling air inlet screen of which approximately 2/3 is hinged to provide an access door

(b) Hinged fairing assembly

1 Part of pylon fairing assy as well as serving as a work platform

2 One located on each side of pylon

3 Three fastener locations

4 Construction

a Pre-impregnated glass fabric skin

b Honeycomb core

5 Aluminum support probe is attached to outside surface for support

6 Support 400 pounds

7 Cooling air screen

(c) Spoilers

1 Location

a Two on fwd fixed section of fairing

b One on each hinged fairing assembly

2 Function

a Improve air flow around pylon for improved flight stability

3 Aluminum pylon cooling air flow

(d) Forward pylon-cooling airflow

D. Cabin fuselage structure

1. Location

a. Station 160 to Station 440

2. Function

a. Section of the aircraft which facilitates cargo handling and troop transportation

3. Specification and construction

a. Cabin framing

(1) Main frames every forty inches in a Station plane to support stringers

(2) Sta. 160 - manufacturing splice

(3) Sta. 440 - manufacturing splice

(4) Constant cross section

(5) Beams, inter-coastal, and stiffeners interspersed for additional strength

(6) Support structure covered with aluminum skin

b. Cabin crown tunnel covers

(1) Function to allow access to drive shafting and supports, hydraulic lines and flight control rods

(2) Six covers located between Sta. 160 and Sta. 440

(a) Numbered (1) through (6) from fwd to aft

(b) Honeycomb material sandwiched between aluminum skin

(3) First, third, and fifth covers have:

(a) Three hinges

(b) Two struts

(c) Hand grip

(d) Three turn lock features

(e) Sealed overlap

(f) Recessed area for drive shaft flex plates

(4) Second, forth, and sixth covers have

(a) Two hinges

(b) Two turn lock fasteners

(5) First cover contains a formation light

c. Fuel vent-fairing assembly

(1) Location

(a) Three on each side of aircraft common to top of fuel pod structure

(2) Function

(a) Provide cover and screen for fuel vent system

(b) Construction and specification

1 Aluminum sheet metal

2 Stainless steel, 18 gage, wire mesh

3 Attached to A/C structure with four bolts

d. Multiple cargo hook structure

(1) Location of triple hooks

(a) Lower fuselage, Sta. 249, WL 0

(b) Lower fuselage, Sta. 330, WL 0

(c) Lower fuselage, Sta. 409, WL 0

(2) Fwd structure support

(a) Fitting between Sta. 240 - Sta. 260

(3) Center structure support

(a) Fitting between Sta. 320 - Sta. 360

1 Fitting can be rotated for storage under floor boards

(4) Aft structure support

(a) Fitting between Sta. 400 - Sta. 420

(5) Capacity

(a) Fwd and aft hooks

1 17,000 pounds

(b) Center hook

1 26,000 pounds

e. Rescue hatch lower door

(1) Location

(a) Lower area of center cargo rescue hatch

(2) Function

(a) Seal off lower hatch area

1 Center hook assembly must be stowed or out of aircraft

(3) Construction and specification

(a) Sandwich honeycomb construction

(b) Cutout for hook assembly stowed

(c) Handle for opening door

(d) Latches controlled through latch actuator

(e) Door parallel to floor when open

1 Controlled by linkage

2 Sta. 360 - Sta. 400

(f) Cabin floor access door must be open to open hatch lower door

E. Aft Fuselage Structure

1. Function

a. Supports (4) aluminum ramp hinge fittings

b. Support for attachment of aft pylon

c. Supports fittings for engine mounting

d. Support for aft end of combining xmsn

e. Support aft end of deck at WL48

f. Supports APU

g. Support structure for aft landing gear

2. Location

   a. Sta. 440 to Sta. 630.50

   b. Approximately WL-40 to WL+72.0

3. Construction and specification

   a. Frame assembly - Station 440

      (1) Manufacturing splice

      (2) Supports end of tunnel and beginning of combiner drip pan at WL42

      (3) Aluminum material

      (4) Supports stringers

      (5) Supports WL 72 deck structure

   b. Frame assembly - Station 482

      (1) Aft support for aft end of combiner drip pan at WL 72

      (2) Attachment for aft landing gear

      (3) Attachment for cargo ramp

      (4) Supports WL 72 deck structure

      (5) Aluminum material

      (6) Supports fwd fitting for engine mounting

   c. Frame assembly - Station 534

      (1) Supports WL 72 deck structure

      (2) Aluminum material

   d. Frame assembly - Station 594

      (1) Supports WL 72 deck structure

      (2) Supports forward mounts for APU

      (3) Aluminum material

   e. Former assemblies

      (1) Location

(a) Both sides of fuselage structure

(b) Stations 502, 437, 555, and 575

(2) Function

(a) Support for fuselage skin

(b) Support for inter-coastal and beams

(3) Construction

(a) Aluminum material

(b) Opening for Start of plenum structure

Airflow exhaust

f. Tail cone assembly

(1) Location

(a) Sta. 594 - Sta. 630

(b) Ramp enclosure to WL 72

(2) Function

(a) Enclosure for APU

(b) Upper portion contains the plenum for cooling air flow

(3) Construction and specification

(a) Aluminum structure

1 Sheet metal

2 Formers

3 Stiffener

4 Skin

(b) A portion of the bottom liner is fiberglass

(c) Structure ties into

1 Sta. 594 frame assembly

2 Ramp closure structure

(d) Aluminum sheet-metal including deck of WL 72 form a box like structure for cooler exhaust air.

g. Engine fairing and cowling

(1) Located as outside cover of engine

(2) Functions as protective housing and streamlined cover for each engine

(3) Construction

(a) Upper cover assy

1 Made of aluminum skin with stringer and formers for stiffening

2 Contains screening for engine cooling

3 Two stepping areas on top

4 Hinged at forward end to fitting on engine

5 Contains support strut

6 Access panels

(b) Side-cover assy

1 Two per engine

2 Made of aluminum material

3 Hinged to upper cover assy in two places and latch to fittings on engine when closed

(c) Lower cover assembly

1 Hinged to fuselage below engine

2 Made of aluminum material

3 Hinges downward

4 Contains screened area for engine cooling

F. Aft pylon structure

1. Location

a. Sta. 440 - Sta. 630

b. WL 72.00 and above

2. Function

a. Supports aft xmsn

b. Supports aft vertical shaft

c. Oil cooler support

d. Supports hydraulic modules for boost systems

e. Upper flight control support

3. Construction and specification

   a. WL 72 is a field splice for transportability

      (1) Drive shaft installed

      (2) Drive shaft removed

   b. WL 72 deck

      (1) Aluminum structure

         (a) Webs

         (b) Stiffeners

         (c) Support brackets

      (2) Location of hydraulic module supports

      (3) Contains fittings for mounting of aft xmsn

   c. WL 90.75 deck

      (1) Sta. 502.4-Sta. 575.0

      (2) One on each side

      (3) Aluminum webs, formers, and stiffeners riveted together

   d. Upper canted DECK

      (1) Sta. 482-Sta. 594

      (2) WL 119 (canted)

      (3) Aluminum webs, stiffeners, and formers

      (4) Two hole for cooler ducting

      (5) Contains fitting for mounting aft rotor drive shaft

   e. Structure support former assemblies

      (1) Aluminum material

      (2) Support pylon structure

      (3) Location

         (a) Sta. 482, Sta. 534, Sta. 575, Sta. 594

f. Beam assembly (BL 8.00)

(1) Two beam assemblies

(a) RBL 8.00 and LBL 8.00

(b) Sta. 534-Sta. 575.5

(c) WL 72 to upper canted deck

(2) Function

(a) Main thrust bearing assemblies for aft vertical shaft and aft xmsn

(3) Construction and specifications

(a) Aluminum webs, stiffeners, and fittings

g. Swash plate actuator support beam assembly

(1) Location

(a) Angular beam assembly intersecting former assembly (Sta. 534.0) at LBL 6.369

(b) WL 72.0 deck to canted deck

(2) Function

(a) Load carrying beam for support fitting

(3) Construction and specification

(a) Aluminum webs, stiffeners, and caps

h. Fairings, doors, and access panels

(1) Hinged fairing (work platforms)

(a) Location

1 One located on each side of the aft pylon

2 WL 100-WL 142, Sta. 534-Sta. 575.5

(b) Function

1 Provides a work platform for access to aft upper controls, hydraulic modules, and drive system items located in aft pylon area.

(c) Construction and specifications

1 Honeycomb core sandwiched between aluminum skins

a Lower half, inside skin is rigidified aluminum for standing on

2 Substructure and supports are aluminum

3 Latches at

a WL 130.0 Sta. 575

b WL 124.64, Sta. 532.79

4 Two hinges on bottom surface

5 Two-cable assemblies for support

6 Walkway materials is applied to working area of platform

(2) Leading edge hinged fairing

(a) Location

1 Fwd of Sta. 482 above WL 72.0

(b) Function

1 Provide cooling air inlet

2 Protect under structure and provide an air foil

(c) Construction and specifications

1 Honeycomb core covered with fiberglass

2 Hinged at Station 482

3 Two halves with latches on fwd edge at top and bottom

4 Latch release in LH fairing

(3) Forward crown fairing

(a) Location

1 Sta. 481.87 to Sta. 834

2 Above canted deck

(b) Function

1 Enclosure and protection for pylon structure

2 Provide opening air flow

(c) Construction and specification

1 Aluminum skin with contour maintained by aluminum formers and stiffeners

2 Assembly hinged in the middle

3 LH side permanently attached with screws and a permanent brace structure

4 RH side contains (5) turn lock fasteners

5 RH side contains a support strut mounted on the inside

6 Both halves contain (2) aluminum screens for cooling system air exhaust

(4) Mid-crown fairing

(a) Location

1 Upper drive shaft enclosure above pylon work platform

(b) Function

1 Provide smooth air foil and protect aft upper control area

(c) Construction

1 Fiberglass skin with aluminum material for formers and stiffeners

(5) Aft crown fairing

(a) Location

1 Between Sta. 575.5 and Sta. 597 above canted bulkhead

(b) Function

1 Provide smooth air foil and protect aft upper control area

(c) Construction

1 Aluminum skin riveted to aluminum stiffeners and formers

2 Top surface is location of anti-collision light

(6) Trailing edge fairing

(a) Location

1 Sta. 594 to Sta. 627.4 above WL 72

(b) Function

1 Provides trailing edge air foil of pylon

2 Provides mounting for AS-2892/APR-39 antenna, (Radar Detecting)

(c) Construction and specification

1 Upper crown skin is made of fiberglass with fiberglass stiffeners for support

2 Bottom portion is aluminum skin supported with aluminum substructure

3 Attached to Sta. 594 former assembly and WL 72 deck assembly

4. Aft pylon air flow

G. Landing Gear Improvements

1. High Flotation Gear

2. Landing Gear Switches (Squat Switches)

H. Self-tuning Absorber Modifications

1. Weight Assembly Change - Tungsten

2. Tuned to 100% rotor RPM (equal 225 rotor RPM)

CHAPTER 3

ALIGHTING GEAR

LANDING GEAR

DESCRIPTION AND OPERATION

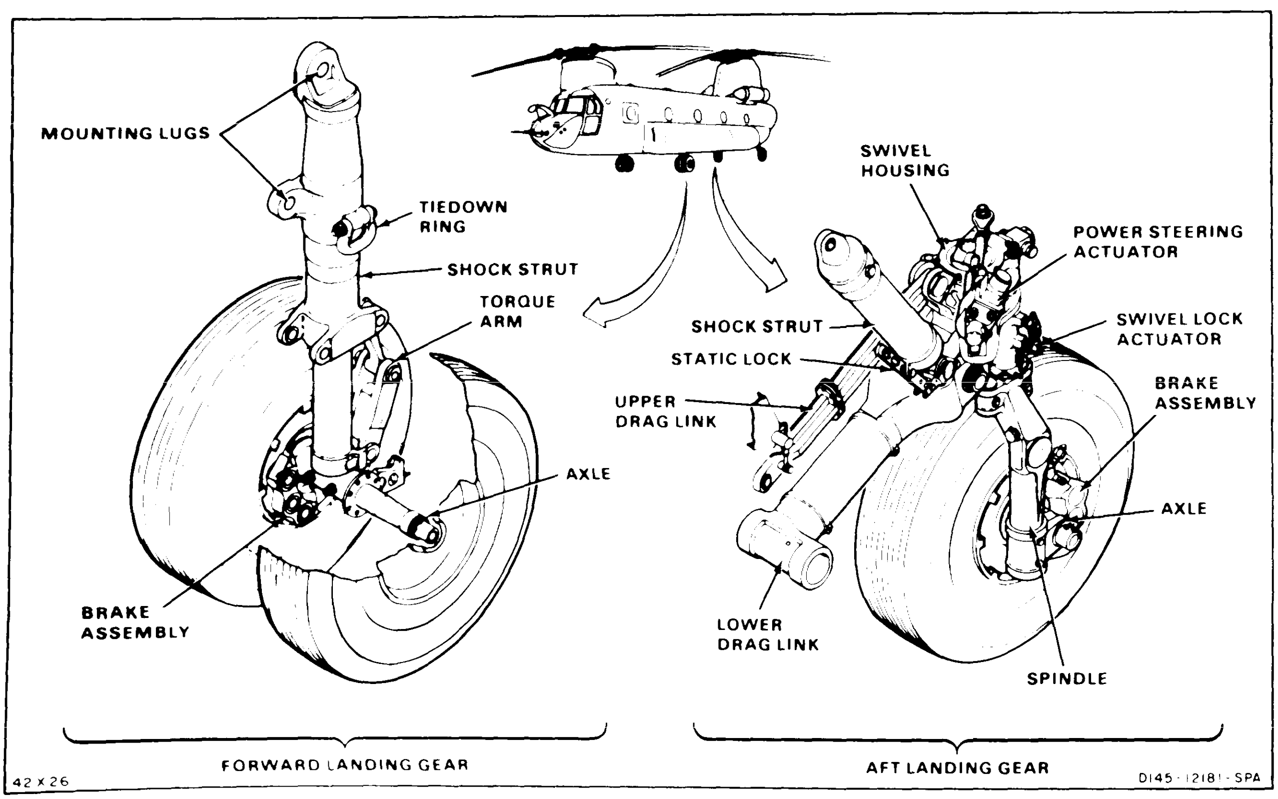
There are four high-flotation landing gear assemblies, two forward and two aft. The two forward assemblies have dual wheels Each aft assembly has a full-swivel single wheel. The aft wheels can be locked in trailng positlon. A power steering unit is Installed on the aft right landing gear assembly

FORWARD LANDING GEAR

The forward landing gear dual wheels are Installed on a fixed axle. The axle IS mounted on an air-oil shock strut bolted to the fuselage support structure. A torque arm keeps the assembly aligned. A disk and brake unit are provided for each wheel. Hinged panels allow access to the forward landing gear assemblies. Each assembly has a towing and tledown fitting. The wheels can be raised at jacking points on the lower torque arms. Left and right landlng gear assembles can be converted for use in either forward position.

AFT LANDING GEAR

An aft landing gear assembly is Installed on each side of the fuselage. Each aft wheel IS mounted on an axle supported by a spindle The spindle rides on bearings in the swivel housing Upper and lower drag links support the swivel housing Both drag links are connected to fuselage fittlngs A shock strut IS mounted between the lower drag link and a fuselage fitting, The shock strut has a static lock mechanism to prevent strut extension during helicopter jacking. A disk and brake unit are Installed on each wheel The aft wheels can be free to swivel, or they can be locked In trailing position. A centering cam in the swivel housing centers each wheel in trailing position. A hydraulically-operated swivel lock secures the wheel in this position. The power steering actuator IS connected to the aft right landlng gear swivel housing, A towing and tiedown fitting is also attached to this housing Static ground wires are Installed on each landlng gear axle housing. A proxlmity switch IS mounted on the forward bulkhead of each aft landlng gear compartment Linkage from the upper drag llnk IS connected to a target which is sensed by each switch. The switches are operated as the helicopter takes off or lands, Extensions on the aft axles are used for connecting a tow bar. An aft landing gear assembly can be In - stalled on either side of the helicopter This requires disassembly and reposltloning of certain components.

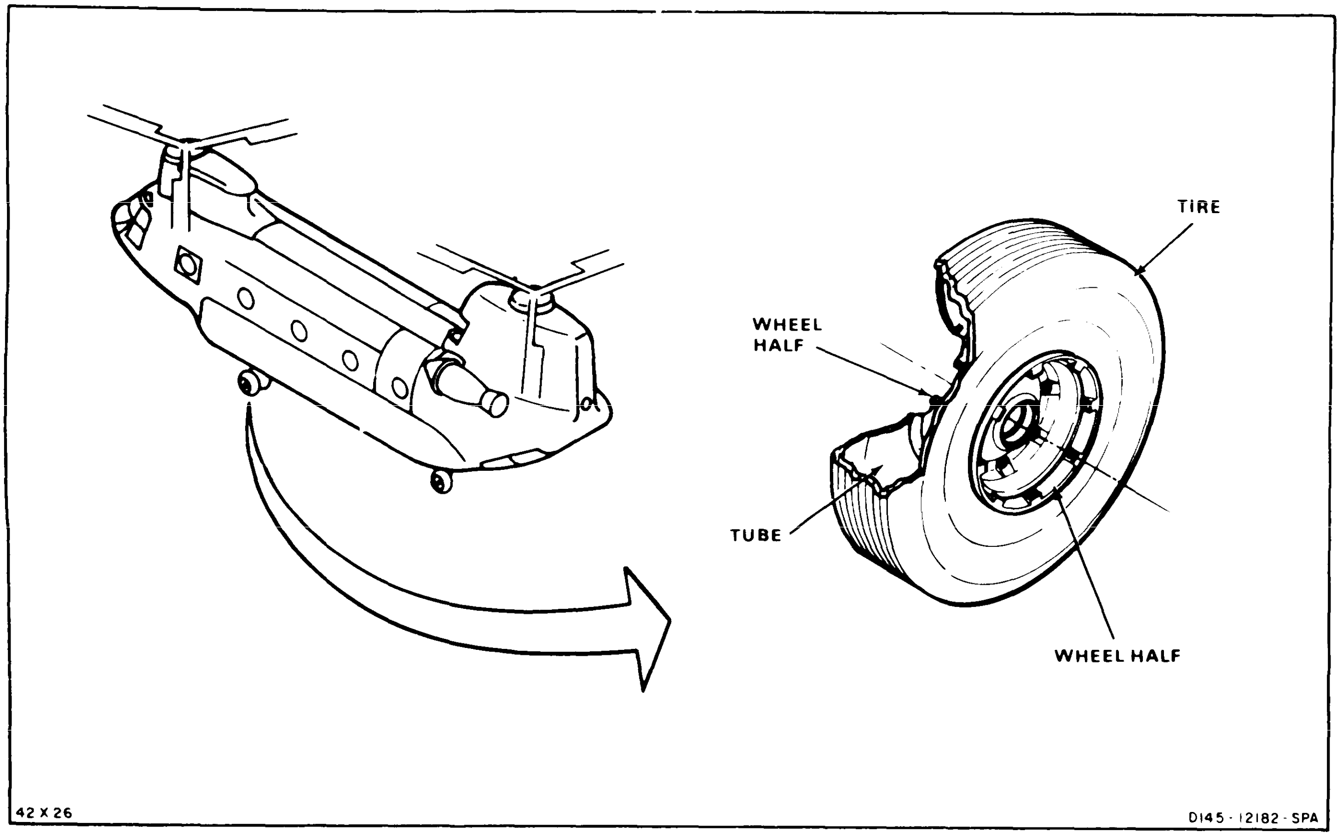


TIRES AND TUBES

Tires are Interchangeable on all SIX wheels The tires are 10 ply or 10-ply rating. Tubes are required for both tubeless and tube-type tires

WHEELS

The wheels consist of two halves. Moisture-proof seals protect the bearings. Wheels are separated for removing or mounting tire or tube.



AXLES

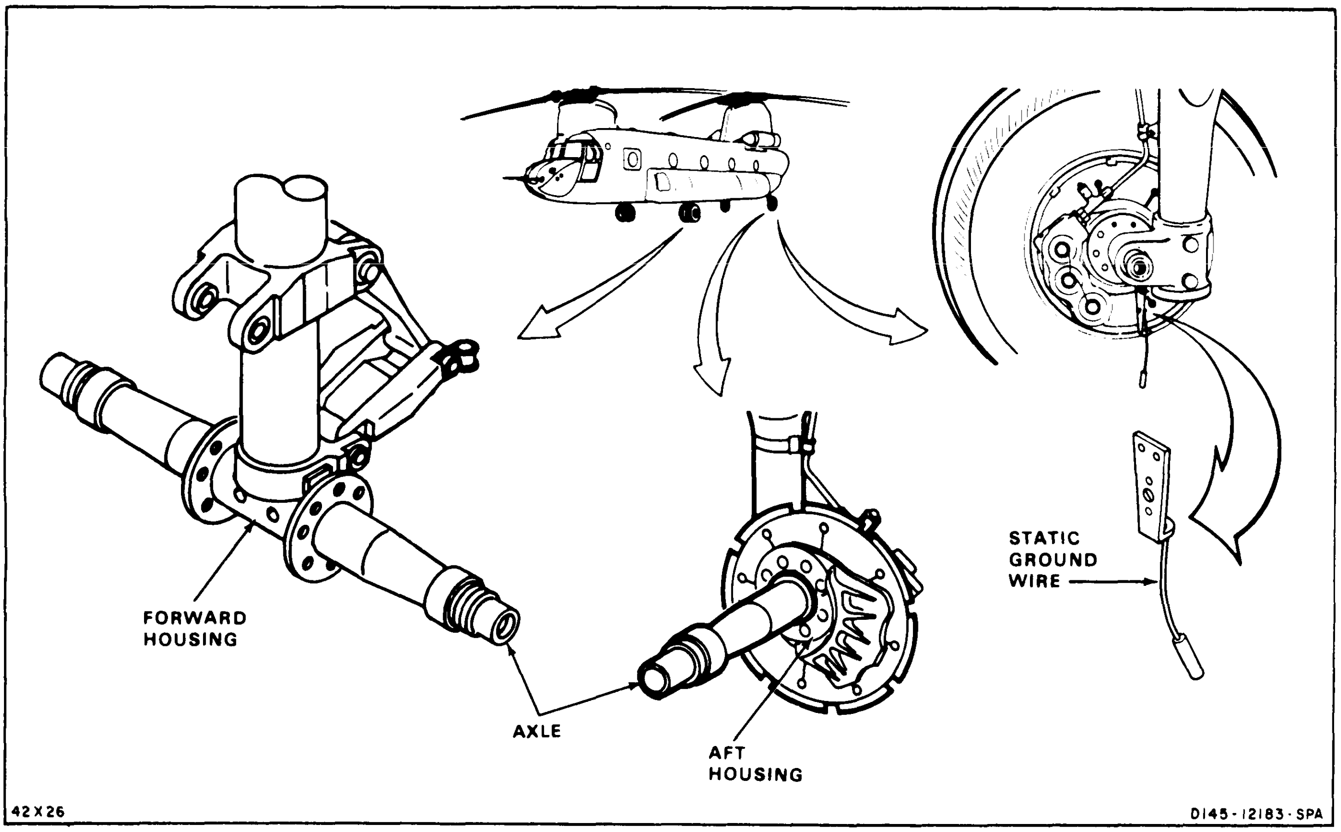
Forward and aft axles are removable and can be used on either forward or aft landing gear. Each axle is secured to the axle housing by a bolt which passes thru the axle.

SHOCK STRUTS

All landing gear shock struts are air-oil units. Compressed air absorbs shock, and hydraulic fluid dampens up and down movements,

STATIC GROUND WIRE

A static ground wire is installed on the aft left landing gear. The wire consists of a cable and tube attached to a mounting bracket. Three holes on the mounting bracket provide for wire length adjustment. The mounting bracket is installed on a clip on the axle housing.



PROXIMITY SWITCHES

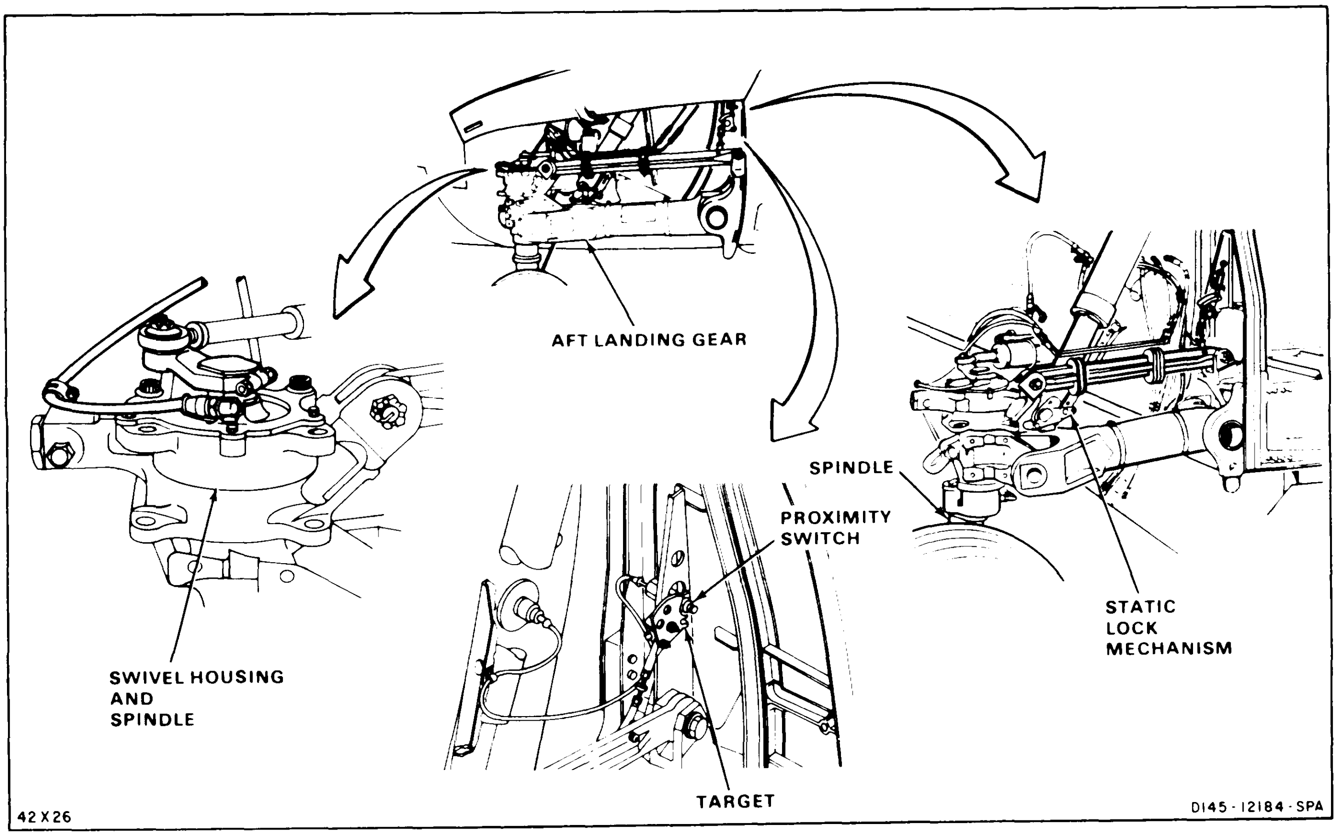
Linkage from the aft landing gear upper drag link is connected to a target. The target is set so the proximity switch is open when the helicopter is in flight. When the helicopter is on the ground, the switch is closed. The switches prevent DASH actuator input during lift-off to hover. They also reduce AFCS sensitivity 50 percent until lift-off. The right switch turns off the IFF when the helicopter is on the ground.

STATIC LOCK MECHANISM

The static lock mechanism is a link attached to aft landing gear shock strut. It is operated by hand to lock the shock strut in the up position when the helicopter is jacked.

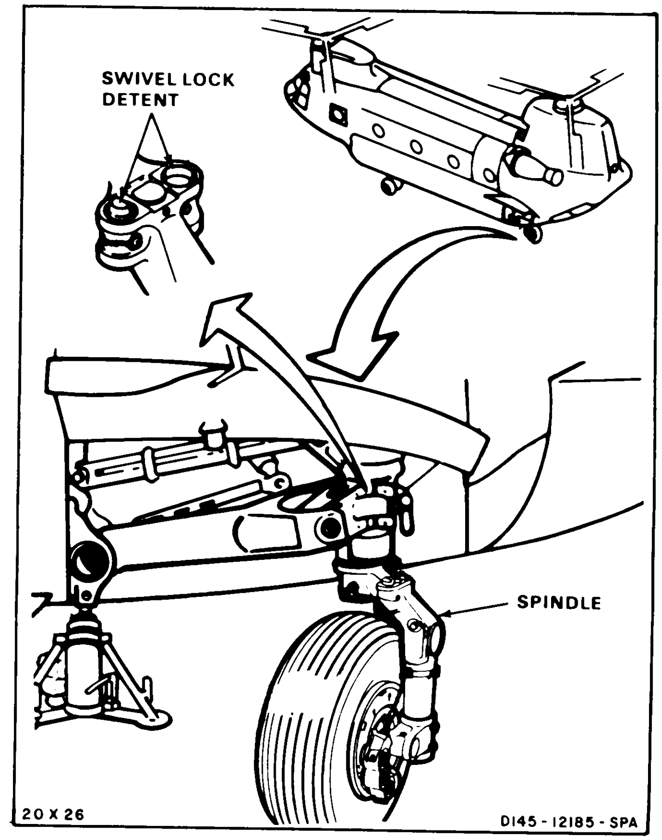
SWIVEL HOUSING AND SPINDLE

A swivel housing is supported by the two drag links and shock strut of each aft landing gear. The housing allows the spindle and wheel to swivel 360 degrees. A centering cam in the housing centers the wheel in the trailing position for taxiing or flight. The swivel locking pin can lock the wheel in this position.



SWIVEL LOCK DETENTS

Two spring-loaded swivel lock detents are mounted in each spindle. The spring permits the detent to move down allowing the swivel locking pin to pass for centering.



CHAPTER 4

POWERPLANT

POWERPLANT DESCRIPTION

AND OPERATION

Power Plant System

A. Description

The CH-47D is powered by two T55-L-712 engines. The engines are housed in separate nacelles mounted externally on each side of the aft pylon. The T55-L-712 engine has the capability to produce emergency power on pilot demand.

Each engine has two main sections: a gas producer section and a power turbine section. The gas producer supplies hot gases to drive the power turbine. It also mechanically drives the engine accessory gearbox. The power shaft extends coaxially through the gas producer rotor and rotates independently of it. The gas producer section and the power turbine section are connected by only the hot gases, which pass from one section to the other. During engine Starting, air enters the engine inlet and is compressed as it passes through seven axial stages and one centrifugal stage of the compressor rotor. The compressed air passes through a diffuser. Some of the air enters the combustion chamber where it is mixed with star fuel. The mixture is ignited by four igniter plugs. Some of the air is directed to the fuel nozzles. After the engine is started, it continues to operate on metered fuel supplied to the fuel nozzles. Hot expanding gases leave the combustion chamber and drive a two-stage gas producer turbine. Energy from the combustion gases also drives the two-stage power turbine, which drives the power turbine shaft to the engine transmission. The engine lubrication system has an integral oil tank, which is inside the air inlet housing and is serviced with 14 quarts.

B. Introduction

1. The CH-47D is powered by two power plant assemblies, designated as No. 1 (left) and No. 2 (right).

2. Each power plant assembly consists of an engine and subsystems, for Starting; operating, monitoring, and protecting the engine, as follows:

   a. Avco Lycoming T55-L-712 Engine

   b. Air Induction System

   c. Nacelle Cowling (Cooling) System

   d. Exhaust System

   e. Engine Mount System

   f. Fuel System

   g. Lubrication System

   h. Start System

   i. Engine Control System

   j. Electrical System

   k. Fire Detection System

l. Fire Extinguishing System

m. Indicating Systems

n. Maintenance and Operation

3. Each assembly is identical except for right and left installation requirements.

4. Each assembly is demountable to facilitate off aircraft buildup and to provide a quick-change capability.

C. Location and Access

1. A power plant assembly is located on either side of the aft pylon, centered on butt lines 48 right and left and waterline 66, and extending from Station 450 to Station 552.

2. The power plant assemblies are structurally attached to the top of the aft fuselage.

3. Each engine is secured by three mounts; two forward at Station 482 and one aft at Station 502.

4. A drag link provides diagonal stability between the forward outboard mount and the aft mount.

5. Normal access for maintenance is gained through hinged access doors on either side of the engine covers.

6. A walkway is provided between the power plant assemblies and the aft pylon for access to the inboard and upper engine areas.

7. A hinged, stowable work platform is provided below each power plant assembly (as part of the fuel pod fairing) to open the outboard hinged side panels and the lower panel for access to the outboard and lower engine areas.

8. Steps and handholds are provided just forward of the work platforms for access to the top of the fuselage (right side) or to the open work platform (both sides).

9. The air inlet bypass screens are removable for access to the engine air inlet and engine transmission fairing. The screens do not have to be removed to open the upper cover.

10. The engine transmission fairing has hinged panels for access to the engine drive shaft couplings and lubrication system. The fairings are quickly removable for engine transmission removal.

11. Maintenance, removal, replacement, or "quick-change" of either engine is facilitated by the location of the nacelles, the design of the engine mounts, and the use of quick-disconnect couplings on specified lines which lead to the primary structure.

D. Summary of Leading Particulars

1. Model

   a. Military — T55-L-712

2. Type

   a. Gas producer turbine — Two-stage

   b. Free power turbine — Two-stage

3. Dimensions

   a. Overall length 48.53 inches

   b. Nominal diameter 28.72 inches

4. Weight

   a. Specification weight (dry) — 750 pounds

5. Rotational Directions

   a. Compressor rotor Counterclockwise

      (1) First stage turbine rotor assembly — Counterclockwise

      (2) Second stage turbine rotor assembly — Counterclockwise

   b. Power output shaft — Clockwise

   c. Power turbine shaft — Clockwise

      (1) Third stage turbine rotor assembly — Clockwise

      (2) Fourth stage turbine rotor assembly — Clockwise

6. Type fuel

   a. Army standard — MIL-T-5624 (Grade JP-8)

   b. Alternate — MIL-T-5624 (Grade JP-5) MIL-T-83133 (Grade JP-8)

7. Type oil — MIL-L-23699 or MIL-L-7808

8. Miscellaneous

   a. Combustion chamber — External annular

   b. Compressor ratio 8 to 1 minimum

   c. Guaranteed minimum altitude — 25,000 feet

D. T55-L-712 Engine Specific Ratings (See Table 1)

1. All T55 series engines are designed to develop a minimum 3750 SHP with a gas producer turbine inlet temperature of approximately 1875°F and a specific fuel consumption of 0.525 with a minimum airflow rate of 28.2 lbs./sec.

2. The -712 series engines are rated for an emergency power of 4500 SHP for a 30-minute cumulative time, with the following conditions: max. T4 of 2050°F, mas. T4-5 of 1670°F, a max. fuel flow of 2340 lbs. per hour, and a max. airflow rate of 30 pps.

E. CH-47D Helicopter Operational Ratings (See Table 2)

1. Operational ratings and limits result from the power train and rotor systems when the engines are installed on the helicopter.

2. These ratings and limits are monitored and controlled from the cockpit.

F. Dimensional Data

1. Overall length

   a. Basic engine 48 inches

   b. Basic engine with engine transmission and fairing installed — 71 inches

   c. Basic engine with exhaust cone installed — 79 inches

   d. Basic engine with engine transmission, exhaust cone, and fairing installed — 102 inches

2. Overall diameter

   a. Basic engine 28 1/4 inches

   b. Basic engine with air inlet fairing installed — 31 inches

   c. Basic engine with air inlet fairing and air inlet bypass screen installed — 43 inches

G. Center of Gravity (CG) Data

1. Center of gravity locations are measured from the centerline of the forward engine mounts (Station 482).

a. 14.3 inches aft (Station 496.3) - engine transmission and fairing installed.

b. 19.0 inches aft (Station 501.0) - engine transmission and fairing removed.

H. Weight Data

1. Specification dry weight, as received from the manufacturer. 750 lbs.

2. Built up weight, ready for installation, without engine transmission and engine transmission fairing. 904 lbs.

3. Built up weight, ready for installation, including engine transmission and engine transmission fairing, less air inlet bypass screen (16 pounds). 1041 lbs.

I. Terms and Abbreviations

1.	GI	Ground Idle - The lowest self-sustaining power setting
2.	40% MAX CONT.	Low Idle Power setting
3.	75% MAX CONT.	High Idle Power setting
4.	MAX CONT.	Maximum power setting for continuous engine operation
5.	INT.	High Power setting, 30-minute duration
6.	MAX	Maximum Rated Power, Top power setting for a 10-minute duration
7.	EMER	Highest Power setting, 30 minute cumulative time
8.	P	Pressure - Absolute - PSIA
9.	T	Temperature - Absolute - °C A/C - °P Test Cell
10.	SFC	Specific Fuel Consumption - LB/hr/shaft horsepower
11.	SHP	Shaft Horsepower - Power output of the engine
12.	Wa	Airflow Rate - lb./sec
13.	Wf	Fuel Flow Rate - lb./hr
14.	MGT	Measured Gas Temperature - °C - °F
15.	NR	Aircraft Rotor Speed - % of RPM

16. NG (N1) N = Speed, G = System (GP) Gas Producer = % of RPM

17. NP (N2) N = Speed, P = System (NP) Power Turbine = % of RPM

J. T55-L-712 Engine Difference and Improvements

1. Emergency power rating of 4500 SHP for 30 min. cumulative time.

2. Fixed inlet guide vanes, elimination of actuator.

3. Sealed output shaft with improved lubrication to No. 1 main bearings.

4. Improved vane cooling to 1st and 2nd stage gas producer nozzles.

5. Improved retention to gas producer turbine wheels and spacer assembly.

6. Improved gas producer turbine wheel cooling.

7. Improved 3rd stage nozzle airflow and cooling characteristics.

8. Main oil filter with bypass indicator button.

9. Air-blast atomizing fuel injector nozzles.

10. Barrier fuel filter with throw away filter.

11. Improved inline fuel filter with bypass indicator.

12. Flow divider changes to accommodate swirl cups and air-blast fuel injectors.

13. MGT changes to 5 dual probe segments and bus bars for ease of troubleshooting and replacement.

K. Engine Construction and Description

1. All AVCO Lycoming T55 series engines are direct-drive shaft turbine engines, incorporating a two-stage free power turbine section, a combination axial-centrifugal compressor driven by a two-stage gas producer turbine section and fitted with an external annular atomizing combustor.

2. The engine consists of:

   a. An air inlet section

   b. A gas producer compressor section

   c. Accessory drive gearbox

   d. Air diffuser section

   e. Gas producer turbine section

   f. The combustor turbine section

3. All sections, except the accessory gearbox, provide an annular flow path for air and hot gases, and are structurally interdependent and support internal rotating systems. Attaching capabilities are provided for mounting engine required external components and accessories.

4. Air Inlet Housing

   a. The air housing is a one-piece magnesium alloy sand casting, integrally constructed as an inner housing, outer air inlet shell, and four hollow connecting struts.

      (1) The inner housing contains:

         (a) Output shaft and its supporting structure

         (b) Compressor rotor forward bearing support structure

         (c) Electrical torque-meter head assembly

         (d) Oil tank cavity, a 3.75 gallon capacity

   b. Four hollow struts connect the outer shell to the inner housing which supports the forward end of both gas producer and power turbine shaft by supporting No. 1 and No. 3 bearings respectively. They serve as oil passages and enclosures for accessory drive shafts.

   c. Internally, the inner housing contains the integral oil tank, power output shaft, No. 6 and No. 7 bearings, output shaft support housing, accessory drive gear carrier, torque-meter head assembly, and No. 3 bearing support assembly.

   d. This assembly is the main support structure for the engine and contains four mounting pads from which the engine may be cantilevered. The front face of the inner casing includes studs for mounting the engine transmission.

   e. Located around the periphery of the inlet housing are:

      (1) Four front engine mounts

      (2) Accessory gearbox

      (3) Torque system junction box

      (4) Starter gearbox

      (5) Oil tank filter

      (6) Forward hoisting points

      (7) Temperature sensing ports

      (8) Oil level indicator

5. Compressor Section

a. The compressor section consists of:

(1) An upper and lower housing assembly

(2) Compressor rotor assembly

(3) The No. 1 and No. 2 main bearings

b. The housings are constructed of sand cast magnesium alloy with erosion-resistant stainless steel inserts, which provide a running area for each axial compressor rotor disc.

c. The seven two-piece steel stator assemblies of the axial compressor are bolted to the upper and lower housings.

d. The stator vanes are fixed in position to inner and outer shrouds.

e. The inner shrouds are lined with lead, which when properly fitted, forms an air seal to permit reduced clearance with no resultant danger from rubs against the rotor and spacers.

f. The housings are split axially to permit access to the compressor rotor for inspection and blade or stator rework or replacement.

g. The internal surfaces of the housings are surface treated and coated with epoxy phenolic plus graphite filler. The external areas are treated with epoxy phenolic engine gray pigmented paint.

h. A special air gallery with an easily accessible connection is incorporated to permit customer use of bleed air.

i. The compressor rotor assembly consists of

(1) A seven-stage all steel axial compressor

(2) A titanium two-piece centrifugal impeller

(3) The No. 1 and No. 2 main bearings

j. The seven-stage axial and single-stage centrifugal compressors are fitted to a shaft to form a single rotating member.

k. The titanium centrifugal compressor is connected by a spline press fit to the compressor shaft.

l. The compressor parts form a rigid drum compressed together on the shaft and held together by a large high torque lock nut.

6. Air Diffuser Assembly

a. The air diffuser is constructed of stainless steel material located between the compressor housing and the combustion chamber housing.

b. Straightening vanes are incorporated to eliminate swirl as the air is exhausted from the centrifugal compressor.

c. The diffuser supports the:

(1) Combustion chamber housing

(2) Gas producer turbine nozzles and cylinder assemblies

(3) Curl assembly

(4) The rear (No. 2 main) compressor rotor bearing housing

7. Combustion Chamber:

a. The stainless steel combustor housing is fastened to the air diffuser with 52 bolts around the outer circumference.

b. The combustion chamber is a reverse-flow external annular type with a fuel atomizing system.

c. The folded design permits maximum utilization of space and reduces gas producer (compressor) and power turbine shaft lengths.

d. The atomizing combustor utilizes 28 main fuel-atomizing nozzles of dual orifice design in two interchangeable dual channel fuel manifolds.

e. Each manifold supplies fuel to 14 main fuel nozzles.

f. Main fuel is supplied to a flow divider, which directs primary fuel through the aft channel in the manifolds.

g. Secondary fuel is metered in accordance with the primary fuel flow by the flow divider and delivered through the forward channel of the manifold.

h. The perforated combustor liner is manufactured from (Hastalloy X) heat-resistant alloy.

i. The perforations are arranged to meter air into the combustor for combustion and cooling.

j. Fuel is injected directly into the combustor through the atomizing nozzles, which are evenly spaced around the rear of the combustor.

8. Gas Product Turbine Section

a. The gas producer turbine section is a two-stage axial flow air-cooled turbine system.

b. The two turbines are coupled together and mounted on the rear of the compressor shaft to form a single rotating member. This system consists of the 1st and 2nd turbines and the 1st and 2nd nozzles.

(1) First Gas Producer Nozzle

(a) The 1st gas producer nozzle contains 55 hollow vanes.

(b) The T55-L-712 series incorporates full slotted trailing edge design vane cooling.

(c) The nozzle is bolted on the inner wall to the air diffuser, and the combustor liner is slip-fitted to the outer wall; also fitted to the nozzle is the turbine cylinder, which is a separate removeable and replaceable part.

(d) On the T55-L-712 series the second nozzle is a two-pass air-cooled nozzle with epoxied trailing edge holes for vane cooling.

(e) The 2nd nozzles are bolted to the first nozzle and provide a seat for the 3rd nozzle seal rings.

(2) First Gas Producer Turbines

(a) The first gas producer turbine is splined to the compressor shaft and held in place by a single high torque lock nut.

(b) The turbine disc is fitted with base shrouded, ball-root, three-pass air-cooled blades held in place by a cooling disc on the front side and a sealing ring on the rear.

(3) Second Gas Producer Turbine

(a) The second gas producer turbine is bolted to the first turbine and fitted with two-pass air-cooled, base shrouded, ball-root blades.

(b) The blades are retained axially to the disc with pins.

(c) The area between the blade base shroud and the disc is sealed with a sheet metal sealing plate.

(d) The axial relation of these two turbines is fixed by a spacer.

9. Power Turbine Assembly

a. The power turbine (PT) is a two-stage axial flow turbine system coupled together and supported on the rear by a dual set (No. 4 and No. 5) of main bearings which are located in the fourth PT nozzle and on the front end by the No. 3 main bearing.

b. The turbine rotor assembly includes the third and fourth Stage steel turbine discs both of which are fitted with steel, tip shrouded, ball-root blades fixed in place with steel pins.

c. The third PT turbine rotor consists of four major parts:

(1) The forward spline

(2) Power turbine shaft

(3) Third power turbine disc

(4) The stub shaft

d. These four parts are inertia welded to form one rotating member.

e. The third power turbine nozzle houses the five sets of MGT probes, whose harness passes through a tube located on the fourth PT nozzle.

f. The fourth power turbine is splined and held fast to the shaft by a special high torque lock nut.

g. The AVCO Lycoming T55 series shaft turbine engines have two major functional systems. A gas producer N1 (NG) system and a power turbine N2 (NP) system. These systems are mechanically independent of each other; however, they are both controlled by a single hydro-mechanical fuel/power regulator.

h. Basically, the function of the gas producer is similar to that of a straight jet engine, in that it produces hot pressurized gases (thermal energy).

i. The power turbine system extracts the thermal energy from the gas producer system and delivers mechanical power to the output shaft.

10. Engine Main Bearing Identification

a. Number One Bearing:

(1) A ball bearing, supporting the fwd end of the compressor assembly.

b. Number Two Bearing:

(1) A roller bearing, supporting the aft end of the compressor assembly.

c. Number Three Bearing:

(1) A roller bearing supporting the fwd end of the power turbine shaft.

d. Number Four (fwd) and Five (aft) Bearings:

(1) Two ball bearings between third and fourth turbine discs supporting the aft end of the power turbine shaft.

e. Number Six (fwd) and Seven (aft) Bearings:

(1) Two ball bearings supporting the forward end of the power output shaft.

11. Accessory Gear-case

a. The accessory gear-case housing is sand cast from magnesium alloy and mounted on the air inlet housing at the 6 o'clock position.

b. It contains a vertical power shaft (driven by the compressor rotor shaft) and the necessary gears, shafts, bearings, mounting pads, and studs for the engine driven accessories.

c. Accessories driven by the gear-case are:

(1) Fuel control and power turbine speed governor

(2) Engine oil pump

(3) Gas Producer (N_1) tachometer generator

(4) Fuel boost pump

(5) Power turbine (N_2) tachometer generator (when used).

d. The accessory gearbox also houses the main oil filter and magnetic chip detector.

L. Engine Operation during Start Cycle

1. The engine is started by energizing the starter with utility hydraulic pressure, starting fuel solenoid valve, and ignition system. During this operation, the N1 lever is set at GROUND IDLE.

2. Air enters the inlet housing assembly and into the compressor section. The air is compressed by the seven-stage axial-compressor rotor assembly and the centrifugal compressor impeller. The compressed air flows through the diffuser housing assembly and into the combustion chamber assembly where a portion of the air mixes with the fuel from the starting and/or main fuel nozzles to form a combustible mixture.

3. Starting fuel flows into the combustion chamber through two Starting nozzles, located at 6- and 9-o'clock positions. It is ignited by four equally spaced spark plugs.

4. Combustion occurs and the expanding gases are discharged through the turbine rotor and exhausted through the fourth turbine assembly. Energy is extracted from the gases by two separate and independent turbine rotors (gas producer and power turbine). The gas producer turbine rotors drive the compressor rotor assembly, which compresses the air. The power turbine rotors supply the driving force through the power turbine shaft to the power output shaft.

5. Approximately two-thirds of the gas energy passing from the combustion chamber is extracted to drive the compressor rotor; the remaining energy is extracted by the third and fourth turbine rotors to drive the power turbine shaft.

6. At 8 to 13 percent N1 speed, the main fuel flows into the combustion chamber via the oil cooler, in-line fuel filter, flow divider and fuel manifold to 28 air blast nozzles where it is ignited by the burning Starting fuel.

7. Compressor rotor speed (N1) increases to the set idle speed as additional fuel mixes with compressed air and burns. When compressor rotor speed increases to idle speed, the Starter, Starting fuel solenoid valve, and ignition systems should be de-energized.

8. Combustion gases pass through the gas product, turbine nozzle assemblies and impinge upon the blades of the gas producer rotor assemblies; then pass through the power turbine nozzle assemblies and onto the blades of the power turbine rotor assemblies.

9. The power turbine rotor assemblies are mechanically connected to the power turbine shaft. The power turbine shaft is splined directly into the power output shaft.

10. Exhaust gases are expelled through the fourth turbine nozzle, fourth stage power turbine rotor blades and exit vane assembly into the atmosphere.

1. Description

   a. Fuel System

      The engine fuel system consists of the fuel boost pump and barrier fuel filter, the fuel control unit, the start fuel solenoid valve, inline fuel filter, flow divider dump valve, the starting and main fuel manifolds, the igniter nozzles, and the combustion chamber vaporizers. The system delivers atomized starting and main fuel to the combustion chamber. A pressure-closed drain valve, located at the bottom of the combustion chamber housing, automatically opens and allows unburned fuel to drain from the combustion chamber following a false start or when the engine is shutdown.

   b. Fuel Control

      The fuel control unit is a hydro-mechanical device containing a fuel pump section, gas producer, and power turbine speed governors, an acceleration and deceleration control, an air-bleed signal mechanism, and a fuel shutoff valve.

      Functionally, the fuel control unit is divided into the flow control section and the computer section. The flow control section consists of the components that meters engine fuel flow. The computer section comprises elements that schedule the positioning of the metering valve of the flow control section as a function of the input signals to the fuel control unit.

2. Starting Fuel Flow

   a. Engine Boost Pump (Driven From AGE)

      The engine fuel boost pump is located on the rear right-hand surface of the AGB assembly, adjacent to the main oil pump. It is used with the barrier fuel filter to provide a pressure head to the fuel control.

   b. Barrier Fuel Filter

      (1) Location - the barrier fuel filter is located on the LH side of the engine, directly above the start fuel solenoid valve.

      (2) Function - filters the fuel prior to the fuel control assembly.

      (3) Specifications

         (a) Consists of three (3) principle subassemblies

            1 The bowl

            2 The head

3 The filter element

4 Impending bypass indicator

(4) The fuel from the boost pump is passed through a quilted paper filter that removes 96 percent of all particles larger than 5 microns. There is a valve incorporated in the filter housing that bypasses the filter element if clogged. The valve opens at 5.5 ±0.25 psid and is sufficiently large to allow a flow of 1800 pph with a pressure drop of less than 6.5 psi. The filter housing also incorporates an impending bypass indicator that senses the pressure both upstream and downstream of the filter element. At a pressure drop of 3.6 ±36 psi, the indicator signals an impending bypass condition via a pop-out button.

(5) Barrier Filter Indicator

(a) The filter pressure drop indicator is a pop-up type indicator that mounts directly to the filter housing on the pad previously used for an electrical pressure-drop switch. The pressure port at this location provides actual filter-element "in" and "out" pressures so that a true filter-element pressure drop is obtained. The actuating pressure for this unit is 3.6 ±0.36 psid.

(b) The pressure-drop indicator consists of two major components.

1 One part is the actuator assembly which consists of a spring-loaded pop-up button and a magnet.

2 The other part is the diaphragm assembly whose main parts are a diaphragm, spring, and magnet

(c) The only dynamic interface between these two components is the force between the two magnets. As filter-element pressure drops below the trip point, the force of the magnet in the diaphragm assembly keeps the indicator magnet in its standby position. When the pressure difference across the diaphragm exceeds its restraining spring force, the magnet moves away from the indicator magnet. When the resultant magnetic forces between the two magnets become less than the indicator spring, this spring forces the indicator to its activated position. Once activated, the indicator will stay in its activated position until reset by hand. A guard is provided over the indicator button so that it cannot be inadvertently reset.

c. Starting Fuel Solenoid Valve

The electronically operated, normally closed starting fuel solenoid valve is located on the compressor housing in the 9 o'clock position. The solenoid valve is actuated by a cockpit mounted switch, which energizes the valve and allows fuel to flow from the fuel control unit through the starting manifold and to the starting fuel nozzles.

d. Starting Fuel Manifold and Nozzles

There are two Starting fuel nozzles connected to the starting fuel manifold at approximately the 3 and 9 o'clock positions. Starting fuel passes through these nozzles into the combustion chamber where it is ignited by a spark from an igniter adjacent to each Starting fuel nozzle.

3. Main Fuel Flow

a. Main Fuel Shut-off Valve (HP Cock)

The HP cock has three functions; to cut off the fuel from the FCU, to prevent fuel passing to the burners until adequate pressure has built up and to provide a bypass circuit within the FCU when the engine is wind-milling after fuel is cut off. A mechanical input comes from the ECL servo; with the ECL at STOP, the bypass is opened and fuel servo pressure closes the HP cock; with the ECL at GROUND the bypass is closed, but the HP cock remains held closed by a spring until main fuel pressure has built up sufficiently.

b. In-line Fuel Filter

(1) The final fuel filtering before the flow divider takes place in the in-line filter assembly.

(2) The filter element has a 7-micron absolute filtering ability.

(3) The assembly incorporates a bypass valve, which will go into the relieving position when 20 to 34 psi pressure drop is encountered.

(4) Maximum pressure drop across the assembly is 4 psi under normal conditions at 1500 pph fuel flow.

(5) An impending bypass visual pop-out button is incorporated in the bottom of the filter assembly for visual inspection of filter.

c. Left and Right Fuel Manifolds

(1) Two manifolds are positioned on the rear surface of the combustion chamber assembly.

(2) Each is supplied secondary and primary fuel through two hose assemblies from the flow divider. Each manifold assembly incorporates 14 dual orifice (air-blast type) fuel nozzles.

(3) Each nozzle delivers fuel to the combustion chamber through a primary (pilot) flow orifice and a secondary (air blast) flow orifice.

d. Air Blast Injector Nozzles and Swirl Cups - the 28 air blast injector nozzles function is dependent upon the flow divider, the dual channel manifold, and the 28 air blast swirl cups.

(1) Operation

After metered main fuel leaves the fuel control, it passes through a fuel/oil heat exchanger (cooler) mounted on the right side of the engine. The cooler uses fuel to cool the oil. Fuel flows from the cooler to an inline fuel filter and then to a flow divider. The flow divider provides primary and secondary fuel flow to a dual-passage fuel manifold, incorporating 28 dual orifice atomizing fuel nozzles for introducing fuel into the combustor. The fuel nozzles are air-blast type.

In the flow divider assembly, this fuel is directed through the flow divider piston to the main fuel pilot channel of the main manifold, fuel is then directed to the 28-injector nozzles. Fuel enters the center pilot channel of the nozzle and passes internally to the swirl chamber, the fuel is then sprayed out through the pilot orifice into the combustor at a predetermined angle.

To atomize this fuel, combustor air blast air is introduced into the injector nozzle through drilled passages where it flows internally to the pilot swirl chamber outer housing. The air is imparted upward and out into the combustor where it mixes with and atomizes the fuel to a fine spray fuel pattern. Associated with the four air-blast passages there are also eight secondary air-blast drilled air channels in the injector nozzle. Combustor air pressure enters the nozzle through the eight passages and flows internally to a series of swirl slots where it is swirled around the fuel forming the flame pattern and providing additional atomization. Fuel is introduced in the outer rear orifices of the nozzles where it flows forward through the secondary channel to the inner casing of the nozzle tip. At this point the fuel would serve no significant purpose without air blast air as in pilot fuel flow. Air blast air enters the four drilled passages. While fuel is being forced down into the air blast channels, air pressure is contacting the fuel and "blasting" it out into the combustor at as a fine fuel spray.

The secondary air blast air passes through the eight drilled passages into the swirl slots and mixes with the fuel to provide flame pattern and further atomize the fuel to a state where the mixture becomes a film of fuel. Another component associated with the air blast system is the swirl cup, which serves a dual function. The injector nozzle is placed in the center of the swirl cup so that it divides the air holes. As air passes through the series of holes of the swirl cup, half of the flow contacts the nozzles and is deflected up the forward face of the cup, thereby preventing carbon build up, and the remaining air contacts the secondary air blast fuel that is being thrown outward and helps control the flame pattern, thereby preventing it from contacting the swirl cup or the combustor liner.

The combined efforts of pilot fuel flow, secondary air blast fuel flow, and the three modes of air blast air provide a very high density fuel flow with low fuel pressure, thereby eliminating premature hot end component failure. The air blast system provides a more efficient operating engine by providing a more stable combustor temperature.

e. Engine Drain Valves

Pressure-operated engine drain valves are in the bottom of each engine combustion housing. The valves automatically drain unburned fuel from the combustion chamber following a false Start or whenever the engine is shut down. One valve is at the forward end of the combustion chamber and the other is at the aft end to ensure complete drainage.

f. Engine Inter-stage Air Bleed

To aid compressor rotor acceleration and prevent compressor stall, and inter-stage air bleed system is provided on each engine. A series of vent holes through the compressor housing at the sixth stage vane area allows pressurized air to bleed from the compressor area. This enables the compressor rotor to quickly attain a pre-selected rpm. The pneumatic inter-stage air bleed actuator controls operation of the air bleed by tightening or loosening a metal bank over the vent holes. The inter-stage air bleed system operated automatically when the engine condition levers or the engine beep trim switches are used to govern rpm. Should the bleed band malfunction and remain open, there would be a noticeable loss in power.

g. Fuel Flow System

(1) The aircraft is equipped with a fuel flow indicating system. Its function is to indicate to the pilot and copilot the fuel flow rate in pounds per hour to the aircraft's two turbo shaft engines. Rate of fuel flow is detected by respective engine fuel flow transmitters and displayed in the cockpit on one indicator on the center instrument panel.

(2) System components

(a) Transmitter - Qty (2)

1 Location

a Station 492, WL +23 left side

b Station 492, WL +23 right side

2 Description and Data:

a Drives cockpit indicator as a function of fuel flow from tank to engine.

b Transmitter impeller motor receives power from indicator

(b) Indicator

1 Location:

a Cockpit center instrument panel

2 Description and Data:

a Power input - 115 VAC 400 HZ from AC No. 1 bus

b Power input - 115 VAC 400 HZ from AC No. 2 bus

c Indicates fuel flow in pounds per hour

d Graduated from 0-28 (X100) with markers at every 100 PHr point.

(c) Power Supply Unit:

1 Location:

a Station 534 left side in cabin.

2 Description:

a Provides power supply to both transmitter motors.

3 Maintenance

(3) System Operation

(a) The No. 1 and No. 2 engine fuel flow systems are identical

(b) Power to operate each system is routed from the 115-volt ac bus through 5 ampere FUEL FLOW circuit breaker to the indicator.

The 115-volt ac from No. 2 bus is applied to the No. 2 power supply circuit.

(c) The fuel flow indicator power supply furnishes power to the transmitter motor, the rotor of which is an impeller. This impeller is driven at a constant angular velocity. As fuel passes through the impeller it attains the angular velocity of the impeller. The angular momentum of the fuel induced by this rotation is imparted to a spring-restrained turbine, which causes the turbine to deflect through an angle proportional to the flow-rate. This angular deflection is converted to an electrical signal by magnets in the turbine and pick-off coil around the turbine. The electrical signal is applied to the fuel flow indicator, thereby indicating the flow-rate.

(d) Voltage is also applied as a reference voltage to the coil that drives the pointer and the coil that is driven by the transducer turbine. The No. 2 power supply provides two stepped dc voltages displayed by 90°. Each voltage has a repetition rate of 6 Hertz. These voltages are applied to the windings of the two-phase motor that drives the impeller at a constant speed.

(e) The reference voltage in the coil driven by the turbine induces voltages at the taps. This voltage varies with the position of the turbine. The voltages are applied to the coil that drives the pointer, and will position the pointer to the fuel flow as directed by the turbine.

(f) The indicator is illuminated by integral lamps powered from the center instrument panel lighting circuit. This circuit provides between 0 and 5-volt dc depending on the setting of CTR SECT INST LTS dimmer control.

A. Engine Starting System Improvement

1. Single-switch Starting

2. Indicating LTS for Start Motors

3. Start Circuits not Inter-locked with ECL

B. Description

1. Starting System

Each engine is started using hydraulic power from the utility hydraulic system until self-sustaining speed has been achieved. The Start system for each engine includes an ignition system, a hydraulically operated start motor, a start fuel solenoid valve, a START switch, and an ignition logic switch.

2. Ignition System

The ignition system has 4 igniter plugs in the combustion chamber which are energized by a coil assembly supplied from the No. 1 or No. 2 DC bus-bar, as appropriate. An ignition exciter unit converts low voltage DC to the high voltage required at the igniter plugs.

3. System Operation

a. Starting Procedure

When the start switch is moved to MOTOR, the STARTER ON caution light comes on and the start valve opens. The start valve applies utility system pressure from the apu to the engine starter; rotating the engine starter and compressor. At 10 to 15 percent N1, the engine condition lever is moved to GROUND. The start switch is immediately moved to START, energizing the ignition exciter. Start fuel is sprayed into the combustor and combustion begins. Prior to ptit reaching 450°C, the START switch is manually released to MOTOR. At MOTOR, the Start fuel valve is closed and the ignition exciter is de-energized. The start valve remains open, however, and the starter assists the engine until starter cutout speed of 50 percent N1. The engine then accelerates to a ground idle speed. At 50 percent N1, the START switch is manually moved to the locked OFF position. At OFF, the pilot valve closes, closing the start valve and de-energizing the STARTER ON caution light. A relay in each engine start circuit is energized when either START switch is at MOTOR or START. The relay, when energized, disables the start circuit of the opposite engine, preventing simultaneous dual engine starts. The start and ignition circuits receive power from No. 1 and No. 2 dc buses through the START & TEMP and IGN circuit breakers on the power distribution panels.

b. Aborting a Starting Cycle

A starting cycle can be aborted at any time by moving the ECL to STOP. If venting run is required, the engine is motored over by setting the ECL to STOP and then setting the ENG START switch to MOTOR, at which gives 15 to 17% N1.

c. Ignition Lock Switch

An ignition system lock switch is installed on the right side of the console forward of the thrust control. The key-operated switch prevents unauthorized use of the helicopter. When the switch is off, the circuits to the ignition exciters and the start fuel solenoids of both engines are open. Therefore, the engines cannot be started. Be sure both START switches are OFF before turning the ignition lock switch ON or OFF.

d. Engine START Switches

Two engine start switches are on the START panel on the overhead switch panel. The switches are locked in OFF, detented in motor and spring-loaded from START to MOTOR. At START, the engine is rotated with Start fuel and the ignition circuits are energized. At MOTOR, the engine is rotated by the starts, but ignition and start fuel circuits are de-energized. MOTOR is selected during starting, in case of engine fire, or to clear the combustion chamber after a false start.

e. STARTER ON Caution Lights

The STARTER ON caution lights, one for each engine, are on the START panel. The lights will come on when the associated START switch is moved to MOTOR or START. The light alerts the pilots when the START switch is inadvertently left at MOTOR. The lights receive 28-volt dc from the No. 1 and No. 2 dc buses through the START & TEMP circuit breaker on the power distribution panels.

4. Malfunctions - TM 55-1520-240-10 (Emergency Procedures)

C. Introduction

1. The helicopter contains a separate starting and ignition system for each engine.

2. Each system consists of an ignition exciter, four igniter plugs, ignition hardness assembly, engine start switch, caution lights, ignition lock switch relays, and solenoid valves.

3. The ignition exciter converts low voltage DC into pulsating high voltage DC through the use of a vibrator and transformer.

4. The ignition lead assembly from the exciter, to a spark splitter that contains high voltage coils carries the high-tension voltage.

5. High voltage is then distributed to the four igniter plugs in the engine.

6. Each engine has a hydraulically powered starter motor. Hydraulic pressure to operate the starter is provided by the utility hydraulic system.

7. Starting fuel is automatically programmed to the engine combustor during the Start cycle.

8. The ignition lock switch is located on the right (pilot's) side of the center console.

9. The engine start switches, start caution lights, engine condition levers, and start and ignition relays are located in the overhead console panel, and above the pilot's and copilot's heads.

10. Engine mounted components include the starter motor, Start fuel solenoid, 4 igniter plugs, ignition exciter, and ignition lead assembly.

11. The engine start solenoid valves are part of the utility system hydraulic pressure control module. Starter hydraulic returns are plumbed to the utility hydraulic return control module. Both modules are located overhead in the aft cabin at Station 534, waterline +50, butt-lines 15 right and left.

12. The engine main electrical harness connects the engine mounted electrical components to the airframe wiring at the engine quick disconnect shelf, and located immediately below each engine. Fuel and hydraulic quick disconnects are also located on the same shelf. The disconnect shelf is accessible through the nacelle cowling lower cover.

13. The start circuit is interlocked to prevent motoring both engines at the same time.

D. Presentation

1. Components

a. Engine start switches

(1) Location: On the engine start panel mounted on the overhead switch panel; one per start system.

(2) Function: Provides electrical power to initiate the engine starts cycle.

(3) Specifications: Three-position switch marked OFF, MOTOR, & START.

(4) Operation: Placing the switch in MOTOR or START connects 28 VDC from the No. 1 or No. 2 DC bus to other system components required for engine start. It also provides a path for 28 VDC to light the respective motor indicating light.

b. Engine start relays

(1) Location

(a) 101K1: Engine No. 1 start relay

(b) 101K2: Engine No. 2 start relay

(c0 Cockpit area, one on each side of the overhead panel

(2) Function

(a) 101K1 completes electrical control circuits to the No. 1 engine and interlocks to prevent starting No. 2 engine.

(b) 101K2 completes the electrical control circuits to the No. 2 engine system and interlocks to prevent starting No. 1 engine.

c. Igniter fuel solenoid valve

(1) Location: Mounted on the engine, left sides, directly above the fuel control unit.

(2) Function: Controls fuel flow to the start fuel nozzles

(3) Specifications:

(a) Normally closed valve

(b) Requires 28 VDC for operation

(4) Operation

(a) With the start switch in START position, the engine start relay energized, the valve receives 28 VDC from the No. 1 or No. 2 DC bus.

(b) The valve energizes open and programs start fuel to the start fuel nozzles.

(c) When the start switch is positioned to the OFF position, power is removed from the valve, it de-energizes closed removing Start fuel.

d. Ignition Unit

(1) Location: On the upper right side of the compressor housing, directly in front of the air-bleed actuator and above the oil cooler.

(2) Function: Supplies high voltage necessary for spark plug operation.

(3) Specifications: A vibrator transformer within the ignition unit converts low voltage to high voltage. The high voltage ionizes the gap in each igniter plug to produce a combustion-inducting spark.

(4) Operation

(a) During an engine start, the control circuitry connects 28 VDC to the unit through the engine start switch.

(b) The high voltage output of the exciter is supplied to the igniter plugs in the engine combustion chamber.

(c) When engine operation is self-sustaining on main fuel, the start switch is placed to OFF and ignition is removed.

e. Ignition Coil and Cable

(1) Location: Between the ignition unit and the four igniter plugs of each engine.

(2) Function:

(a) The ignition coil and cable assembly transmits high voltage from the ignition unit to the four igniter plugs in the combustion chamber.

(b) The spark splitter coil, located below the ignition unit, distributes high voltage to each igniter plug (provides four leads).

f. Igniter Plugs

(1) Location: Four igniter plugs are installed in receptacles in the aft end of the combustion chamber at approximately the 12-, 3-, 6-, and 9-o'clock positions.

(2) Function: The igniter plugs provide the gap for high voltage to sparks to ignite the fuel mixture in the combustion chamber.

g. Engine Starter

(1) Location: On the starter drive assembly on the engine air inlet housing.

(2) Function: Provide cranking power to the compressor section of the engine during the start cycle.

(3) Specifications

(a) The engine starter is a piston-type constant-displacement hydraulic motor.

(b) Pressure of 3350 psi is delivered to the motor from the utility hydraulic system when the engine start valve is operated.

(c) The engine starter hydraulic pressure is supplied the utility system pressure control module which also houses the engine Starter solenoid valves for each engine. Starter return pressure is plumbed to the utility system return control module.

h. System Operation

(1) The starting and ignition system for each engine is controlled by an ignition lock switch, a start switch, and the engine Start and ignition relays. The circuits are not routed through the engine condition control, nor are they dependent on its setting. A key is required to operate the lock switch.

(2) Power for the engine starting and ignition circuit is obtained from the 28-volt No.1 DC bus for No. 1 engine and the 28-volt DC No. 2 bus for the No. 2 engine.

(3) Setting the ignition lock switch S7 to ON implements the arming of engine No. 1 and No. 2 ignition circuits through contacts C1, C12, and C2, C22 respectively.

(4) Setting the No. 1 engine start switch to the MOTOR detent, power from ENG. No. 1 START and TEMP circuit breaker is routed through contacts 5 and 4 of switch S1 and the normally closed contacts D2 and D3 of relay K2 to energize relay K1. Contacts 8 and 7 are closed to light the STARTER ON caution light.

(5) With relay K1 energized, engine start solenoid valve 11 is opened and utility hydraulic system pressure is supplied to the No. 1 engine start motor. Contacts A1 and A2 are closed to complete arming of engine No. 1 ignition circuit. Contacts D2 and D1 are closed, preventing an inadvertent start of No. 2 engine.

(6) Holding the No. 1 engine start switch S1 in the momentary START position completes the pre-armed ignition circuit through momentary contacts 2 and 1 to the ignition exciter, and 11 and 10 to the start fuel solenoid valve. DS1 is also energized to keep the STARTER ON caution light ON.

(7) When engine rpm reaches 10 to 15 percent N1 speed, the No. 1 ENGINE CONDITION lever is placed in the GROUND detent position, supplying run fuel to the engine. The START switch S1 is released to the MOTOR detent position at 200° PTIT.

(8) In this position, the ignition circuit is open allowing the start fuel solenoid valve to close and the ignition exciter is de-energized. The engine start solenoid valve is held open to assist engine N1 speed.

(9) At 45 to 50 percent N1 speed, the start switch S1 is placed in the OFF detent position. The engine combustion is self-sustaining and the start and ignition cycles completed.

(10) Engine No. 2 start and ignition circuit is identical in operation, except the normally closed contacts D2 and D3 of relay K1 energize relay K2 in the MOTOR and START positions of Start switch S2.

A. Engine Control System Improvements

1. Emergency Power up to 4500 SHP

2. Starting Interlock Removed

3. AFCS Bite Interlock Installed

B. Description

Each engine is controlled by a separate power control system which includes cockpit controls and an engine fuel control unit. Each system provides automatic control of engine gas producer rotor speed and power turbine speed in response to any setting of the engine controls selected by the pilot. Engine gas producer rotor speed (N1) and power turbine speed (N2) are controlled by the fuel control unit, which varies the amount of fuel delivered to the engine fuel nozzles. During normal operation, the fuel control unit automatically prevents power changes from damaging the engine. Fuel flow is automatically monitored to compensate for changes in outside air temperature and compressor discharge pressure.

1. Operation

a. Engine Fuel Control Units

Each engine fuel control unit contains a single element fuel pump, a gas producer speed governor, a power turbine speed governor, an acceleration-deceleration control, a fuel flow limiter, a fuel control fuel shutoff valve, and a main metering valve. Two levers are mounted on the fuel control unit: a gas producer (N1) lever and a power turbine (N2) lever. Limiting the maximum fuel flow to the gas producer restricts output power of the power turbine (a function of speed and torque). Maximum gas-producer rotor speed is set by the engine condition levers in the cockpit. The engine condition lever electro-mechanically positions the gas producer lever, which controls the fuel control fuel shutoff valve and the operating level of the gas producer. During flight, the engine condition lever is left at FLIGHT position and the output shaft speed is regulated by the power turbine speed (N2) governor. The power turbine lever is electro-mechanically positioned by the engine beep trim switches, thrust control, and emergency engine trim switches. Output shaft torque is limited by the fuel flow limiter, which limits the maximum fuel flow. The position of the main metering valve is determined by the gas producer speed governor, power turbine speed governor, the acceleration-deceleration control, or the fuel flow limiter, depending on engine requirements at that time. The governor or the control unit demanding the least fuel flow overrides the other in regulating the metering valve.

b. Speed Governing

The power turbine speed governor senses the speed of the power turbine and regulates the amount of fuel, which is supplied to the gas producer. This slows down or speeds up the gas producer rotor so that power turbine and rotor system speed remains nearly constant as loads vary. At minimum rotor blade pitch, the amount of power being supplied by either engine is at a minimum. As pitch is increased, more power is required from the engine to maintain constant rotor speed and power turbine speed (N2) Starts to decrease. The power turbine speed governor senses the decrease of N2 RPM and increases the flow of fuel to the gas producer. This creates more hot gases for the power section of the engine. Decreasing pitch causes N2 to increase. The power turbine governor senses the increase and reduces the flow of fuel to the gas producer, thus decreasing the amount of hot gases for the power turbine. The power turbine speed governor allows the power turbine output speed to decrease (droop) approximately 10 percent when the power loading varies from minimum to full load. A droop eliminator linked to the thrust control rod minimizes this. The droop eliminator automatically changes the power turbine lever to compensate for droop as pitch is increased or decreased. Another type of droop, which is only transient, occurs as a result of the time required for the engine to respond to changing loads due to N2 governor lag.

c. Engine Condition Levers

Two engine condition levers (ECL), one for each engine, are on the ENGINE CONDITION panel on the overhead switch panel. Each lever is used to select appropriate fuel flow rates for GROUND, FLIGHT, and STOP (engine shutdown). Operation of the ECL moves a position sensor resulting in movement of the N1 actuator. If the N1 actuator fails to align to the position selected by the ECL, or the ECL is not in a detent, the N1 CONT caution light will illuminate. The actuator mechanically operates a lever, which controls the fuel control fuel shutoff valve and the operating speed of the gas producer. The engine condition lever positions are STOP, GROUND, and FLIGHT. Each lever is spring-loaded outboard and is inhibited by lock gates. The ending condition lever must be at GROUND before the engine will Start. When a condition lever is advanced from STOP to GROUND, power is then supplied to the electromechanical actuator, which establishes an appropriate fuel flow rater at ground idle. The speed of the gas producer with the lever at GROUND should be 60 to 63 percent N1. When an ECL is moved to FLIGHT, the engine is operating within the N2 governing range, unless the engine is "topped out" at which time it goes back to N1 governing. The N2 governor then takes control to maintain selected rotor rpm in response to the engine beep trim switches and collective pitch changes. When an ECL is moved to STOP, the gas producer lever closes the fuel control shutoff valve, which stops fuel flow to the gas producer. The engine condition levers and gas producer actuators allow the pilot to proportionally control acceleration of the gas producer from STOP to FLIGHT. Interlock switches within the ENGINE CONDITION panel and N1 actuators turn on the N1 CONT caution light when the N1 actuator position does not agree with ECL position in STOP, GROUND, or FLIGHT. Each electrical system is completely separate and a failure in one system will not affect the other. A built-in mechanical brake holds the actuator at its last selected position if loss of electrical power occurs. ECL friction is provided to reduce the possibility of over-torquing the engine transmissions by resisting movement of the engine condition levers. The ECL friction brake cannot be adjusted by the pilot and a force of 4 to 5 pounds on the engine condition levers is needed to move them. Electrical power is supplied by the 28-volt dc essential buses through No. 1 and No. 2 COND CONT circuit breakers on the power distribution panels.

d. Engine N1 Control Caution Lights

Two engine control caution lights are on the master caution panel. They are marked No. 1 ENG N1 CONT and No. 2 ENG N1 CONT. The lights normally come on when the engine condition levers or the N1 actuators are at an intermediate position between STOP, GROUND, or FLIGHT. They go out when ECL and N1 actuator positions agree. However, they remain on if a component of the system (actuator, control box, or condition panel) has failed in other than a detent position. The 28-volt dc essential bus supplies electrical power to the caution lights. A circuit breaker marked CAUTION PNL on the No. 1 power distribution panel protects the caution light circuit.

e. Normal Engine Beep Trim Switches

Two momentary switches for engine beep trim are on the auxiliary switch bracket of each thrust control. Both switches have three positions: RPM INCREASE, RPM DECREASE, and a normal position. One switch, marked No. 1 & 2, is normally used to select desire rotor rpm. Holding the switch forward increases rotor rpm. Holding the switch aft decreases rotor rpm. When the switch is released, it returns to the center or normal position. The switch electrically controls both power turbines by movement of the N2 actuator through each engine power-turbine control box. The second beep trim switch, marked No. 1 engine. This switch is used to match engine loads, which is indicated by dual torque-meters. Because No. 1 engine beep switch will also change rotor rpm, the procedure for matching engine load requires that No. 1 & 2-beep switch be used in conjunction with No. 1 engine beep switch. when No. 1 engine beep switch is moved forward (RPM INCREASE), the torque of No. 1 engine increases. At the same time rotor rpm increases, even though No. 1 engine torque decreases slightly. Moving No. 1 & 2-engine beep trim switch aft (RPM DECREASE) causes both engine torques to decrease and reduce rotor rpm. If torque is still not matched, this procedure is continued until torque is matched and desired rotor rpm is attained. The opposite action occurs when No. 1 engine beep switch is moved aft. The engine beep trim switches should not be used during power changes initiated by thrust rod movement because rotor rpm droop should only be momentary. The engine beep trim system adjusts engine rpm only if the respective engine condition lever is at FLIGHT. At STOP and GROUND, it is possible to move the power turbine lever by moving the engine beep trim switches to DECREASE or INCREASE: but in either case, engine rpm will not be affected because then engine is not operating in the N2 governing range. Power to operate the beep trim system is supplied by the 28-volt dc and the 115-volt ac buses. Power to operate the power turbine actuators is dc voltage. This dc voltage is derived from the 115-volt ac primary bus after the ac is transformed and rectified by the engine power turbine control box. AC circuit breakers are marked ENGINE NO.1 and NO. 2 TRIM & TIMER. DC circuit breakers are marked ENGINE NO. 1 and NO. 2 TRIM. The circuit breakers are on their respective power distribution panels.

NOTE:
No two engines provide matched performance with regard to torque, rpm, ptit or fuel flow. With torque matched all other parameters may not be matched.

f. Normal ENGINE TRIM System Disable Switches

Two guarded switches are on the emergency engine trim panel on the console. The switches permit the pilot to disable either of both normal beep trim systems. This prevents unwanted signals from the normal beep trim system from interfering with the operation of the emergency engine trim system. Each switch is marked AUTO and MANUAL. When either switch is at MANUAL, the respective normal beep trim system is disabled (115-volt ac from the ac bus to the engine power turbine control is interrupted). When the switch is at AUTO (cover down), the normal beep trim system is functional (115-volt ac from the ac bus is reconnected to the associated engine power turbine control box).

g. Emergency Engine Trim Switches

Two momentary switches for emergency engine trim are on the emergency engine trim panel on the console. Each switch is used to change the power turbine speed of its respective engine if the power turbine control box (normal beep trim system) malfunctions. When the normal trip system fails, the droop eliminator also fails to function. Each switch has three positions: INC, DECR, and a spring-loaded center position. When one of the switches is held at INC, power from the 28-volt dc essential bus goes directly to the respective power turbine actuator and increases the lever setting and the power turbine speed. When the switch is held at DECR, the lever setting is decreased, and the power turbine speed is decreased. The emergency engine trim switches are to be used when the normal beep trim system is disabled. If one of the switches is used while the respective power turbine control box is functioning normally, the power turbine actuator setting will temporarily change but will return to its original setting when the switch is released. Power to operate the emergency engine beep trim switches and actuators is supplied by the 28-volt essential dc bus through the No. 1 and No. 2 EMERG ENG TRIM circuit breakers on respective power distribution panel.

CAUTION:

Engine response is much faster when rotor rpm is controlled with emergency engine beep trim system. It is possible to beep the rotor speed below safe operating speed and low enough to disconnect the generators from the buses. The generators are disconnected at 85% to 82% rotor rpm after a 3 to 7 second time delay.

2. Emergency Power

a. Emergency Power System

An emergency power system is included with T-55-L-712 engines. With the emergency power system, increased power is available on pilot demand and is actuated by raising the thrust control into the emergency power range. When fuel flow increases to the point where power turbine inlet temperature is 890° to 910°C, the EMERG PWR light will come on. If temperature is maintained in this range for more than 5 seconds, the emergency power indicator will display a black-and-white flag, and the emergency power timer will start. However, the emergency power indicator will continue to display the black-and-white flag. The flag can be reset on the ground only, using a switch in the nose compartment. Topping stops are stowed on each helicopter. The stops are installed on the N1 control of each engine for maintenance engine topping checks. The stops provide an established fuel flow when topping. When not in use, the stops are stowed on the right side of the console of the pedals.

b. Emergency Power Panel

The emergency power panel is on the overhead switch panel. The panel is labeled EMERGENCY POWER. The panel consists of an emergency power indicator and a digital timer for each engine. The timer counts the minutes that emergency power is in use.

c. Emergency Power Caution Lights

Two amber press-to-test caution lights labeled EMERG PWR are installed: one light is on the copilot's instrument panel outboard of the rotor tachometer and torque meter. The other light is on the pilot's panel inboard of the rotor tachometer and torque meter. When on, the lights indicate ptit on one or both of the engines are in the emergency power range.

C. Power Turbine Inlet Temperature System

1. PTIT can provide the pilot with a primary indication of an impending emergency situation ranging from "Hot Starts" to "Flame Outs".

2. The PTIT System in the aircraft monitors the temperature of the air as it passes into the third power turbine wheel.

3. There is one complete PTIT System per engine.

4. Each system requires 10 thermocouple type-sensing devices, an indicator, interconnecting wiring, and contingency power indicator panel.

5. Provides circuit supply for over temperature warning. (Contingency Power)

D. Presentation

1. PTIT Components:

a. PTIT Indicator

(1) Location:

(a) Each engine instrument is located on the center instrument panel.

(2) Description of Data

(a) Range 0 degrees to 1200 degrees centigrade

(b) System Limits

1 400°C to 780°C continuous operation

2 810°C maximum for not more than 30 minutes

3 890°C maximum for not more than 10 minutes

4 781°C to 940°C starting, acceleration, and time-limited operation

5 890°C to 930°C emergency pwr (single-engine)

6 940°C maximum, not more than 12 seconds

(c) The operation of the indicator is basically a DC servo type of instrument.

(d) Set point in rear of instrument adjusted for 890 +5 and/or -0 degrees.

b. Thermocouple Harness

(1) Location:

(a) A thermocouple harness is provided with each engine and is mounted circumferentially to the third turbine nozzle.

(b) The 10 probes extend through the nozzle outer shroud into the gas path between the third nozzle vanes.

(c) The output leads extend from the harness through an existing guide tube and forward to the thermocouple bulkhead mounting bracket on the compressor housing.

(d) Replacement of probes is accomplished with engine removed from aircraft.

(2) Description of Data

(a) The thermocouple harness consists of:

1 An electrical connector

2 Shielded manifold

3 Ten Chromel-Alumel thermocouple probes

(b) The thermocouple harness is not part of the engine main electrical cable assembly because the system used Chromel-Alumel wires.

(3) Operation

(a) The thermocouple is made of two high temperature dissimilar metals (Chromel-Alumel) joined together to form a hot junction.

(b) Heat applied to the thermocouple produces an electron flow (current) through the junction.

(c) The amount of current generated is a function of the temperature of the thermocouple.

1 High Temp = High current (in "MA")

2 Low Temp = Low current (in "MA")

(d) The current from the thermocouple is directed to the indicator for instrument operation.

c. Reset Switch

(1) Location

(a) Nose electronic compartment.

(b) Between Station 30 and Station 40, BL 8.69 RH

(2) Description and Data

(a) Once the counter has started the flag also drops

(b) The flag will stay down after the counter has stopped and temperature is back to normal.

(c) To reset the flag the reset switch for the respective engine must be operated

d. Contingency Power Panel

(1) Location:

(a) Overhead Panel

(2) Description of Data

(a) Consists of:

1 Operates from 28-vdc. Engine Start and temperature circuit breaker.

2 Elapse time indicator (999 minutes).

a Operates from 115-vdc, 400 Hz from eng trim & timer AC breaker.

3 Flag indicator. (Black - normal, striped - tripped)

4 Relay. (5 second time delay)

a Operates from 28-vdc

(b) Flag Indicator:

1 For Black Flag - Red and yellow terminals are energized by 28-vdc

2 For Striped Flag - Blue and yellow terminals are energized by 28-vdc

3 Yellow Terminal - Ground

2. System Operation:

a. Current generated through the thermocouple junction is sensed by the indicator and causes the meter to deflect.

b. When the pointer indicates more than 890°C, 28-vdc power is sent to the contingency power panel.

c. When the temperature is exceeded, the light will come on.

d. After 5 seconds at high temperature, the indicator flag will drop and the elapsed time indicator will start.

(1) Delay allows transients without tripping flag

e. When the PTIT drops below 890°C, the light will go out and the timer indicator will stop, but the flag will stay down.

f. To reset the flag a switch must be operated in the nose compartment. Can only be reached by personnel on the ground.

g. The time indicator cannot be reset on the aircraft. It must be run through its cycle of 999 minutes or 16 hours and 39 minutes.

h. Continuity/Resistance Check of Harness

(1) Disconnect A/C wiring at the engine connector.

(2) Measure resistance between pins A and B with ohmmeter on RX1 setting.

(a) Meter indication should be between 2.3 and 2.5 ohms at 65°F or between 2.4 and 2.6 at 110°F.

(3) Measure between any one pin and the harness outer braid with the ohmmeter at RX100.

(a) Resistance shall be 400 ohms minimum.

(b) If limits are not met - check the connector.

1 If resistance is taken from pin A to pin C or pin B to pin C, the meter indication should be between 3.5 and 4.1 ohms depending upon temperature.

ENGINE SYSTEM - LUBRICATION SYSTEM, FIRE DETECTION AND EXTINGUISHING SYSTEM, AND ANTI-ICING SYSTEM

A. Lubrication

1. Description

a. Oil Supply System

The oil supply system is an integral part of the engine. The oil tank is part of the air inlet housing. The tank filler neck is on top of the housing. An oil level indicator is on the left side of the engine inlet housing.

If the oil level decreases to about 2 quarts usable, the corresponding ENG OIL LOW caution light will come on. Tank capacity 3.7 gallons.

Operational usage of the engine should not be restricted because of excessive oil consumption, unless the rate will curtail the mission.

b. Engine Oil Temperature Indicator

Two engine oil temperature indicators are on the center section of the instrument panel. Each engine oil temperature indicator is calibrated from -70° to +150°C. A temperature probe within the lubrication lines of the engine, before the fuel-oil cooler, is the point at which the temperature is sensed. Power to operate resistance-type oil temperature circuit is supplied by No. 1 and No. 2 28-volt dc buses through the ENGINE OIL TEMP circuit breakers on the power distribution panels.

c. Engine Oil Pressure Indicator

An engine oil pressure indicator on the center instrument panel is provided for each engine. Each indicator relates pressure sensed at No. 2 bearing by an oil pressure transmitter mounted near the engine. Each engine oil pressure indicator displays a pressure range from 0 to 200 psi. Power to operate the engine oil pressure circuit is supplied by the 26-volt ac instrument buses through the ENGINE OIL PRES circuit breakers on both power distribution panels.

d. Engine Chip Detector Caution Lights

Two ENG CHIP DET caution lights are on the master caution panel. The caution lights are electrically connected to a chip detector in each engine and engine transmission. If a detector is bridged by metal particles which may indicate impending engine or engine transmission failure, the corresponding ENG CHIP DET caution light will come on. Also, the associated ENGINE CHIP DETECTOR or TRANSMISSION CHIP DETECTOR magnetic indicator on the maintenance panel will trip.

e. Engine Oil Level Caution Light

Two engine oil level caution lights, marked NO. 1 ENG OIL LOW and NO. 2 ENG OIL LOW, are on the master caution panel. When a caution light comes on, there are about 2 quarts of usable oil remaining in the respective engine oil tank. Each low oil level caution light is activated by a micro-switch inside the oil quantity indicator. Power to operate the oil level caution lights is supplied by the 28-volt dc essential bus through the CAUTION PNL circuit breaker on No. 1 power distribution panel.

f. Engine Chip Detectors.

Two caution lights, marked NO. 1 ENG CHIP DET and No. 2 ENG CHIP DET, are on the master caution panel. The engine accessory section oil sump chip detector is connected to the corresponding ENG CHIP DET caution light on the master caution panel and to the ENGINE CHIP DETECTOR indicators on the maintenance panel.

g. Oil Cooler

The engine oil is cooled by the inlet air flowing around the tank and the liquid to liquid cooler.

ENGINE SYSTEM

A. Fire Detection and Extinguishing System

1. Description

a. Sensing Wires

Continuous-type sensing elements which are routed around each engine connected to a control unit on the airframe.

b. 2 Extinguisher Bottles

Two extinguisher bottles in the aft pylon. The bottles contain monobromotrifloromethane (CDrF3) and are pressurized with nitrogen; each has two discharge valves connected to two discharge nozzles each engine bay.

c. Fire Control Handles

Two control handles for the engine fire extinguisher system are on the center section of the instrument panel. Each handle contains two red warning lights and control switches that close the engine fuel shutoff valve and arm the fire extinguishing system circuits. When one of the handles is pulled out, the respective engine fuel shutoff valve is closed and the fire extinguisher agent switch is armed for selection and discharge of either fire bottle by selecting either momentary position on the agent discharge switch. After depletion of the charge in the initially selected bottle, the remaining bottle can be discharged to the same engine compartment by selecting the opposite position on the bottle selector switch. The other fire control handle performs the same function for its respective engine compartment. Power is supplied from the 28-volt dc No. 1 and No. 2 essential gases through FIRE EXT circuit breakers on the No. 1 and No. 2 power distribution panels.

d. Fire Control Handle Warning Lights

Two warning lights are contained in the end of each fire control handle. When an engine compartment fire occurs on either side, the respective pair of warning lights comes on. Each fire handle is marked FIRE-PULL-FUEL SHUTOFF. Power is supplied for each pair of lights from the corresponding No. 1 or No. 2 115-volt ac bus through circuit breakers labeled ENGINE No. 1 and ENGINE No. 2 FIRE DET on the No. 1 and No. 2 power distribution panels.

e. Fire Extinguisher Agent Switch

A three-position fire extinguisher agent switch is above the fire control handles on the instrument panel. The lever-lock momentary switch positions are BOTTLE No. 1, neutral and BOTTLE No. 2. When one of the fire control handles is pulled OUT and the fire extinguisher agent switch is set in BOTTLE No. 1 position, the agent is discharged from the No. 1 container into the selected engine compartment. If the switch is set in BOTTLE No. 2 position in the above case, agent from No. 2 container will be discharged into the same engine compartment. Only two fire extinguisher agent containers are provided. If the agent from both containers is used in combating a fire in one engine compartment, agent will not be available should a fire occur in the other engine compartment.

f. Fire Detector Test Switch

The fire detector test switch is below the fire extinguisher agent switch on the center section of the instrument panel and is labeled FIRE DETECTOR-TEST. The two-position toggle switch is spring-loaded to FIRE DETECTOR. The switch is used to check the operation of the fire detection system. When the switch is actuated, relays in both control units close and the lights in both fire control handles come on. Power to operate the test circuit is supplied by the 28-volt dc essential bus through the CAUTION PNL circuit breaker on the No. 1 power distribution panel.

2. <u>Operation</u>

a. Engine Compartment Fire Extinguisher System

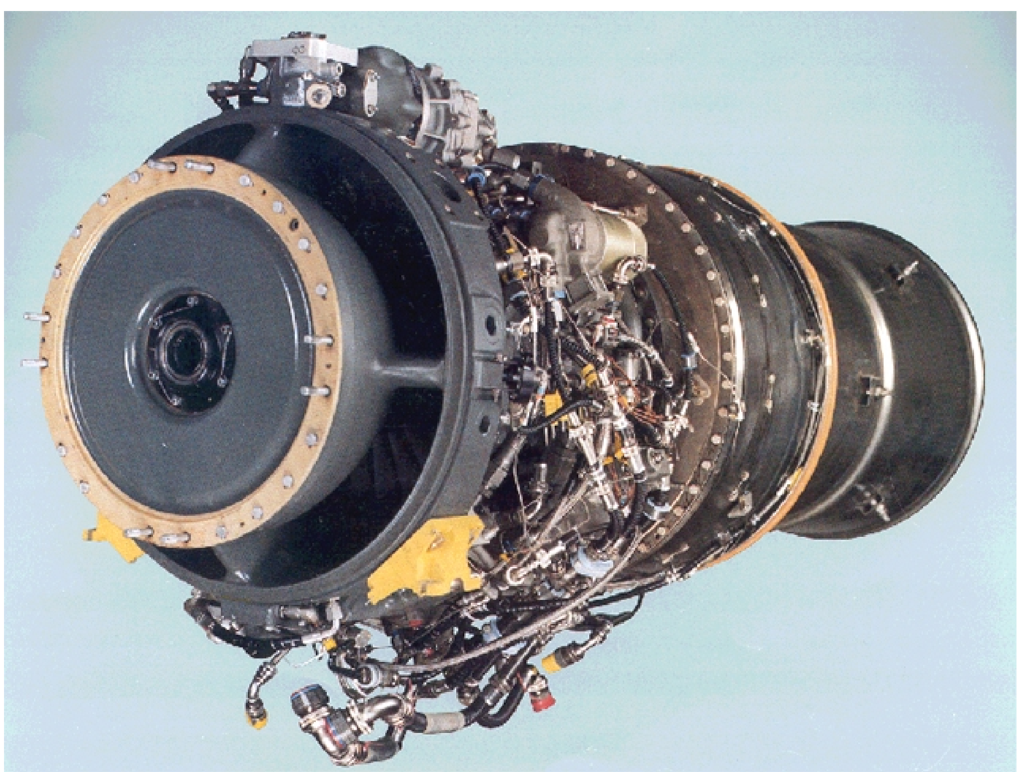
The engine compartment fire extinguisher system enables the pilot or the copilot to extinguish a fire in either engine compartment only. It is not designed to extinguish internal engine fires. The system consists of two fire control handles, a fire extinguisher agent switch, a fire detector test switch on the instrument panel, and two extinguisher agent containers on the overhead structure at Stations 482 and 502. The containers are partially filled with monobromotrifloromethane (CB4F3 or CF3BR) and pressurized with nitrogen. The agent in one or both of the containers can be discharged into either engine compartment. Selection of the compartment is made by pulling the appropriate fire control handle. Selection of the container is made by placing the fire extinguisher agent switch in the appropriate position. Decontamination of the engine is not required when the extinguisher has been discharged.

c. Engine Inlet Screens

An engine inlet screen which maximizes foreign object damage (FOD) is installed on each engine. The reduction in engine power available with screens installed is negligible. The engine inlet screens have bypass panels. These two panels are on the aft end of each screen. Quick release fasteners attach the panels to the screens. They are removed if the ambient temperature is 4°C or below and there is visible moisture.

a. T55-GA-714A ENGINE GENERAL DESCRIPTION

(1) Two Allied Signal Model T55-GA-714A gas turbine engines power the aircraft modified by ECP D 218. A derivative of the T55-L-712, and the improved T55-L- 714 used on the MH-47E the engine is configured with a combination seven-stage axial/single-stage centrifugal compressor driven by a two-stage gas producer (GP) (N1 section) turbine. Gas flow is directed through a reverse flow annular atomizing combustor, through the two-stage GP turbine and two-stage free power turbine (PT) (N2 section). The PT shaft is positioned co-axially within the gas producer shaft and directly drives the power output shaft located at the engine compressor inlet. Power output shaft speed is equal to power turbine speed. The engines are attached to either side of the aft fuselage section by a three-point mount system. Engine electrical, fuel, water wash, hydraulic, and drain system components are connected to the airframe at a quick- disconnect (QD) shelf below each engine.Compared to its predecessors, the T55-GA-714A has been improved to provide additional power and reduce the frequency of required engine maintenance. The power growth as well as the maintainability enhancements are a result of improvements to several areas of the engine.



b. POWERPLANT IMPROVEMENTS:

(1) Replacement of the hydromechanical fuel control system with a Full Authority Digital Electronic Control (FADEC) system.

(2) Engine lubrication system improvements.

(3) The configuration, alteration, and material composition, of the engine compressor, combustion, and turbine assemblies.

(4) Removal of the exit guide vane.

(5) Improved Magnostrictive Torquemeter system

(6) Installed engine water wash system.

(7) Installation of an improved, deflective, tailcone assembly.

T55-GA-714A CHARACTERISTICS

Dimensions	
Overall Length	46.53 Inches
Overall Length (Tailpipe inst.)	77.53 Inches
Nominal Diameter	24.25 Inches
Weight (Less Eng. Transmission and Exhaust Cone)	832 Pounds
Combustion chamber	External annular
Compression ratio (max)	9.32 to 1
Horsepower	(max rated) 4,867 (10 minutes) Emergency 5,069 (2 minutes)
Maximum altitude	25,000 feet
Power level	N1 100% = 18,720 RPM
Power level	N2 100% = 15,333 RPM

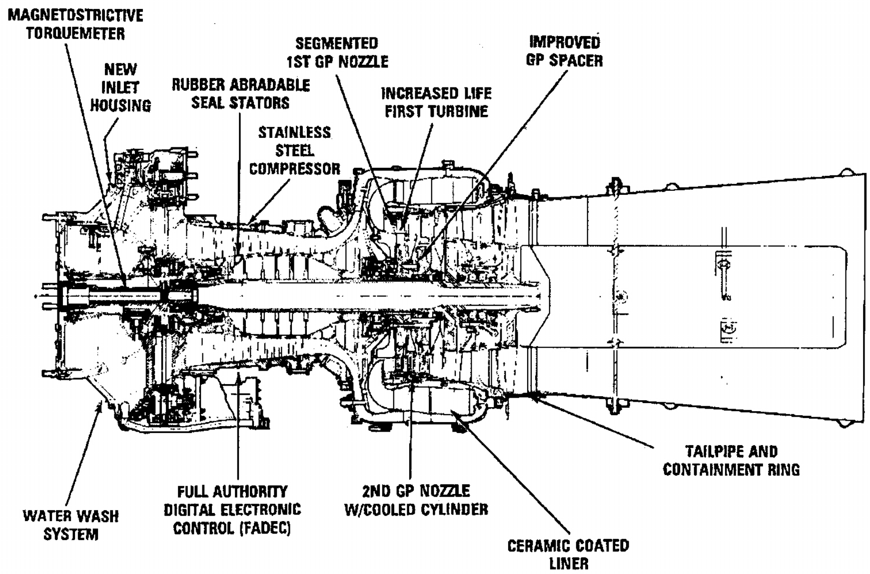


Figure 2 714 A Powerplant Characteristics (72-A0)

PGS-PP-3

a. POWERPLANT INSTALLATION

(1) Maintenance, removal, and installation of either engine is facilitated by the location of the nacelles, the design of the engine mounts, and the use of quick-disconnect couplings on lines which lead to the aircraft structure. Three mounts secure each engine: two forward and one aft. Access for maintenance is gained through hinged access doors and cowlings on the engine and aircraft structure. Engine total weight, ready for installation (including engine transmission, and exhaust cone) is 1,411 pounds.

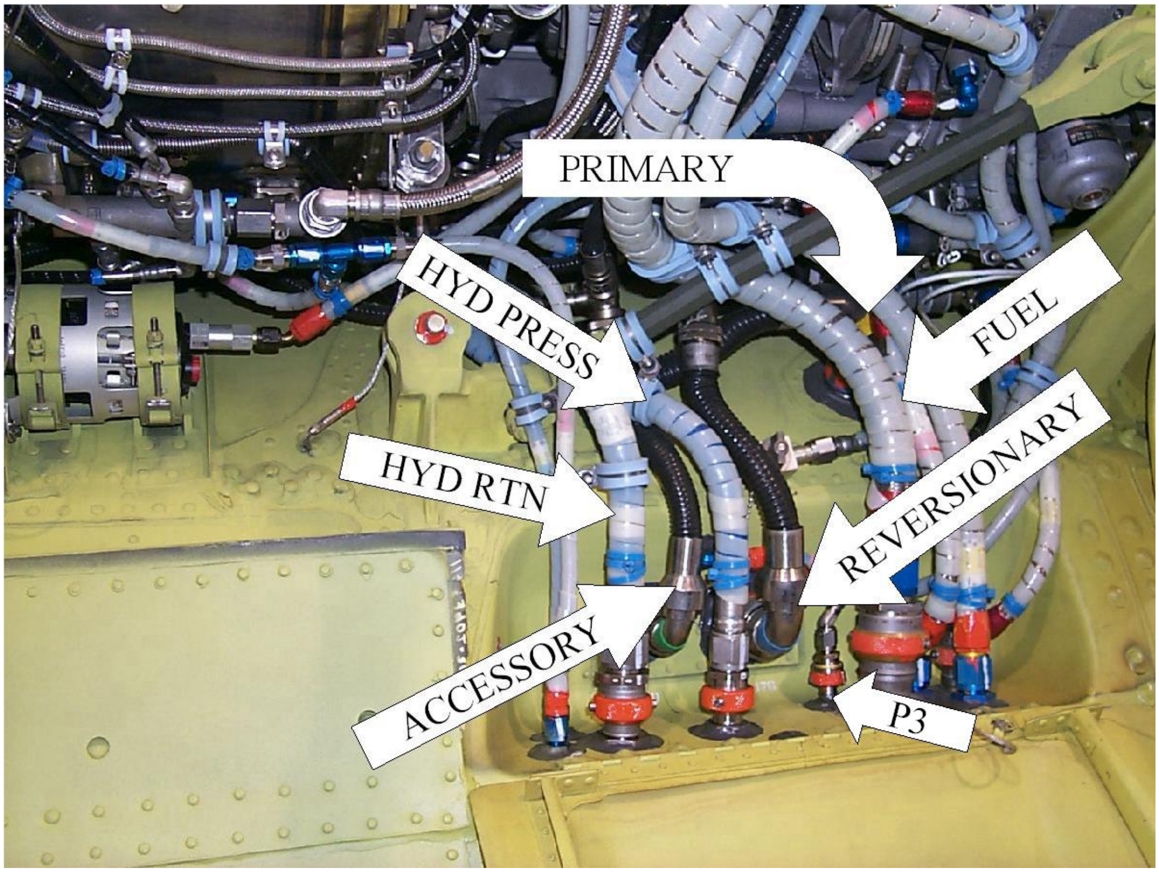
b. Unique T55-GA-714A Engine Installation And Removal Task:

(1) The tailcone is clamped and bolted (6 bolts) to the engine turbine assembly.

(2) FADEC primary, reversionary, and accessory harnesses.

(3) The P3 pressure line to the Digital Electronic Control Unit (DECU).

(4) The water wash system pneumatic and fluid lines.



c. The engine mounts provide a three-point structural support, two forward and one aft, for each engine. The mounts are accessible through the hinged engine cowlings.

(1) The aft engine mount is an adjustable link that has replaceable bearings. Each link is adjusted to ensure the proper alignment of the engine drive shaft and combining transmission input adapter. Once the alignment is completed, a rig plate is installed on the fuselage of the aircraft just below the aft end of the engine. This fixture is used to check the aft engine link prior to installation. Each engine installation has a unique rig

plate.

(2) The drag strut for each engine is a forged strut about 20 inches in length. The drag strut is designed with a 2-degree bend.

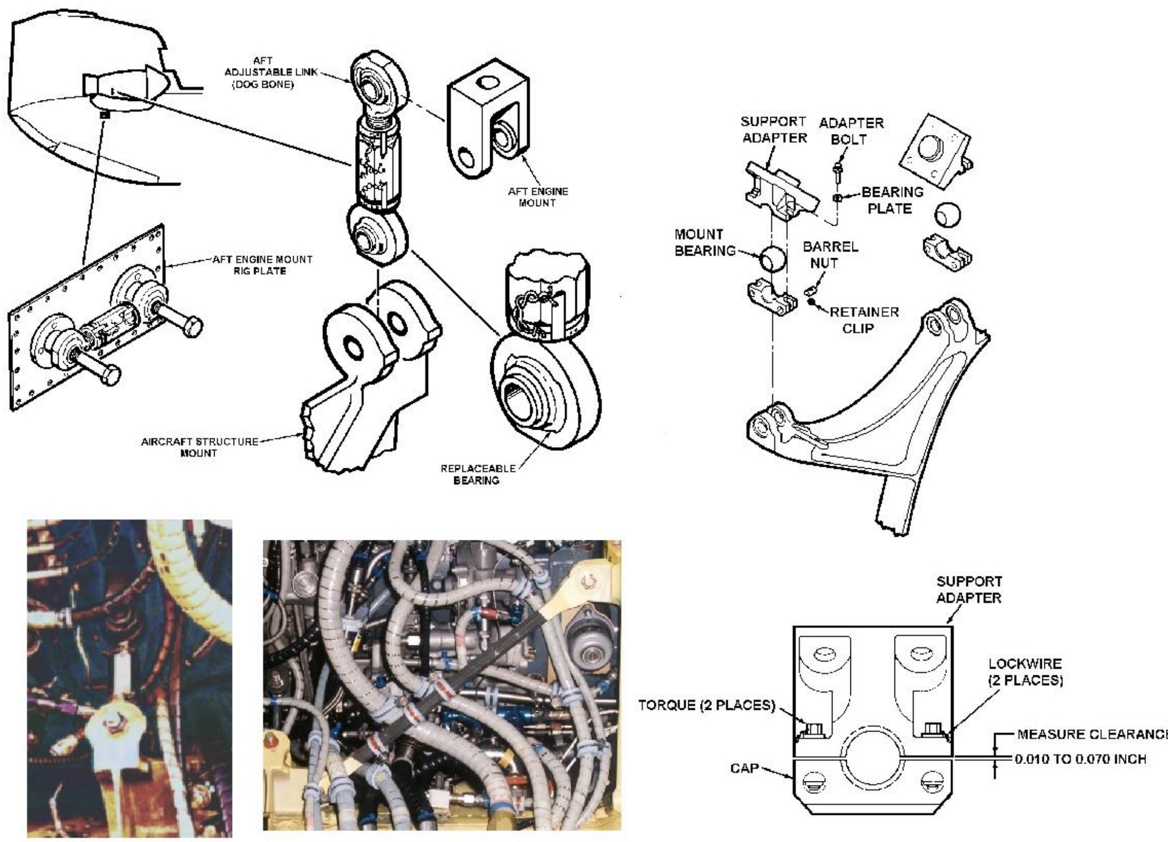


Figure 1 Powerplant Installation (Adjustable link) (72-A0)

a. AIR INLET SECTION

(1) Located at the front of the engine. A one-piece casting, the inlet housing is divided into two principal areas. The outer housing, supported by four hollow support struts, forms the outer wall of the air inlet area. The inner housing forms the inner wall of the air inlet area. The engine oil supply tank is contained within the cavity formed by the inner housing. This configuration creates the air inlet path to the engine compressor section; Located in the inner section is the engine oil tank. This arrangement aids in cooling of the engine oil, as the airflow over this section will reduce oil temperatures as

the oil is returned to the oil tank. The inlet housing encloses the output shaft support housing, torquemeter head, power turbine overspeed governor drive, all accessory drive gearing, No. 1 and 3 bearings and supports, and No. 6 and 7 bearings. The inlet housing provides mounting for the torquemeter junction box, starter drive, oil tank filler, and accessory drive gearbox. The starter drive system originates at a pad on the top of the inlet housing and extends into the inner housing where it is connected to the compressor rotor by a shaft and gearing. Four engine mount pads are on the inlet housing external surface.

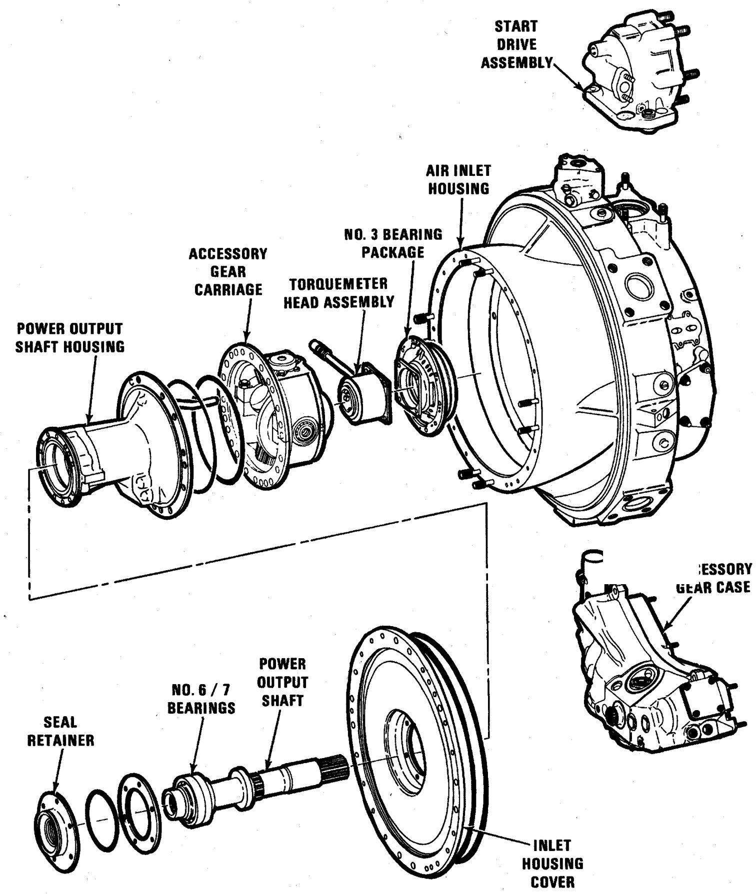


Figure 2 Engine Air Inlet Section (72-A00)

(2) The compressor section of the engine consists of the following components: upper and lower compressor housing assemblies, compressor rotor assembly, and the No. 1 and 2 bearing packages. The compressor bleed system and attaching locations for externally mounted engine components.

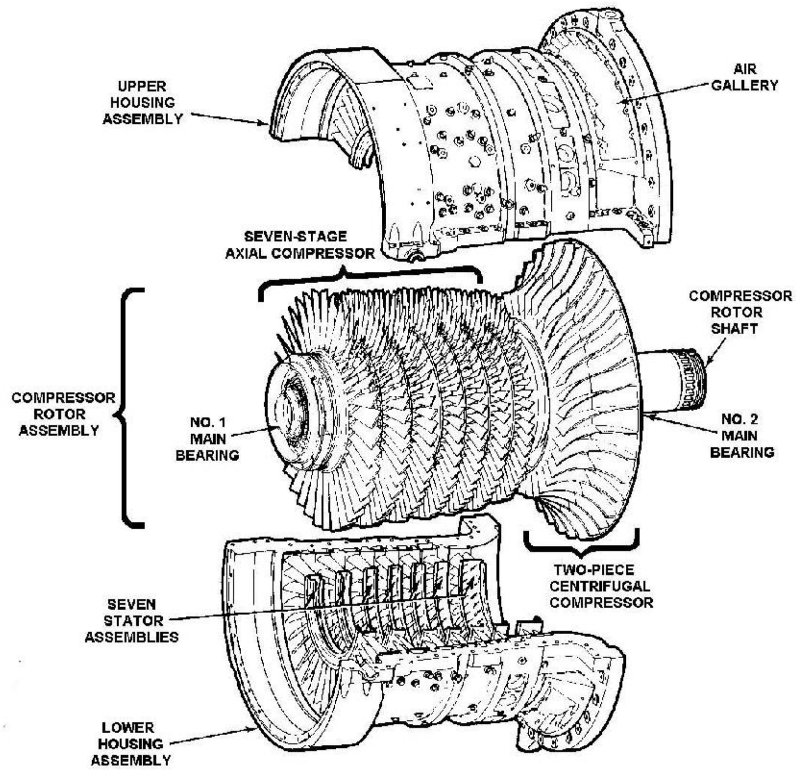


Figure 3 Compressor Section (72-A00)

(3) The housings assemblies are constructed of a stainless steel alloy that has four times the strength of the housings utilized on the 712 and 714 engines, plus the added advantage of the corrosion resistance of the stainless steel. The stainless steel housings also provide enhanced tip clearance control due to its improved thermal compatibility with the compressor rotating components, erosion resistant stainless steel inserts in the compressor housings provide a turning clearance area for each axial compressor rotor disk. The seven two-piece steel stator assemblies of the axial compressor are bolted to the upper and lower housings. The inner portions of the stators (except the second stage stator) are lined with lead labyrinth seals. The inner portion of the No. 2 stator assembly is lined with a rubber abradable seal which when properly fitted forms an airtight seal of the stator assembly to the gas producer shaft. The housings are split axially to permit access to the compressor rotor for inspection, repair, or rework. The engine bleed band covers air passages in the compressor assembly housings.(picture caption)

c. COMPRESSOR ROTOR ASSEMBLY

(1) Supported at the air inlet housing assembly by the No. 1 main bearing and at the air diffuser assembly by the No. 2 main bearing. The compressor rotor assembly consists of seven steel axial compressor blade assemblies and a titanium two-piece centrifugal impeller tightly fitted onto a common shaft.

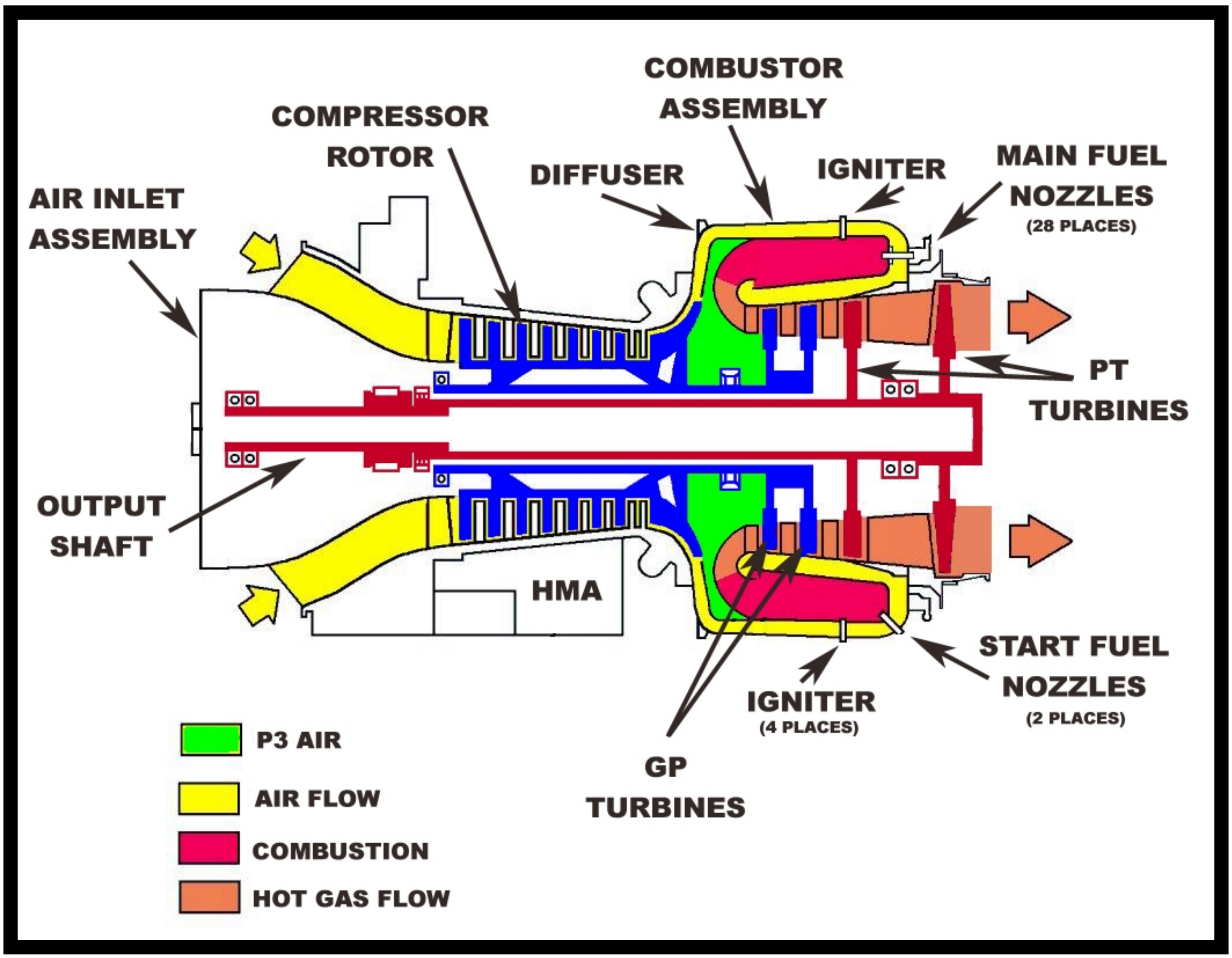


Figure 4 Engine Internal View (N1 & N2)

d. DIFFUSER SECTION

(1) Constructed of stainless steel, the diffuser assembly is mounted between the compressor housing assembly and the combustor section. The diffuser provides support for the combustor assembly and non-rotating components of the turbine assembly. A mounting surface for the No. 2 bearing package that supports the aft end of the gas producer shaft. Vanes on the backside of the diffuser assembly direct and reduce the swirl effect of the airflow as it flows into the combustion section. Oil inlet and scavenge ports and internal oil supply tubes provide lubrication to the No. 2 bearing package. P3 compressor discharge pressure (CDP) ports provide pressure for bleed band operation and a source of P3 air for the Hydromechanical Metering Assembly (HMA) and Digital Electronic Control Unit (DECU).

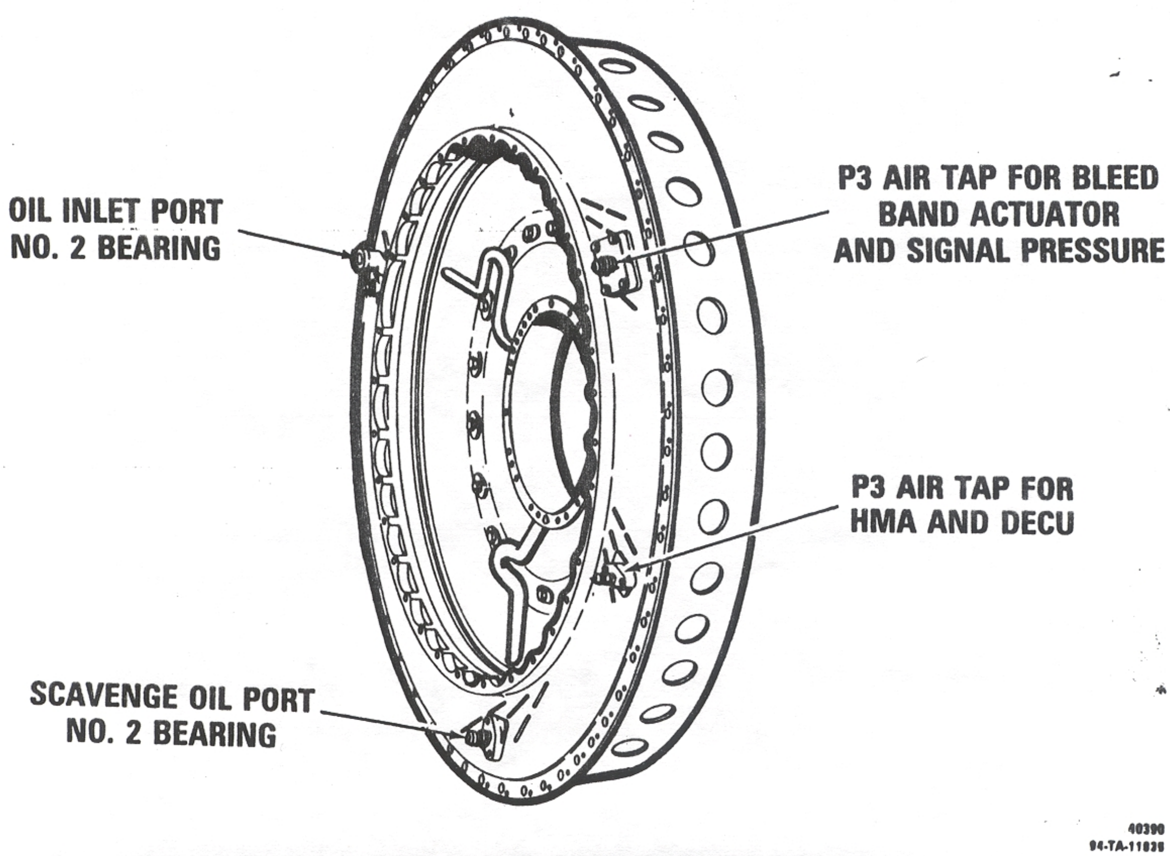


Figure 5 Diffuser Section (FADEC Engine) (72-A0)

e. COMBUSTOR HOUSING

(1) Bolted to the perimeter of the diffuser section. The combustor housing Consists of a Ceramic coated combustor chamber and vane assembly. The combustion chamber is a reverse flow external annular type combustor. This folded design permits maximum utilization of space and reduces gas producer and power turbine shaft lengths. The combustion chamber shrouds the gas producer and power turbine assemblies.

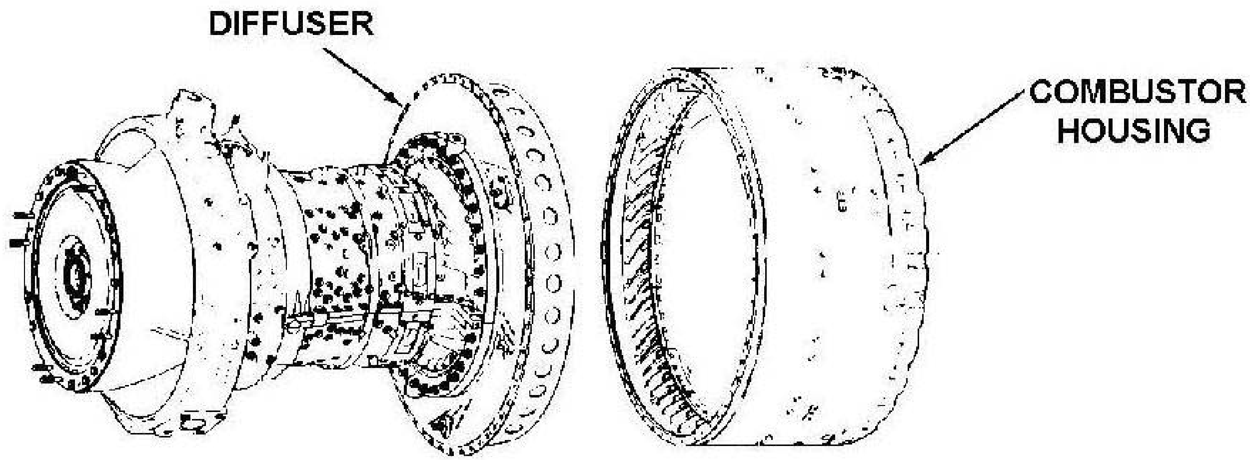


Figure 6 Combustor Housing (72-A0)

f. GAS PRODUCER TURBINE SECTION

(1) The first, and second stage Gas Producer (GP) nozzle assemblies, and GP turbines make up a two-stage axial flow, air-cooled turbine system. The two turbines are coupled together and mounted on the rear of the gas producer shaft to form a single rotating assembly.

The No. 2 main bearing supports the aft end of the GP shaft.

GP Improvements include:

(a) A segmented 1st stage nozzle replacing the integral nozzle assembly installed in the T55-L-712. The segmented nozzle has improved cooling airflow, reduced stress areas, and independently replaceable segments. The first stage of the GP rotor will incorporate the ALF-502 turbine disk assembly. The disk has improved bore-cooling airflow, and stressed aerodynamically improved blades. An air-cooled 1st stage cylinder provides better tip clearance control, increasing engine life. An air-cooled 2nd stage segmented cylinder over the second GP turbine disk replaces the previously installed solid cylinder. The 2nd GP nozzle area has also been improved. The seal between the 2nd GP nozzle and the 2nd GP turbine incorporates a honeycomb seal in place of the previously installed sheet metal finger seals. The GP spacer inner diameter has been redesigned to eliminate high stress areas.

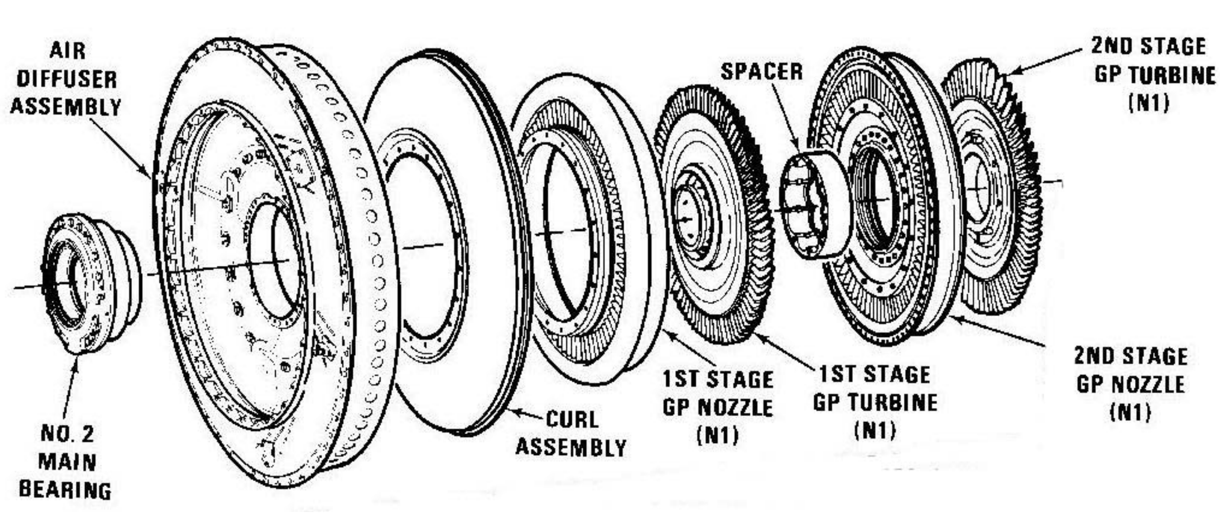


Figure 7 Gas producer Turbine Sections (72-A0)

g. POWER TURBINE SECTION

(1) The Power Turbine (PT) is a two-stage, axial flow, free power turbine, coupled together and supported at the rear by the NO. 4 and 5 bearing packages, the NO. 3 bearing supports the forward end. The PT assembly is identical to the T55-L-712 in design and configuration. The 714 hot section components as compared to those used in the 712 are produced from superior alloys providing higher tolerance across the engine temperature ranges. Engine shaft horsepower is increased as the engine is allowed to operate at higher temperatures.

(2) To provide an increased temperature margin, the exit guide vane has been removed from the 714 engine. The primary function of the exit guide vane was to restrict the exhaust gas flow, increasing shaft horsepower and lowering engine thrust. A secondary function was to provide blade containment in the event of turbine wheel disintegration.

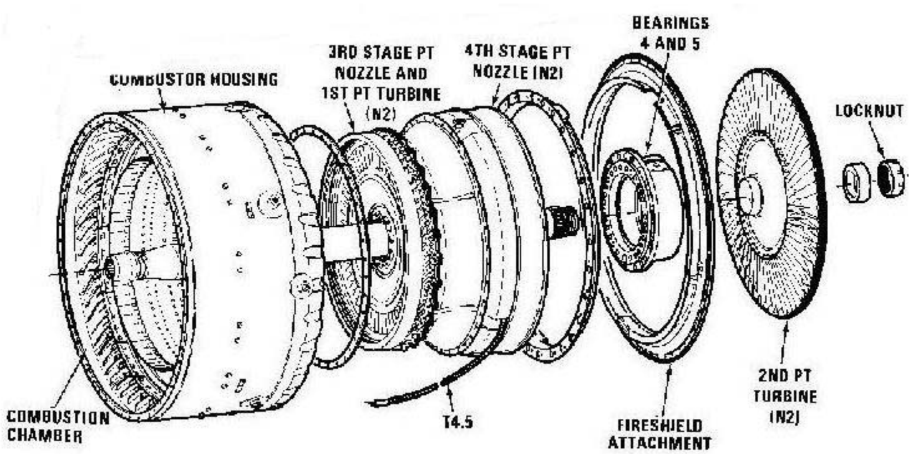


Figure 8 Power Turbine Section (72-A0)

h. TAILCONE ASSEMBLY

(1) The canted – 09 degree tailcone with inner cone assembly and a stressed blade containment area replaces the previously installed tailcone. The improved inner cone reduces the swirling effects of the exhaust gas-flow, aiding in the removal of the engines exhaust gases. The stressed blade containment area was added to the new tailcone due to the removal of the engine exit guide vane found on the T55-L-712 engine. The stressed area is provides limited protection against disintegrating turbine wheels. Four improved support rods and associated hardware improvements maintain the positioning of the inner cone.

(2) Clamped and bolted to the rear of the engine, the tailcone can to be installed on either left or right engine by properly aligning the left or right index mark (on the tailcone) and aligning the six bolt holes.

Figure 9 Powerplant Tailcone (714A) (72-A0)

i. ACCESSORY GEARBOX ASSEMBLY

(1) Mounted on the inlet housing, driven by inputs from the gas producer and power turbine shafts. The accessory gearbox contains the drive gears and provides mounting pads for the:

(a) Engine Driven Fuel Boost Pump.

(b) Oil Pump.

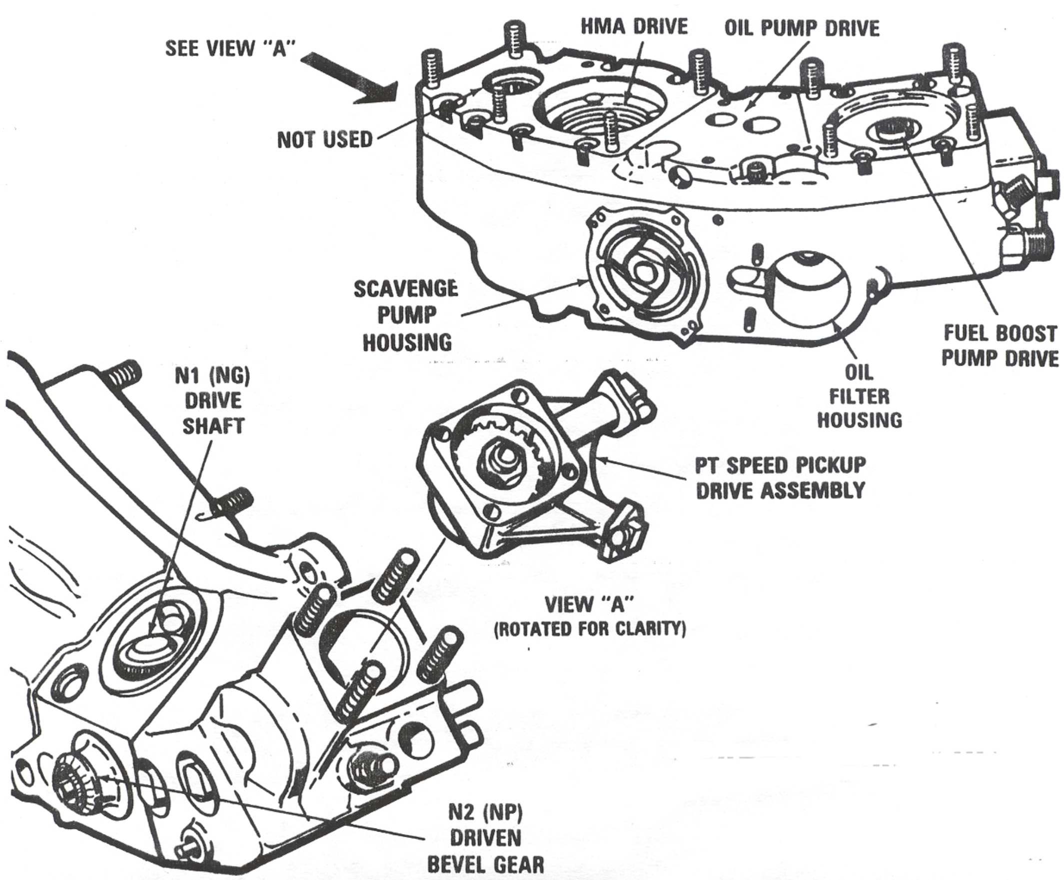
(c) PT Speed Pickup Drive Assembly.

(d) Hydromechanical Metering Assembly (HMA)

(e) Oil Filter Housing.

(f) Scavenge Pump Housing

(2) The accessory gearbox has a self-sealing fuzz burn-off/chip detector installed. The fuzz burn-off feature of the chip detector is designed too electronically burn-off the minute particle(s) which bridge the contacts of the chip detector. Should the fuzz-burnoff system fail to eliminate the chip(s) the chip detector provides a signal to the cockpit and aircraft maintenance panel indicating the presence of an engine chip(s).



a. LUBRICATION SYSTEM

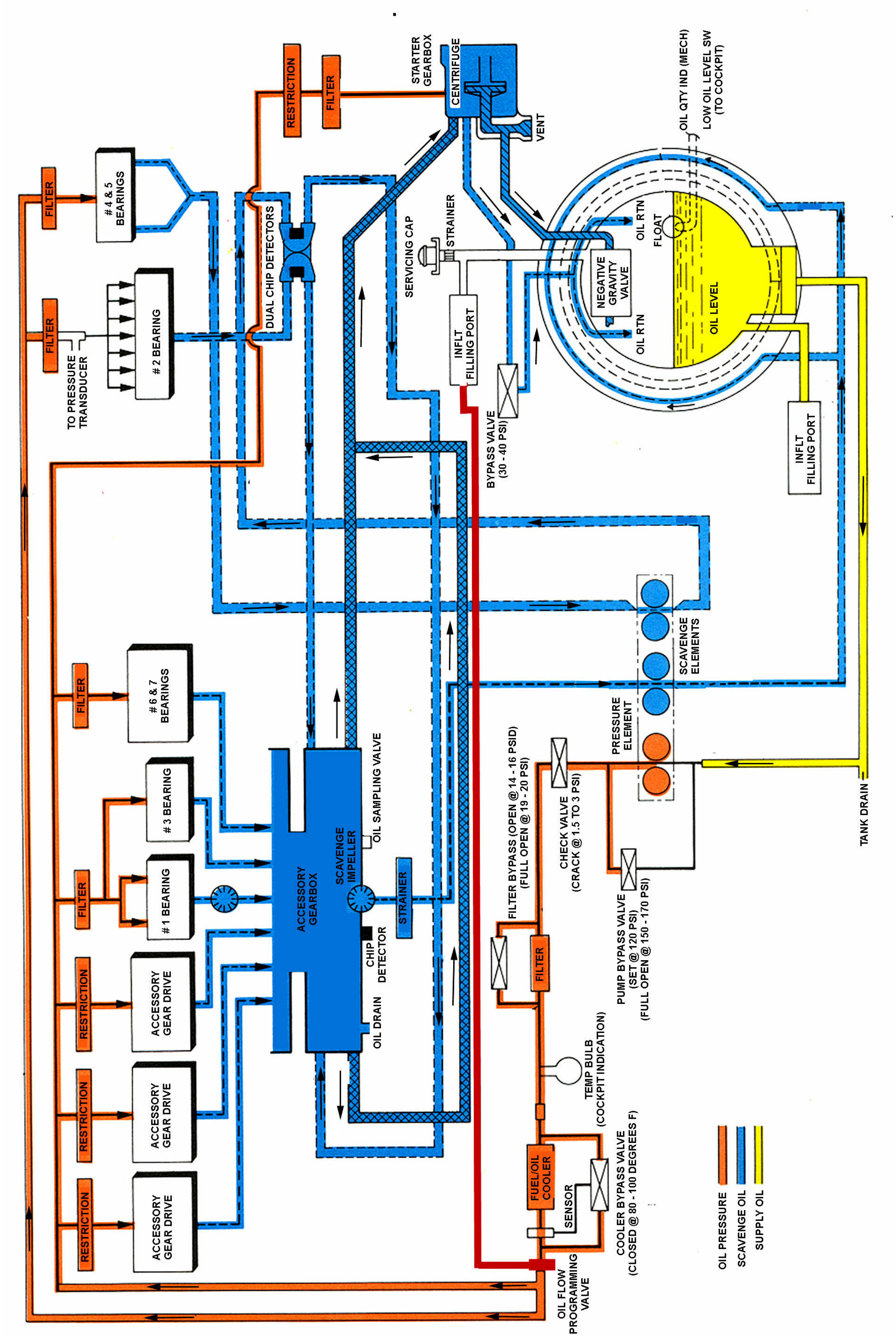
(1) The engine lubrication system is a self-contained system designed to satisfactorily operate throughout the operational envelope, utilizing either MIL-L-23699 or MIL-L-7808 engine oil. The system has been designed to ensure adequate operation in ambient temperatures ranging from -65ºF to 130ºF. The T55-GA-714A lubrication system utilizes many of the same components found on the T55-L-712 engine.

b. OIL PUMP

(1) Mounted on the accessory gearbox. The oil pump contains three separate pump elements. Pressure pump, Main Scavenge pump, Scavenge pump for the No. 4 & 5 bearing cavities. The pressure pump (120 to 160 PSI) with Increased oil flow capability (2000 to 2500 LB/hr) provides oil flow to the engine bearings, starter drive, and accessory gearbox.

(2) An integral, adjustable pressure relief valve regulates pump output pressure between 50 and 90 PSI. Protecting the lubrication system from over-pressurization a pump bypass valve will begin to open at 120 PSI, and will be full open at 150 to 170 PSI. A check valve in combination with the flow-programming valve will provide reduced oil flow at low engine speeds, and trap oil in the engine and oil lines during the coast-down operation.

(3) Mounted on the rear and driven by the oil pump is the GP magnetic speed sensor. The speed sensor provides a gas producer (N1) speed signal to the cockpit N1 indicator. The sensor does not interface with the FADEC system.



STARTER GEARBOX
CENTRIFUGE
VENT
RESTRICTION
FILTER
FILTER
4 & 5 BEARINGS
FILTER
2 BEARING
TO PRESSURE TRANSDUCER
DUAL CHIP DETECTORS
SERVICING CAP
STRAINER
INFLT FILLING PORT
BYPASS VALVE (30 - 40 PSI)
OIL QTY IND (MECH)
LOW OIL LEVEL SW (TO COCKPIT)
OIL RTN
FLOAT
NEGATIVE GRAVITY VALVE
OIL RTN
OIL LEVEL
INFLT FILLING PORT
SCAVENGE ELEMENTS
PRESSURE ELEMENT
TANK DRAIN
FILTER
6 & 7 BEARINGS
3 BEARING
FILTER
1 BEARING
ACCESSORY GEARBOX
SCAVENGE IMPELLER
OIL SAMPLING VALVE
STRAINER
CHIP DETECTOR
OIL DRAIN
RESTRICTION
ACCESSORY GEAR DRIVE
RESTRICTION
ACCESSORY GEAR DRIVE
RESTRICTION
ACCESSORY GEAR DRIVE
FILTER BYPASS (OPEN @ 14 - 16 PSID) (FULL OPEN @ 19 - 20 PSI)
CHECK VALVE (CRACK @ 1.5 TO 3 PSI)
PUMP BYPASS VALVE (SET @ 120 PSI) (FULL OPEN @ 150 - 170 PSI)
FILTER
TEMP BULB (COCKPIT INDICATION)
FUEL/OIL COOLER
SENSOR
COOLER BYPASS VALVE (CLOSED @ 80 - 100 DEGREES F)
OIL FLOW PROGRAMMING VALVE
OIL PRESSURE
SCAVENGE OIL
SUPPLY OIL

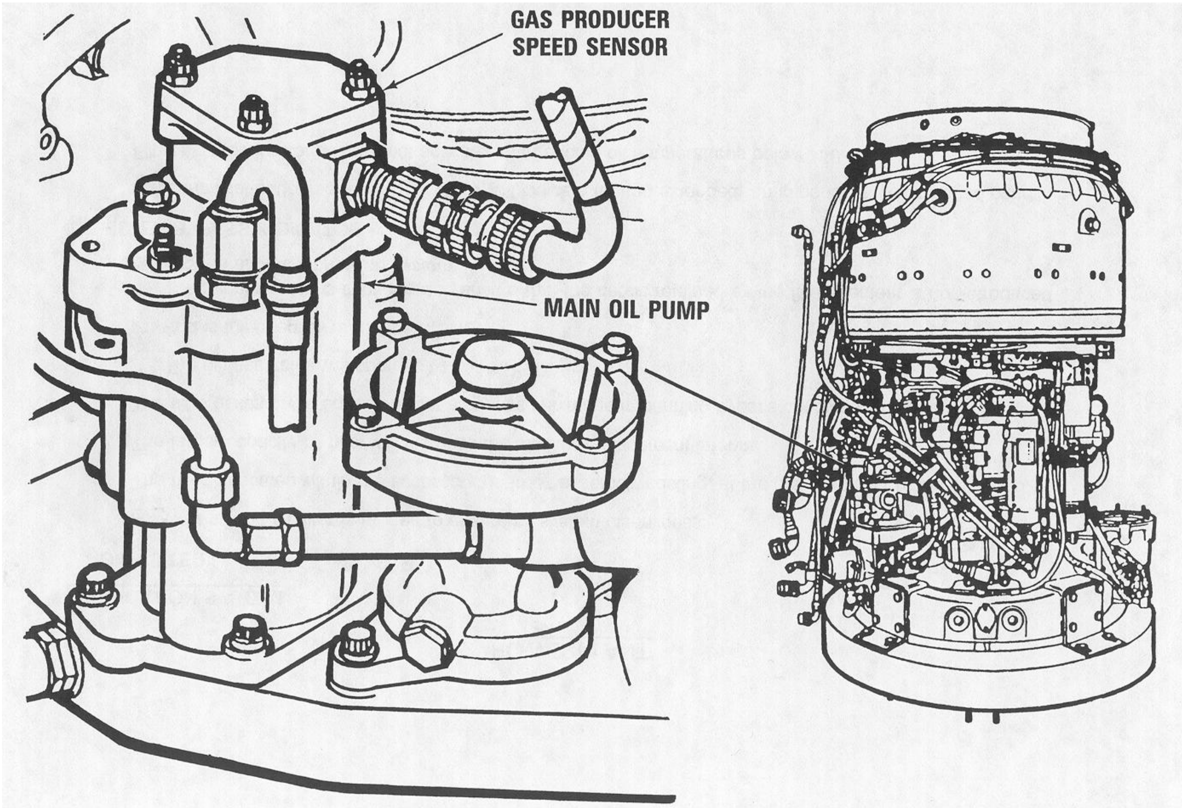
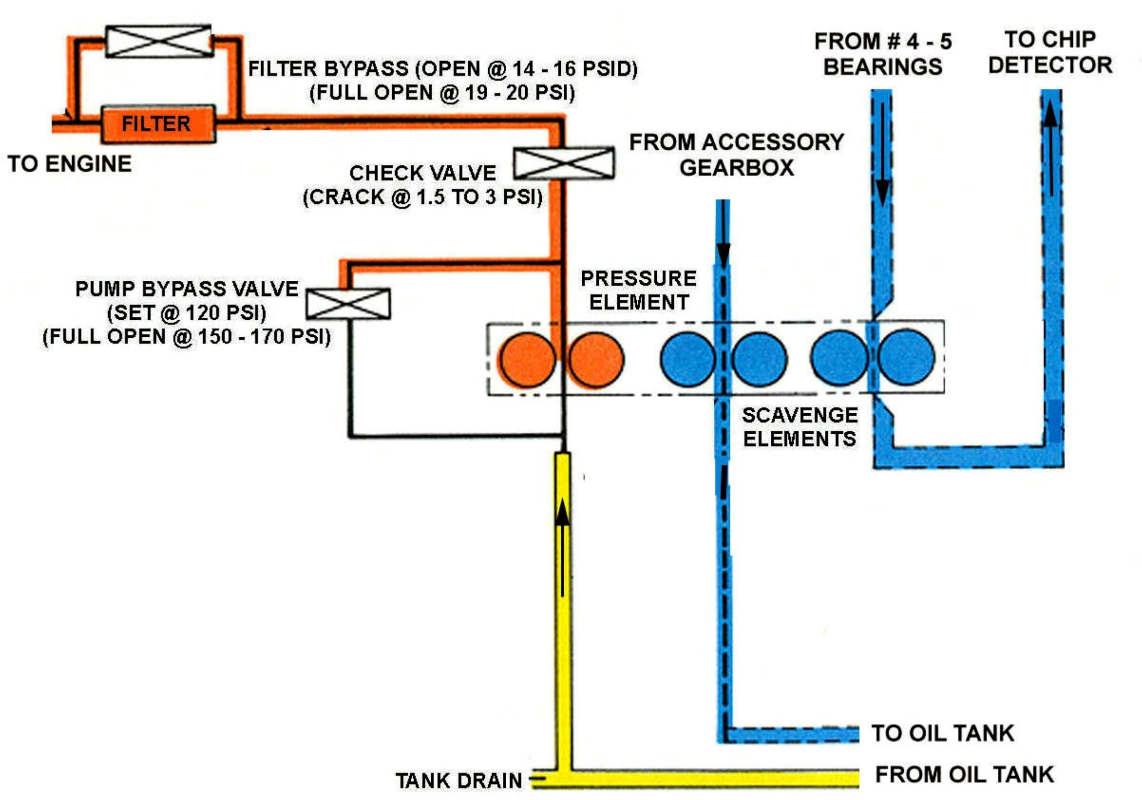


Figure 10 Oil Pump-Gas Producer Speed Sensor (79-A0)



c. OIL FILTER

(1) A seven-micron oil filter is utilized to ensure oil system cleanliness. The filter is located within the accessory gearbox assembly, at the pressure port of the oil pump. The larger capacity oil filter will increase the oil filter replacement interval. The filter assembly is equipped with a bypass valve and impending bypass condition indicator.

(2) The bypass valve will open at 14 to 16 PSID. And is full open at 19 to 21 PSID. The bypass valve is configured to ensure that the debris retained by the filter element is not introduced into the engine lubrication system. A mechanical filter bypass indicator button will extend if filter bypass pressure reaches 9 to 12 PSID indicating (button extended) an impending filter clogged condition. Filter clogged indications are not activated with engine oil temperatures below 150ºF.

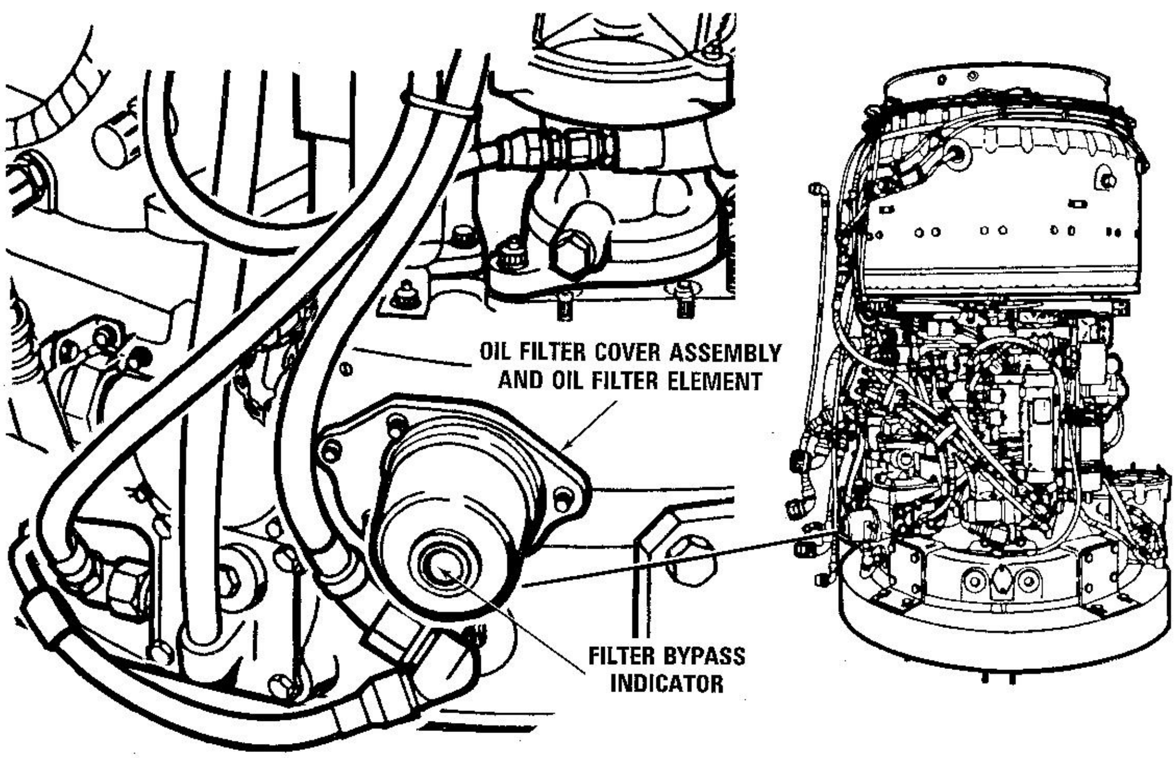


Figure 12 Oil Filter (79-A0)

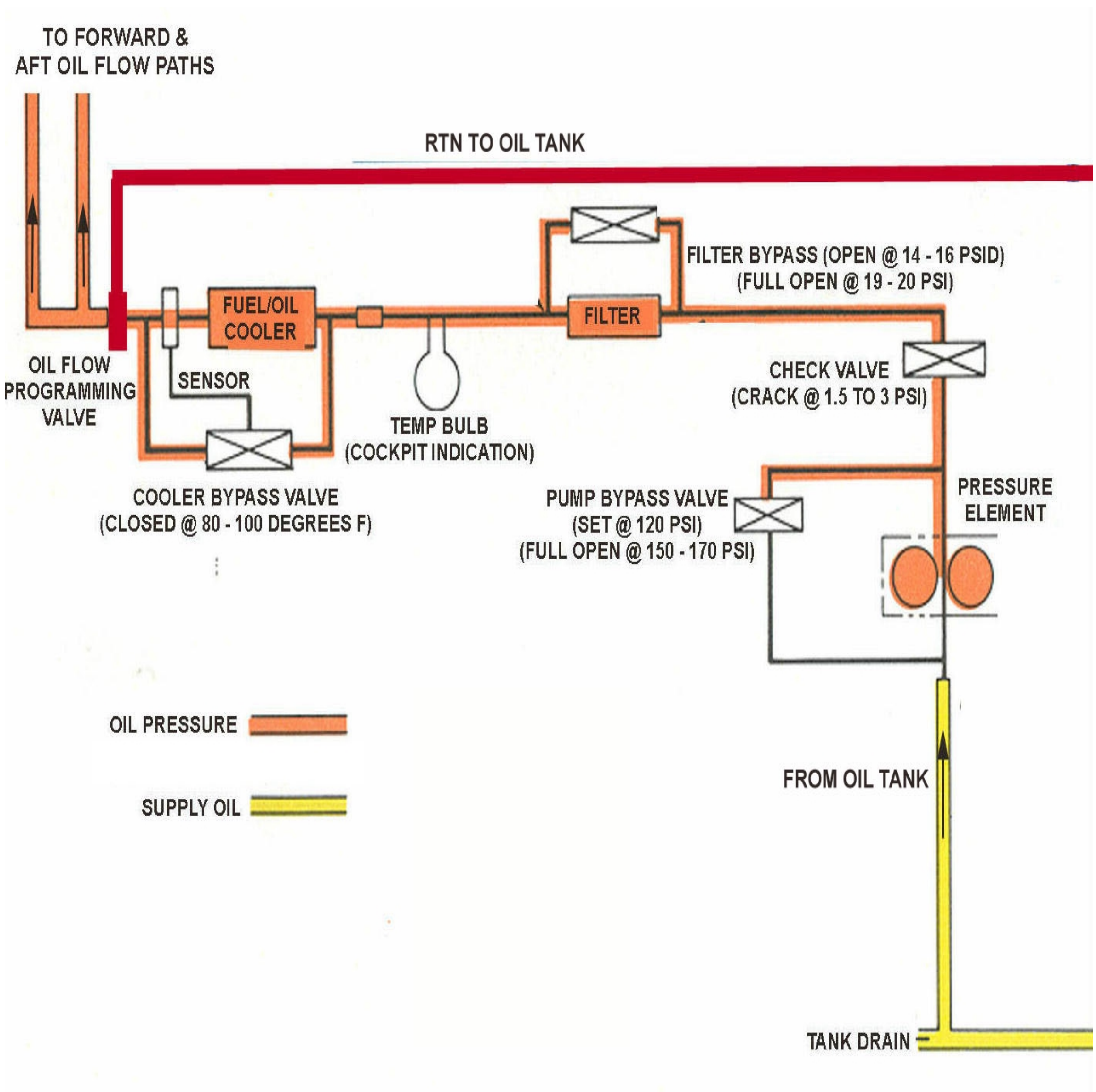


Figure 13 Oil Flow Schematic (Oil pressure Path 2)

d. OIL FLOW PROGRAMMING VALVE

(1) The oil flow-programming valve installed downstream of the oil cooler will prevent oil from choking the bearing cavities at low power settings. At lower engine power settings, the oil pump will provide more oil flow than required by the engine lubrication system. The programming valve will control the oil flow based on engine demand, and bypass excess oil flow back to the engine oil tank.

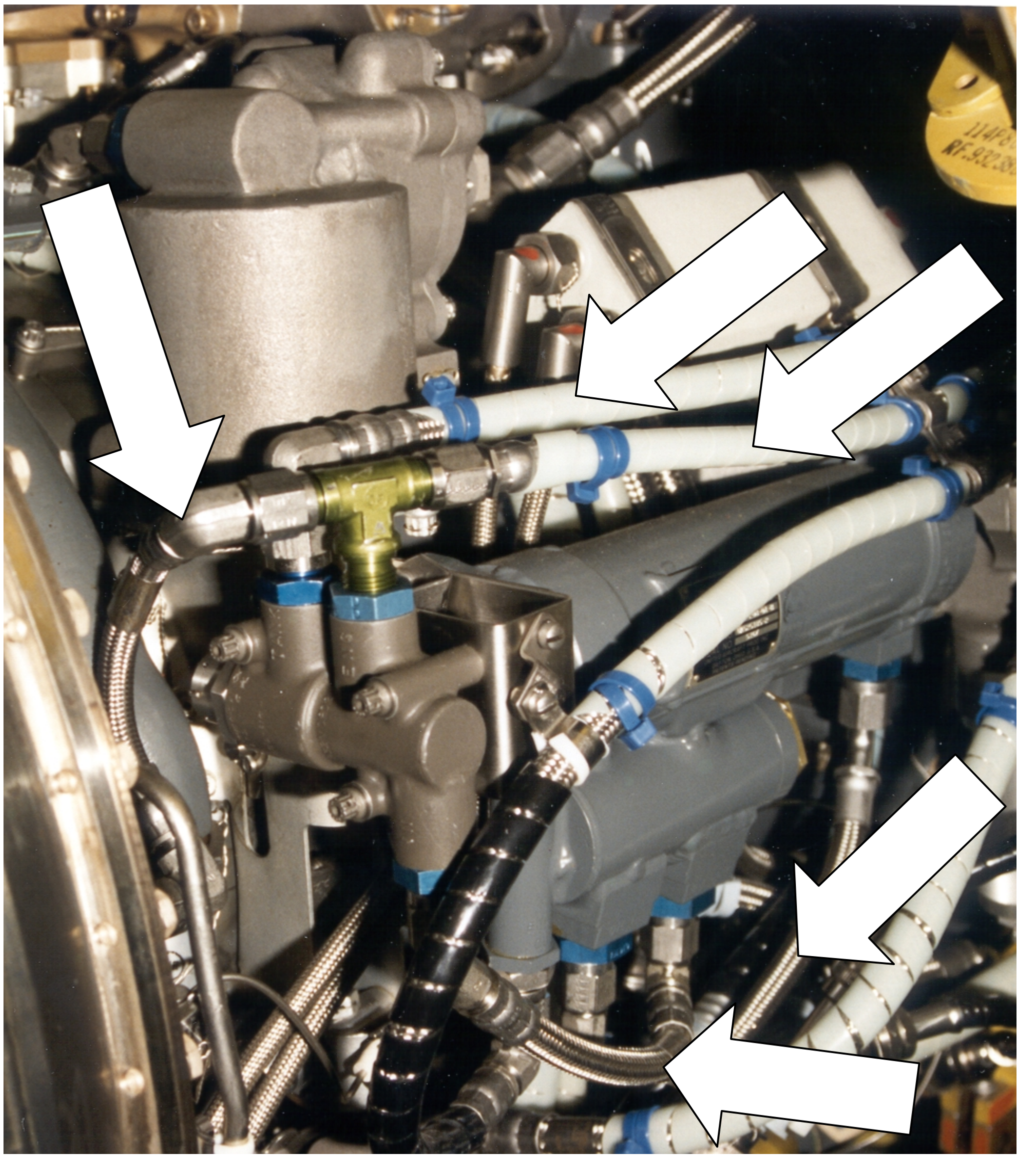


Figure 14 714A Engine RH Side Oil Cooler Area (72-A0)

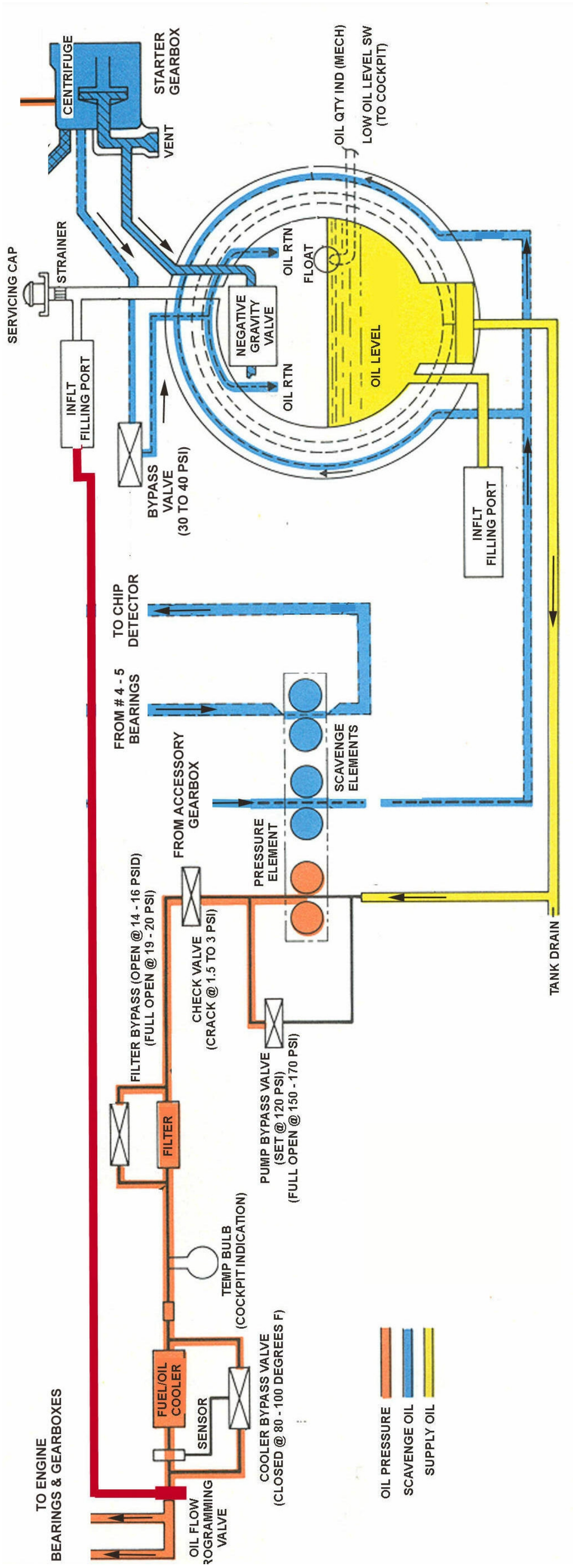


Figure 15 Oil Flow Schematic (Oil Pressure Path)

(1) The engine chip detector is installed in the engine accessory gearbox sump. The system consists of an electrical circuit with the ability to eliminate nuisance chips caused by minute (0.002) metallic particles that collect on the chip detector. The response time of the fuzz burn-off circuit is faster than that of the Caution/Advisory system, and a successful burn-off of the particle(s) will preclude the engine CHIP caution from being displayed. Failure of the fuzz burn-off circuit to eliminate the particle(s) will be indicated by the ENG 1 (2) CHIPS caution being displayed on the caution/advisory panel, and the chip indication displayed on the maintenance panel.

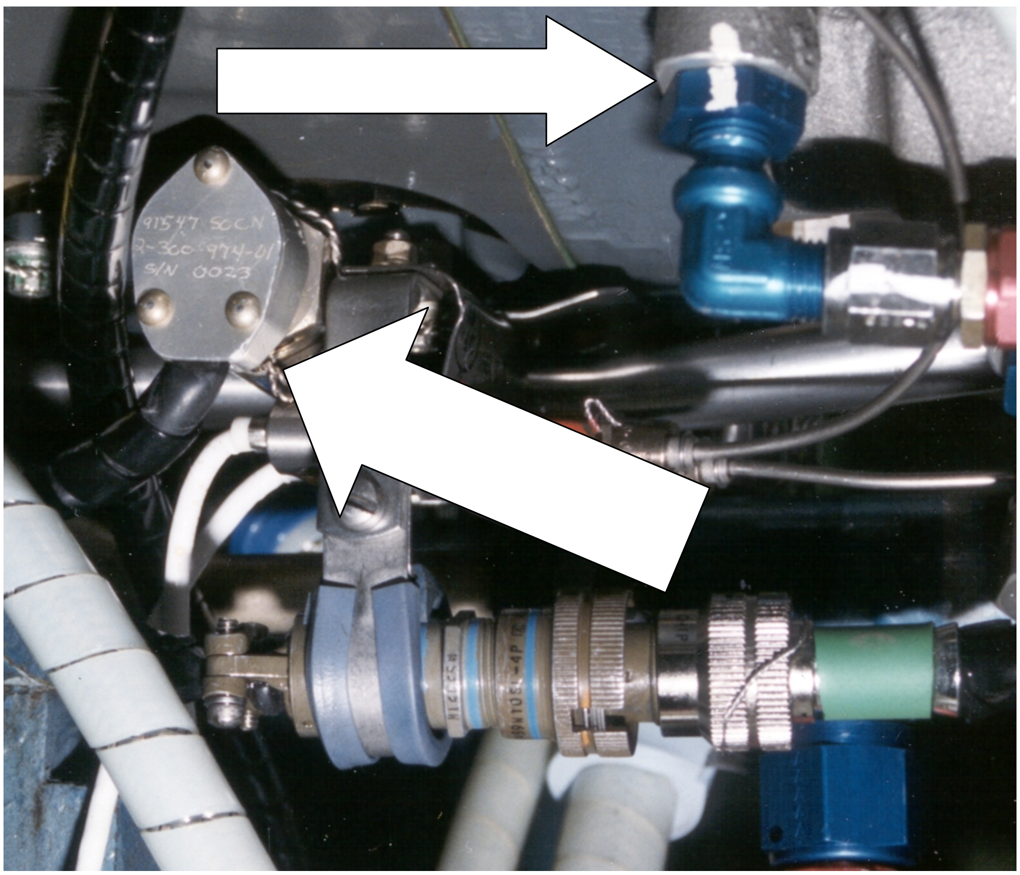


Figure 16 Chip Detector (714A) (72-A0)

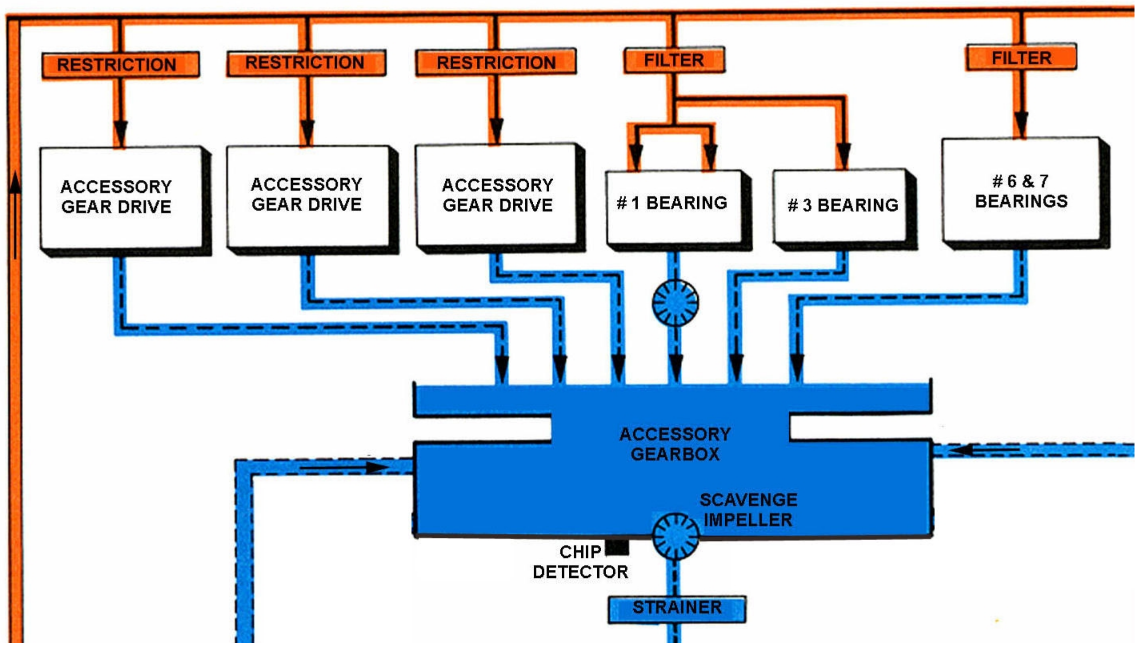


Figure 17 714 Oil Flow Schematic (Forward Oil Path)

a. POWERPLANT FUEL SYSTEM

(1) ENGINE FUEL FLOW DIAGRAM

Modifications to the 714 fuel system include:

(a) Installation of the HMA.

(b) Installation of the overspeed solenoid valve.

(c) Installation of the fuel pressurizing valve.

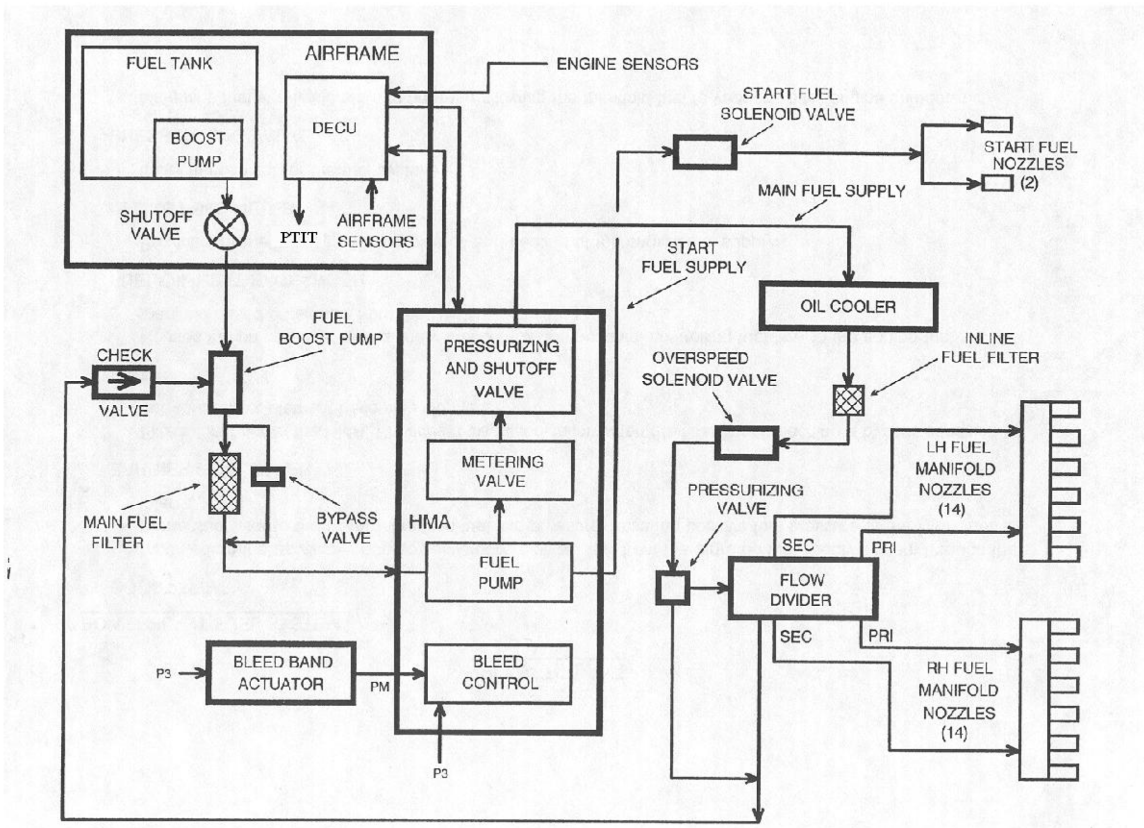


Figure 18 Engine Fuel Flow Diagram (714A) (73-A0)

b. BOOST PUMP

(1) Mounted on the accessory gearbox assembly, the pump delivers fuel from the airframe fuel supply system through the barrier fuel filter to the HMA. Increases fuel line pressure to 35 PSI, ensuring positive fuel pressure at the HMA fuel inlet.

c. BARRIER FUEL FILTER

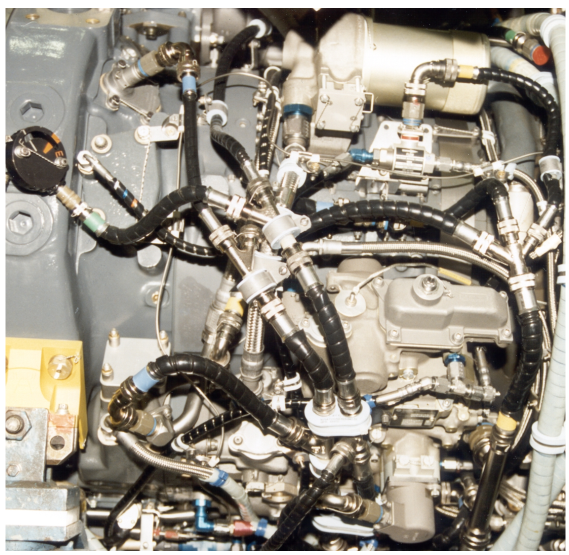
(1) Filters fuel prior to the HMA. Provides a visual indication when the filter is approaching a bypass condition due to the filter element becoming clogged.

d. HYDROMECHANICAL ASSEMBLY (HMA)

(1) Houses the primary and reversionary fuel control components, controlling fuel flow to the engine fuel manifold based on signals from the DECU.

e. START FUEL SOLENOID VALVE

(1) Controls engine fuel flow to the start nozzles during the engine start phase. An engine start switch on the FADEC control Panel (Overhead switch panel) will initiate the start sequence by energizing the start relay. The start fuel solenoid is controlled by the DECU which will energize the solenoid valve, initiating start fuel at the proper time interval after certain engine start conditions have been met (Engine Condition Lever (ECL) in the GND position and at least an N1 speed of 10%).



g. IN-LINE FUEL FILTER

(1) Last chance filter for the fuel system.

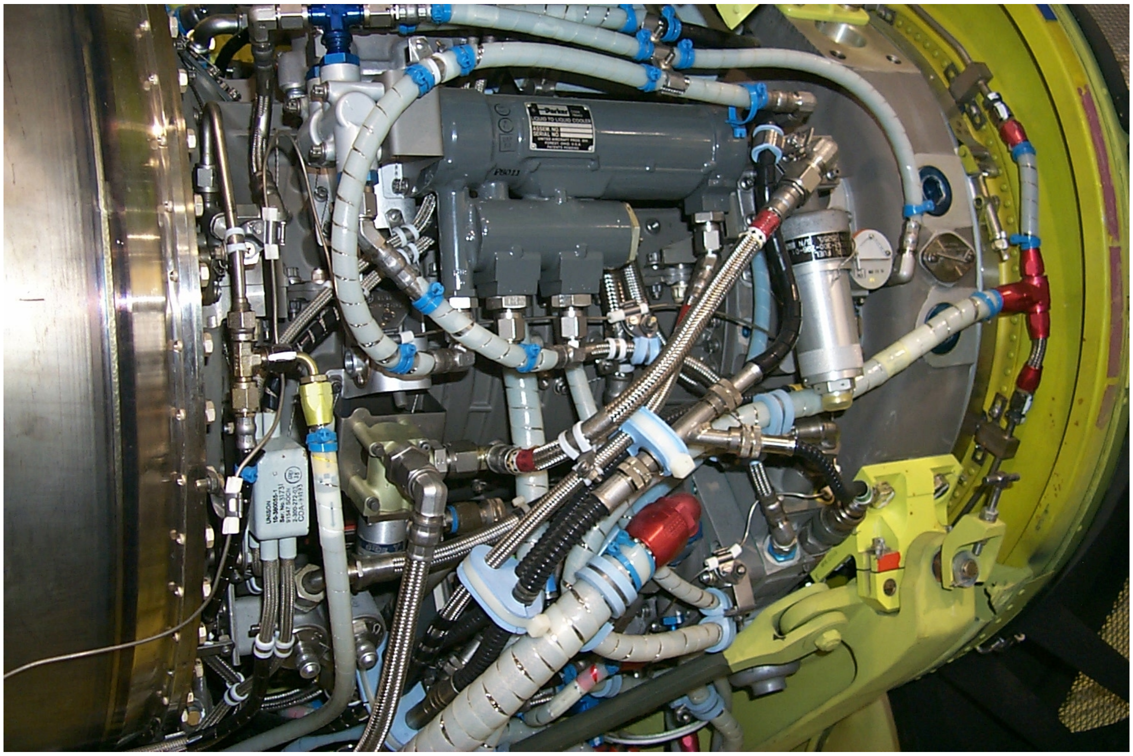


Figure 19 714A Engine Right Side (71-A0

h. PRESSURIZING VALVE

(1) Maintains fuel in a liquid state rather than allowing the manifold fuel to vaporize after engine shutdown.

(2) A fuel-pressuring valve has been added to the engine fuel system to prevent post-shutdown engine fires. The valve installed prior to the fuel flow divider will raise the vapor pressure of the fuel that has passed through the fuel/oil heat exchanger. The fuel will be maintained in a liquid state rather than evaporating and expanding through the fuel nozzle system after engine shutdown.

NOTE: The remainder of the engine fuel system components are the same as found on the T55-L-712

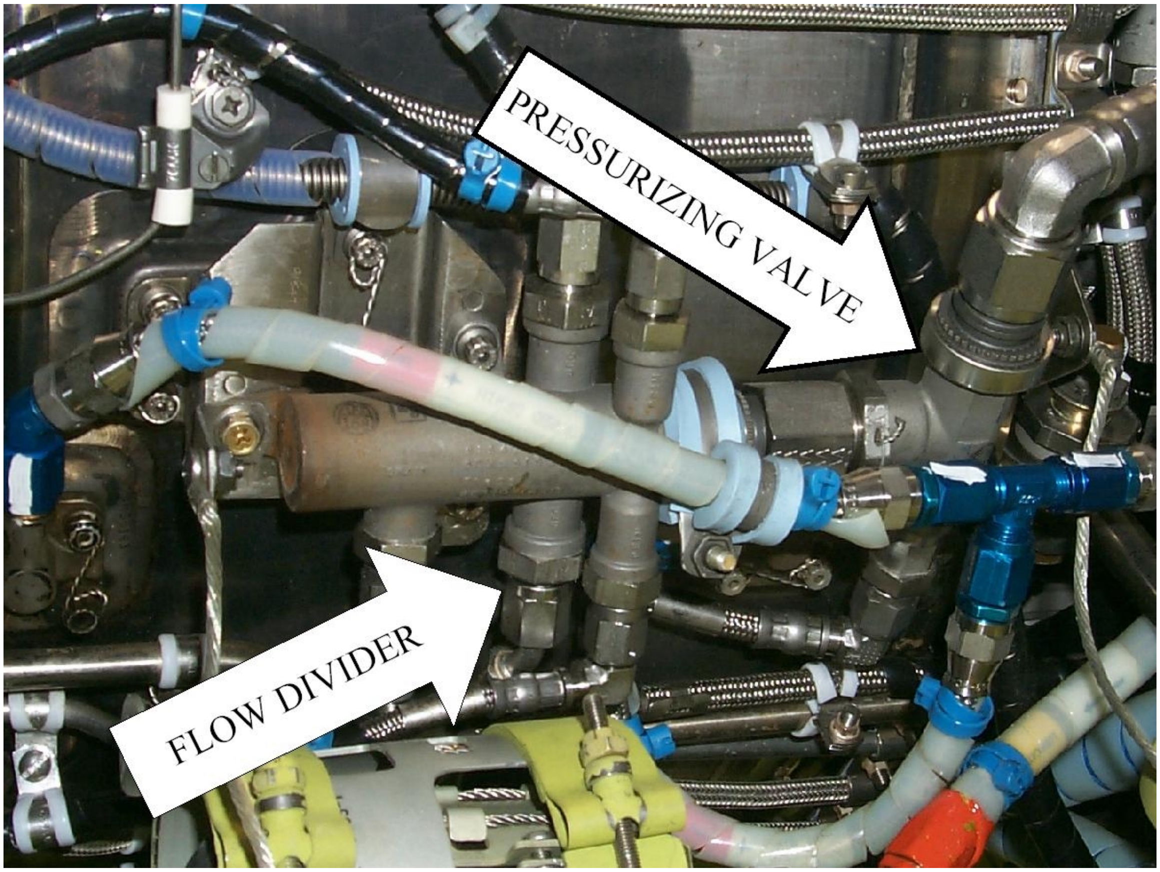


Figure 20 Pressurizing Valve (714A) (72-A0)

a. FULL AUTHORITY DIGITAL ELECTRONIC CONTROL (FADEC)

(1) Includes an airframe mounted DECU and an engine mounted, HMA. The FADEC system utilizes many of the original airframe and T55-L-712 engine sensors. The FADEC system is a three-channel engine control system:

(a) A Primary channel to control engine performance electronically at a superior level as compared to the existing fuel control. The reversionary channel serves as a backup that can take over automatically should the primary channel fail (Hard Fault). The pilot can select the reversionary channel.

(b) Engine overspeed protection is provided by an independent analog overspeed circuit.

(c) The FADEC system includes self-test and self-diagnostics programs which report failure through a hexadecimal display on the face of the DECU.

(2) HMA CONNECTIONS

(a) FUEL IN, FUEL OUT (START), FUEL OUT (METERED).

(b) Primary, Reversionary, and Alternator electrical connectors.

(c) P3 pressure connection to the HMA and to the DECU,

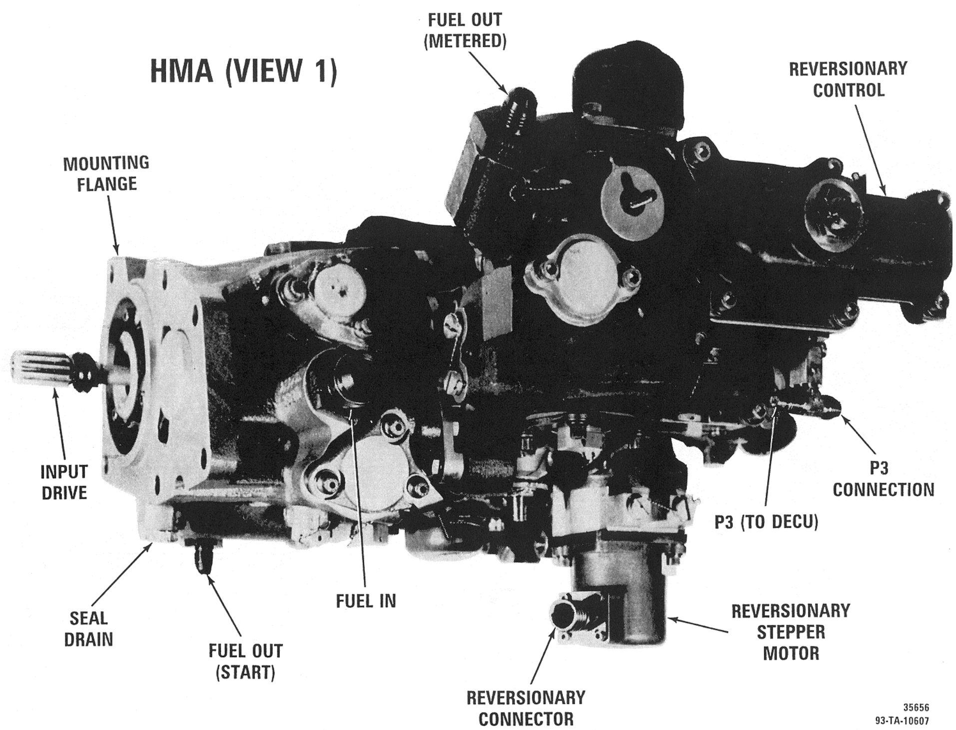


Figure 21 HMU View 1 (73-A0)

HMA VIEW 2 (Rear of unit)

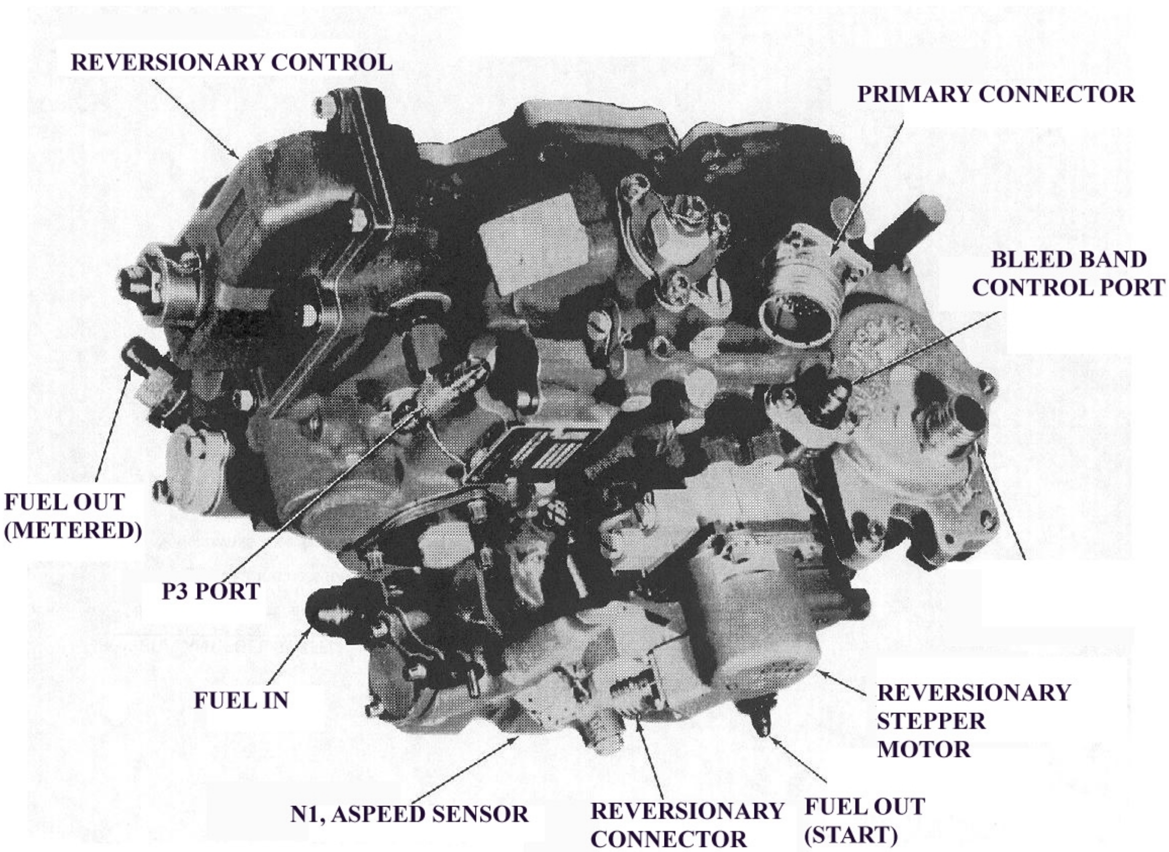


Figure 22 HMU View 2 (73-A0)

HMA VIEW 3 (Right side of unit)
Long bolt for the right forward mounting stud.
Not shown is a second seal drain for the Hydromechanical Metering Unit (HMU).

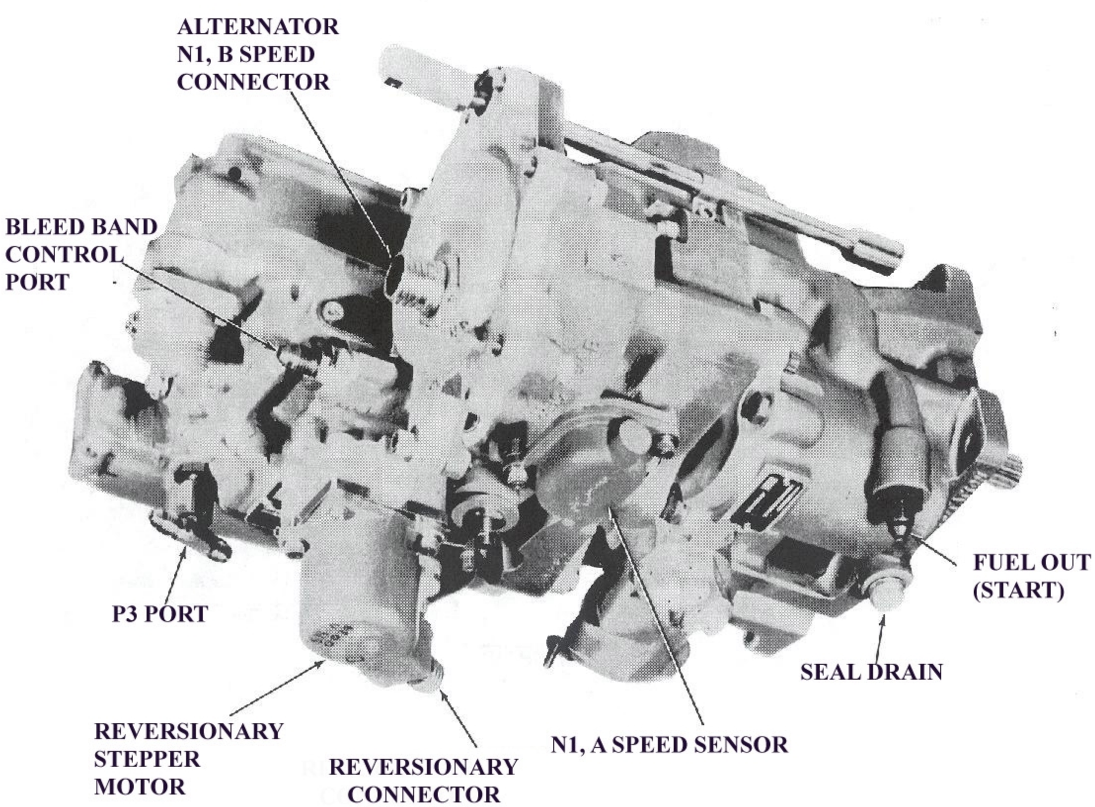
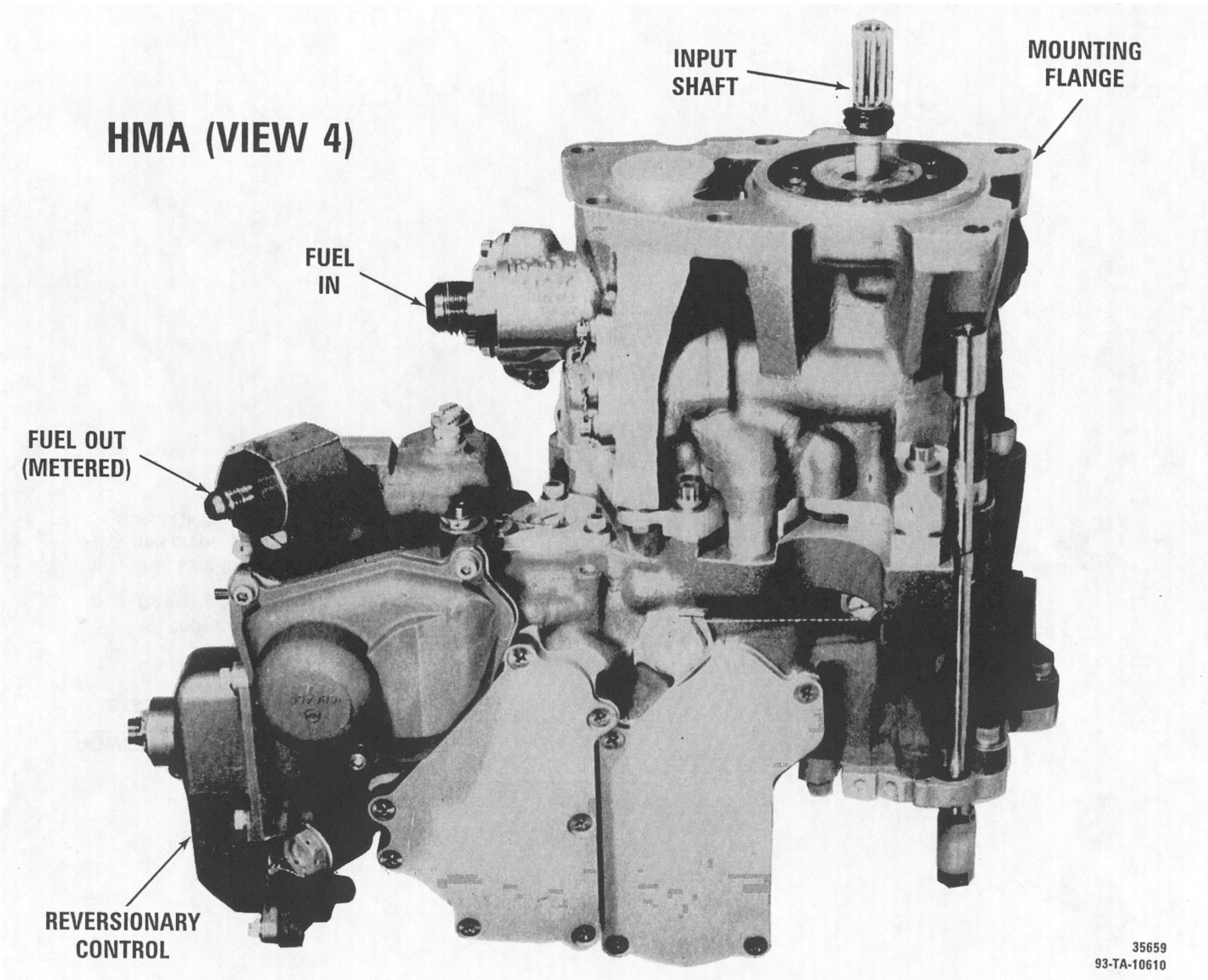


Figure 23 HMU View 3 (73-A0)

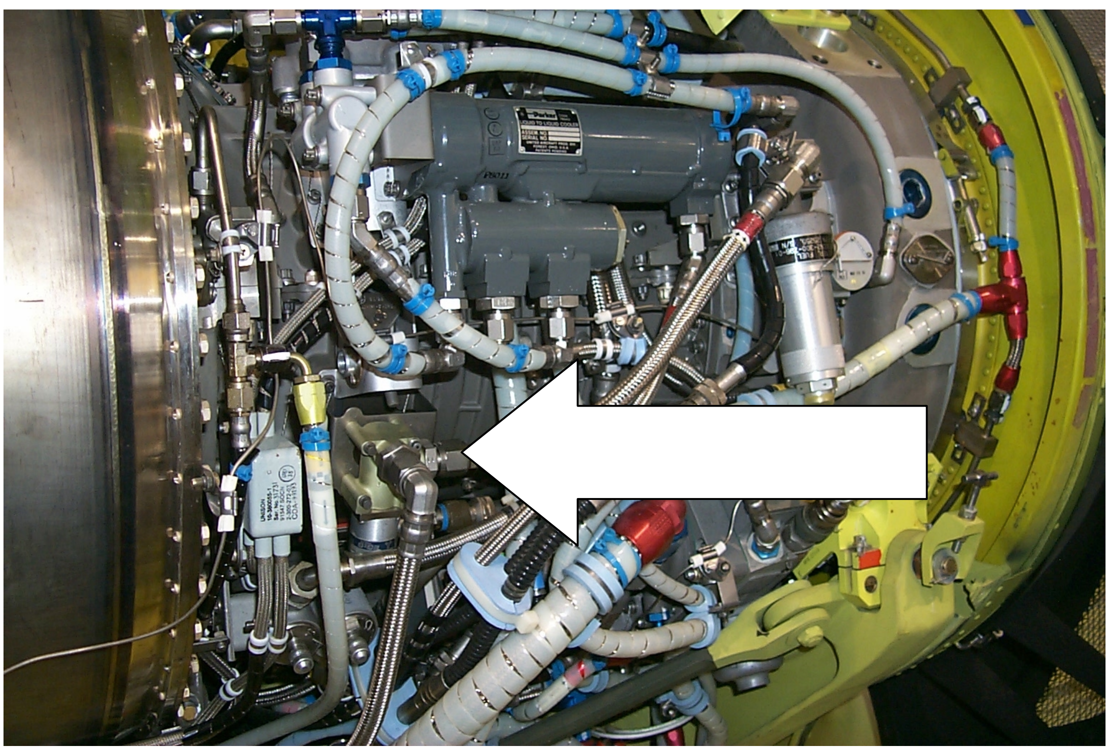
HMA VIEW 3 (Right side of unit)
Long bolt for the right forward mounting stud.
Not shown is a second seal drain for the Hydromechanical Metering Unit (HMU).



b. Figure 24 HMU View 4 (73-A0)OVERSPEED SOLENOID VALVE

(1) Engine over speed protection is provided through the incorporation of an independent, FADEC controlled, over speed solenoid valve. A dual coil/duel pick-up magnetic speed sensor is mounted on the accessory gearbox. The unit senses the speed of the power turbine, providing the FADEC system with redundant power turbine speed signals (two N2, A signals and two N2, B signals).

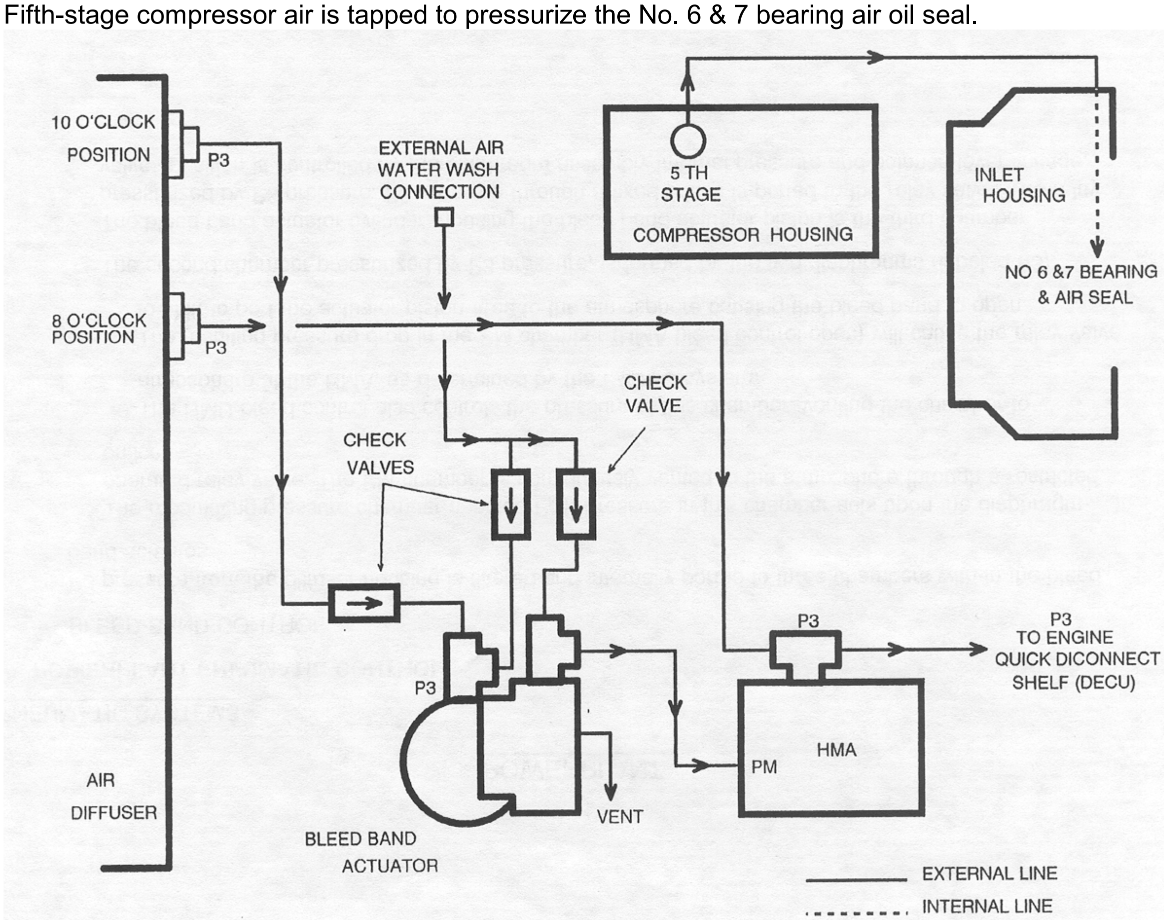
(2) With both a N2, A and N2, B signal indicating an engine over speed, and the other engine currently NOT experiencing an over speed, the FADEC system will energize the over speed solenoid valve, reducing engine fuel flow, eliminating the over speed condition. The over speed valve will remain energized as long as the over speed conditions are present. Once the over speed condition is below the engine over speed value the over speed valve will return to a full fuel flow condition. An over speed system test is conducted with the FADEC system Over speed test switch at predetermined time intervals or after engine fuel system maintenance has been performed.



a. POWERPLANT PNEUMATIC CONTROL

(1) The engine bleed band and bleed band actuator is the same as those installed on the 712 engine. As on the 712, the system is designed to ensure stable engine operation during low speed and transient operations. Check valves have been incorporated in the bleed actuator control lines to protect the engine bleed system during the water wash procedure.

Fifth-stage compressor air is tapped to pressurize the No. 6 & 7 bearing air oil seal.



b. BLEED BAND OPERATION

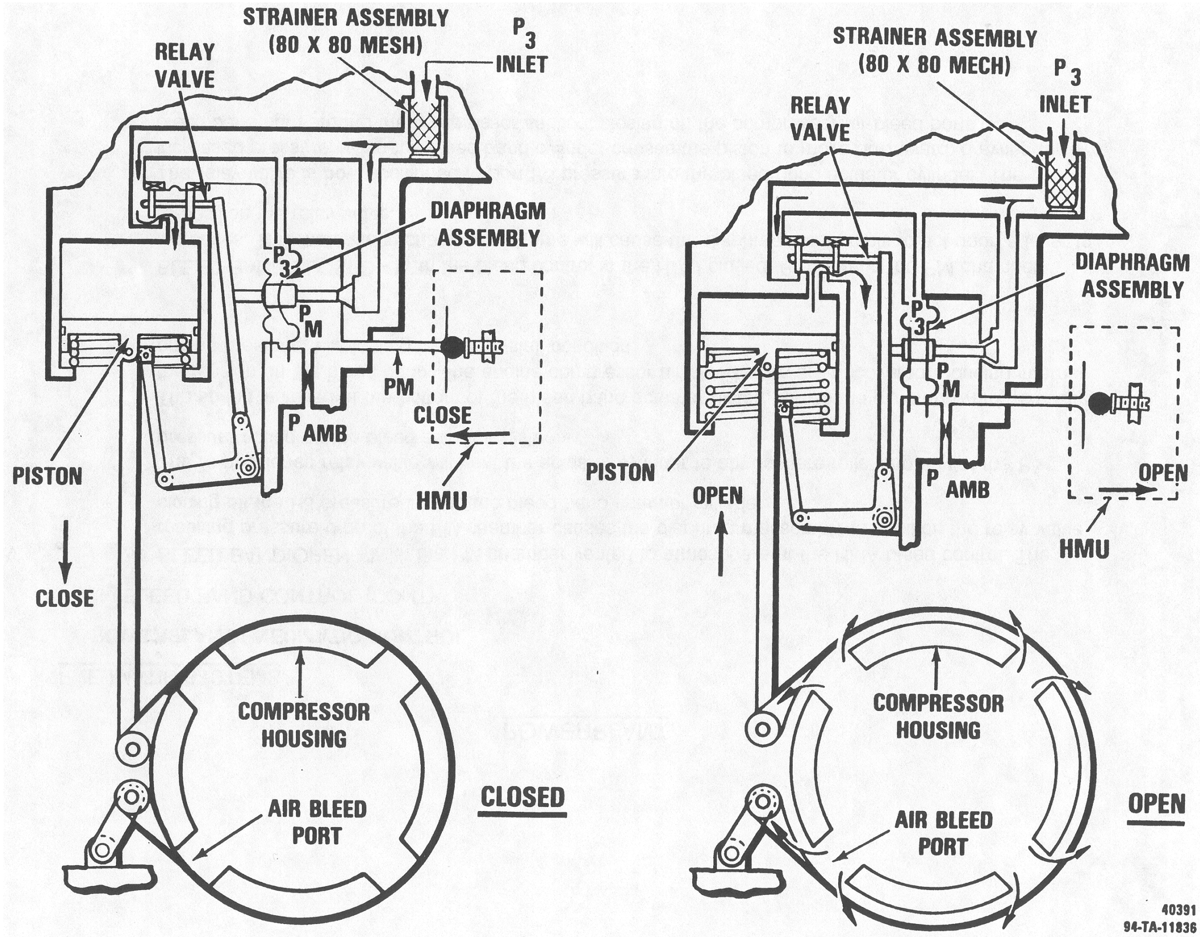
(1) Compressor Discharge Pressure (CDP) (P3) for the operation and control of the bleed band actuator is the tapped off the diffuser at the 10 o'clock position and enters the interstage airbleed actuator assembly through a check valve and filter. From the 8 o'clock position tap on the diffuser housing, CDP (P3) pressure is tapped off for HMA functions. A tee fitting on the HMA provides CDP (P3) pressure to the DECU for the calculation of engine fuel flow. Relieving PM pressure at the

HMA controls the bleed band actuator operations.

(a) BLEED BAND CONTROL - P3 pressure from the diffuser housing is filtered and internally ported to three chambers within the bleed band actuator. The modulating pressure chamber (labeled PM). Pressure in this chamber acts upon the diaphragm-operated relay valve. The PM chamber is continuously vented to the atmosphere through a restricted orifice. The HMU bleed control also controls the pressure of this chamber, venting the chamber to atmosphere at the HMA, when required as determined by the FADEC system. The resulting pressure drop in the PM chamber (HMA bleed control open) will cause the relay valve to shift to port the actuator piston area to the atmosphere causing the bleed band to open. The two diaphragms (labeled P3) form the second chamber pressurized by P3 pressure. The bleed band actuator cylinder, housing the bleed band actuator piston is the third chamber pressurized by P3 pressure. P3 pressure through a fixed orifice is ported to the relay valve. The relay valves position is controlled by the diaphragm assembly internal pressure and balance lever linkage.

(b) BLEED BAND OPEN - With the PM chamber vented to atmosphere at the HMA bleed control. The resulting pressure drop of the PM chamber causes the diaphragm assembly to position the relay valve, closing off the P3 pressure inlet to the bleed band actuator cylinder. The re-positioned relay valve will vent the actuator cylinder to atmosphere relieving any of the P3 pressure acting on the bleed actuator piston. The spring installed at the bottom of the bleed band actuator piston forces the piston upward, releasing the tension on the bleed band. The engine compressor air bleed ports are uncovered reducing internal engine pressures, eliminating the surge/stall condition.

(c) BLEED BAND CLOSED - With the bleed control in the HMU closed, Pressure in the PM chamber increases. This increase in chamber pressure will cause the diaphragm assembly to act upon a lever to re-position the relay valve. The relay valve is now positioned to port P3 pressure into the bleed band actuator cylinder. The increased pressure within the bleed band cylinder causes the piston to move downward, drawing the bleed band tight around the compressor section, closings off the compressor air bleed ports.



STRAINER ASSEMBLY
(80 X 80 MESH)
P3
INLET
RELAY
VALVE
DIAPHRAGM
ASSEMBLY
P3
PM
PM
P AMB
CLOSE
HMU
PISTON
CLOSE
COMPRESSOR
HOUSING
AIR BLEED
PORT
CLOSED
STRAINER ASSEMBLY
(80 X 80 MECH)
P3
INLET
RELAY
VALVE
DIAPHRAGM
ASSEMBLY
P3
PM
P AMB
OPEN
HMU
PISTON
OPEN
COMPRESSOR
HOUSING
AIR BLEED
PORT
OPEN
40391
94-TA-11836

(2) ENGINE WATER WASH SYSTEM

(a) Each engine of the helicopter is equipped with an installed engine wash system. Pneumatic and water connections are externally mounted behind each engine work platform.

(b) A series of spray nozzles are installed at the engine inlet. An airline is routed to the bleed band actuator for the purpose of closing the engine bleed band during the engine wash process.

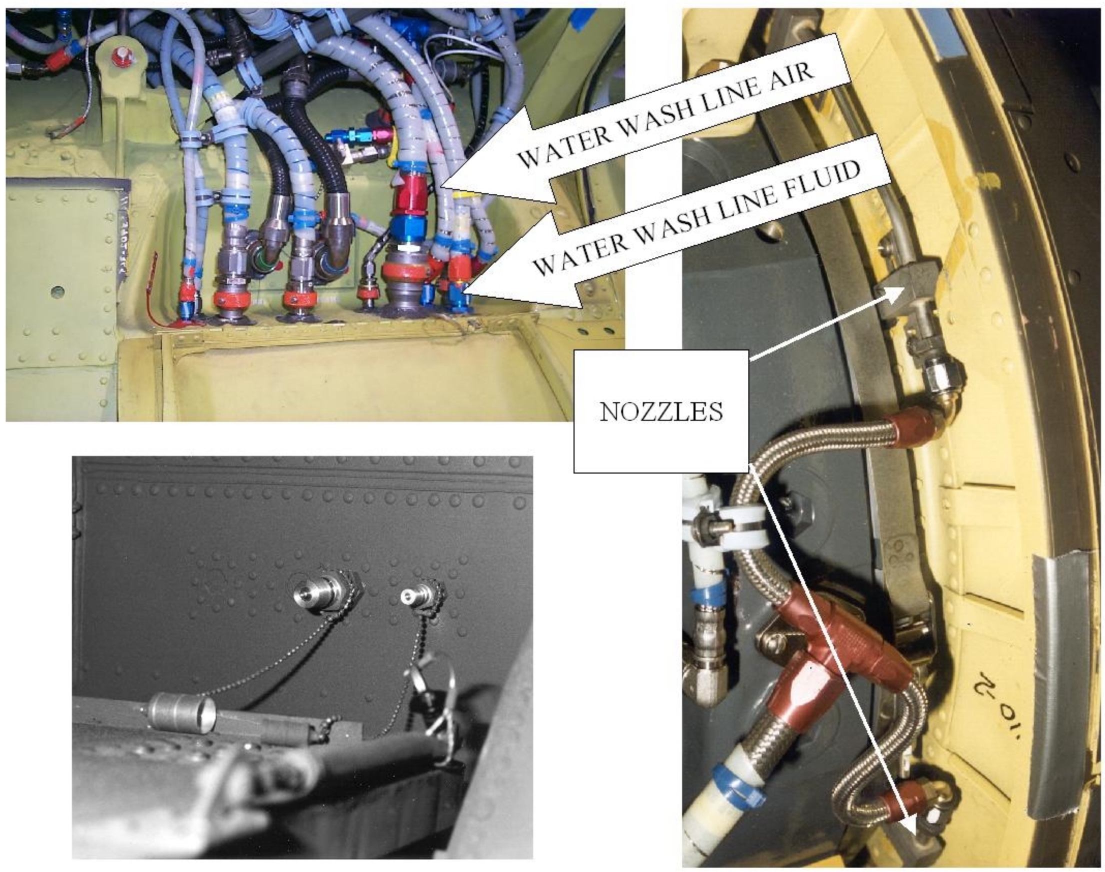
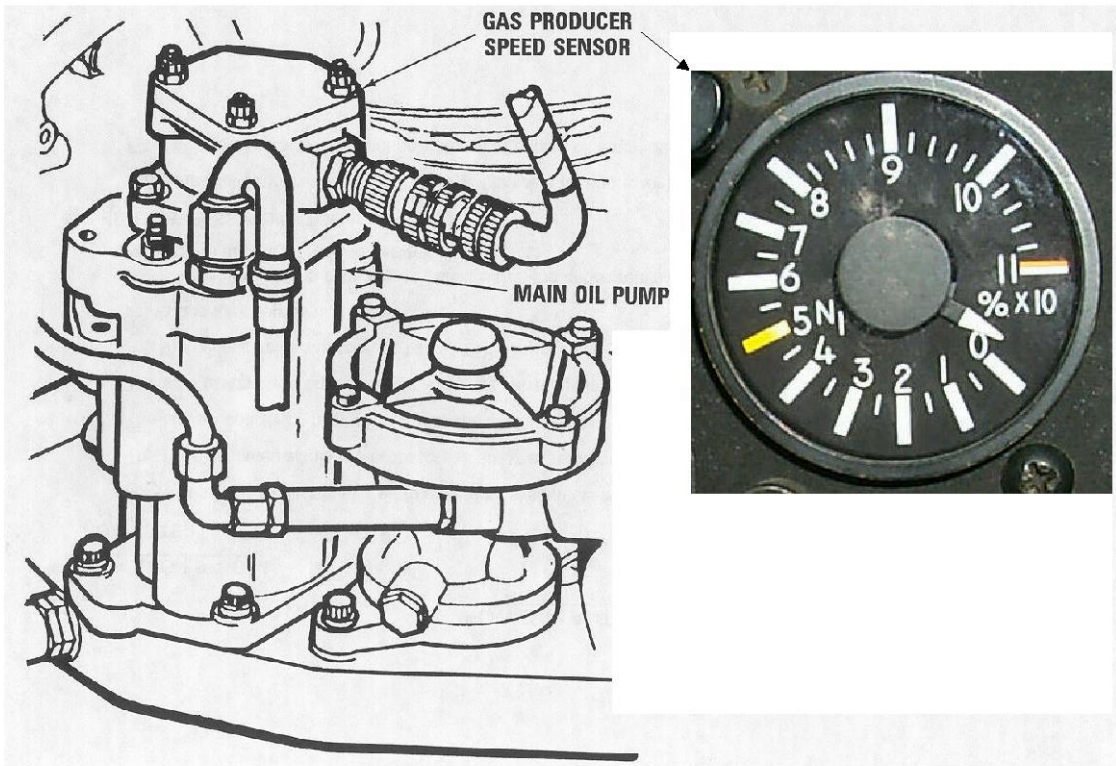


Figure 25 Engine Wash (71-A0)

a. N1 INDICATION

(1) The N1 Indication system as modified by ECP d 218 incorporates a modified N1 RPM indicator. The GP speed signal is now provided by the N1 magnetic pickup on the rear of the engine mounted oil pump.



b. PTIT INDICATION

(1) On aircraft modified with the FADEC system the Power Turbine Inlet Temperature (PTIT) is first provided to the DECU than is forwarded to the cockpit indicator.

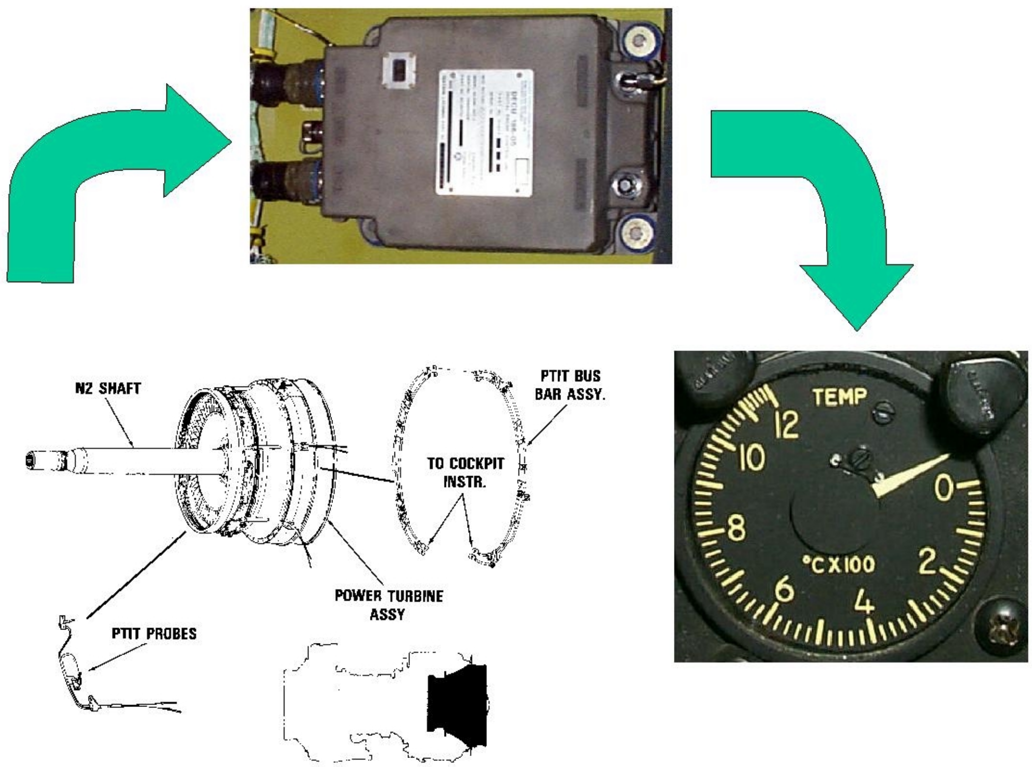


Figure 26 PTIT System (72-A0)

c. TORQUE INDICATION

(1) The four components that make up the Improved Magnostrictive Torquemeter (IMT) system are the torquemeter head assembly, Junction Box, Engine Torque Signal Processor and the torque indicators. The torquemeter head assembly encircles the power output shaft sleeve, which is an internal component of the engine. The torquemeter head is the transformer containing both primary and secondary coils. The junction box converts the output of the secondary coils of the torquemeter head to direct current and provides the electrical signal for operation of an aircraft mounted torque indicator. The engine torque signal processor is an airframe mounted unit consisting of an inverter, a signal conditioner and a power supply. It provides alternating current to the primary coils of the torquemeter head, receives direct current signals from the junction box, and provides output signals proportional to engine torque to the DECU and cockpit engine torque indicators. The prior system required the engine mounted components to be replaced as a set. The IMT system allows for the individual replacement of these components.
A line test set will evaluate system operation and permit making system adjustments. The line test supports the individual replacement of the engine-mounted components.

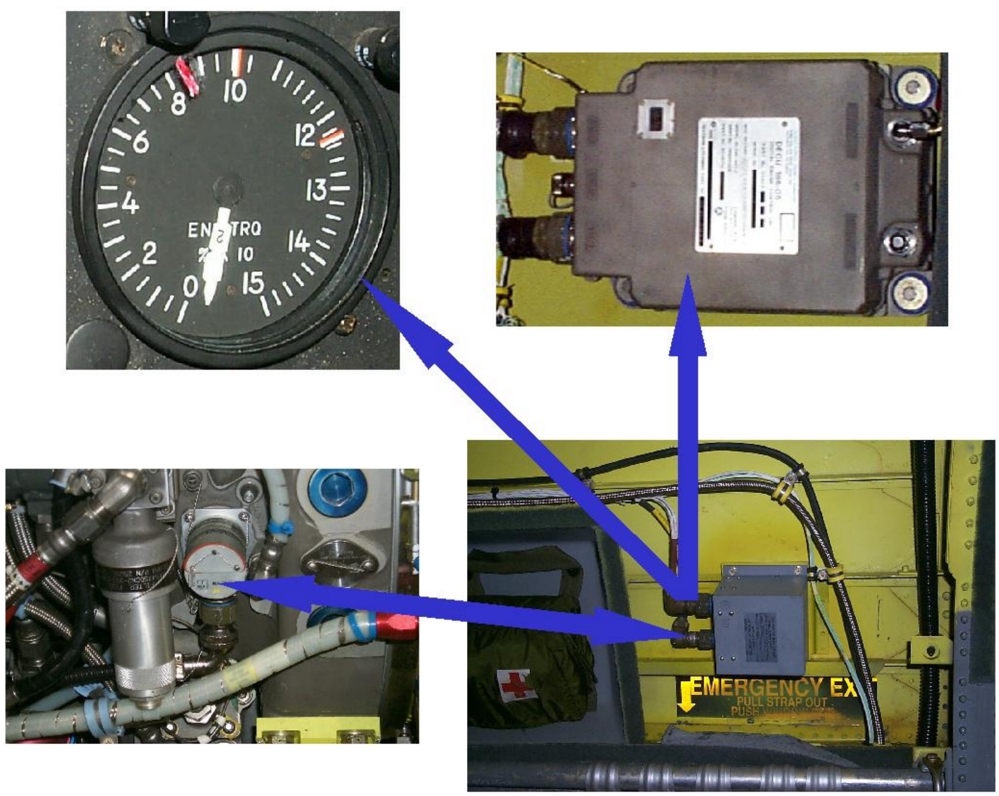


Figure 27 IMT Torque System (72-A0)

d. ENGINE OIL PRESSURE

(1) Unlike the oil pressure normally seen with the 712 powerplant the oil pressure for the 714 will vary with gas producer speed due the installation of the oil flow programming valve.

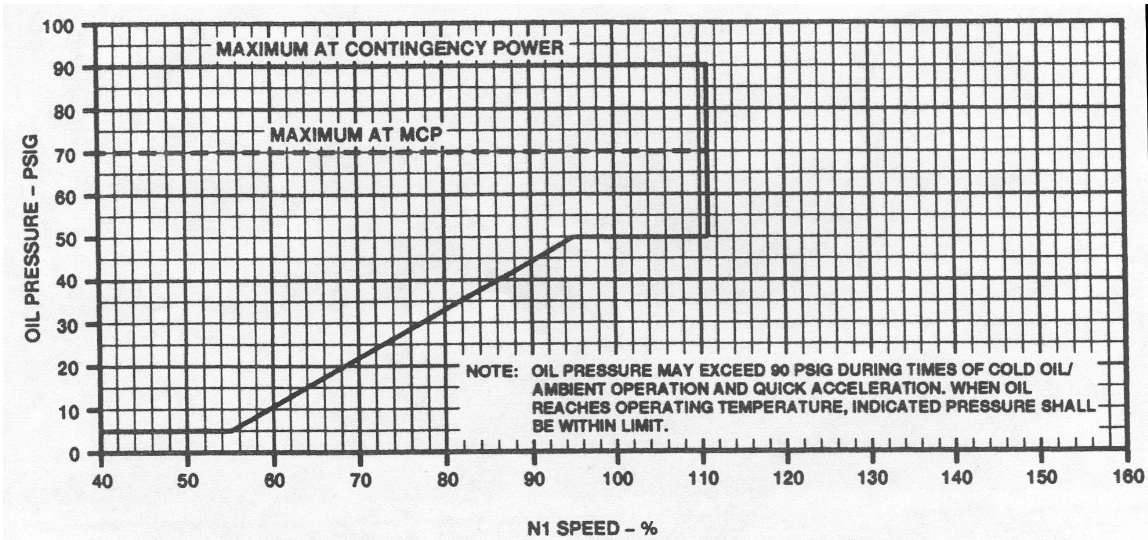


Figure 28 Engine Oil Pressure (72-A0)

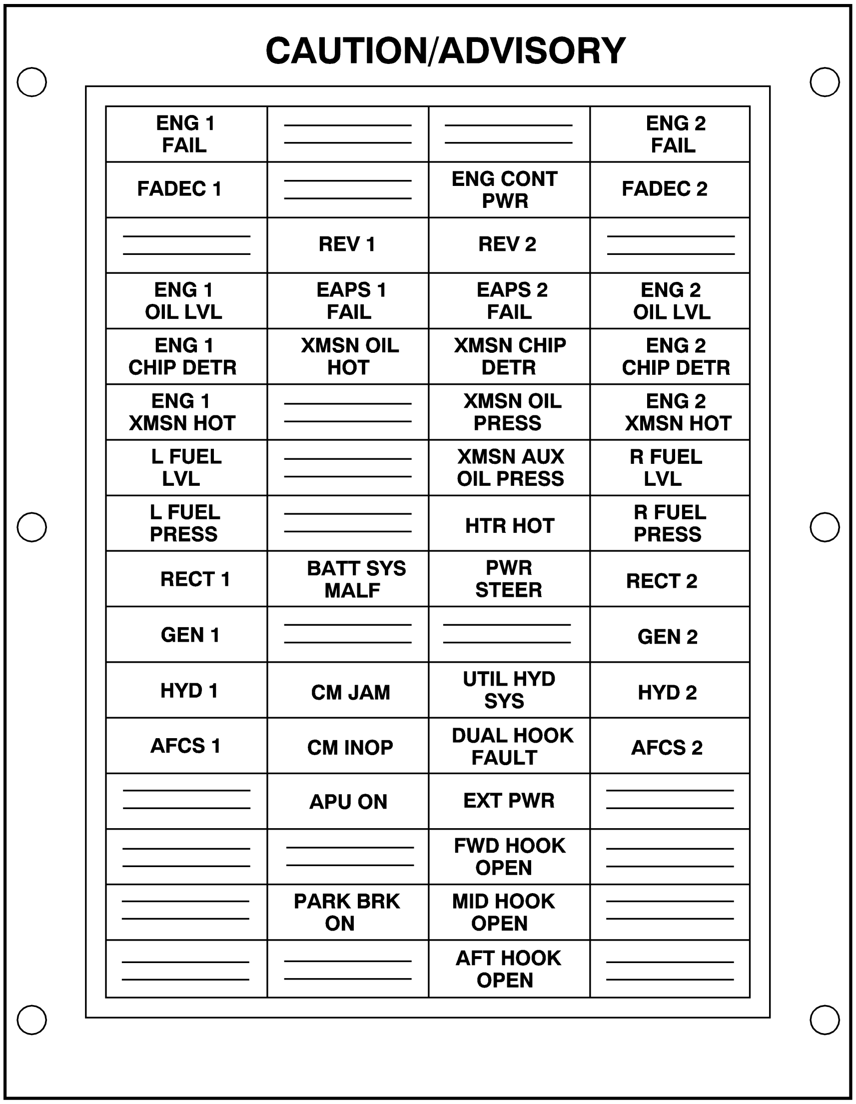
e. CAUTION/ADVISORY PANEL

(1) ENGINE 1 (2) FAIL Power turbine shaft failure, N1 Underspeed, Flameout. Overtemperature during start, start abort, or Primary/Reversionary hard fault (freeze) in primary mode (only).

(2) FADEC 1 (2) No.1 (2) PRI System Hard Fault or if REV selected (pilot action).

(3) REV 1 (2) No.1 (2) REV System Hard Fault.

(4) ENG CONT PWR PTIT is within contingency power range.


CAUTION/ADVISORY
ENG 1 FAIL
ENG 2 FAIL
FADEC 1
ENG CONT PWR
FADEC 2
REV 1
REV 2
ENG 1 OIL LVL
EAPS 1 FAIL
EAPS 2 FAIL
ENG 2 OIL LVL
ENG 1 CHIP DETR
XMSN OIL HOT
XMSN CHIP DETR
ENG 2 CHIP DETR
ENG 1 XMSN HOT
XMSN OIL PRESS
ENG 2 XMSN HOT
L FUEL LVL
XMSN AUX OIL PRESS
R FUEL LVL
L FUEL PRESS
HTR HOT
R FUEL PRESS
RECT 1
BATT SYS MALF
PWR STEER
RECT 2
GEN 1
GEN 2
HYD 1
CM JAM
UTIL HYD SYS
HYD 2
AFCS 1
CM INOP
DUAL HOOK FAULT
AFCS 2
APU ON
EXT PWR
FWD HOOK OPEN
PARK BRK ON
MID HOOK OPEN
AFT HOOK OPEN

A65142

FADEC CONTROL SYSTEM

a. PURPOSE

(1) The Full Authority Digital Electronic Control (FADEC) system replaces the hydromechanical engine control system. The practical limit to the level of complexity for this control system as to installation, weight, accuracy, and more importantly, the ability to implement complex control functions had been reached by the existing fuel control system.

b. SYSTEM DESCRIPTION

(1) The FADEC system is designated model EMC-32T-1 or –2
The primary components of the FADEC system are the Digital Electronic Control Unit (DECU) and Hydromechanical Metering Assembly (HMA).

(2) The DECU includes a microcomputer-based primary control channel with an independent microcomputer-based electronic reversionary back-up channel.

(3) Engine overspeed protection is provided for by an independent analog overspeed limiter should both the primary and reversionary channels fail to control engine speed.

(4) Multi-engine helicopters utilizing hydromechanical control systems, can encounter the following conditions:

(a) Marginal starting during hot restarts and cold temperature operations.

(b) Slow engine acceleration rates.

(c) Compressor stalls or surges.

(d) Mismatching of engine torque under heavy load conditions.

(e) Rotor speed droop during transient maneuvers.

(f) Lack of safety features or mode failure protection.

(g) Lack of built-in test or self-diagnostics.

(h) Inability to record engine faults, history, and limit exceedence values.

(i) High pilot and maintenance workload.

(j) Require a large spares inventory.

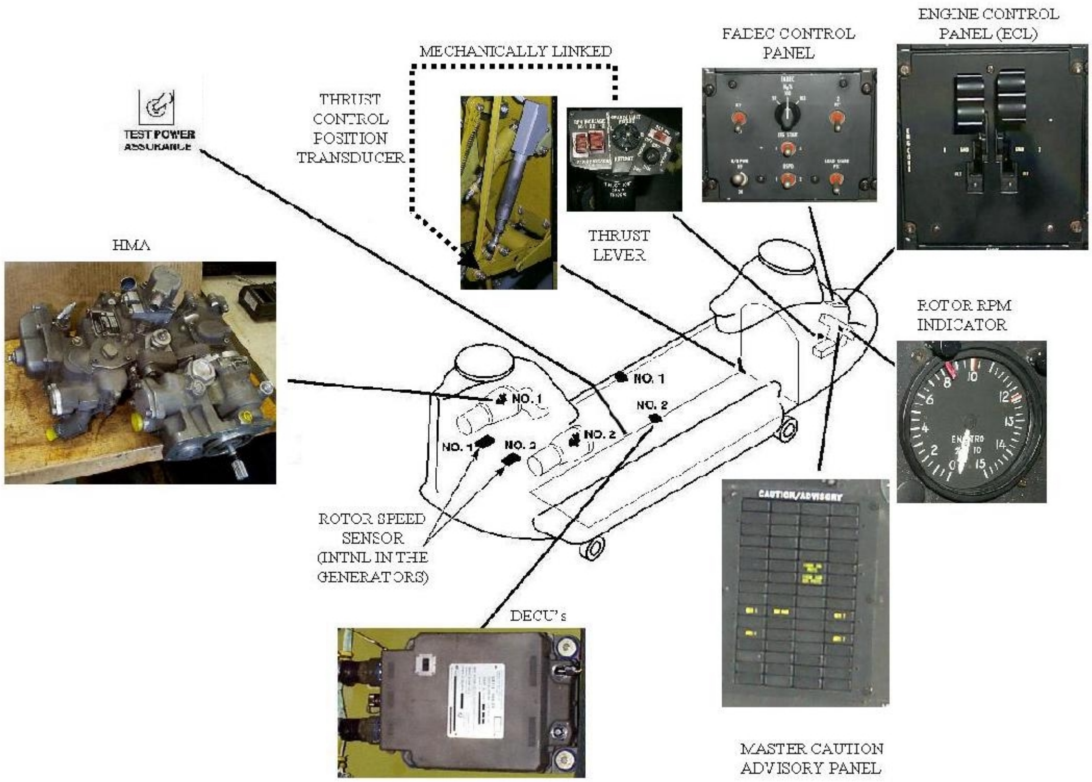


Figure 29 FADEC System (73-A0)

c. GENERAL SYSTEM FEATURES

(1) The HMA is divided functionally into two sections, a Hydromechanical Metering Unit (HMU), and high pressure Fuel Pump Unit (FPU). Within the HMU are the fuel metering components which support both primary and reversionary fuel metering, a built-in alternator to provide electrical power to the system primary channel electronics, primary and reversionary compressor bleed system controls, compressor speed signals, and redundant engine power turbine speed sensors.

(2) The FPU contains the jet pump, gear pump, pressure regulator, bypass screen, and relief valve. A splined shaft from the accessory gearbox drives the FPU. A second splined shaft between the FPU and HMU provides drive power to the

HMU components.

d. SYSTEM INTERFACES

(1) The FADEC system utilizes many of the existing engine and aircraft sensors and controls (i.e., T4.5, P3, start fuel solenoid, bleed band actuator, and engine condition levers (ECLs).

(2) Modifications to the airframe include replacing the (flight control closet) dual element resistor (droop eliminator) with a thrust control position transducer. And the Installation of a FADEC control panel in the overhead switch panel.

e. GENERAL OPERATION

(1) The FADEC system installed will provide technical features that were not available with the hydromechanical control system used on the earlier engine installations. These features enhance functional engine performance and reduce the flight and maintenance crew workloads. FADEC advantages include:

(a) Simplified hands-off Engine Starting.

(b) Improved Engine Acceleration/Deceleration Control.

(c) Power Assurance/Overspeed Test.

(d) Independent Electronic Engine Overspeed Protection.

(e) Engine Compressor Surge Detection And Avoidance.

(f) Control System Self-Test, Self-Diagnosis And Fault Identification.

(g) Engine History, Start/Component Cycle And Limit Exceedence Recording.

(h) Load Anticipation (Minimizing Rotor Droop).

(i) Accurate Torque Matching.

(j) Automatic Switch-over to an Independent Back-up Control System.

(k) Engine Over-Temperature Avoidance.

(l) No Field Level, System Adjustments.

(m) On-Condition Maintenance.

(n) Fuel Consumption Reductions of 200 PPH.

f. PRIMARY MODE FUNCTIONS

(1) The primary channel provides not only all functions available in the current hydromechanical fuel control, but in addition, incorporates advanced features that enhance engine operation and performance.

(a) Twin Engine Load Sharing.

(b) Electronic Power Turbine Speed Governing.

(c) Transient Load Anticipation Using Rotor Speed and Thrust Rate

(d) Transient Torque Smoothing Using Power Turbine Rates.

(e) Contingency Power to Meet Aircraft Demands.

(f) Acceleration and Deceleration Using Closed Loop NDOT* Control

(g) Automatic Engine Starting, Sequencing Ignition, Start Fuel, and Stabilized Engine Operation at Idle.

(h) Engine Temperature and Temperature Rate Limiting .

(i) Surge Detection/Surge Recovery.

(j) Compressor Bleed Valve Control (for both Transient and Steady State Surges)

(k) Fuel Flow Limiting.

(l) Engine Fail Detection.

(m) Engine Power Assurance Check.

(n) Engine History/Fault Recording.

(o) Automatic Switch Over to the Reversionary Channel in the Event of Primary Channel Hard Fault

(p) Data Bus for DECU to DECU Communication.

NOTE: (N = Speed – DOT = Derivative Over Time or Rate Of Change)

g. REVERSIONARY MODE FUNCTIONS

(1) Automatic Start Sequencing Including Over Temperature Protection.

(2) Pilot Controlled Start Fuel Enrichment/De-Enrichment, if Required Through ECL Modulation.

(3) Proportional Power Turbine Governing and Automatic Power Modulation Response to Thrust Rate Position.

(4) Engine 1 (2) Increase/Decrease Switch to Input Power Turbine Changes for Accurate Load Matching of the Engines .

(5) Full Contingency Power Capability .

(6) Over Temperature Protection Throughout the Engine Operational Range .

(7) Engine Shutdown In Response to the ECL.

(8) Tracking Of The Primary Channels Operation Allowing A Smooth Switch- Over when the Reversionary Channel is Selected, or the Primary Channel Fails.

a. System Description

(1) Hydromechanical Metering Assembly (HMA)
Mounted in place of the existing fuel control.

(2) Digital Electronic Control Unit (DECU)
Installed overhead in the aft cabin (FS 400).

(3) PWR ASSURANCE Switch
In the aft cabin at STA 523, RBL 48, WL 27

(4) PWR ASSURANCE
Determine engine performance based on current conditions.

(5) Trust Control Position Transducer
Flight control closet. Replaces the dual element resistor.

(6) FADEC Control Panel
FADEC system selections

(7) Thrust Grip
INC/DEC Switches

(8) Engine Condition Lever (ECL)
Establish engine operational parameter

(9) Torquemeter
Power indications to the drive system

(10) Master Caution Panel
System failure Indications

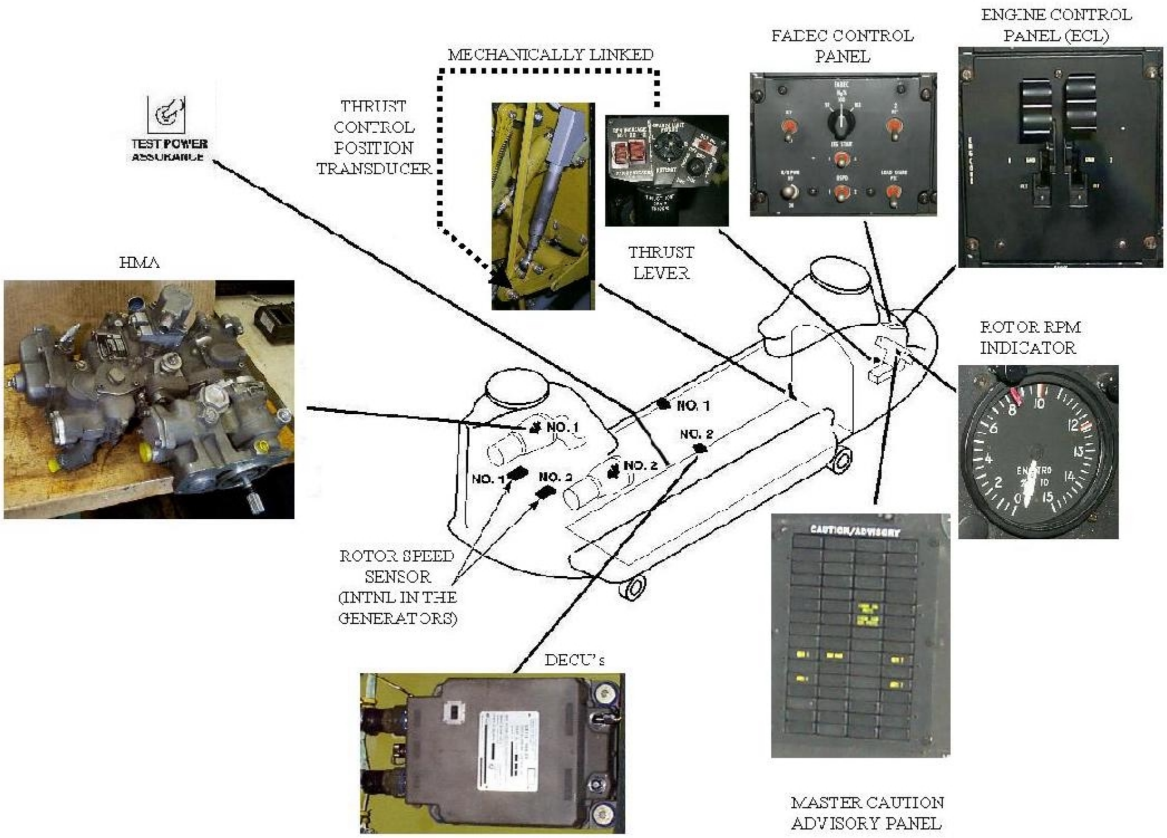


Figure 30 FADEC System (73-A0)

b General system features.

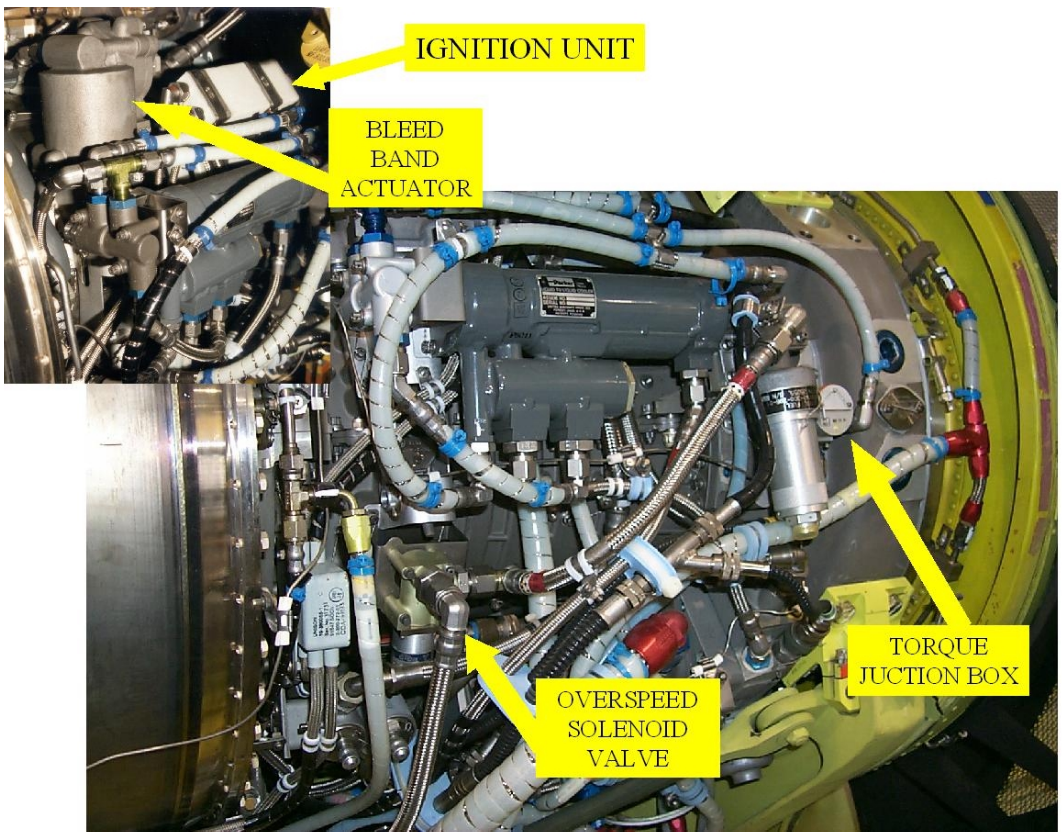
(1) Engine right side.

(a) Overspeed Solenoid Valve.

(b) Torque Junction Box.

(c) Bleed Band Actuator

(d) Ignition Exciter.



FF Figure 31 Engine RS Components (73-A0)

(2) Engine left side.

(a) T1 Sensor.

(b) Power Turbine Speed Sensor (N2 A, N2 B).

(c) Start Fuel Solenoid.

(d) HMA (HMU/FPU).

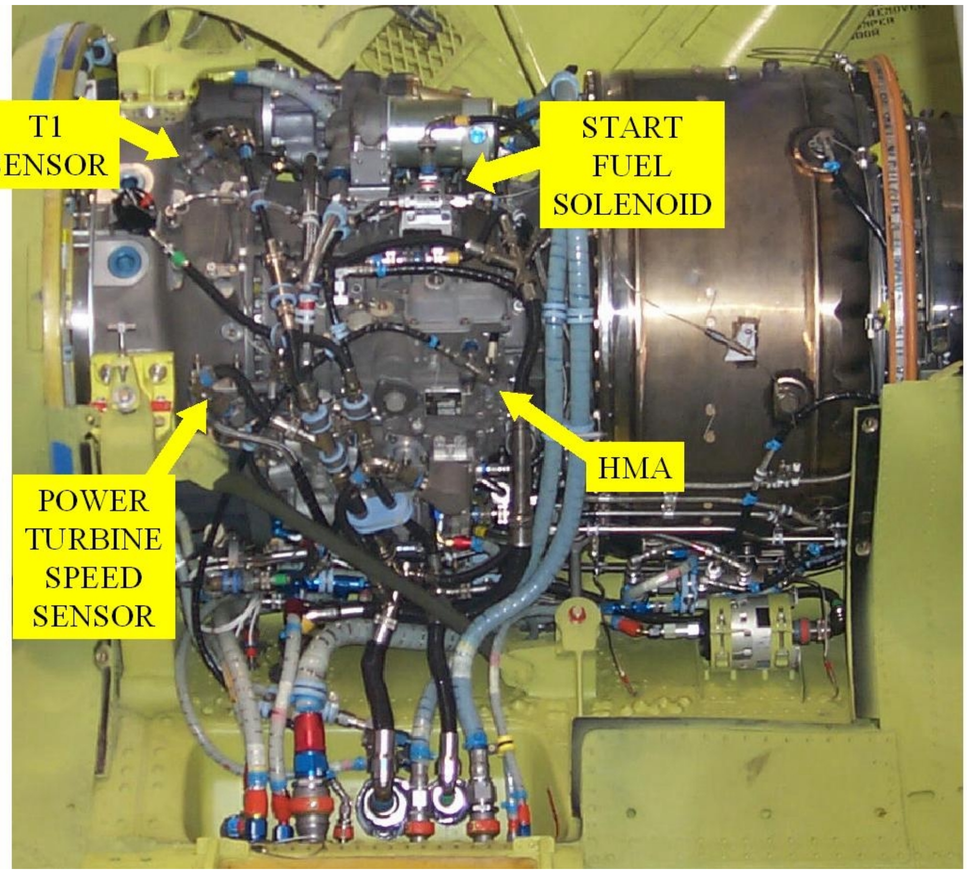


Figure 32 Engine LS Components (73-A0)

Figure Engine LS Components (73-A0)

c. System interfaces

(1) The engine mounted Hydro-Mechanical Assembly (HMA) interacts with the airframe mounted Digital Electronic Control Unit (DECU). The DECU receives signals from airframe and engine, controls engine operation, and provides engine system failure indications.

d. General operation.

(1) The HMA (Hydro-Mechanical Unit (HMU)/Fuel Pump Unit (FPU) mounted on the accessory gearbox, is divan by the gas produced section of the engine though shafting. The FPU is a high-pressure pump assembly providing high-pressure fuel for engine consumption and system operation. The HMA is the controlling part of the assembly providing an all-electronic engine fuel metering system in the primary mode and a hydraulically operated fuel metering system in the reversionary mode. The reversionary system serves as the back-up fuel metering system. While not as operationally fast as the primary system it is still more reliable than the previously installed hydro-mechanical fuel control. Under normal operation the reversionary system shadows the operation of the primary system. As a shadow system it is completely independent of the primary system using unique system in-puts and controlling the operation of the engine without aid of the primary engine control system. An independent engine overspeed protection system protects against engine overspeed in both channels of operation.

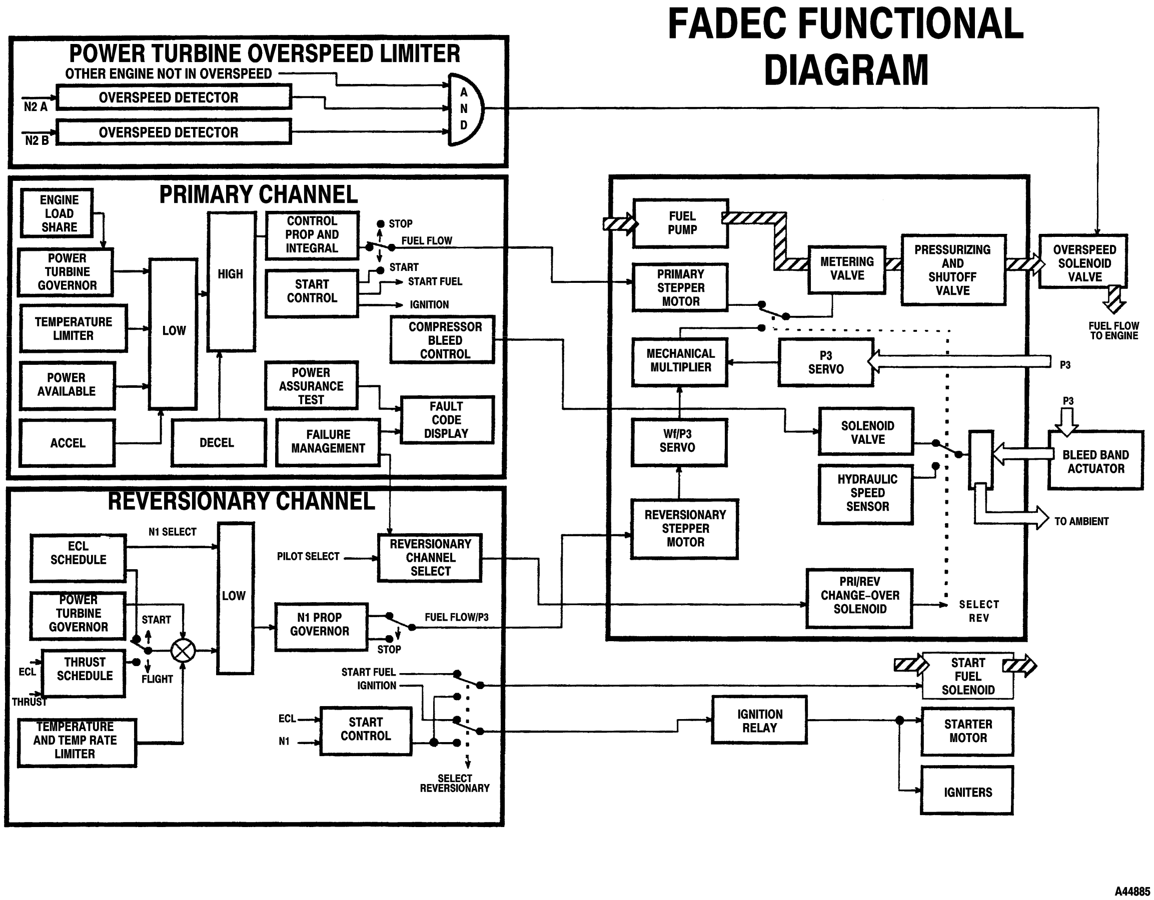


Figure 33 FADEC Functional Diagram (73-A0)

e. Purpose

(1) The HMA is comprised of the Hydromechanical Metering Unit (HMU) and the Fuel Pump Unit (FPU). The FPU increases fuel pressure. Providing fuel pressure for engine operation and the operation of components with-in the HMU. The HMU Controls fuel pressure/flow for engine operation.

f. Location

(1) Mounted on the engine accessory gearbox in the same location as the hydro-mechanical fuel control.

g. Description/Features

(1) Weight 31.6 lbs. (14.4 kg)

(2) Gear Pump Rating 8100 PPH/700 PSI 100 N1 speed

(3) Boost Stage - Pressure regulated jet pump (770 to 9260 PPH)

(4) Metering Valve - Flat plate orifice, wiper controlled.

(5) Primary Control - Stepper motor, direct drive to valve wiper.

(6) Reversionary Control - Stepper motor, control through Wf/P3 servomechanism, and P3 servomechanism, via the mechanical multiplier.

(7) Bleed Band Control.

(a) Primary Control.
Electronic (solenoid controlled valve).

(b) Reversionary Control.
Hydromechanical (hydromechanical speed sensor).

(8) Speed Sensing

(a) Primary Control.
Magnetic sensor, Alternator winding.

(b) Reversionary Control.
Alternator Winding, hydromechanical speed sensor for bleed band control

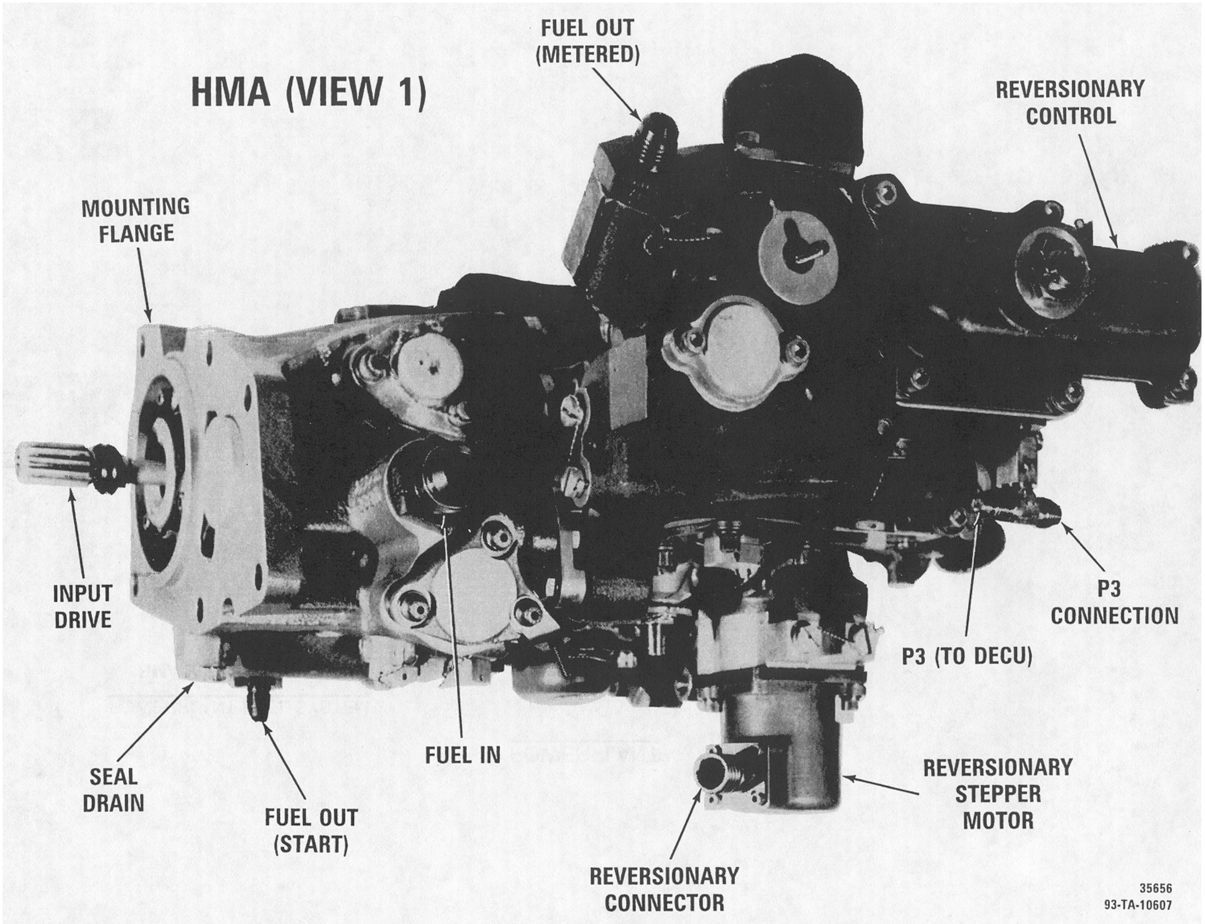


Figure 34 HMU View 1 (73-A0)

h. External connections to the HMA include:

(1) Three Electrical Connectors:

(a) Alternator connector - at the HMU alternator, supplies electrical power to the primary channel and gas producer N1 B speed signal.

(b) Main HMU connector - primary mode control functions and gas producer N1 A speed signal.

(c) Reversionary stepper motor connector - reversionary mode control functions.

(2) Three Pneumatic Ports:

(a) Compressor Discharge Pressure (CDP) (P3) sensing. (P3 servomechanism and DECU).

(b) Modulated air pressure control port (bleed band control).

(c) Ambient relief port (bleed band control).

(3) Three Fuel Connections:

(a) Fuel inlet.

(b) Fuel Out Metered.

(c) Fuel Out Start.

(4) Seal Drains:

(a) HMA input shaft.

(b) HMA cavities.

WARNING: Liquid fuel present at the seal drain could indicate fuel leaking into the HMU dry cavities in which are housed the HMU electronic components or the HMA mounting flange. The seal drains connect to the engine drain system.

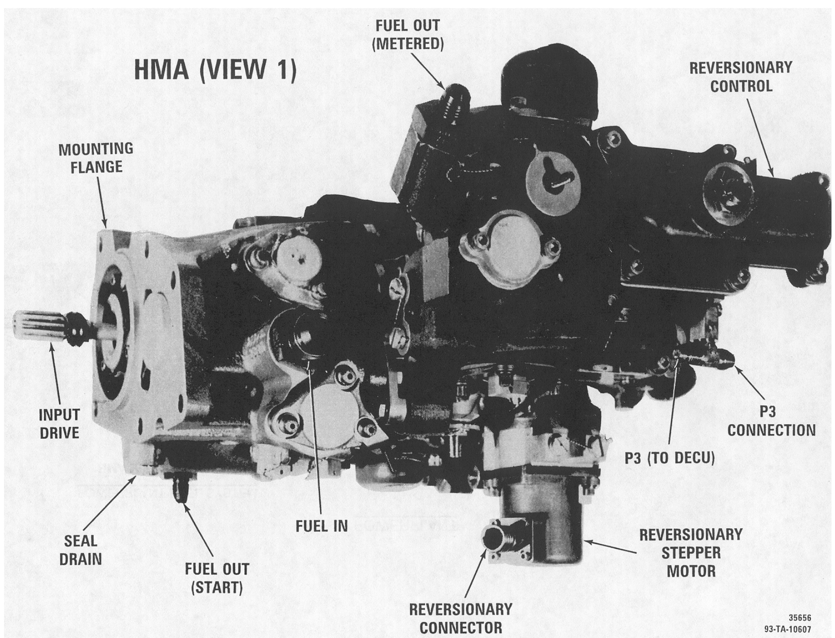


Figure 35 HMU View 1 (73-A0)

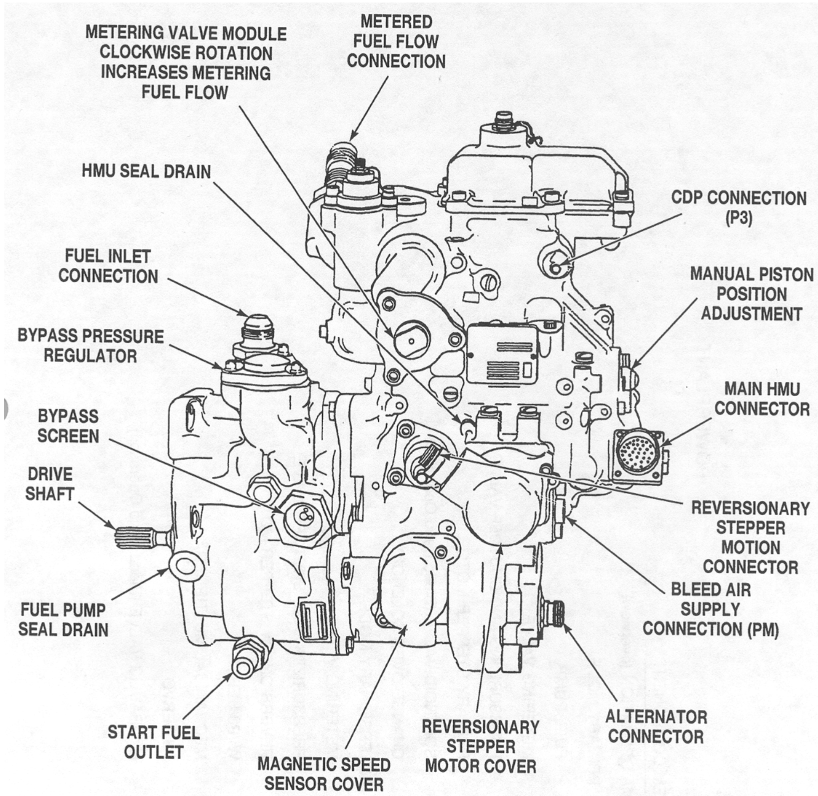


Figure 36 HMU (73-A0)

i. Description/Features HMA OPERATION

(1) PRIMARY MODE

(a) Fuel Pump.

(b) Metering Valve.

(c) Pressurizing and Shutoff Valve.

(d) Primary Stepper Motor.

(e) Solenoid Valve (Bleed Band Operation).

(f) Pri/Rev Change-Over Solenoid.

(2) REVERSIONARY MODE

(a) Fuel Pump.

(b) Metering Valve.

(c) Pressurizing and Shutoff Valve.

(d) Reversionary Stepper Motor.

(e) Wf/P3 Servo.

(f) Mechanical Multiplier.

(f) P3 Servo.

(g) Hydraulic Speed sensor (Bleed Band Operation).

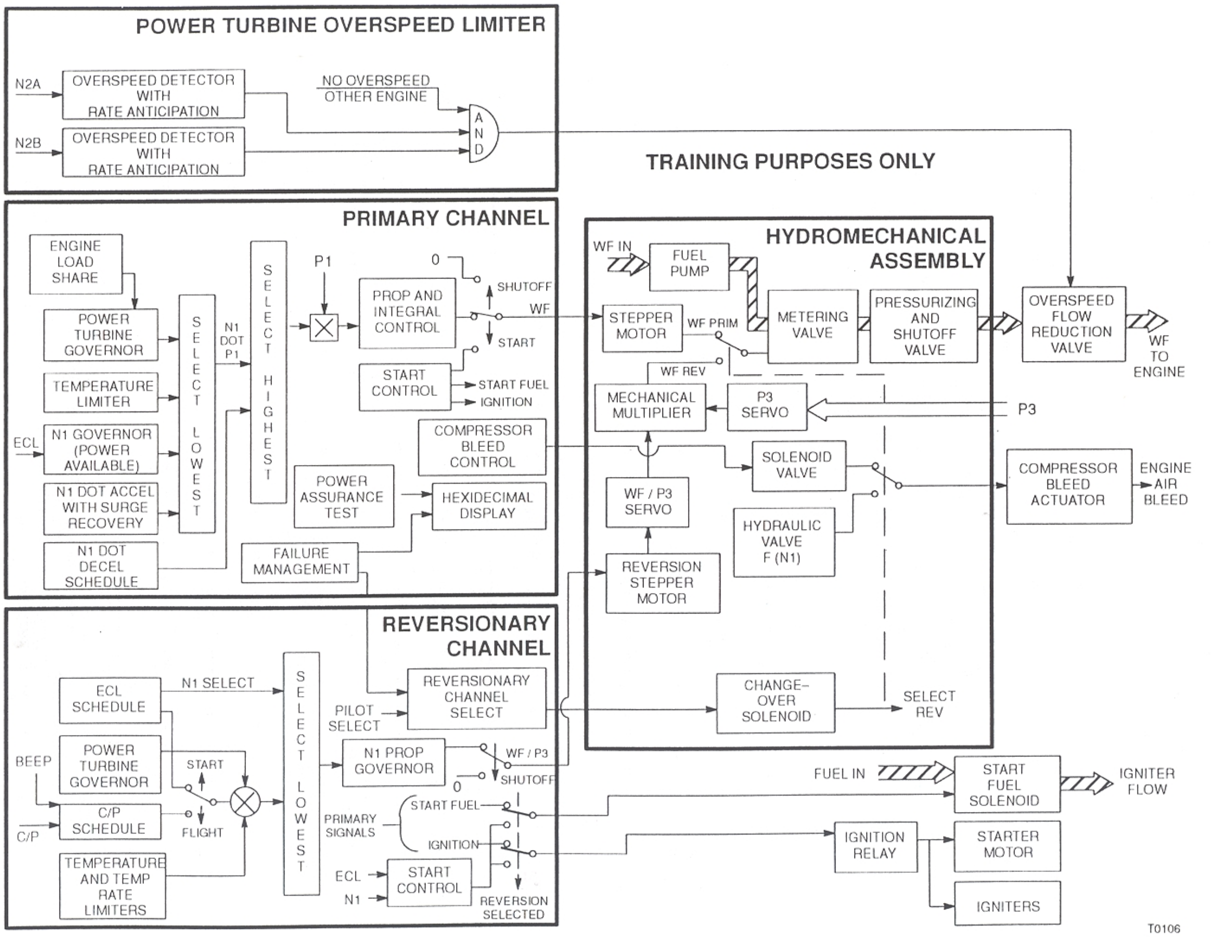


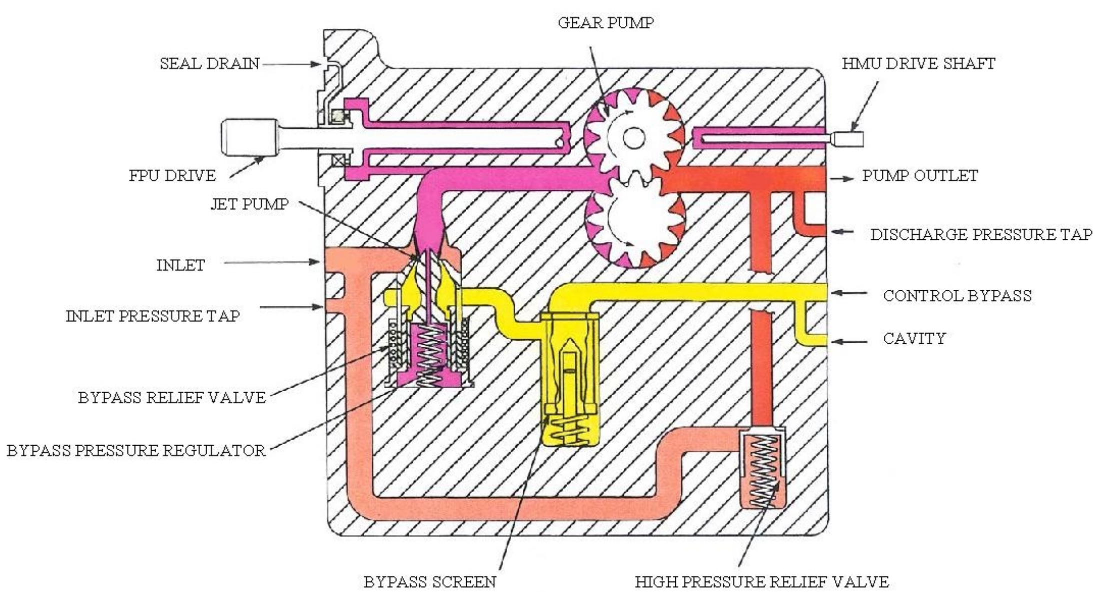
Figure 37 FADEC Functional Block Diagram (73-A0)

j. Fuel pump unit (FPU)

(1) Purpose: Receive fuel from the low-pressure components of the engine fuel system. Provide fuel under high pressure for engine operation and provide fuel under pressure to be used as the hydraulic medium for the operation and cooling of the components with-in the HMU.

(2) Location: Mounted to the engine accessory gearbox.

(3) Operation: The FPU jet induced gear pump delivers pressurized fuel to the HMU flat plate-metering valve. Fuel flow and pressure are determined by pump speed. The action of the FPU is the same for either the primary or reversionary mode of operation. The FPU driven gear is powered by a splined input shaft, and meshes with a pump driven gear. The gear pump is a positive displacement; pressure loaded pump capable of delivering a maximum flow of 26 GPM @ 4200 RPM. A jet pump utilizes bypassed fuel from the HMU metering head regulator to increase the gear pump inlet pressure. A pressure regulator built into the jet pump controls the jet pump output pressure by varying the nozzle area of the jet. The metering head regulator in the HMU maintains a constant pressure differential across the metering valve so that fuel flow to the engine will vary in proportion to the metering valve position. Fuel flow in excess of the engine requirement is bypassed back to the FPU to be utilized by the jet pump. A high-pressure relief valve is adjusted to limit the gear pump discharge pressure to 750 PSI. The 24-mesh screen, filters HMU bypassed fuel prior to the jet pump. Should the screen become clogged it will bypass flow 15 PSID. An output shaft between the gear pump and the HMU provides drive power to the HMU internal components.



k. Hydromechanical Metering Unit (HMU) internal components.

HMU Schematic See Appendix A

(1) Purpose: Govern fuel flow for engine operation.

(2) Location: Component of the HMA, mounted on the Fuel Pump Unit (FPU).

(3) Operation.

The following components function in the same manner in both the primary and reversionary modes.

(4) Metering valve.

(a) Meters fuel flow based on the position of a spring-loaded wiper, which rotates over an orifice in the flat metering by the primary stepper motor, which is controlled by commands from the DECU. In the reversionary mode, the wiper is controlled mechanically by linkage, with inputs from the Wf/P3 servomechanism and P3 servomechanism (transducer). The fuel type is not a factor in the operation of the metering valve.

(5) Metering head regulator.

(a) Regulates fuel pressure to the metering valve and bypasses excess pump discharge flow back to the fuel pump inlet. Ports all metering valve inlet pressure back to the fuel pump inlet with the ECL in the STOP position.

(6) Pressurizing and shutoff.

(a) Provides the means for maintaining sufficient backpressure for the pump at all fuel flow schedules, and provides a positive fuel shutoff when the ECL is placed in the STOP position.

(7) Windmill bypass valve.

(a) A cam operated valve, operated by the reversionary stepper motor. The valve when activated relieves the control pressure of the metering head regulator causing the fuel pressure to drop at the metering valve, in-turn decreasing metering valve downstream pressure at the pressurizing and shutoff valve. With the pressurizing and shutoff valve closed the fuel flow to the engine fuel nozzles is shutoff.

(8) Magnetic speed sensor: The magnetic speed sensor provides the main speed signal to the DECU primary channel (N1 A).

(9) Alternator: Serves as a power supply to the DECU primary channel. Provides sufficient electrical power above 49% N1 speed (low idle is 50%) to operate the DECU/HMU primary control system. A dedicated winding in the alternator provides the DECU with a redundant speed signal (N1 B).

The following components function in the primary mode of operation only.

(10) Primary stepper motor: Rotates the main metering valve shaft, positioning the metering valve wiper over the metering valve orifice. Full travel of the metering valve wiper is approximately 55 degrees. The stepper motor is capable of 500 steps/second. Full travel of the metering valve wiper takes approximately one second.

(11) Metering valve feedback: The metering valve shaft through a mechanical linkage directly drives the primary feedback potentiometer. Provides the DECU with metering valve position, creating a closed loop system.

(12) Bleed solenoid valve: The bleed solenoid valve is controlled by the DECU preventing engine surge. In the primary mode the position of the bleed band is either full open or fully closed (No modulation). De-energizing the bleed solenoid will open the bleed band, with the solenoid energized the engine bleed band will be closed.

(13) Primary/reversionary change over solenoid valve: In the primary mode, the solenoid is energized, disabling the reversionary WF/P3 servomechanism. With a hard fault in the DECU primary channel, or if the reversionary mode is selected by the pilot, the solenoid is de-energized and the reversionary mode is enabled. Fuel pressure is ported to the Wf/P3 servo and to the hydromechanical speed sensor for reversionary mode operation.

(14) Reversionary stepper motor (primary mode): The reversionary stepper motor shadows the operation of the primary stepper motor, positioning the Wf/P3 servo contour valve in response to commands from the reversionary channel of the DECU. Positions a cam activating the windmill bypass valve, which will cause the fuel pressure to be removed from the metering head regulator, metering valve, and pressurizing and shutoff valve, effecting engine shutdown.

The following components function only in the reversionary mode.

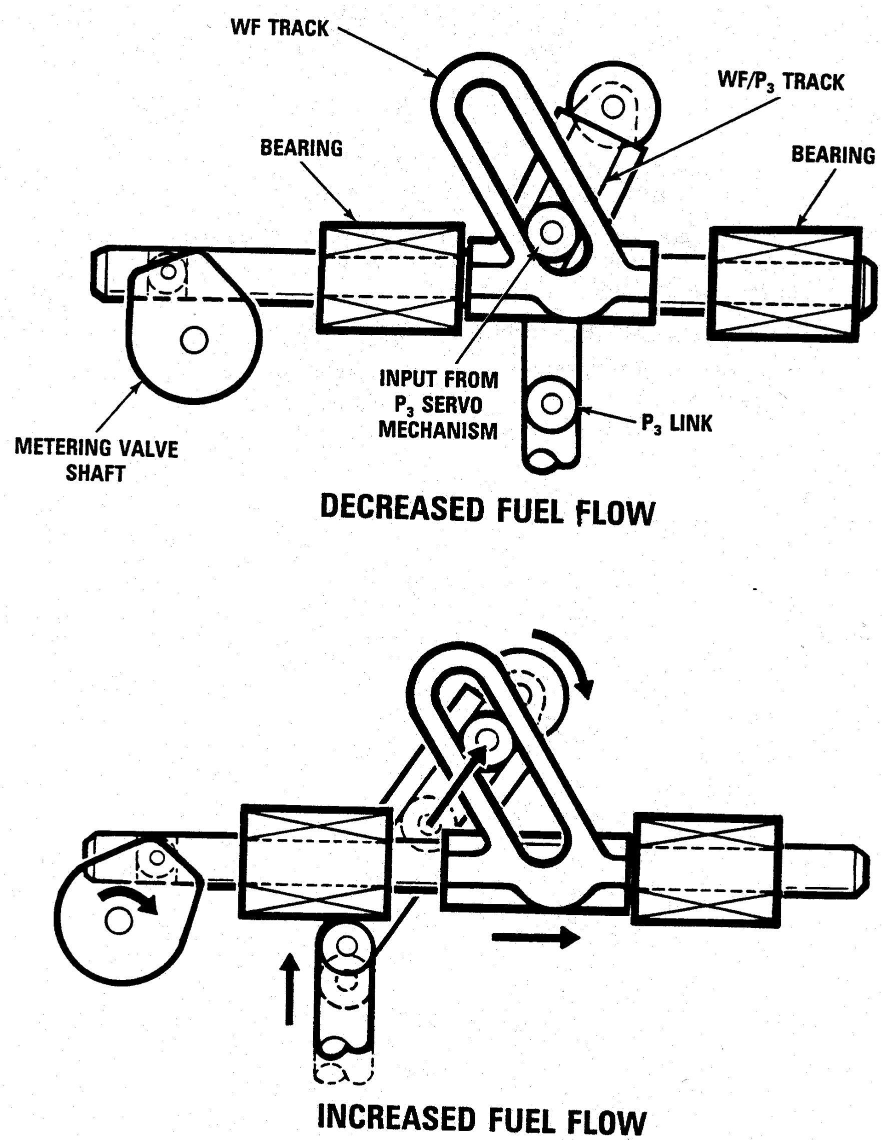
(15) Reversionary stepper motor: The reversionary stepper motor provides a means for positioning the Wf/P3 servo contour valve in response to commands from the reversionary channel of the DECU. Positions a cam activating the windmill bypass valve, which will cause the fuel pressure to be removed from the metering head regulator, metering valve, and pressurizing and shutoff valve, effecting engine shutdown.

(16) Power lever angle (PLA) feedback potentiometer: The reversionary stepper motor shaft directly drives the PLA feedback potentiometer. Provides the DECU reversionary channel with the reversionary stepper motor position. Reversionary Wf/P3 Servomechanism positions the metering valve wiper through the mechanical multiplier linkage, controlling engine fuel flow in the reversionary mode. P3 Servomechanism (transducer) in conjunction with the reversionary Wf/P3 servomechanism, Controls fuel flow by providing an input to the mechanical multiplier linkage proportional to P3.

(17) Hydromechanical speed sensor: The hydromechanical speed sensor controls the operation of the piston operated bleed valve, controlling the engine bleed band in the reversionary mode.

(18) Piston operated bleed valve: Changes in this pressure will operate the bleed band actuator, providing engine surge protection.

(19) Mechanical multiplier: Position the metering valve wiper over the metering valve discharge orifice, metering fuel flow in the reversionary mode. The mechanically linkage in positioned based on inputs from the Wf/P3 servomechanism and P3 servomechanism (transducer).



V POWER LEVER ANGLE MECHANISM DIAGRAM

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DECU

a. Purpose

(1) The EMC-32T Digital Electronic Control Unit (DECU) is a dual channel digital controller with independent primary and reversionary channels providing control of the fuel used for engine operation. A stand-alone analog overspeed limiting circuit provide electronic protection against engine overspeed.

b. Location

(1) Two DECU's are mounted inside the aircraft cabin at STA 400.

c. Description/Features

(1) The following major components make up the DECU housing, board assemblies, pressure transducers, connectors and flexible circuits.

d. DECU specification

(1) Weight 3.4 lbs. (6.1 kg).

(2) Dimensions 13.8 in long, 8.7 in wide, 4.21 in height.

(3) Installation Mounted to the airframe with visco elastic isolators.

(4) Construction: Cast aluminum housing, protecting the internal operation from, Electromagnetic Interference (EMI). Radio Frequency Interference (RFI). Electromagnetic Pulse (EMP). Environmentally protected. Multi-layer printed circuit (PC) boards internally connected by multi-layer flexible circuits.

(5) Operating environment Minus 54º C. to 85º C. Sea level to 25000 ft.

(6) Reliability 10, 000 Hrs. Mean Time Between Failure (MTBF).

e. DECU housing

(1) The DECUs internal electronic components are protected from EMI, RFI, and EMP; lightning, water and contaminants with sealed and shielded aluminum housing. O-rings and gaskets prevent external contaminants from entering the DECU. Each printed circuit (PC) board assembly is coated to keep contaminants away from the conductive surfaces. All components within the DECU are ruggedly mounted to withstand vibration and shock. The DECU contains a separate EMI/RFI compartment that contains the RFI board, preventing internal EMI and high-energy (lightning strike) transients from reaching the internal DECU control circuitry. This configuration also prevents DECU generated EMI from exiting the DECU.

Figure 38 DECU (73-A0)

f DECU board assemblies.

Multi-layer printed circuit (PC) boards preserve the noise-free electrical integrity and ensure good thermal performance.

(1) The four PC boards:

(a) Computer.

(b) Analog.

(c) Power Supply.

V (d) RFI.

(2) Are thick multi-layer assemblies, conformally coated and closely bolted, reducing the effects of vibration. Board functions are arranged to maximize the modularity of the internal assemblies. Computer Board-contains all the circuitry for the processing components of the primary and reversionary channels. Analog Board-provides the circuitry for converting signals from the external transducers to a digital format suitable for input to the primary and reversionary channels and the analog overspeed circuitry. Power Supply Board-provides the circuitry to power the primary and reversionary channels and engine and airframe interface components. RFI Board- contains the filtering devices to reduce the amplitude of the external noise as it enters the DECU, as well as the noise generated internally by the DECU.

DIGITAL ELECTRONIC CONTROL UNIT (DECU)

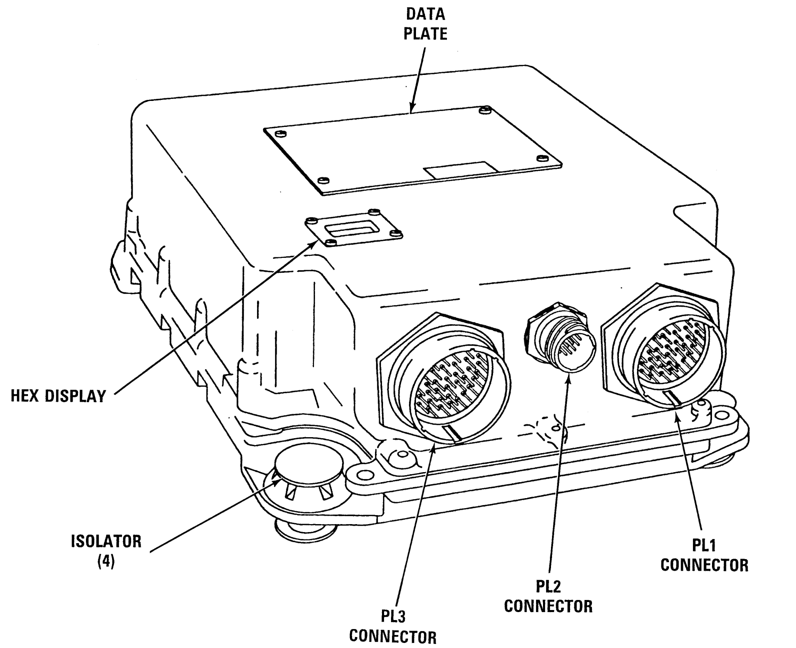


Figure 39 DECU (73-A0)

g. DECU flexible printed circuits.

(1) Internal connections between the DECU external connectors and the RFI board and between the RFI filters and the remaining boards are achieved with flexible printed circuits. These are lighter, more reliable, and allow for faster DECU assembly as compared to conventional point to point wiring.

h. DECU power supplies.

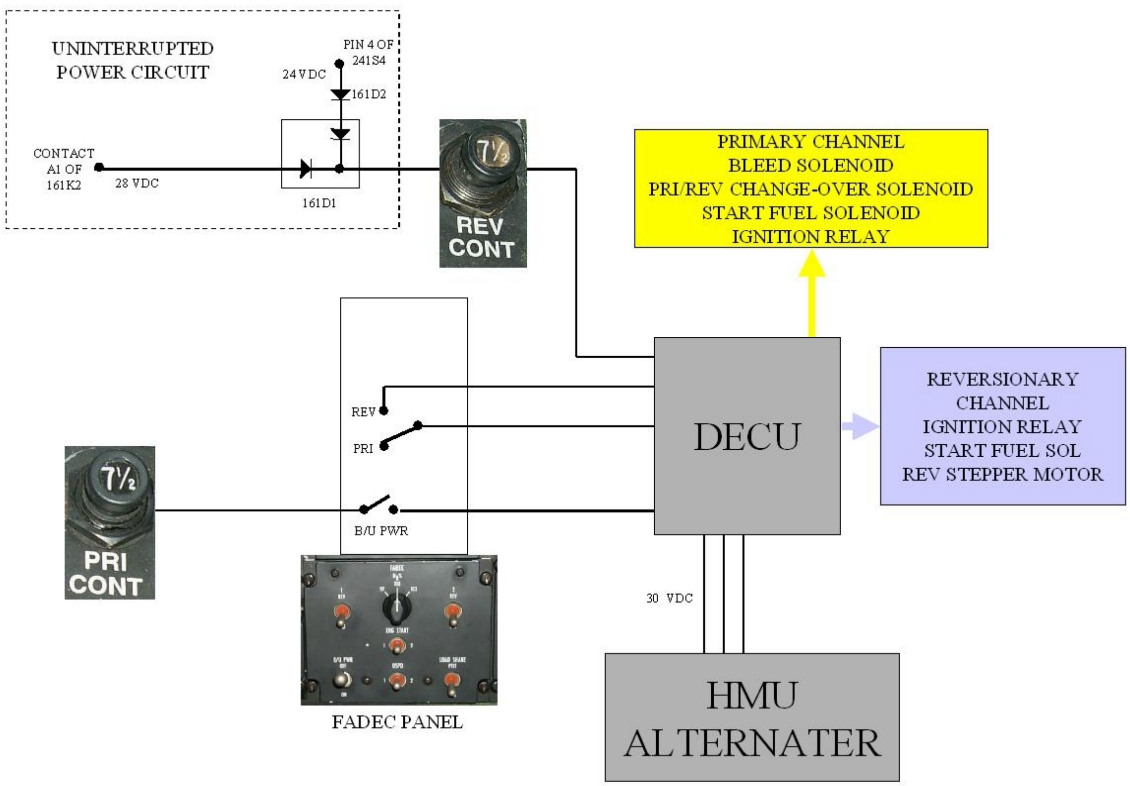
(1) The digital electronic control unit contains separate digital processors for the primary and reversionary channels plus isolated interface circuitry, allowing independent operation of each channel. Each channel is powered by dual independent power sources. The HMU 30 Vdc alternator powers the primary channel with the engine running (N1> 49%) or by the aircraft 28 volt No. 1 (2) ESSENTIAL; DC BUS. The primary power supply selects the higher of the two voltages:

(2) Aircraft DC electrical system 28 volts dc (No. 1 (2) ESSENTIAL DC BUS). 2. HMU alternator output voltage (30 volts ac) rectified to (28 volts dc).

(3) The reversionary channel receives 28-volt electrical power from contact A1 of the essential bus relay or 24 volts from pin 4 of the external power reset switch. Diodes protect the system from an electrical reverse flow.

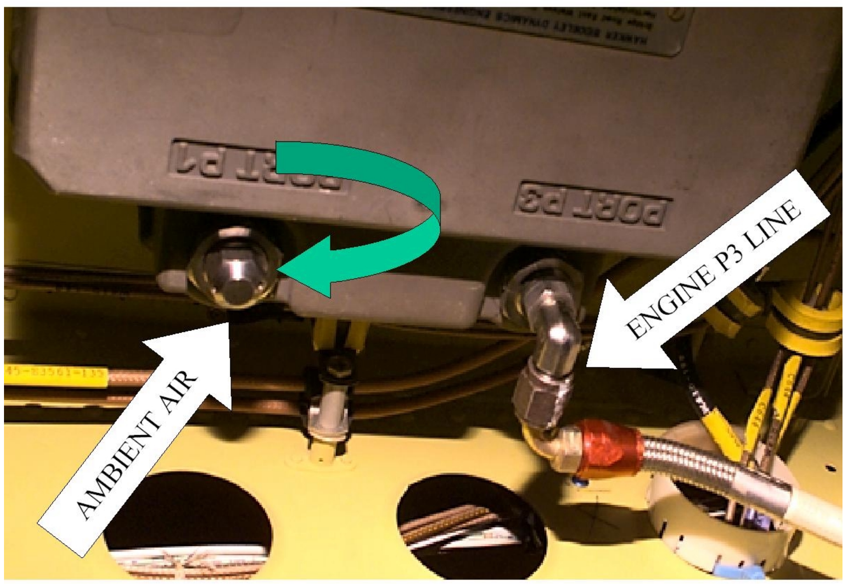
(4) The control panel back-up (B/U) power switch will only remove power from the Primary channel. To remove power from the Reversionary channel the battery must be disconnected or the REV CONT circuit breaker must be open.

(5) The FADEC system is capable of starting both engines in the primary or reversionary mode.



(6) Electrical connections to the DECU are made via two 61-pin connectors. (PL1 and PL3), A third 13 pin connector (PL2) is used for connecting an FADEC Diagnostic Computer.

(7) DECU pressure transducers : Two temperature compensated 0 to 20 psi pressure transducers, (P1) Atmospheric pressure and (P3) Compressor Discharge Pressure (CDP) are mounted in the DECU housing. O-rings provide sealing for the fittings that protrude through individual holes in the DECU cover assembly. The P1 transducer senses atmospheric pressure that will vary with altitude. The transducer fitting is covered with a vented cap. The P3 transducer is connected with flexible pneumatic line to the engine P3 CDP tap via the HMU. CDP is utilized by the DECU for sensing engine stall or surge conditions.



P3 CONDENSATION DRAIN

Drains the P3 system of accumulated moisture. A glass vile with a spring loaded check valve will provide visual indication of the accumulated moisture.

WARNING/CAUTION

Do not depress the check vale while the engine is operating, this will cause the DECU to lose its P3 reference pressure.

Do not use the lower flats of the vile to remove or install the vile/check valve assembly, always use the upper flats.

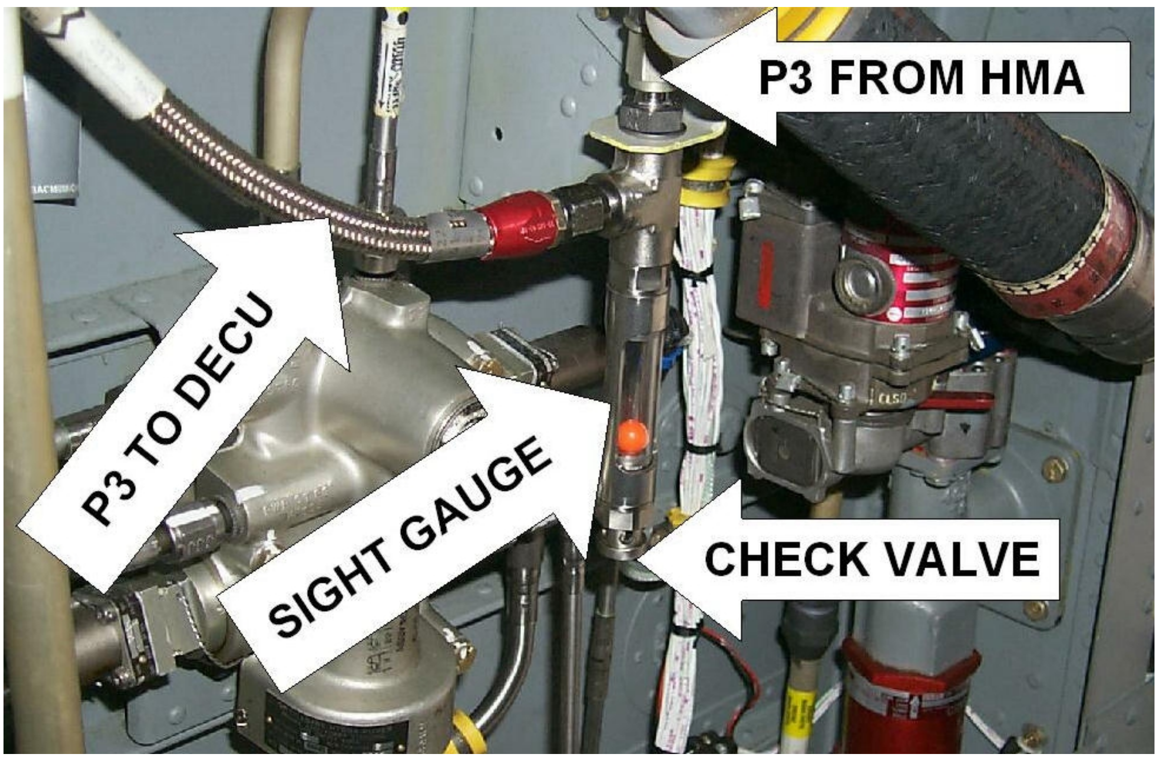


Figure 40 FADEC P3 Drain Check Valve

Figure 41 FADEC Power Supply System (73-A0)

j. ELECTRICAL HARNESSES

B (1) Description/Features: Design Philosophy - The FADEC electrical harnesses were designed to allow replacement of the same pin twice without degrading the performance of the harness assembly. The outer protective harness covering is convoluted tubing constructed with Fluorinated Ethylene Propylene (FEP) inner and outer jackets. Sandwiched between the jackets are two layers of nickel-coated copper braid. Harnesses are sealed environmentally. All fittings, transitions, coupling nuts and tubes are nickel-plated aluminum. Ferrules are corrosion resistant steel. All harness connector ends are color coded by harness function and identified with a connector P-number. Color band and number identification:

(2) PRIMARY HARNESS - YELLOW BAND.

PRIMARY HARNESS ASSEMBLY

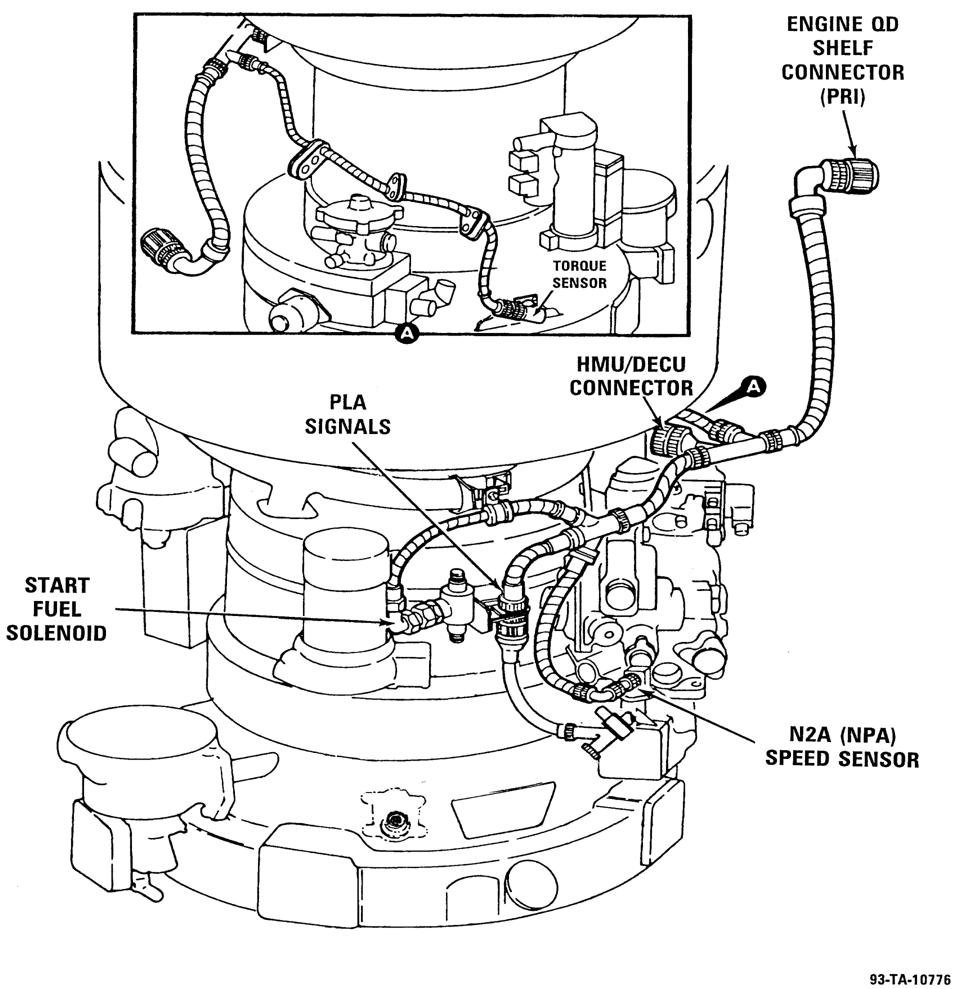


Figure 42 Primary Harness (73-A0)

(3) REVERSIONARY HARNESS - BLUE BAND.

REVERSIONARY HARNESS CONNECTIONS

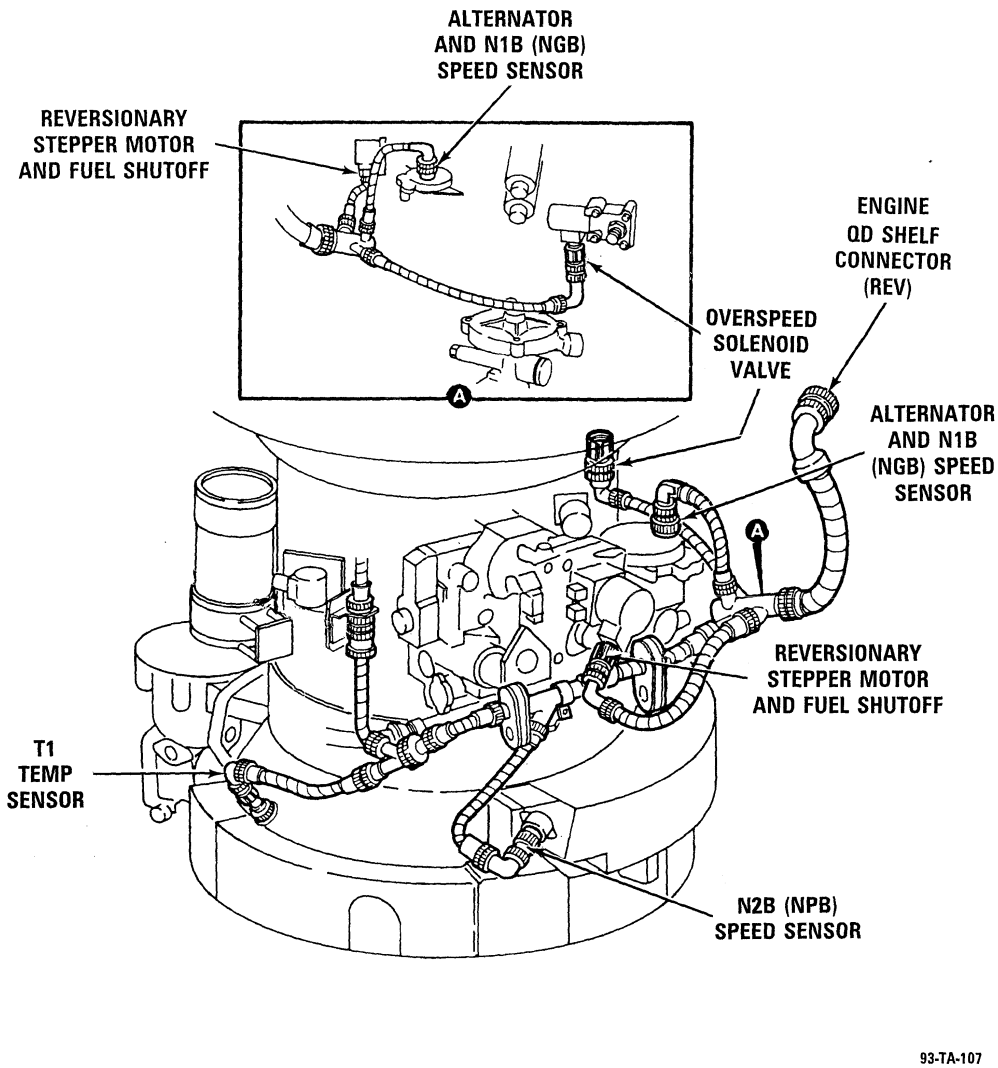


Figure Reversionary Harness (73-A0)

(4) Accessory harness: GREEN BAND Engine signals (N1, Oil Low, Oil Temp, Oil Pressure.

(5) The identification band is clearly visible on main trunk of harnesses and lists the P/N, S/N Rev letter, and vendor identification.

k. Measured gas temperature (MGT) harness.

(1) Purpose: The Measured Gas Temperature (MGT) harness provides Power Turbine Inlet Temperature (PTIT) signals directly to the DECU. PTIT is provides to the cockpit indicator form the DECU.

(2) Location: The thermocouples are located in the engine turbine section.

(3) Description/Features: The engine temperature measuring components consist of five dual element (total of ten elements) temperature probes, each of the dual element assemblies is connected externally to bus bars located on the engine fire shield. The probes protrude into the gas flow at the power turbine inlet (T 4.5) between the No. 2 and No. 3 turbines. The probes react to variations in turbine inlet temperature by varying an output voltage proportional to the temperature of the gas flow. The MGT portion of the harness is not repairable.

PTIT HARNESS ASSEMBLY

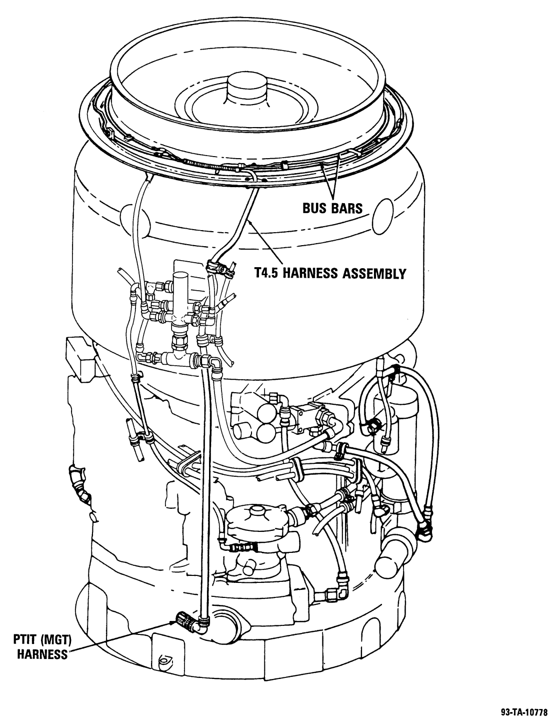


Figure PTIT Harness (73-A0)

l. Thrust control position transducer .

(1) Purpose: In primary mode provides the FADEC system (DECU) with signals related to the travel and rate of thrust lever movement. In reversionary only the amount of thrust lever movement is provided for FADEC operation.

(2) Location: In the flight control closet, attached to the components of the thrust artificial feel system.

(3) Description/Features: The thrust control position transducer replaces the dual element resistor (drop eliminator), and is installed in the same location. When the thrust lever is moved, the transducer varies a voltage signal to the DECUs relative to the distance and rate the lever is moved.

(a) In primary mode, (load anticipation) the DECU uses this signal to determine the distance and rate the thrust lever is being moved and thereby anticipates a required rate of acceleration/deceleration to precisely maintain the N2 speed. In the reversionary mode (load scheduling) the distance the thrust lever is moved provides a signal to adjust the DECU N2 governor.

(b) In the reversionary mode, the pilot uses the DEC/INC switches for load matching and fine tuning the governed N2 speed.

NOTE: Sometimes referred to as: Thrust Position Sensor Collective Pitch (C/P) Sensor Rotor Thrust Lever (RTL) Sensor Linear Variable Displacement Transformer (LVDT).

Figure Thrust Position Sensor (73-A0)

m. T1 Temperature sensor.

(1) Purpose: Provides ambient air temperature for FADEC operation.

(2) Location: Attached to the engine air inlet housing at the 10 o'clock position, the probe protrudes into the inlet air stream.

(3) Description/Features: The T1 temperature sensing system consists of a variable resistance temperature sensor that detects the engine air inlet temperature (ambient), providing the DECU with a signal proportional to the temperature of the engine inlet air. The temperature signal is processed and utilized within the DECU.

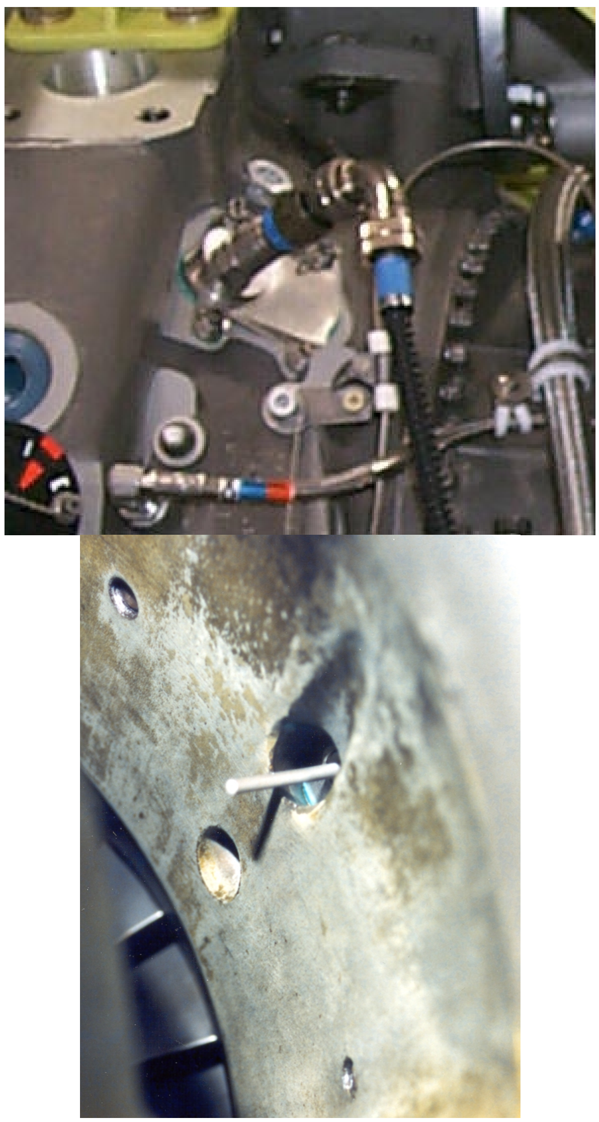


Figure 714A T1 Sensor (72-A0

n. Power turbine magnetic speed sensor.

(1) Purpose: Provides the FADEC system with redundant electronic signals related to the speed of the engine power turbine system.

(2) Location: Mounted on the engine left side on the accessory gearbox.

(3) Description/Features: A magnetic sensor consists of a cylindrical permanent magnet and a wire -wrapped soft iron core. A ferrous metal interrupter (cylinder with symmetrically raised segments around it’s circumference), driven by the gearing of the accessory gearbox the cylinder rotates in close proximity to the end of the sensors at a speed relative to the power turbine system.

(a) The magnetic lines of flux generated by the magnet are low while a raised segment of the interrupter is positioned away from the end of the magnetic sensor. When a raised ent of the interrupter is passed across the end of the magnetic sensor the lines of magnetic flux are strengthened and drawn inward.

(b) The magnetic flux lines passing across the wire coil will induce a voltage proportional to the rate of change of the lines of flux. The speed signal transmitted to the DECU is proportional to the speed at which the raised segments of the interrupter pass across the end of the magnetic sensor. The function of the magnetic sensor is the same for all engine speed sensors (i.e. engine gas producer speed and dual pick-up power turbine speed sensors.

NOTE: The N1 B speed signal is a function of the HMU-driven alternator windings. The N1 speed signal generated by the magnetic sensor mounted on the rear of the engine driven oil pump is for the cockpit N1 speed indication and not utilized by the FADEC system.

N2 (NP) DUAL SPEED SENSORS AND DRIVE ASSEMBLY

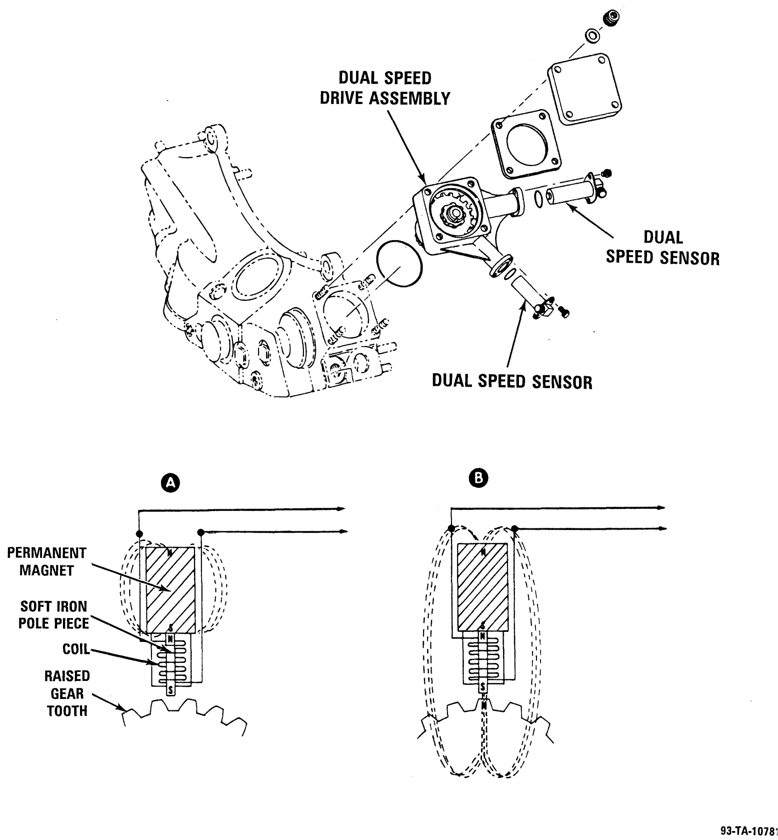


Figure Power Turbine Speed Sensor (73-A0)

o. Start fuel solenoid valve.

(1) Purpose: Provide fuel to the two engine start fuel injectors for engine starting.

(2) Location: The start fuel solenoid is mounted on the left side of the engine just below the main fuel filter assembly.

(3) Description/Features: It consists of a solenoid, spring loaded valve, and 100-mesh filter. The DECU electrically activates the solenoid. With the valve energized to the open position, start fuel flows from the HMA fuel pump, through an external fuel line to the two start nozzles located on the combustor assembly.

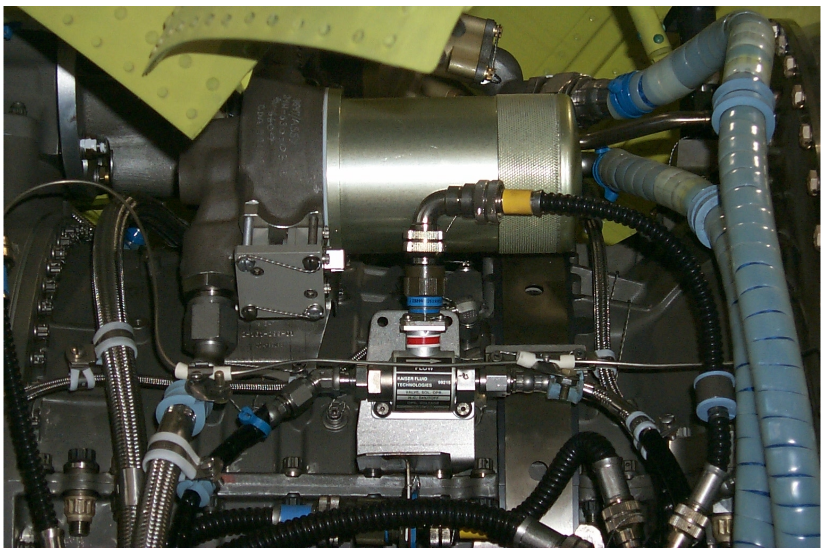
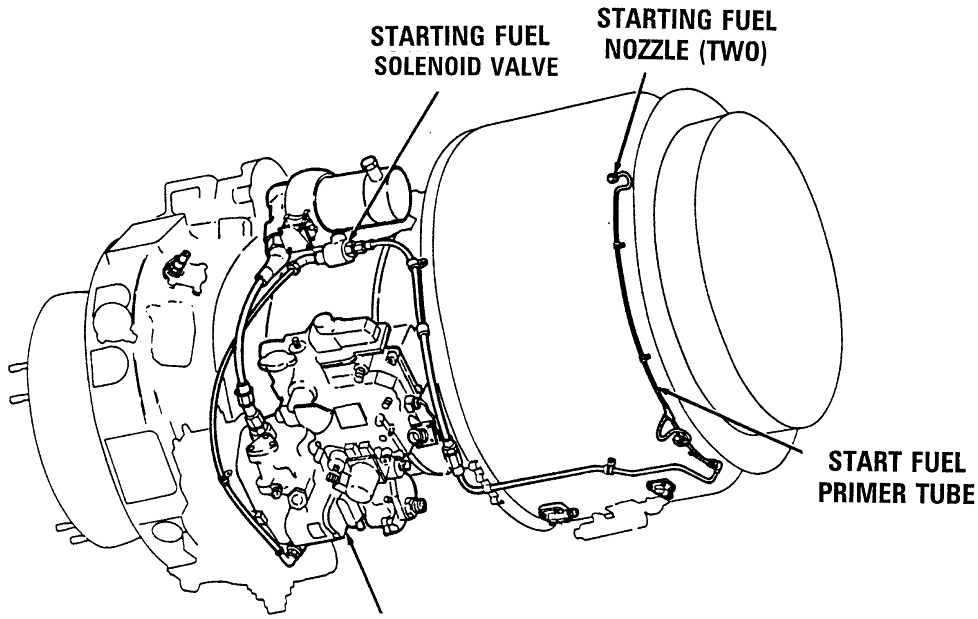
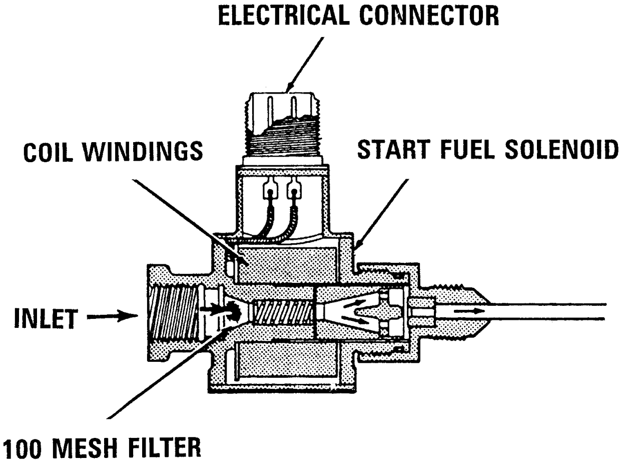


Figure Start Fuel Solenoid Valve (73-A0)

START FUEL SOLENOID VALVE





93-TA-10782

P. Overspeed solenoid valve.

(1) Purpose: Provides power turbine overspeed protection.

(2) Location: The overspeed solenoid valve is mounted on the right side of the engine, between the oil cooler and the dual chip detector.

(3) Description/Features: The valve consists of an electrically controlled valve, spring-loaded to the full open position. The solenoid is controlled by the DECU. If a power turbine overspeed is detected an electrical signal is sent to the overspeed solenoid, activating the valve and reducing engine fuel flow.

(a) Fuel flow can be reduced to the level of flow required to maintain the engine at idle RPM. The solenoid remains activated until the overspeed condition no longer exists, and will reactivate should a power turbine overspeed reoccur.

(b) The valve will open as the power turbine section of the engine slows below the overspeed trip point and close as the power turbine section increases speed above the trip point.

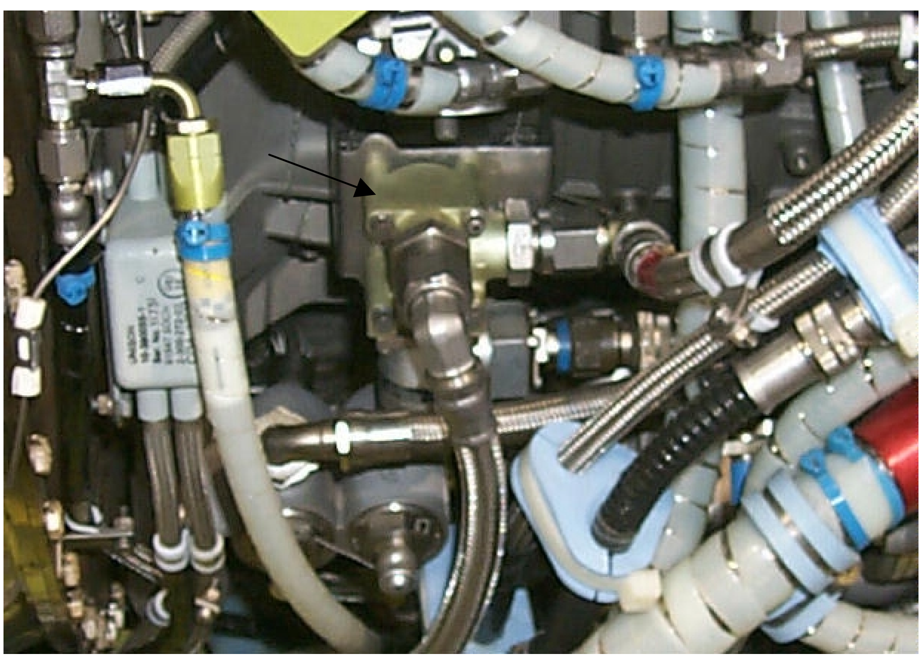


Figure Overspeed Solenoid Valve (FADEC) (73-A0)

OVERSPEED SOLENOID VALVE

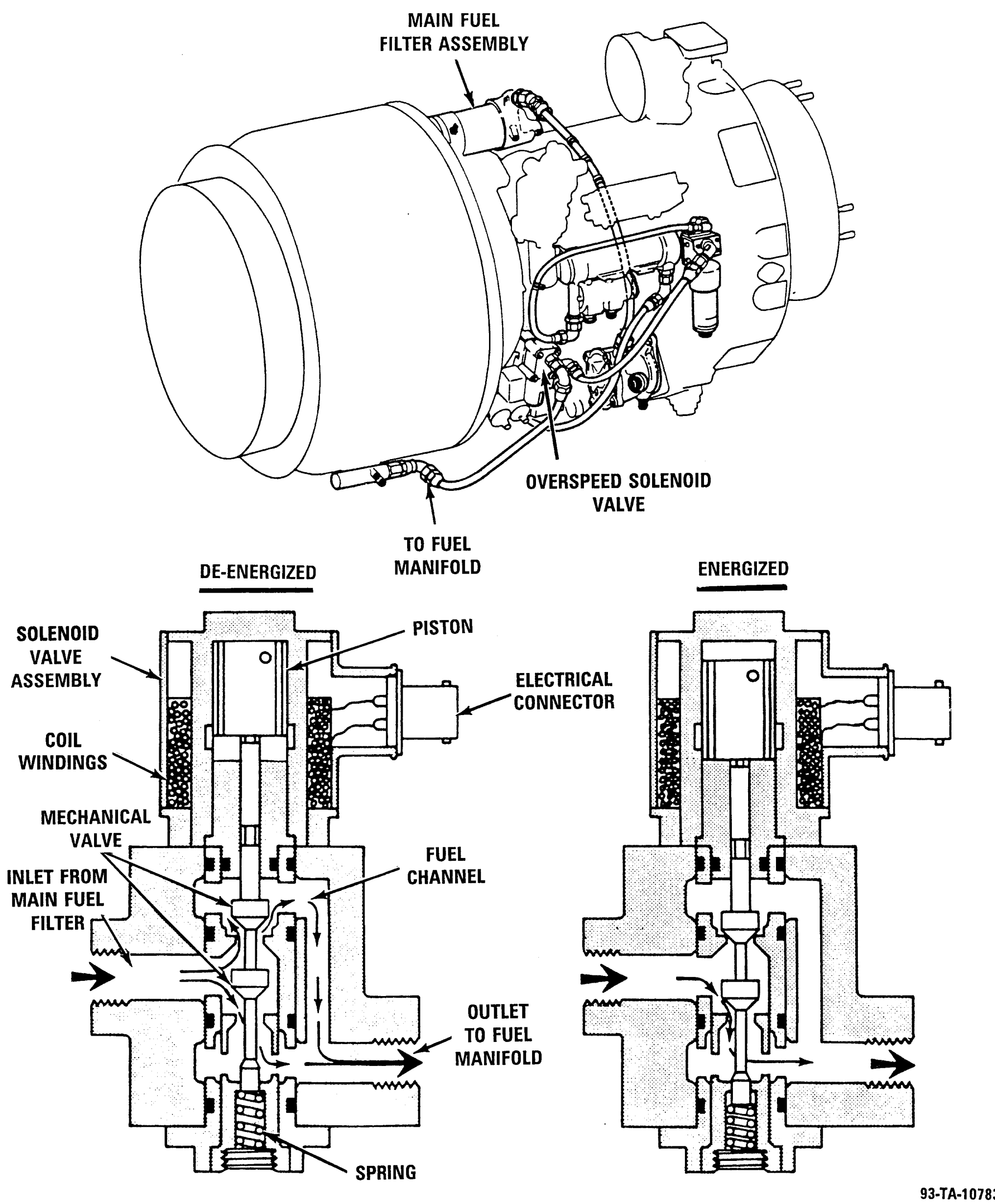


Figure Overspeed Solenoid Valve (FADEC) (73-A0)

q. FADEC control panel.

(1) Purpose - Make FADEC system control selections.

(2) Location - On the overhead switch panel.

(3) Description/Features

(a) NR SELECTOR - (N2SET) A rotary switch which provides variable rotor rpm control, when operating in the primary mode. The labeled positions are 97, 100, and 103. With the engine condition levers (ECLs) in the FLT position, NR will be maintained at the selected speed. The selector is detented at the 100 position only. Rotor speed selections can be set from 97 to 103.

(b) 1 AND 2 PRI/REV SELECT SWITCHES - Two switches, labeled PRI, and REV, provide control of the primary and reversionary modes of operation. In the REV position, electrical power is removed from the primary channel.

(c) ENG START SWITCH - A three-position switch, spring-loaded to the center position. Labeled 1 and 2 used to initiate the start sequence of the selected engine.

(d) LOAD SHARE SWITCH - A two-position switch used to select either PTIT or TORQUE as the parameter to be used by the FADEC system as the basis for engine load matching.

(e) B/U PWR SWITCH -- Controls the airframe power (Essential DC bus 1 or 2) to the FADEC system primary channel.

(f) OSPD 1 or 2 the switch is used to perform the N2 overspeed system test. Does not operate above 81.3% N2.

Figure FADEC Control Panel (RAF & ECP D 218) (73-0)

r. INC/DEC SWITCHES.

(1) Purpose: In the reversionary mode, each switch is used to match engine load sharing and in fine tuning the engine N2 governed speed. The DEC/INC switches are inoperative when operating in the primary mode.

(2) Location: On the Pilots and co-pilots thrust grips.

(3) Description/Features: The ENG 1 and ENG 2 switches labeled DEC/INC are spring-loaded to the center position. These switches commonly referred to as beep up and beep down. Inputs result in a decrease or increase in engine core speed (N1).

Figure Thrust Grip (ECP D 218) (73-A0)

s. Engine condition levers (ECL).

(1) Purpose: Control the engine operation during STOP (shutdown), GND (ground operation), and FLT (flight operations).

(2) Location: On the cockpit Overhead Switch Panel.

(3) Description/Features: The ECLs labeled ENG 1 and ENG 2 are three position levers, labeled STOP, GND, and FLT. Each lever independently controls the start, operating speed, and shutdown of the respective engine. STOP - 0 degrees, GND - 30 degrees, FLT - 60 degrees.

NOTE: Movement of the ECL between the GND and FLT positions will effect the ECL position input to the DECU in both the primary and reversionary modes, adjusting the metering valve position based on ECL position. An intermediate position between GND and FLT can be selected and will effect FADEC system operations.

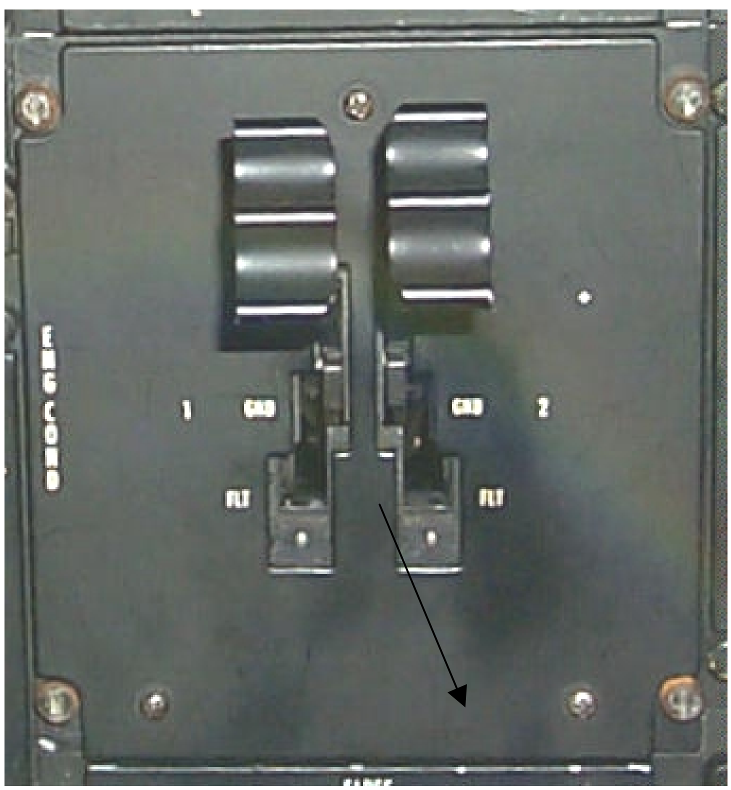
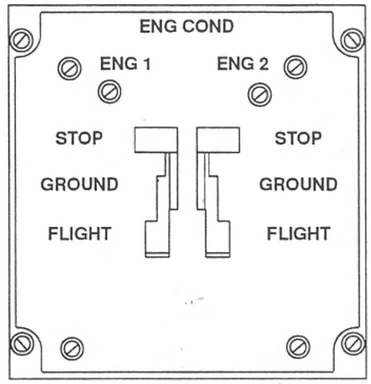


Figure ECL (73-A0)



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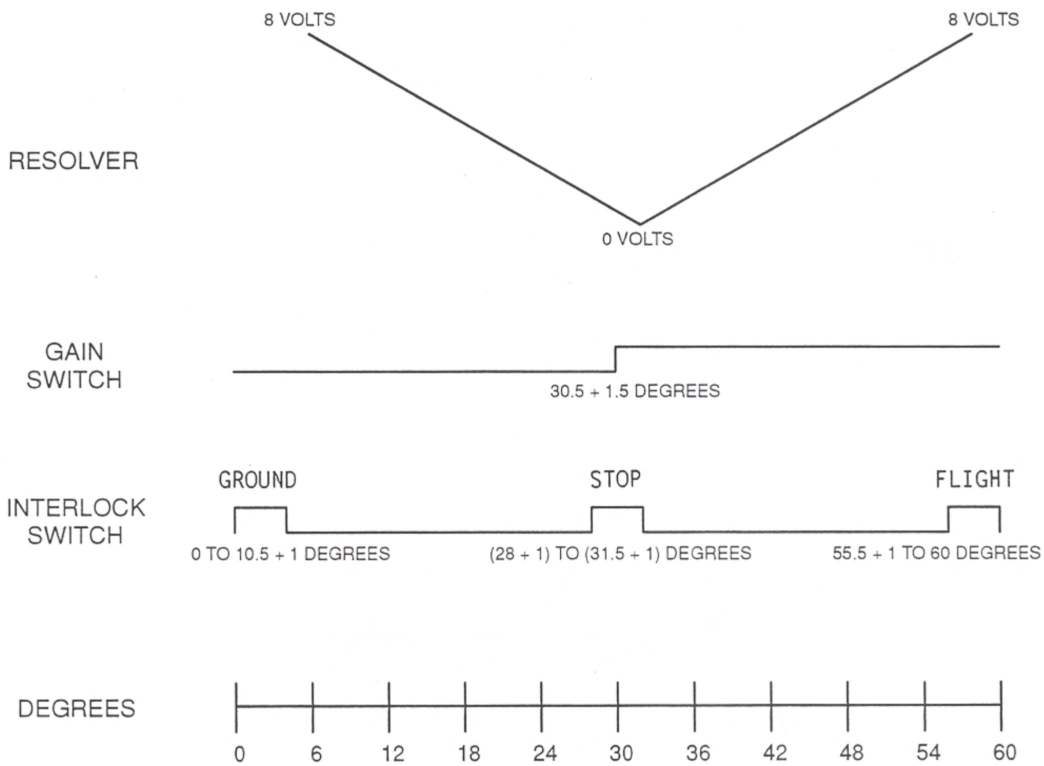
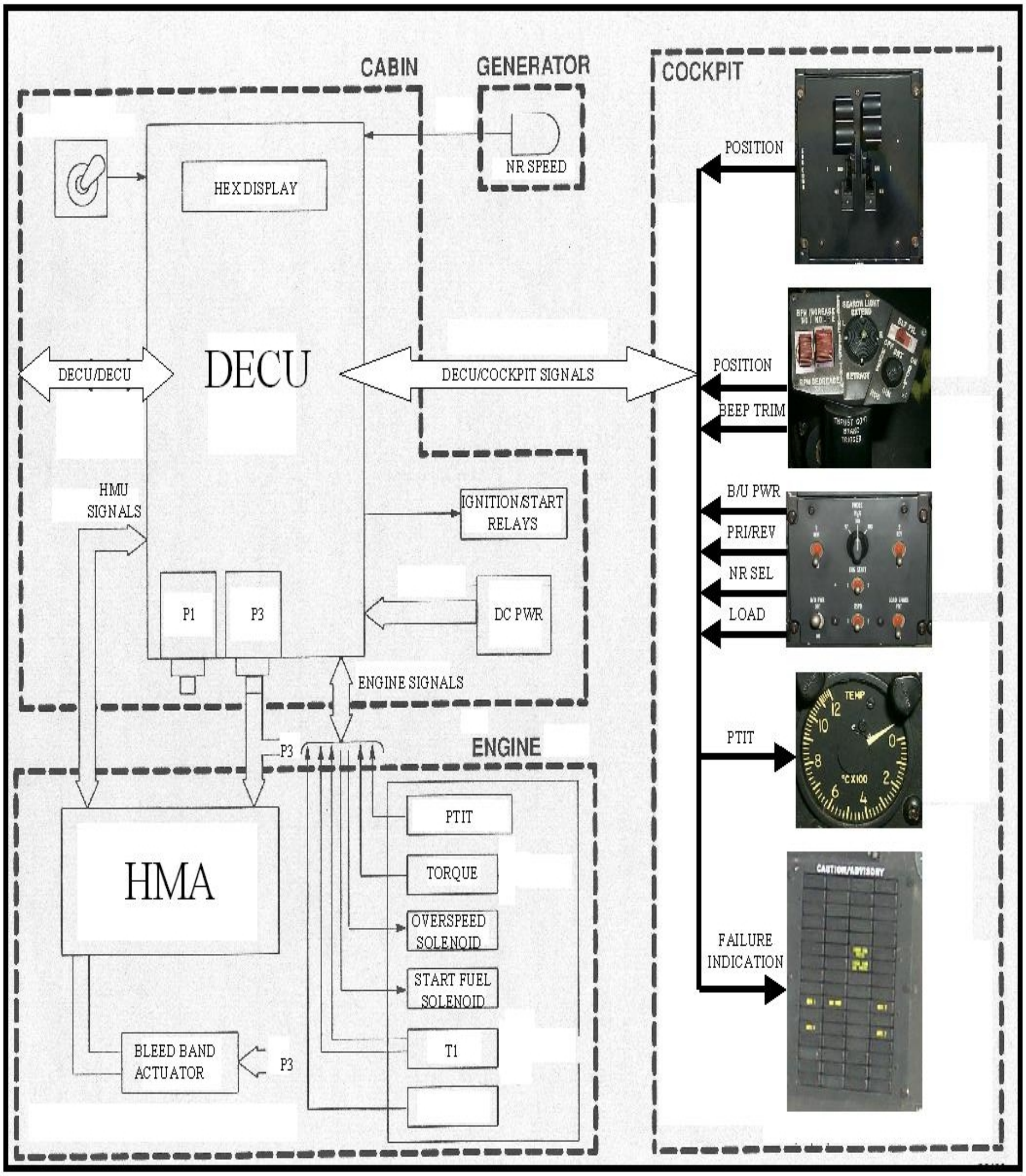


Figure ECL FADEC System (ECP D218) (73-A0

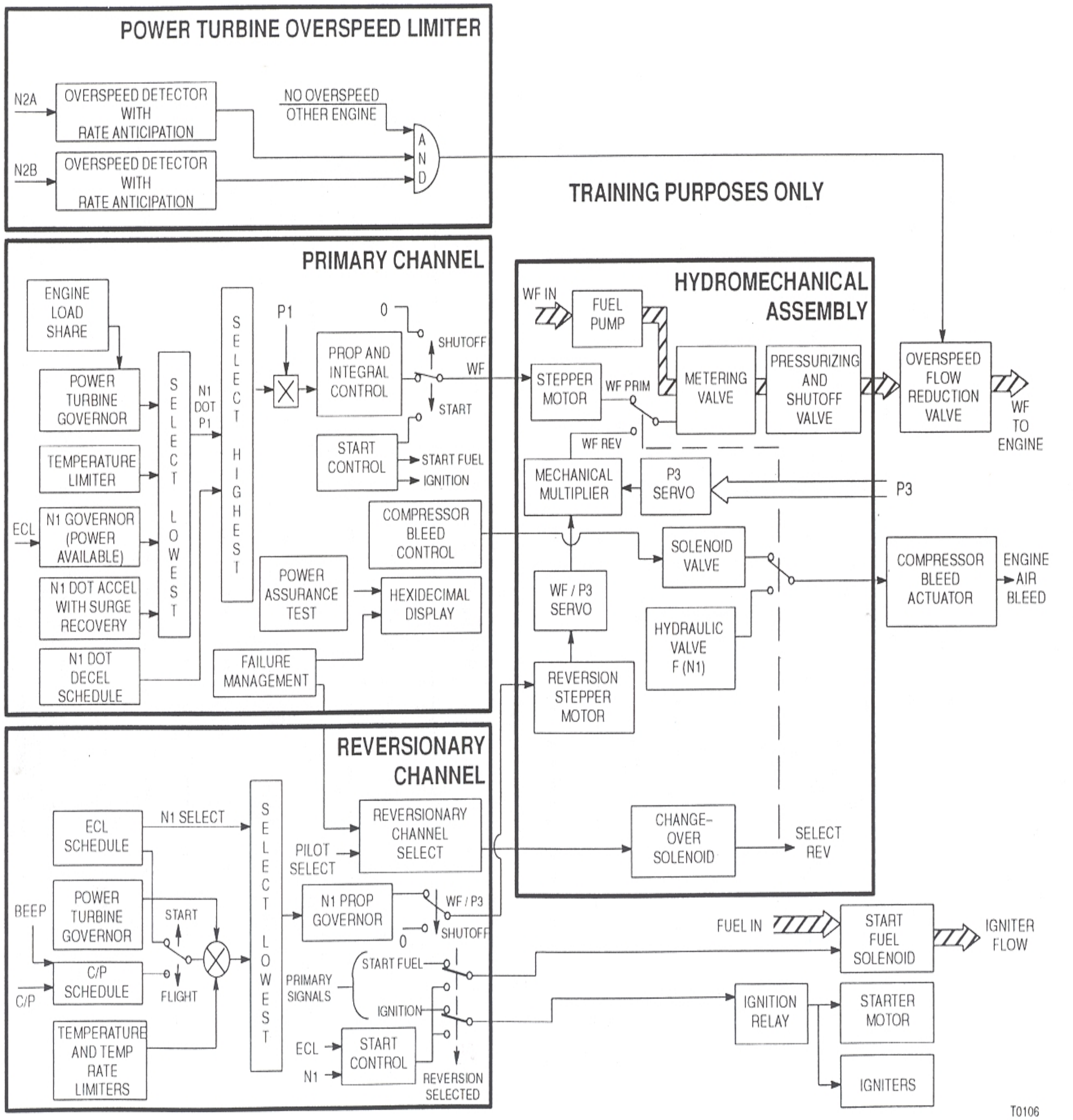
PRIMARY SYSTEM INTERFACE

Controls for primary channel engine operation include:

(1) Engine Start Switch	(11) Control Engine Start and Ignition Relays
(2) Engine Condition Lever (ECL)	(12) Schedules Core engine Speed (N1) and Controls Fuel Shutoff
(3) NR Selector (N2SET)	(13) Sets Power Turbine Speed (N2)
(4) Thrust Control Position Transducer	(14) Load Anticipation
(5) PRI/REV Switch	(15) Selects Operation of the PRI or REV Mode
(6) B/U Power Switch	(16) Removes Electrical Power from the Primary Channel
(7) Load Share Switch	(17) Selects PTIT or Torque for engine load sharing
(8) Engine Overspeed Test Switch	(18) Activates Overspeed Test Function N2 < 81.3%)
(9) Engine Power Assurance Test Switch	(19) Perform Tmargin test.
(10) Hexadecimal Display	(20) ENG TEMP margin



CABIN
GENERATOR
COCKPIT
NR SPEED
HEX DISPLAY
POSITION
DECU/DECU
DECU
DECU/COCKPIT SIGNALS
POSITION
BEEP TRIM
HMU
SIGNALS
IGNITION/START
RELAYS
B/U PWR
PRI/REV
NR SEL
LOAD
P1
P3
DC PWR
ENGINE SIGNALS
P3
ENGINE
PTIT
PTIT
HMA
TORQUE
OVERSPEED
SOLENOID
FAILURE
INDICATION
START FUEL
SOLENOID
BLEED BAND
ACTUATOR
P3
T1
TEMP
°C X100
CAUTION/ADVISORY



FADEC Block Diagram (73-A0)

a. HMU OPERATION (OVERVIEW).

(1) FUEL PUMP.

(a) PRIMARY MODE OVERVIEW.

1. METERING VALVE.

2. PRIMARY and REVERSIONARY STEPPER MOTORS.

3. PRESSURIZING AND SHUTOFF VALVE.

4. OVERSPEED SOLENOID VALVE.

5. SOLENOID VALVE CONTROL OF THE BLEED BAND ACTUATOR.

(b) REVERSIONARY MODE OVERVIEW.

1. PRI/REV CHANCE-OVER SOLENOID.

2. MECHANICAL MULTIPLIER.

3. Wf/P3 SERVOMECHANISM.

4. P3 SERVOMECHANISM.

5. REVERSIONARY STEPPER MOTOR.

6. HYDRAULIC SPEED SENSOR CONTROL OF THE BLEED BAND ACTUATOR.

b. PRIMARY CHANNEL FUNCTIONS.

(1) In the primary control mode, the system performs a number of functions related to controlling the engine during the start and operational phases. The primary channel control function cycle rate is 24 ms (41.6 cycles/sec). The Engine history-recording rate is 192 ms (5 cycles/sec).

(a) Functions.

1. Engine starting.

2. Engine shutdown.

3. Power available.

4. Acceleration and deceleration.

5. Surge recovery.

6. Steady state flight conditions.

7. Transient flight conditions.

8. Temperature limiting.

9. Power turbine overspeed limiting.

10. Power assurance test.

11. Fault code recording.

12. Engine history recording.

(2) The control scheme is based on the computation of a parameter referred to as NDOT (*). (NDOT is directly proportional to the demanded engine fuel flow). Different values of NDOT are computed by each of the following control functions:

(a) Acceleration.

(b) Temperature Limiter.

(c) Power available.

(d) Power turbine governor, (NDOT modified by the selected (PTIT or TORQUE) for load sharing).

(e) Deceleration.

(3) These values of NDOT are passed to the NDOT select logic. This selected value NDOT is checked against surge detection and recovery logic and input to the NDOT governor.

(4) The governor produces a fuel flow demand that after, being checked against fuel flow limitations, is input to the primary stepper motor control logic, after being adjusted by the fuel flow feedback signal from the primary potentiometer. The resulting fuel flow error generates a sequence of phase patterns (steps) that will be output to the primary stepper motor in order to ncrease or decrease fuel flow.

NOTE: (*) DOT - is defined as a derivative (change) over time and can be applied to a variety of parameters, speed (NDOT), temperature (TDOT), or pressure (PDOT).

c. LOAD SHARING.

(1) In non FADEC controlled aircraft the pilots monitor the load share requirements and adjust the engines through a process called beeping, where the engine outputs (torque, PTIT, or N1) are matched the equalize the engine workloads. With the FADEC system Torque, PTIT can be selected to automatically control the engine load sharing requirements. If the selected system fails the system is designed to default to N1 load sharing. If the selected load share signal is loss between the DECU's or one of the two FADEC systems is in the reversionary mode load sharing is disabled. Load sharing is accomplished by bringing up the low performing engine, by adjusting the demanded power turbine speed than reducing the output of both engines simultaneously until the desired power output is shared by both engines. The load sharing circuits are by design slow acting so as not to create an unstable engine condition.

d. HMU PRIMARY OPERATING MODE .

(1) The HMU components used in the primary control mode are the metering valve, metering head regulator, pressurizing and shutoff valve, windmill bypass valve, primary control stepper motor, primary feedback potentiometer, bleed valve solenoid, primary/reversionary change-over solenoid valve, alternator, and N1 speed sensor.

(2) The primary/reversionary changeover solenoid valve is energized by the DECU overriding the WF/P3 servomechanism, and hydromechanical speed sensor. This allows the fuel-metering valve to be directly positioned by the primary stepper motor and gearhead assembly. The four phase primary control stepper motor positions the metering valve in response to signals from \ the DECU increasing or decreasing engine fuel flow, the feedback potentiometer signals the DECU with the corrected position of the metering valve which cancels the signal to the stepper motor (closed-loop operation).

e. PRIMARY MODE ENGINE STARTING.

(1) The method of control during engine starting consists of ramping fuel flow from a lightoff fuel flow level to a ground idle fuel flow. Temperature rate limiting is provided in the start logic. The net ramp rate is biased by altitude compensation. This fuel flow is then compared with a temperature limit.

(2) GROUND STARTING, PRIMARY MODE (NORMAL OPERATION, NO FAULTS).

(a) Set the ECL to GND.

(b) Hold start switch until N1 > 10%.

(c) Primary channel will automatically control the start sequencing.

1. Starter.

2. Fuel flow to start fuel nozzles.

3. Ignition.

4. Fuel flow to main fuel nozzles .

(d) Temperature limiting (after lightoff PTIT > 760º c) Reduces fuel flow to 100 PPH minimum.

(e) Overtemperature during start (abort).

1. Fuel shutoff if PTIT > 815.5ºC

2. ENG 1 (2) FAIL indication.

3. ECL TO STOP resetting the start mode .

(f) AIR STARTS.

1. Procedures are the same as for a ground start

f. PRIMARY MODE ENGINE SHUTDOWN .

(1) When the ECL is moved to the STOP position, the primary system drives the metering valve stepper motor to its fuel shutoff position (40 PPH). This will normally cause a combustor blowout, in which case the engine will spool down and the fuel pressure will drop below the HMU pressurizing and shutoff valve setting, causing the valve to close and shutoff fuel to the engine. To ensure proper fuel shutoff the reversionary control will drive the reversionary stepper motor to the shutoff position positioning the windmill bypass shutoff valve and causing the metering head regulator to bypass total pump output. This drops fuel pressure below the pressurizing and shutoff valve setting, completely shutting off fuel flow to the engine. The primary stepper motor maintains the metering valve at the 40 PPH fuel flow position; ensuring sufficient fuel flow pressure will be available for a subsequent engine start.

(2) PRIMARY MODE ENGINE SHUTDOWN.

(a) ECL moved to GND to allow normal engine cool down .

(b) ECL to STOP.

1. Primary system closes the metering valve to the

2. Reversionary mode will effect complete shutoff of fuel when ECL is moved to STOP .

3. The shutoff feature is the only function of the reversionary mode that impacts the primary mode.

g. PRIMARY MODE POWER AVAILABLE .

(1) The ECL sets the reference speed of the N1 governor. With the ECL in the GND position, the control will maintain corrected engine idle speed. With ECL in the FLT position, the N1 governor sets the maximum allowable core engine speed (N1) to the emergency power limit. When ECL is advanced from GND to FLT, FADEC will accelerate the engine to obtain the governor power turbine set speed (N2).

(2) POWER AVAILABLE.

(a) Ground Idle .

(b) ECL to GND .

(c) Idle speed adjusted for engine inlet temperature.

1. N1 = 50% Cold Day (-65ºF).

2. 55% STD Day (59ºF).

3. 59%Hot Day (135ºF).

(3) GROUND TO FLIGHT TRANSITION.

(a) ECL moved to FLT position.

NOTE: (No special rate limitations required with FADEC).

(b) FADEC will accelerate engine to n2 governor set speed (rotor rpm selected by the NR switch on the FADEC control panel).

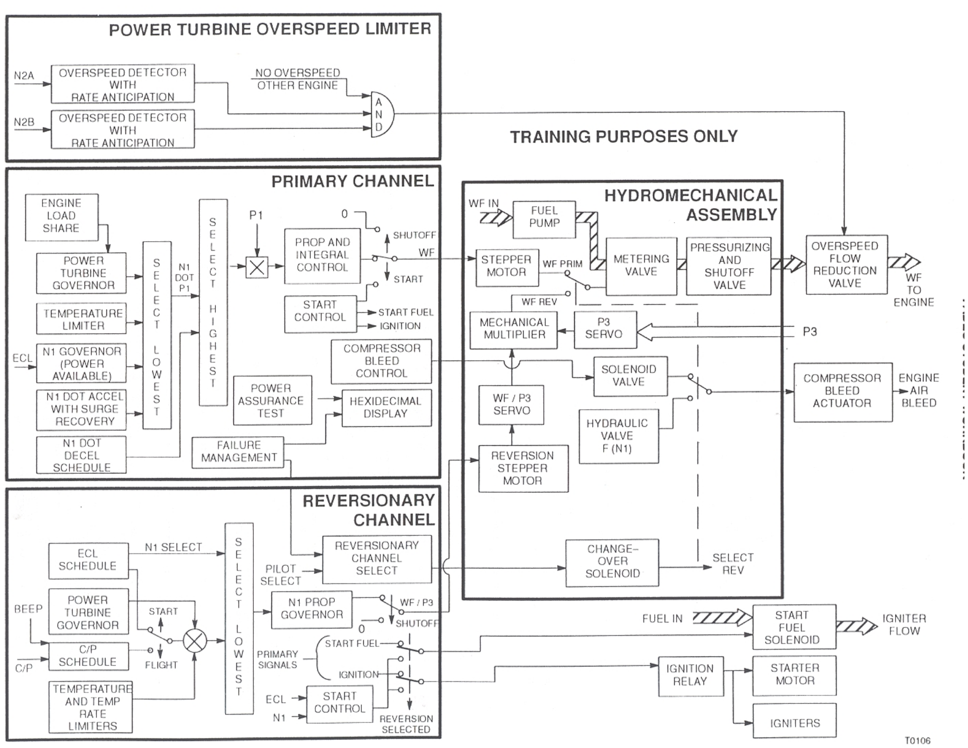
(c) ECL FLT position sets N1 governor to emergency power speed limit.

h. PRIMARY MODE TRANSIENT ENGINE CONTROL.

(1) NDOT Acceleration and Deceleration: Engine acceleration is scheduled as a function of core engine speed (N1). When the acceleration is the lowest value being demanded by the four control loops, the NDOT governor will control engine fuel flow to attain the demanded acceleration schedule from idle to maximum power. When the deceleration schedule is higher than the selected low of the four control loops the NDOT governor will control engine fuel flow to attain the demanded NDOT deceleration schedule. In normal flight operation, the DECU is working to hold N2 constant. Large changes in rotor thrust via the thrust lever (RTL) will cause the DECU to transfer to the acceleration or deceleration schedules.

(2) Compressor Bleed Actuator Control the FADEC system interfaces with the engine bleed band actuator, opening the bleed band during engine acceleration or deceleration or when an engine surge is detected. A bleed valve solenoid valve within the HMU controls the bleed actuator.

(3) Surge Recovery the compressor discharge pressure (P3) is used to detect an engine surge that is determined by P3DOT. If a surge condition occurs, the bleed valve is opened and the acceleration and deceleration schedules are reduced by 25%. When the engine recovers to a steady state condition the surge flag is disabled.



FADEC Functional Block Diagram (73-A0)

i. PRIMARY MODE STEADY STATE FLIGHT CONDITIONS .

(1) Pilot procedures are the same as with the previous engine fuel control system except that INC/DEC (beep) trim is not required to hold set speed or match engine torque After the engine is brought on line, the proportional/integral governor maintains the set speed constant. The load sharing system operates to match the selected load share (PTIT or TORQUE) signals by slowly increasing the power of the low load engine. After the engine outputs are synchronized the PTIT or Torque (whichever is selected) output of both engines are simultaneously reduced to the required level. Rotor speed is selected via the cockpit NR selector (FADEC control panel). The selection sets the power turbine output proportional to the selected rotor speed.

j. PRIMARY MODE TRANSIENT FLIGHT CONDITIONS.

(1) Anticipation: When repositioning the thrust lever at a rate of > 5%/sec, the output of the power turbine governor is reset to cause the engine to accelerate or decelerate to meet the impending change in power requirement. This function helps to minimize rotor droop or overspeed during a power transient.

(2) Torque Smoothing: Minimizes speed and torque oscillation enhancing flight stability.

(3) Recovery from Autorotation: When the rotor is decoupled, the control senses rotor speed decay and automatically accelerates the engine to increase power turbine speed to recouple before an underspeed occurs.

(4) Primary Mode Temperature Limiter: Temperature limiting is scheduled as a function of core engine speed. When the temperature limiter is calling for the lowest NDOT setting, the control through the operation of the proportional/integral governor will provide a constant engine temperature limit.

a. TRANSFER TO REVERSIONARY.

(1) The reversionary channel serves as a backup to the primary mode and is a full authority digital electronic engine controller. Providing all essential engine and rotor speed control functions. Although the reversionary mode is much simpler design with some of the enhancing features of the primary mode eliminated. The reversionary mode will still provide the engine control necessary for mission completion at the expense of a higher cockpit workload.

(2) The reversionary channel electronics have been shadowing the primary channel. The reversionary channel in relationship to the current demanded engine fuel flow is always positioning the reversionary stepper motor (disengaged in the primary mode). Switchover to the reversionary mode is automatic should a hard fault occur in the primary mode. The reversionary mode can also be selected through the use of a pilot activated switch on the FADEC control panel.

b. REVERSIONARY CONTROL (Transfer to Reversionary).

(1) Reversionary Channel (REV 1 (2) OFF).

(2) When in primary, the reversionary control tracks N1.

(3) Pilot selects reversionary or primary channel failure .

(a) Cockpit Display - FADEC 1 (2) ON.

(b) Normal transition to reversionary will be smooth, normally not requiring pilot action.

(4) If the reversionary channel is hard faulted (REV 1 (2) ON).

(a) Primary system fails to fixed fuel flow (failed fixed).

(b) If pilot selects reversionary, control fails fixed to reversionary setting..

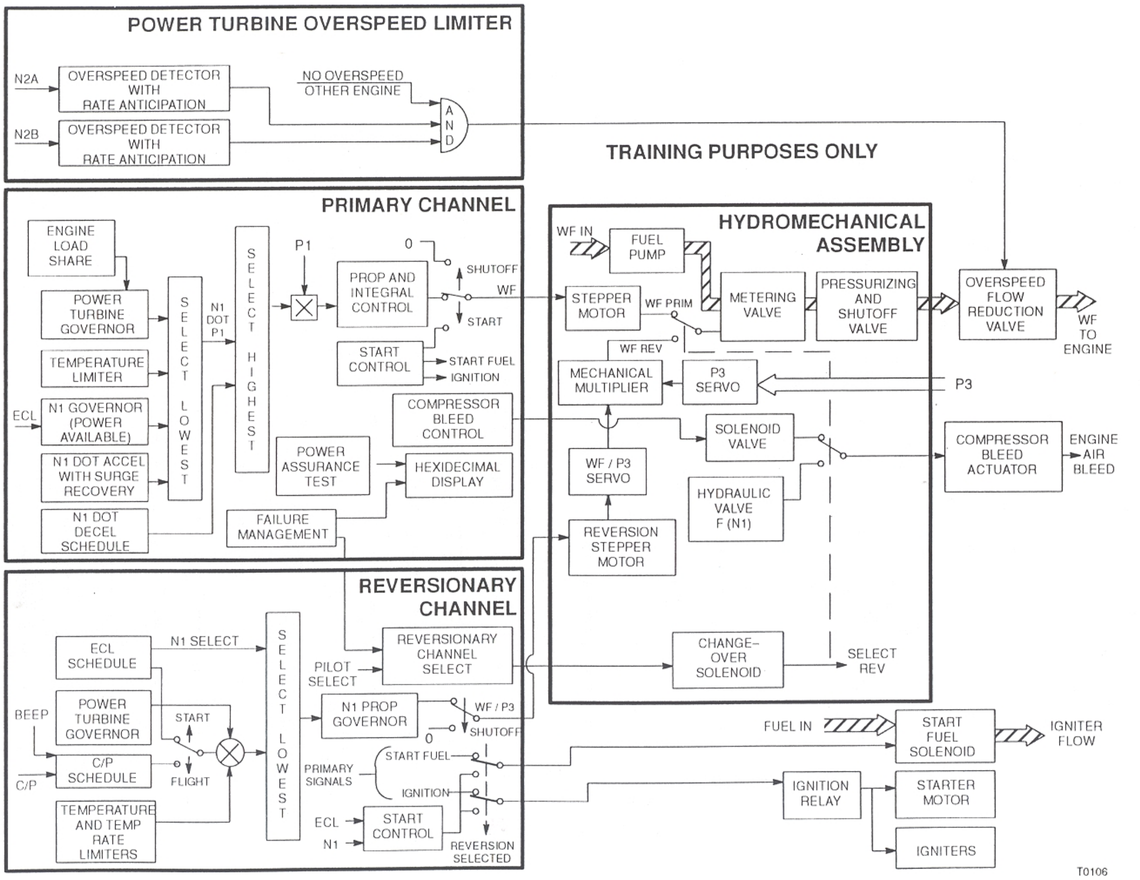
(5) Cockpit display ENG 1 (2) FAIL & FADEC 1 (2) Indication ON.

(6) Cockpit Controls Indications.

(a) Cockpit Display FADEC 1 (2) ON.

(b) The effected engine does not respond to control changes.

(c) Indicated torque splits .

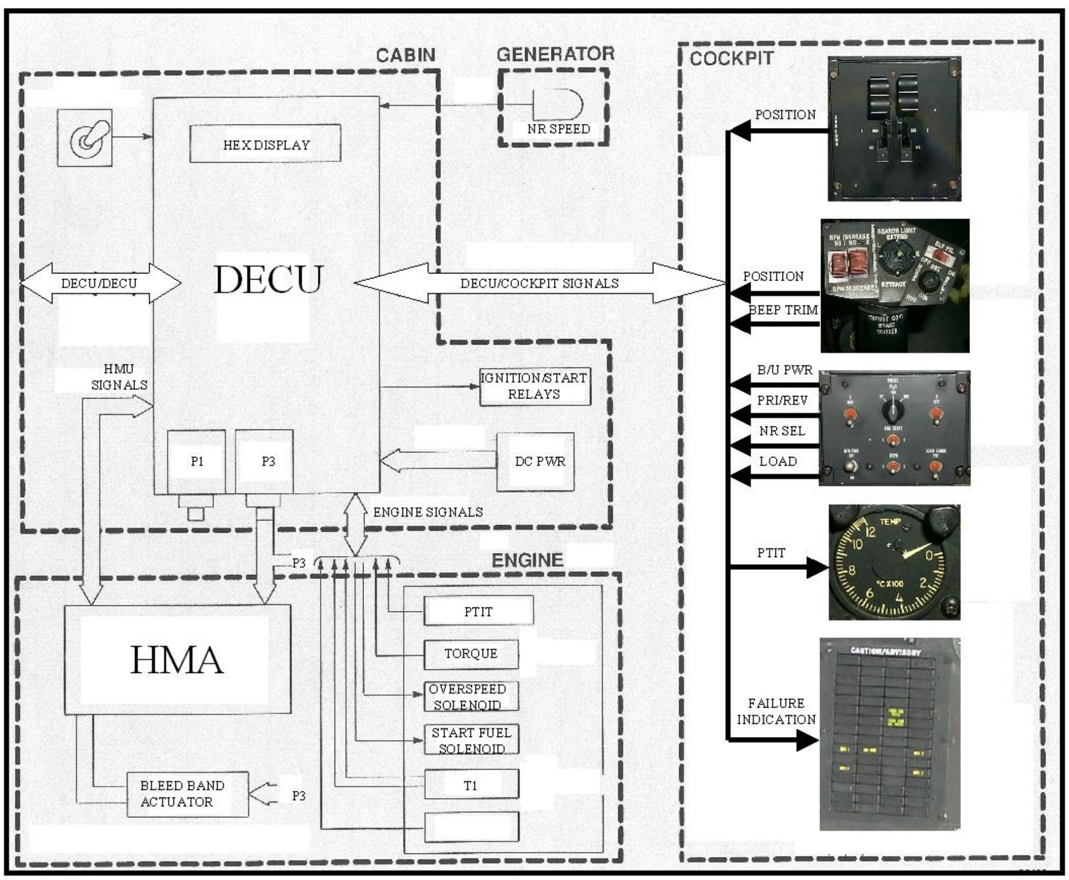


FADEC Functional Block Diagram (73-A0)

c. REVERSIONARY SYSTEM INTERFACE.

Controls for reversionary channel engine operations include:

(1) Engine Start Switch	Control Engine Start and Ignition Relays
(2) Engine Condition Lever (ECL)	Schedules Core engine Speed (N1) and Controls Fuel Shutoff
(3) Thrust Control Position Transducer	Load Scheduling
(4) PRI/REV Switch	Selects The REV Mode
(5) Engine Overspeed Test Switch	Activates Overspeed Test Function N2 < 81.3)
(6) Power Assurance Test Switch	Hexadecimal Display ENG TEMP margin
(7) INC/DEC Switch (beep)	Trims Core Engine Speed (N1)



FADEC Block Diagram (73-A0)

d. REVERSIONARY CHANNEL FUNCTIONS.

NOTE: In the reversionary control mode, the system performs a number of functions related to controlling the engine during the start and operational phases.

(1) The reversionary channels control function cycle rate is also 24 ms (41.6 cycles/sec).

(2) FADEC OPERATIONS.

(a) Engine Starting.

(b) Engine Shutdown.

(c) Core Engine Speed Governor .

(d) Proportional Power Turbine Governor .

(e) Wf/P3dot Acceleration and Deceleration.

(f) Temperature Rate of Change Limiting.

(g) Temperature Limiting.

(h) Hydromechanical Bleed Band Control.

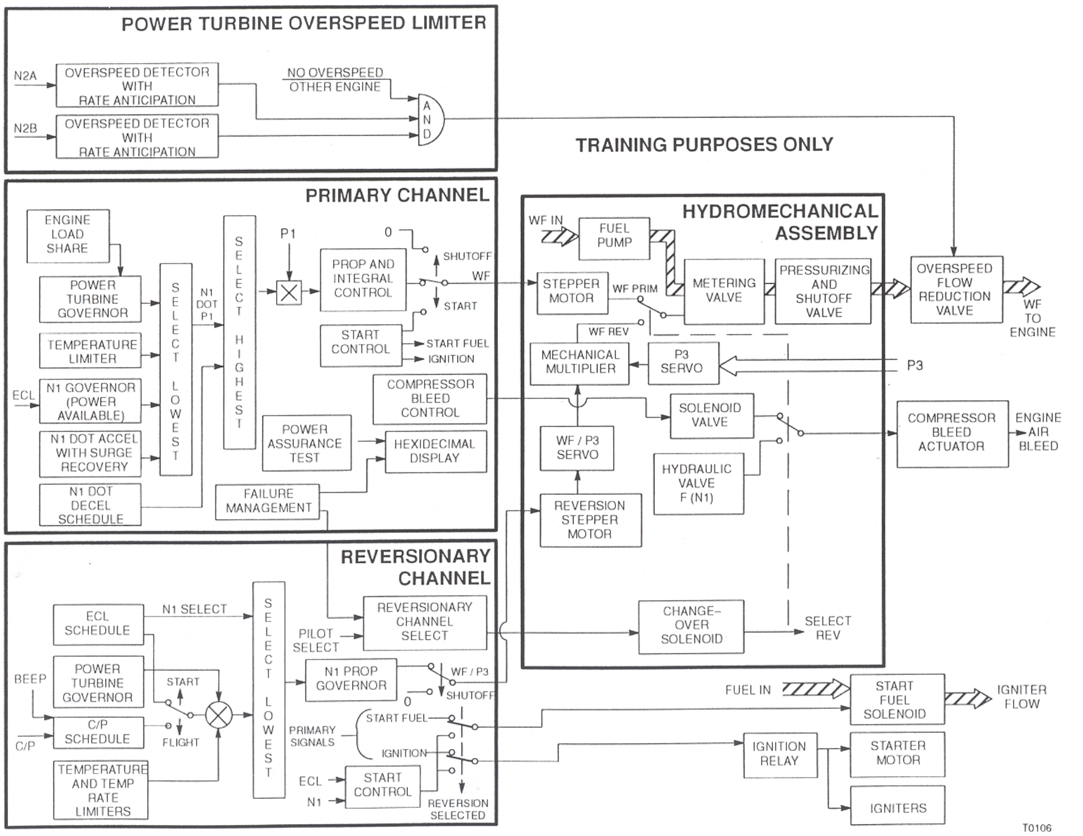
(i) Inc/Dec Trim Function.

(j) Fault Code Reporting.

(3) The reversionary channel utilizes the position of the engine condition lever (ECL), power turbine inlet temperature, core engine speed, and thrust lever position to establish the required fuel flow for engine operation.

(a) Additional inputs are from the INC/DEC switch on the thrust grip.

(4) The reversionary stepper motor control logic, after being adjusted by the fuel flow feedback signal from the reversionary potentiometer, results in a fuel flow error Signal. This generates a sequence of phase patterns (steps) that will be output to the reversionary stepper motor in order to increase or decrease fuel flow.



FADEC Functional Block Diagram (73-A0)

(5) The reversionary control scheme is based on the computation of a parameter referred to as N1SET (demanded engine core speed).

(6) Different values of core engine speed (N1SET) are computed by the:

(a) Power Turbine Governor.

(b) Temperature/Temperature rate limiter.

(7) The reversionary channel proportional speed governor uses the selected low N1SET. The logic for driving the reversionary stepper motor first computes the position of the stepper motor. A feedback signal from the reversionary potentiometer is compared with the required fuel flow signal. The resulting fuel flow computation (error) will generate a signal that will be output to the reversionary stepper motor in order to increase or decrease fuel flow.

(8) The reversionary control scheme is based on the computation of a parameter referred to as N1SET (demanded

engine core speed).

(9) Different values of core engine speed (N1SET) are computed by the:

(a) Power Turbine Governor.

(b) Temperature/Temperature rate limiter.

(10) The reversionary channel proportional speed governor uses the selected low N1SET. The logic for driving the reversionary stepper motor first computes the position of the stepper motor. A feedback signal from the reversionary potentiometer is compared with the required fuel flow signal. The resulting fuel flow computation (error) will generate a signal that will be output to the reversionary stepper motor in order to increase or decrease fuel flow.

f. REVERSIONARY WF/P3 SERVOMECHANISM .

(1) Transfers control of the metering valve from the primary to the reversionary mode also provides the mechanical Wf/P3 input to the mechanical multiplier.

(2) In the primary mode, the opposing reversionary servo and loading pistons are pressure-forced to their retracted positions. In this condition, the Wf/P3 lever is free to move between the pistons as the primary stepper motor operates the metering valve. The reversionary stepper motor still positions the contoured sleeve over the (retracted) reversionary servo piston.

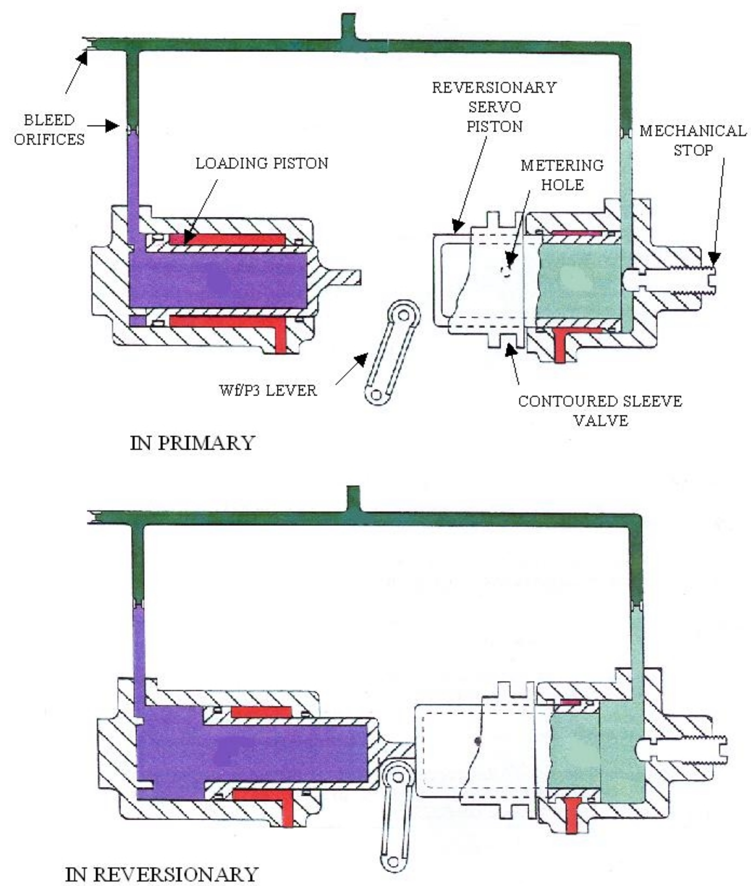
(3) When reversionary mode is enabled, servo pressure, controlled by the primary/reversionary changeover solenoid valve is ported to the Wf/P3 servomechanism. This forces the reversionary servo piston and loading piston to move-outward until they trap the Wf/P3 roller of the mechanical multiplier.

(4) The design of the mechanism ensures that during changeover the reversionary servo piston will reach its position before the loading piston traps the Wf/P3 lever. This is accomplished by the sizing of the orifices in the pressure lines of the two pistons and the distance and rate of movement of the reversionary servo and loading pistons.

(5) The reversionary stepper motor rotates the contoured sleeve that is lap-fitted to the reversionary servo piston. The sleeve covers or exposes an orifice (metering hole) in the piston. Pressure moves the reversionary piston outward until the metering hole is exposed, relieving the reversionary servo cylinder pressure, and stopping the reversionary servo piston extension.

(6) The opposite side of the reversionary servo piston is acted upon by pressure providing an opposing force causing the reversionary servo piston to retract.

(7) As the contour valve rotates the metering hole position under the contour sleeve will be varied increasing or decreasing the internal pressure of the reversionary servo cylinder, in turn controlling the metering valve position through the mechanical multiplier.



FADEC System Reversionary Wf-P3 servo (73-A0)

g. P3 SERVOMECHANISM (TRANSDUCER).

NOTE: The servo provides a mechanical input to the mechanical multiplier.

(1) The transducer utilizes a pair of opposing bellows that are acted upon by P3 pressure. One of the two bellows receives P3 pressure internally, while the other is a void of internal pressure. The bellows assembly connected to P3 pressure thereby produces a force on the P3 lever that is proportional to P3 pressure but independent of the PAF pressure surrounding the bellows.

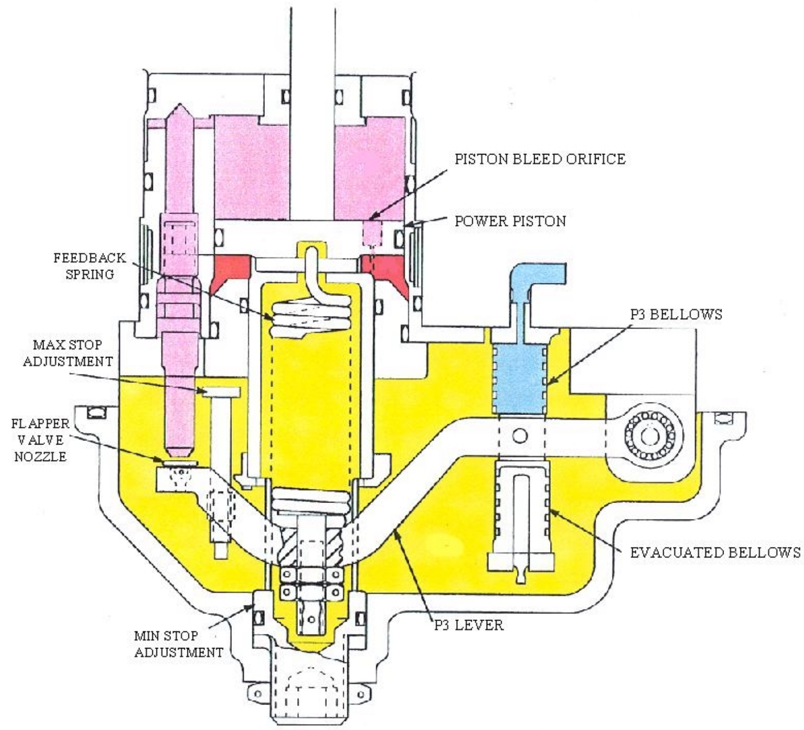
(2) As P3 pressure is increased, the P3 lever is moved, the flapper valve is moved away from the nozzle controlling the pressure in the upper chamber. Allowing the lower chamber pressure to decrease.

(3) The pressure on the under side of the P3 power piston now will move the power piston effecting a change to the mechanical multiplier. An internal spring brings the flapper valve over the control nozzle trapping upper chamber pressure, nulling out the correction made by the P3 pressure.

(4) When the system has reached balance, the output piston will have moved a distance proportional to any increase in P3.

(5) The piston motion is transmitted to the P3 input linkage of the mechanical multiplier.

NOTE: The P3 transducer servo operates in both the primary and reversionary modes. Its operation is required in the primary mode to insure that the maximum Wf/P3 is not exceeded.



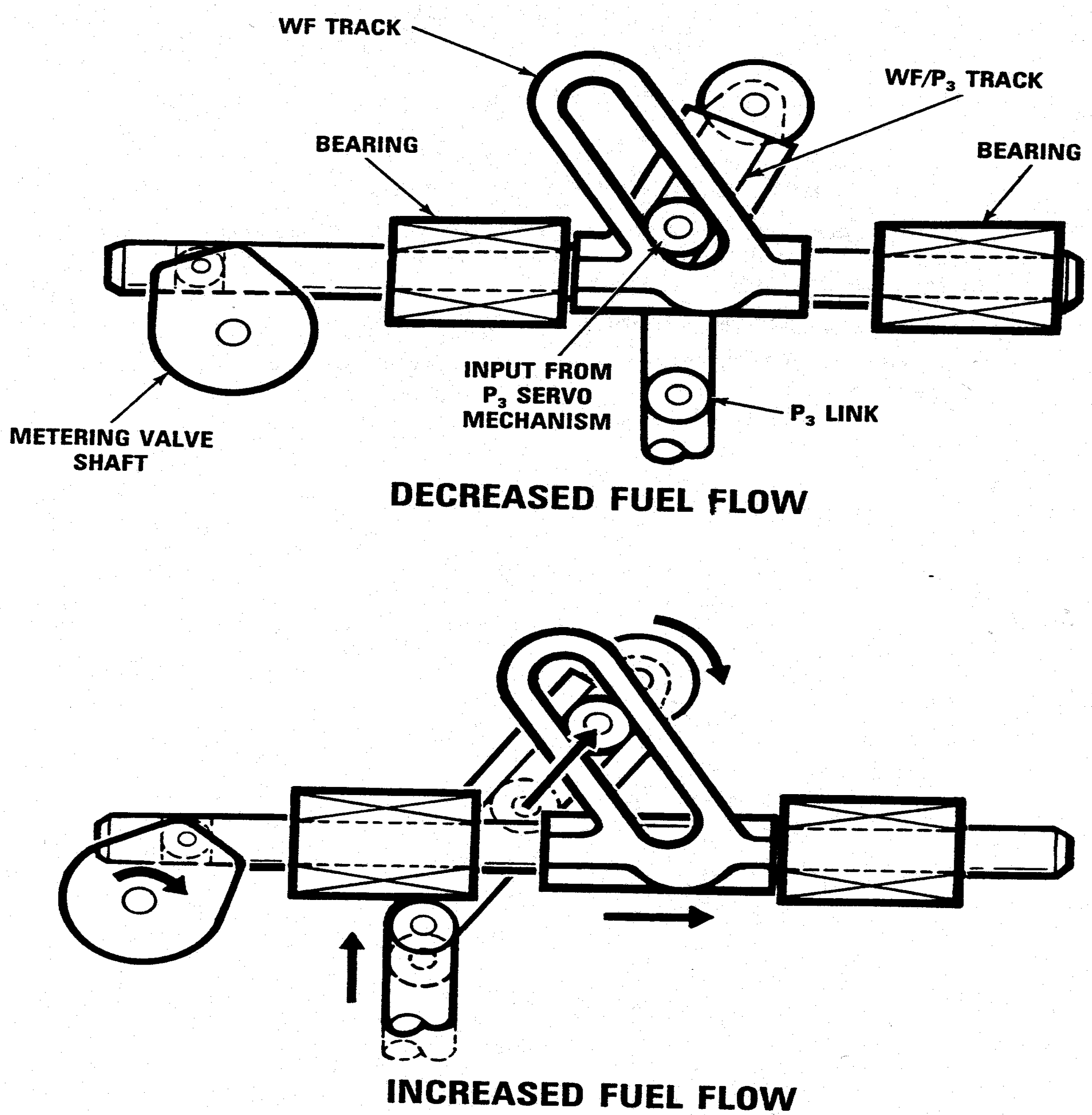
FADEC System Reversionary Wf-P3 servo Mechanism (73-AO)

h. MECHANICAL MULTIPLIER

(1) Positioned by a combination of movement by the reversionary Wf/P3 servomechanism and piston travel of the P3 servomechanism (transducer).

(2) The result positions the metering valve wiper over the metering valve discharge orifice, metering fuel flow in the reversionary mode.

e.



Mechanical Multiplier (73-A0)

i. REVERSIONARY MODE ENGINE START/SHUTDOWN .

NOTE: Start or shutdown of the engine in the reversionary mode is identical to that of the primary mode, with the only exception being the engine start switch is held until the N1 speed is at 8%. The reversionary start is via a Wf/P3 vs. N1 schedule.

Retarding the ECL to STOP will cause fuel shutoff via operation windmill bypass valve and the metering head regulator.

(1) GROUND STARTING REVERSIONARY MODE.

(a) Pilot Sets ECL To GND.

(b) Holds Start Switch Until N1 > 8% .

(c) Automatic Control Of:

1. Starter Motor (Above 8%).

2. Start Fuel Solenoid.

3. Igniters.

4. Start Flow To Main Nozzles.

(d) ECL Enrichment If Engine Tends To Stagnate. Has Not Been Required In Development Engine Tests (-65º To 135º F Starts)

(e) back to 130 PPH Min Flow.

(2) AIR START:

(a) Same Procedure As Ground Starts .

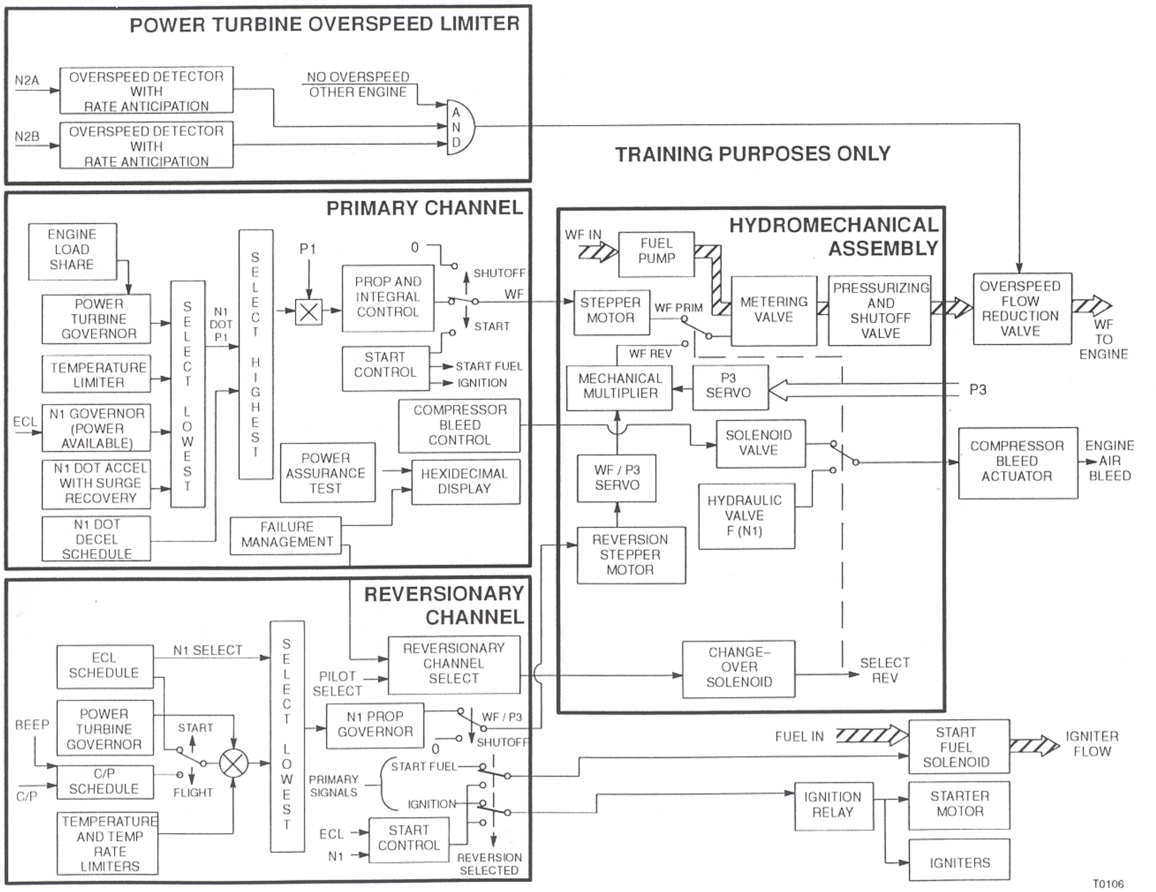
(b) Windmill Speeds Where N1 > 10% Will Start As ECL Is Moved From STOP

(3) SHUTDOWN.

(a) ECL Set To GND for Engine Cool down ECL Set to STOP Reversionary Will Immediately Open Windmill Bypass for Fuel Shutoff.

j. REVERSIONARY MODE TRANSIENT ENGINE CONTROL.

(1) For large errors, limiting the Wf/P3 stepper motor slew velocity provides transient engine control. Also, rate of change of temperature limiting is provided. It operates by resetting the N1 governor. The hydromechanical speed sensor in the HMU controls the compressor bleed valve actuator. The speed sensor has approximately 5% built-in hysteresis.



FADEC Functional Block Diagram (73-A0)

k. REVERSIONARY MODE FLIGHT CONDITION OPERATION.

(1) During flight operations, the proportional N2 governor operates to hold its set speed constant by resetting the demanded N1 governor speed. The pilots thrust lever position is used to schedule a core speed (N1) that can be trimmed up or down via the thrust grip INC/DEC switches.

(2) The demanded N1 speed is selected from the lowest of the RTL scheduled N1, and N1SET speed from the ECL schedule. The selected set speed operates through a proportional N1 governor that outputs a requested Wf/P3. The reversionary control drives the Wf/P3 stepper motor to the requested position, using a feedback potentiometer. Additionally, the RTL input to the reversionary system does a good job of setting power so the pilot will normally not have to use the INC/DEC switches.

a. POWER TURBINE OVERSPEED LIMITER.

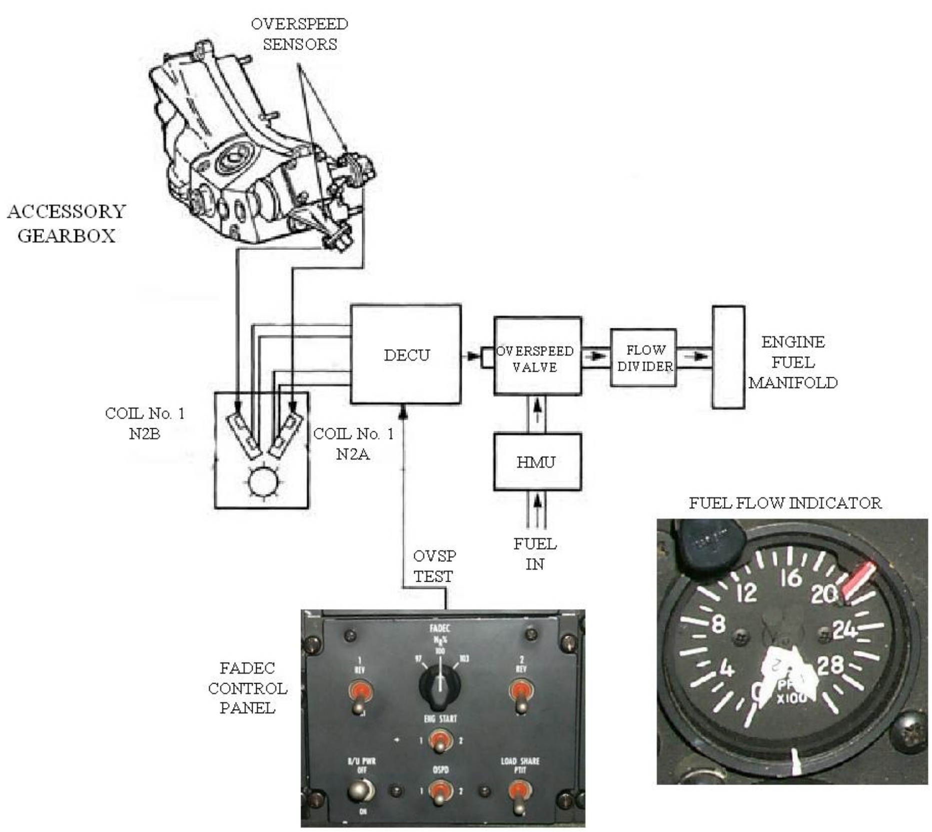
NOTE: A dual channel analog power turbine overspeed limiter circuit activates a solenoid valve in the event of a power turbine overspeed.

(1) When the solenoid valve is actuated, it provides a restriction in the engine fuel supply.

(2) The restriction is sized so that approximately 310 PPH will be metered to the engine.

(3) Each channel operates using separate pickups N2 A and N2 B. An overspeed condition must be indicated by both channels, and the other engine cannot be currently experiencing an overspeed in order for the solenoid to be activated.

(4) Testing the overspeed system is accomplished by a pilot-operated switch which lowers the overspeed trip point to 74.9% of the power turbine speed. The test circuit provides hysteresis that allows the solenoid to open when power turbine speed decreases by 12%. A reduction in core engine speed, and engine fuel flow, provides evidence that the overspeed system is fully operational. The overspeed test is disabled above 81.3% N2.



FADEC Overspeed Test Diagram (ECP D 218) (73-A0)

b. POWER TURBINE OVERSPEED LIMITER OVERSPEED

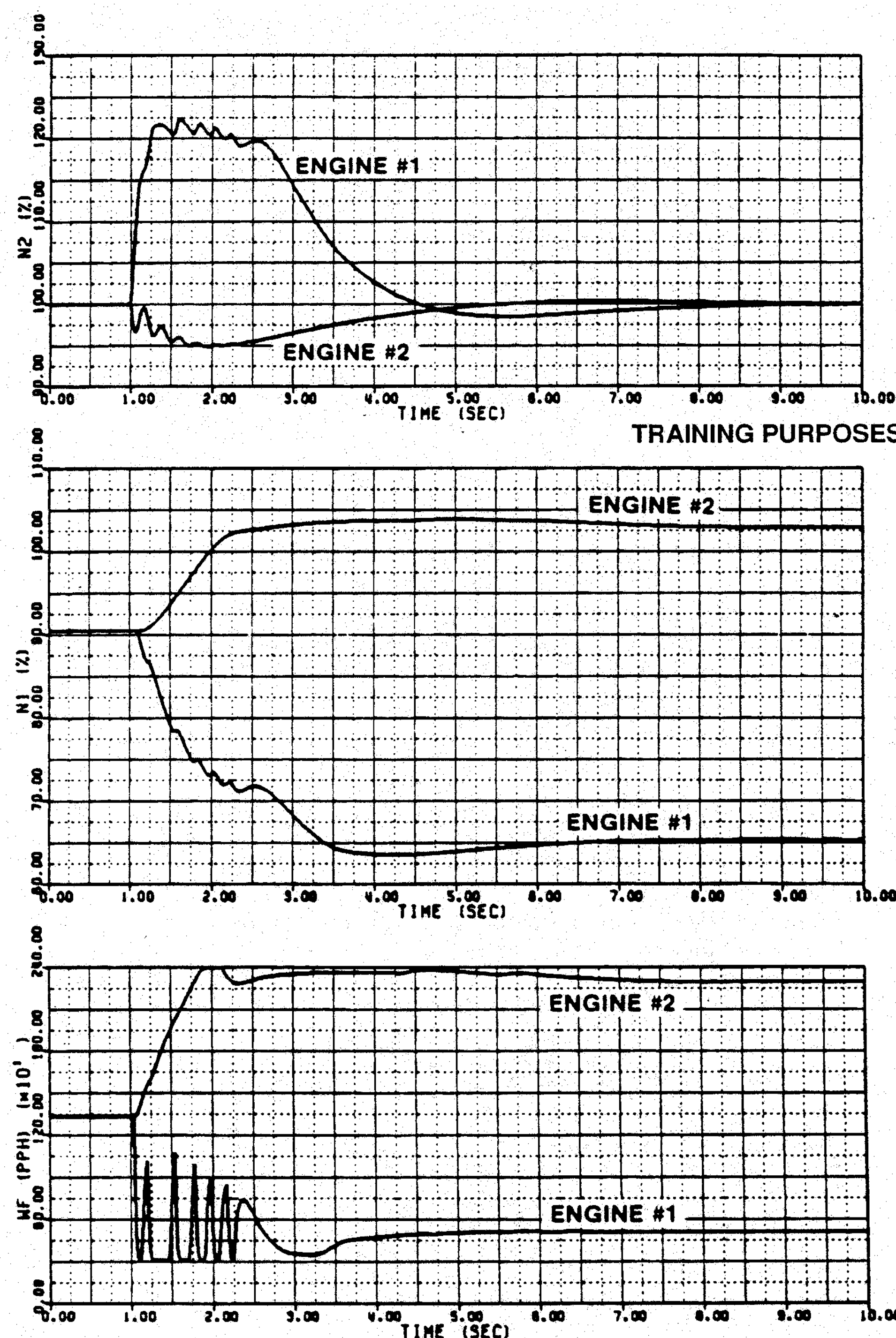
SYSTEM OPERATION.

(1) The following charts depict a simulated shaft failure and the effect of the overspeed solenoid valve on the engine fuel flow, and power turbine speed.

(2) The shaft failure takes place at the one-second mark. The overspeed is recognized and the solenoid is activated within .01 seconds; fuel flow is reduced, the power turbine speed (N2) and core engine speed (N1) both indicate a decrease in RPM.

(3) When the power turbine speed begins to rise again, the solenoid is reactivated. This cycle is repeated until the power turbine governor has closed the fuel valve enough to keep the power turbine speed down.

(4) At the 2.25 second mark, or 1.25 seconds after the shaft failure the engine is again under control. Also shown in the charts are the fuel flow, core engine speed, and the power turbine speed of the other engine, as it compensates for the sudden loss of power.



FADEC System Overspeed Protection Performance (73-A0)

a. POWER ASSURANCE TEST.

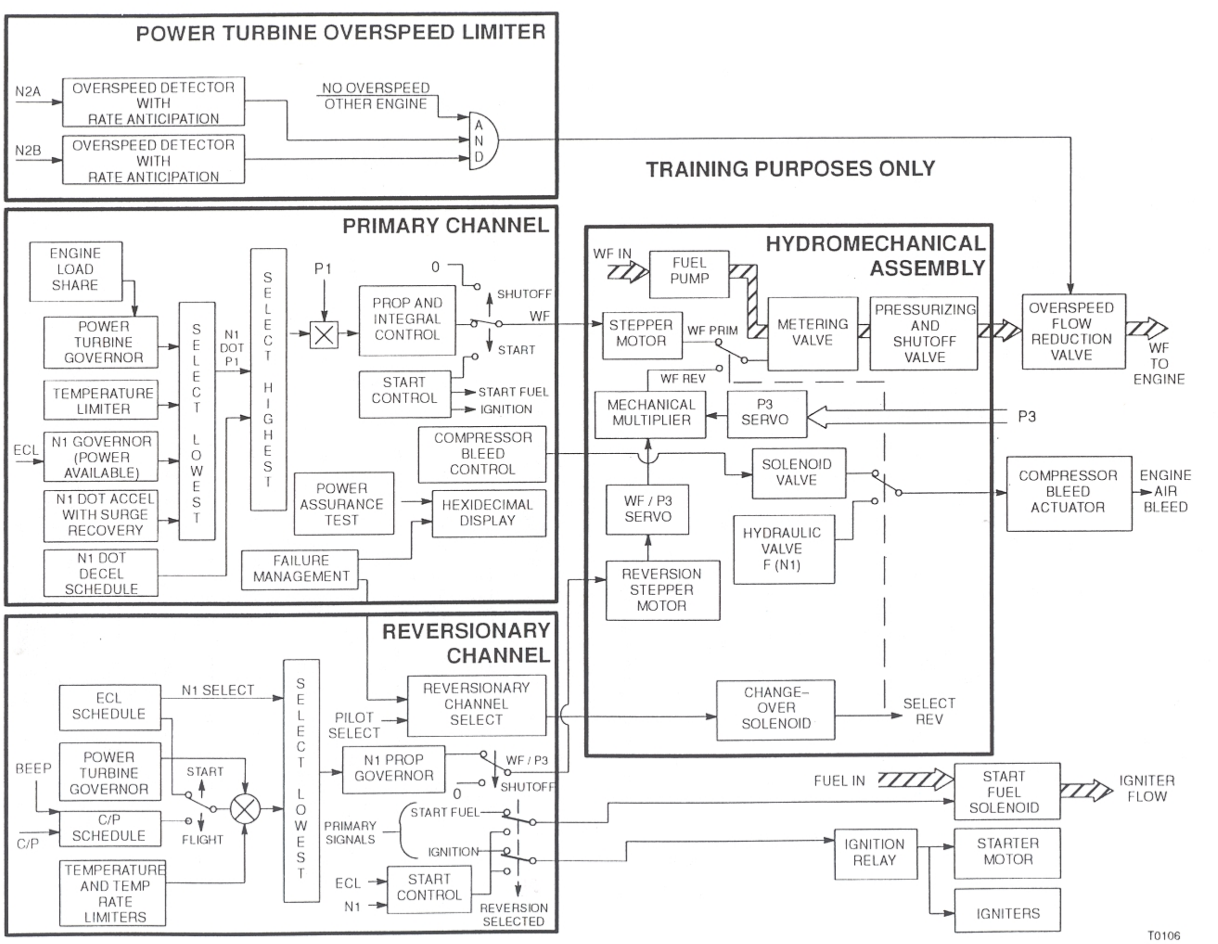
(1) The primary control performs a power assurance test when the POWER ASSURANCE TEST switch, which is located AT STA 523, is placed in the 1 OR 2 position. The results are output to the hexadecimal display. The computation uses sensed T4.5, Torque, T1, and P1 to compute the temperature margin. The test fails if the calculated T4.5 is less than the sensed T4.5 temperature.

NOTE:

TEST PROCEDURES

Power Assurance Test
Power Assurance Check

Refer to the operator’s manual for test procedures.



FADEC Functional Block Diagram (73-A0)

b. FAULT MONITORING PROCESS, PRIMARY MODE.

(1) The fault monitoring process carried out by the DECU consists of power-up, and continuous fault checks. The power-up check is a one time check at aircraft power-up (ECL < 10 degrees, and N1 < 7%), is designed to discover dormant system faults. The process exercises the pressure sensors, bleed valve solenoid, primary reversionary change-over solenoid, watchdog timer circuitry, Programmable Read Only Memory (PROM), and Electronically Erasable Programmable Read Only Memory (EEPROM) logic circuits. At initial power-up, the primary system switchover circuitry (watchdog timer) trip mechanism is exercised and tested for proper operation. All system fault counts are reset to zero at system power-up.

c. CONTINUOUS FAULT CHECKS.

(1) Continuous fault checks are performed during all operating phases, Checking the airframe and engine interface sensors, FADEC system electromechanical components, and the system power supplies. While the continuous fault checks are in-progress on the N1 A, N1 B, thrust control position transducer, N2 A, N2 B, or ECL sensors, a stepper motor position freeze will be enforced, avoiding possible power transients.

d. MONITORING FAULT CHECKS.

(1) Power-Up Prestart Checks.

(2) Presure Sensors.

(3) Bleed Valve Solenoid.

(4) Primary Reversionary Change-Over Solenoid.

(5) Primary Switch-Over (Watchdog Timer) Circuitry.

(6) Programmable Read Only Memory (PROM).

(7) Electronically Erasable Programmable Read Only Memory (EEPROM).

e. CONTINUOUS FAULT CHECKS.

(1) Airframe & Engine Interface Sensors.

(2) Electromechanical Components.

N (3) Power Supplies.

f. FAULT MONITORING PROCESS REVERSIONARY MODE.

(1) Reversionary channel fault checks are continuously conducted during SYSTEM operation. The Reversionary system conducts various operating mode fault checks, including a check of the reversionary channel fault detection circuitry (watchdog timer). The reversionary channel provides a single fault signal to the primary channel.

(2) Hard faults will disable the reversionary stepper motor freezing it at the current position. If the reversionary fail signal sensed by the primary channel is continuous, the primary channel ncrements a fault counter and will log a reversionary fault if the count exceeds a preset limit.

(3) The rate of change of various input signals is calculated over a two cycle sampling period, using the change between the current cycle and the data from two cycles earlier.

(4) If any signal normally transmitted between DECUs has faulted it will not be transmitted.

(5) Both the primary and reversionary channels have a hardware watchdog timer that will hard fault the channel if the fault counter exceeds preset limits.

f. REVERSIONARY MODE FAULT CHECKS.

(1) Rate Of Change Tests.

(2) Signals Transmitted.

(3) Between Decus.

(4) Fault Circuits.

g. DETECTED FAULT CLASSIFICATION.

NOTE: All detected faults are classified into two main categories.

(1) Soft Faults: Are failures that do not impact normal control of the engine or aircraft. Soft faults are not indicated in the cockpit.

(2) Hard Faults: Are failures that could cause unacceptable engine and/or aircraft performances if operations were to continue in the degraded mode of control. Hard faults are detected through software fault limit monitoring or if the primary channel software or computer were to fail. The primary system will fail to reversionary through the operation of the watchdog timer. If the watchdog timer, times out or receives a hard fault signal, it will cause the primary/reversionary change-over solenoid, bleed valve solenoid, and primary stepper motor to be de-energized, enabling the reversionary control

mode. All faults (hard or soft) are logged in an electronically erasable programmable read only memory (EEPROM). Active faults are readable through a two-digit hexadecimal display on the DECU.

FAULT CLASSIFICATION.

(1) Soft Fault:

(a) Failures which will not impair normal mode control of the engine or aircraft.

(b) Pilot action NOT required.

(c) No cockpit indications.

(d) A fault information displayed in the hexadecimal DECU display.

(2) Hard Fault.

(a) Failures which could seriously impair operation of the engine or aircraft.

(b) Primary will fail automatically to reversionary and FADEC 1 (2) indication will be displayed.

i. REVERSIONARY HARD FAULT.

(1) Reversionary fail fixed REV 1 (2) will be displayed.

(2) Primary and Reversionary fail fixed FADEC 1 (2) and REV 1 (2) will be displayed (if primary fails or pilot

j. Primary Hard Fault Options.

(1) Since normal operation in the primary mode is unacceptable under these conditions, the system is designed to take one of two possible options.

(2) Option one - Reversionary System has not failed: In most circumstances, a normal fault free reversionary system will be available as a back up to the failed primary system. In this case the primary system trips the watchdog timer, which results in de-energizing the metering valve primary stepper motor, bleed valve solenoid, and the primary/reversionary change over solenoid. De-energizing the primary/reversionary change over solenoid causes the fuel metering valve position to be controlled by the reversionary channel through the function of the Wf/P3 servo, mechanical multiplier, and P3 servo. The FADEC 1 (2) indication is displayed in the cockpit.

(3) Option Two - Reversionary System Hard Fault (REV 1 (2) ON) Automatic switchover to the failed reversionary mode will not occur and due to the primary mode failure the engine is now in the failed fixed condition. FADEC 1 (2) and REV 1 (2)

will be displayed.

(4) If the reversionary mode was selected over a functioning primary system and the reversionary system experiences a hard fault the reversionary stepper motor freezes at its current setting. Since this may not represent the current engine operating condition (primary does not shadow reversionary), the primary system is designed to fail fixed rather than automatically switch to the primary system. The primary mode will have to be selected through the use of the PRI/REV select switch.

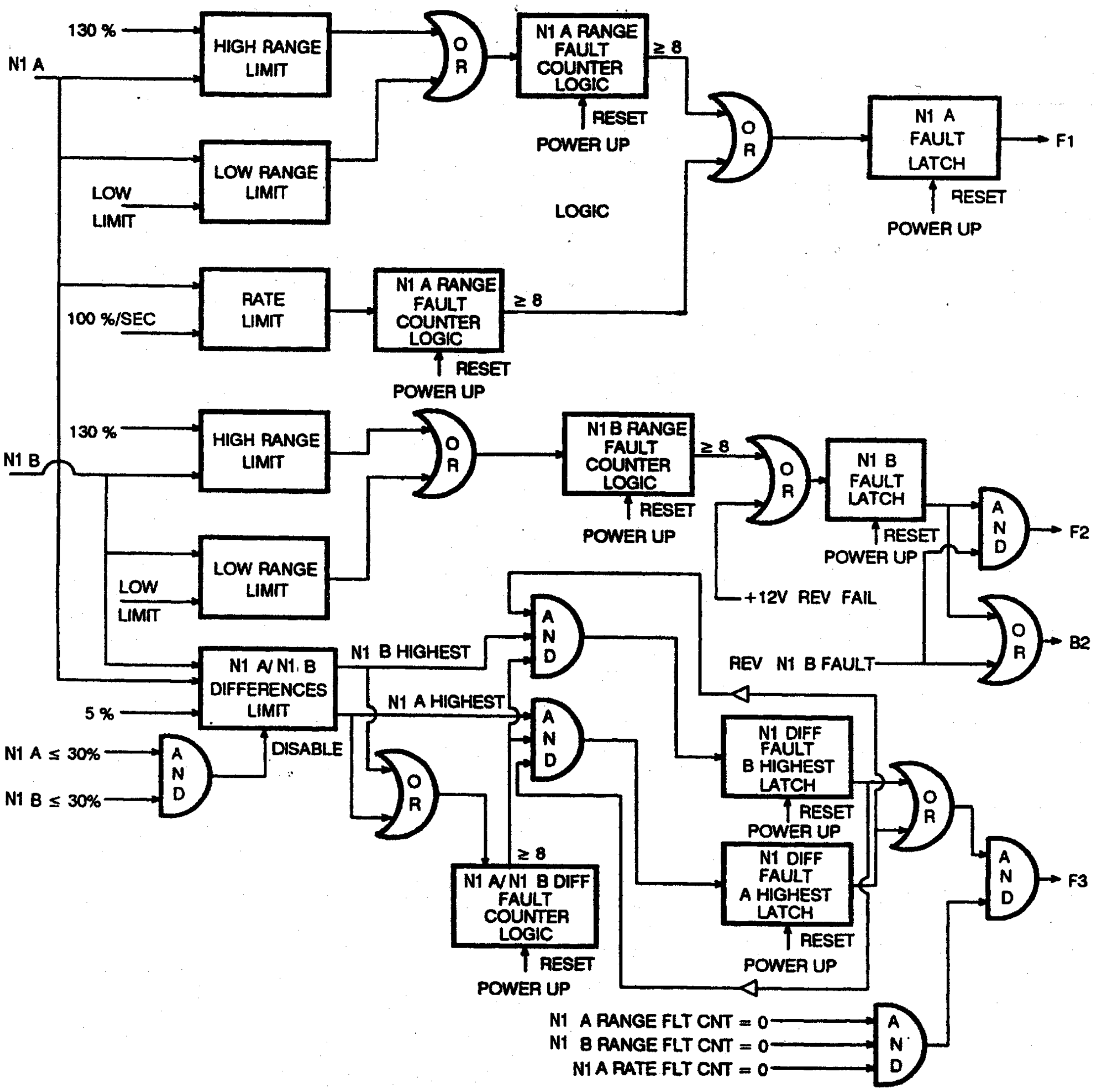
k. FAULT VERIFICATION AND LOGGING.

(1) Signals are checked against high and low limits and where practical against a rate of change limit. Additionally, if the system uses redundant signals (i.e., N1 A and N1 B) the differences between the signals are checked to be within limits. A signal will be determined to have failed when the control has detected and verified a hard or soft failure of the signal. Unless specified otherwise, Verification will be managed by the use of fault counter that increments by two for each computer cycle (24 ms) the signal is outside its limit. The fault count decrements by one count for each cycle where the signal is within its limits, (zero is the minimum count). The count range for the majority of primary channel faults is between zero and eight counts. When the maximum of eight counts is reached, the signal will be classified as either a soft or hard fault and logged in a fault register in the EEPROM. The count range for the majority of reversionary channel faults is between zero and ten counts. When the maximum of ten counts is reached, the signal will be classified as either a soft or hard fault and logged in a fault register in the EEPROM. During cycles where a signal is out of limits and prior to triggering a hard fault, the channel for computation purposes will use it's last good value.

l. SAMPLE FAULT LOGIC (N1).

(1) The N1 fault logic provides means to check the high and low range limit on both the N1 A and N1 B signal. Additionally, an N1 A/N1 B difference limit is checked and both signals are limit checked. Note that all fault counters are reset to zero on a power-up to preclude a fault signal due to an errant count. Logic is provided to set the proper low speed fault limit, depending on the operating condition. Normally, N1 A is the speed signal used by the DECU. The fault logic provides for the DECU to select N1 B under specific fault conditions.

N1 FAULT LOGIC



N1 Fault Logic (73-A0)

m. FAULT STORAGE AND READOUT.

(1) Faults are classified as either soft or hard and each has a two-digit hexadecimal (alpha/numeric) identification code. After a fault is confirmed, the fault is logged in EEPROM. The fault display logic determines when the fault code is output to the two-digit hexadecimal display on the DECU housing. The hexadecimal display is available until the ECL is moved past the 55-degree position (the ECL, FLT position is at 60 degrees except for the power assurance test. The most significant character or digit is used to identify the source of the faulty component. Hexadecimal identification codes.

(a) F - Fluid Controller (HMU).

(b) A - Airframe Sensor.

(c) D, 1, or B - DECU.

(d) E - Engine Sensor.

(e) C - Communications Between the DECUs.

(2) The least significant digit is used to identify the specific fault; for example:

(a) Display E2 = (E) - Engine sensor, (E2) T1 Sensor. (Soft fault)

(b) Display D5 = (D) - DECU, (D5) 15 Volt, (Hard fault).

(3) For every fault, a set of procedures is specified to account for the post-fault operation of the control unit. This varies from simply displaying and logging soft faults, to activating the watchdog timer and tripping the control to the reversionary system for hard faults. For primary signals that also have a backup, the fault procedure is simply to use the backup signal source.

No.	Failed Signal	Fault Procedures	Fault Class	Identifier	Hex. Fault Code
1	T4.5	Set constant = 800ºF	Soft	Sensor or circuit	E1 orB4
2	T4.5 (0)		Soft	Eng./Eng. Communication	C1
3	N1 A	Use N1 B	Soft	Sensor	F1
4	N1 B	a)Select N1 A(if N1 A not faulted)	Soft	Sensor	F2 or B2
		b) Revert to reversionary (if N1 A fault exists).	Hard	Sensor	
5	N1 A/N1 B Diff.	Use highest value sensor	Soft	Sensor	F3
6	P3	Use constant =120 psi	Soft	Sensor	D1
7	P1	Use P1 (0)	Soft	Sensor	D2
8	P1 (0)	No change if using P1	Soft	Eng./Eng. Communication	C2
		Reversionary if P1 fault	Hard		
9	T1	Use T1 (0)	Soft	Sensor	E2
10	T1 (0)	No change if using T1	Soft	Eng./Eng. Communication	C3
		Reversionary if T1 Fault	Hard		
11	Q	Disable load sharing	Soft	Sensor	A1
12	Q (0)	Disable load sharing.	Soft	Eng./Eng. Communication	C4

Table 1 Primary Fault Identification Codes (Sample)

n. REVERSIONARY FAULTS.

(1) The reversionary system has four discrete output signals to provide signal fault status to the primary channel for output on the fault code display (reversionary mode faults are not displayed directly on the fault display). The four signals will represent a four bit binary number that corresponds to a fault code (0-15). Four zeros indicate that there are no reversionary system faults. If all four signals are 1, the Indication is the reversionary system has failed fixed. In this case, the primary system will not trip the watchdog timer for automatic switchover to the reversionary mode. Under these conditions, the primary system will freeze its stepper motor by holding the primary stepper in the fixed position. Both the FADEC 1 (2) and REV 1 (2) indications wil be on. Engine control consists of shutting down the engine, using the engine fire pull handle.

Signal	Fault Limits			Failure Action	Fault Code to Prim.
	High	Low	Conditions		
N1 B	120%	30%	If (ECL >23% and run mode* and N2 > 50%) or (run mode and (last valid N1 B value – current in-put value –30%))	Hold last good value of N1.set WF/P3 = WF/P3	1
N2 B	170%	10%	If N1 > 80%	Set N2 = 100% for control use. (System continues operation without power turbine governor).	2
T4.5	1850º F	250º F	N1> 50% no low limit test if N1 < 50%	Set T4.5 = 0ºF for control use.(system continues operation without T4.5 limiting)	3
RTL	95.0%	-4.0%	All	Fix WF/P3* = WF/P3	4
ECL	64.5	-4.0		Hold 2nd last good value of ECL. (Normal flight operation but cannot shutdown in reversionary). If failed on power up set =30 degrees.	5
PLA	107.5º	-6º		If not power-up, use step count backup. If power-up freeze stepper.	6

*Run mode defined as NOT Start (REV) Mode and NOT Shutoff Mode.

Table 2 Reversionary Fault Identification Codes (Sample)*

o. ENGINE FAILURE DETECTION.

(1) Failure logic recognizes four different engines failed conditions:

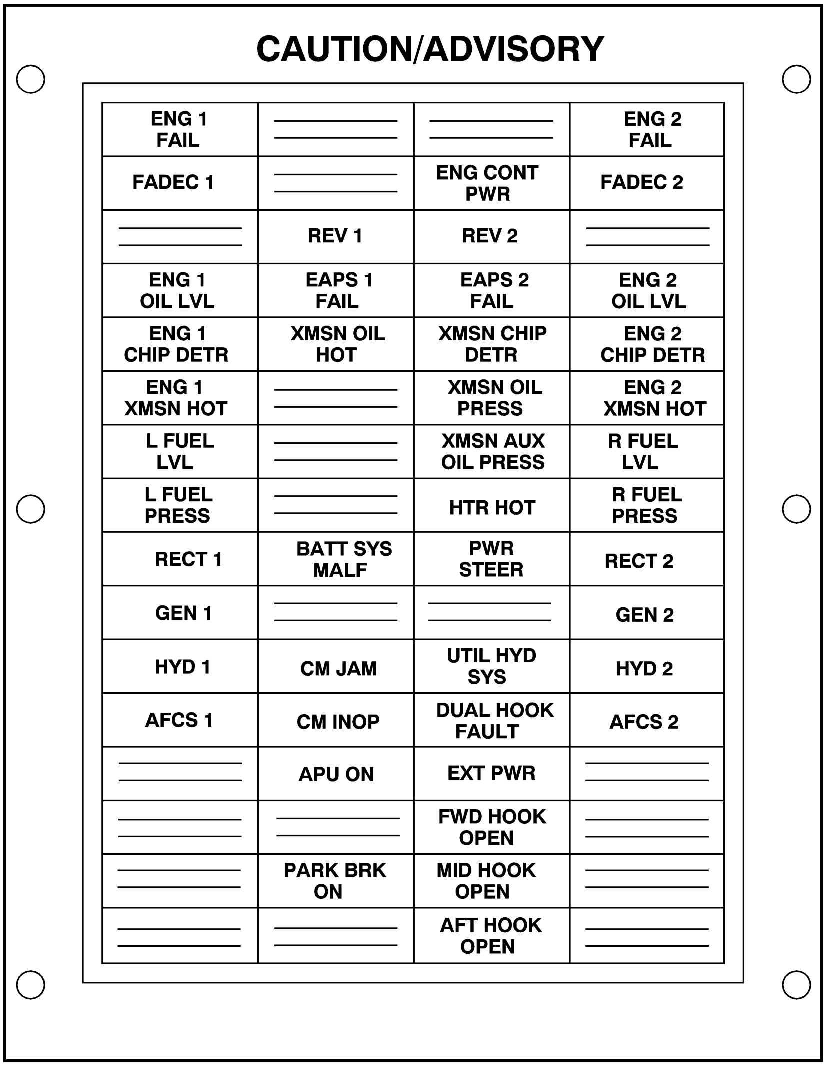
(a) Power absorber shaft failure, = N2 >NR 3%.

(b) Gas producer turbine under-speed, = N1 < 48%.

(c) Engine flameout, = N1 DOT < N1 DOT minimum.

(d) Start abort.

NOTE: Should any of these conditions occur, the ENG 1 (2) FAIL indication is displayed on the Caution panel.


CAUTION/ADVISORY
ENG 1 FAIL
ENG 2 FAIL
FADEC 1
ENG CONT PWR
FADEC 2
REV 1
REV 2
ENG 1 OIL LVL
EAPS 1 FAIL
EAPS 2 FAIL
ENG 2 OIL LVL
ENG 1 CHIP DETR
XMSN OIL HOT
XMSN CHIP DETR
ENG 2 CHIP DETR
ENG 1 XMSN HOT
XMSN OIL PRESS
ENG 2 XMSN HOT
L FUEL LVL
XMSN AUX OIL PRESS
R FUEL LVL
L FUEL PRESS
HTR HOT
R FUEL PRESS
RECT 1
BATT SYS MALF
PWR STEER
RECT 2
GEN 1
GEN 2
HYD 1
CM JAM
UTIL HYD SYS
HYD 2
AFCS 1
CM INOP
DUAL HOOK FAULT
AFCS 2
APU ON
EXT PWR
FWD HOOK OPEN
PARK BRK ON
MID HOOK OPEN
AFT HOOK OPEN

A65142

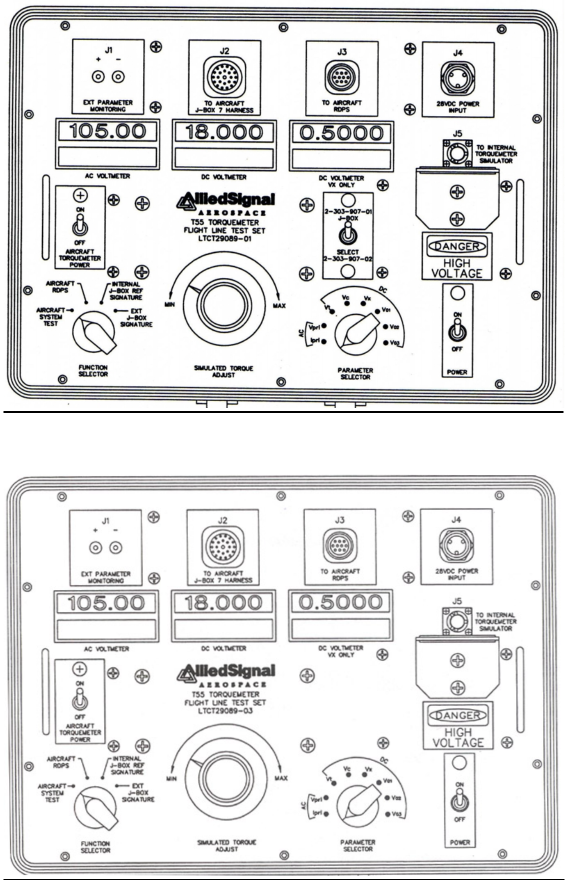


Figure FLTS LTCT 300566-01/03.

OPERATION

The FLTS performs four functions to an aircraft torquemeter system as described below.

AIRCRAFT SYSTEM TEST

This FUNCTION SELECTOR position allows the operator to tap into and monitor aircraft system parameters under normal operating conditions.

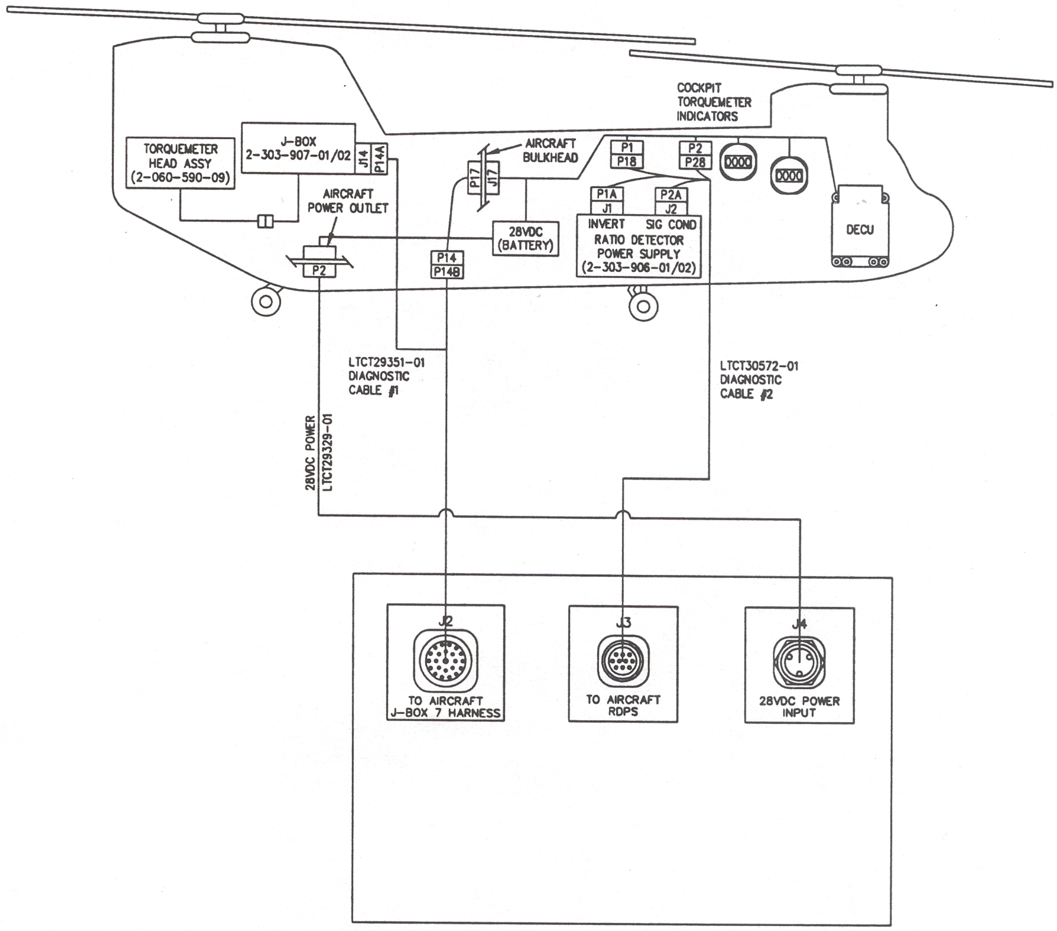


Figure Aircraft System Test interconnect Digram

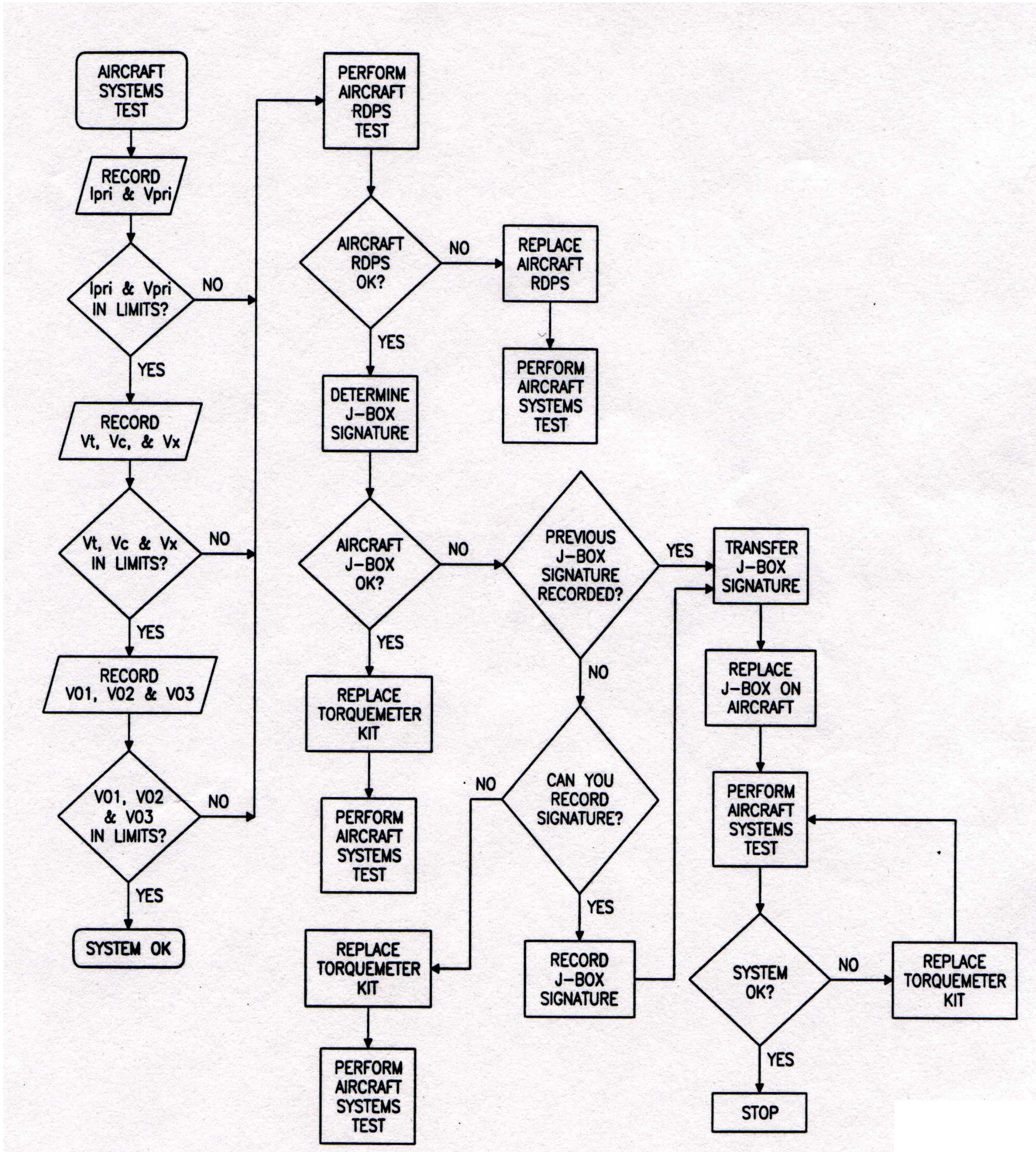


Figure Aircraft System Test

AIRCRAFT RDPS
This FUNCTION SELECTOR position allows the operator to tap into and monitor the aircraft Ratio Detector Power Supply (RDPS) signals, using the FLTSs internal torque simulator, J-Box, and signal conditioning network.

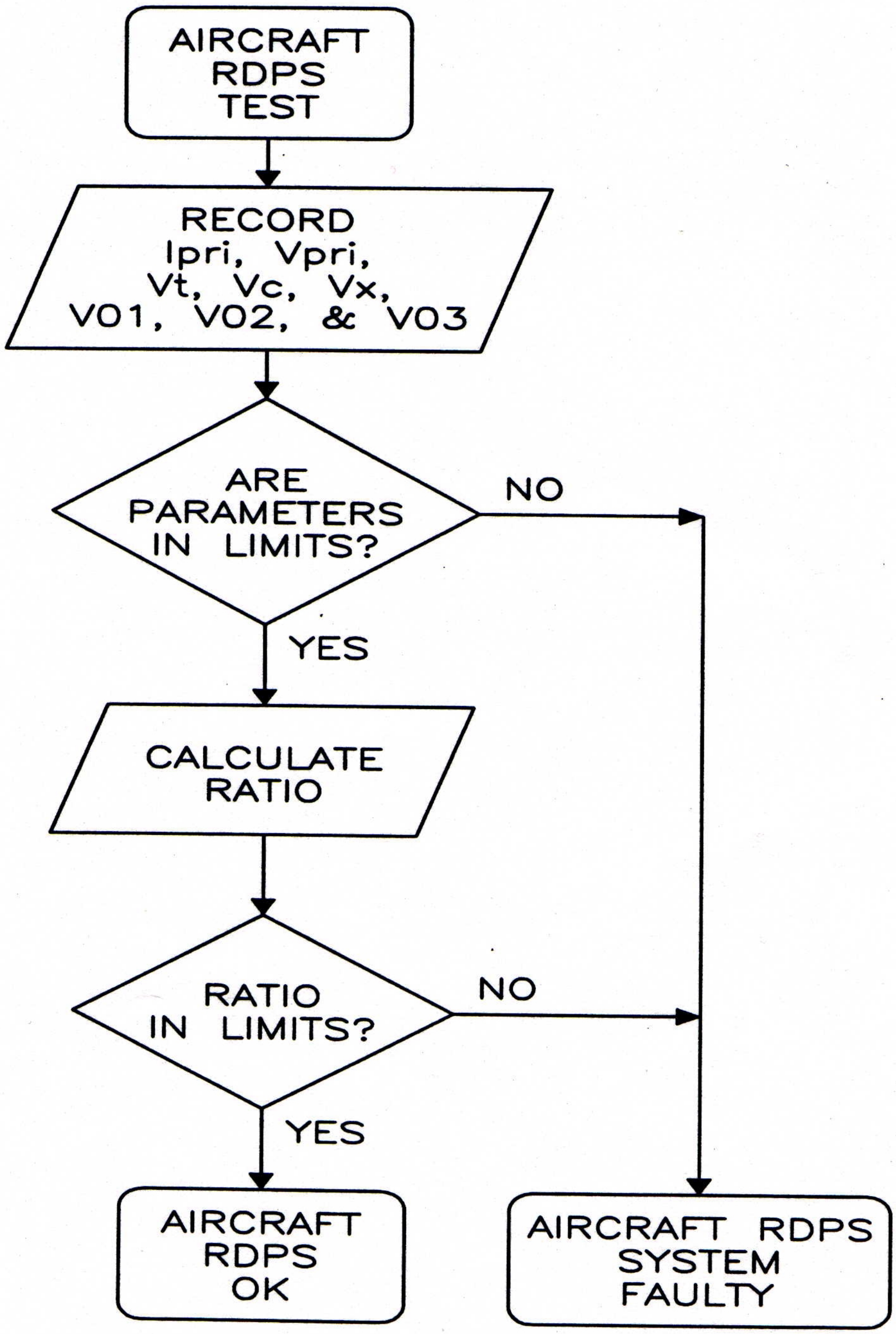


Figure Aircraft RDPS Test

INTERNAL J-BOX REFERENCE SIGNATURE
This FUNCTION SELECTOR position provides readouts for the reference FLTS internal torque simulator, J-Box, and signal conditioning network.

EXTERNAL J-BOX SIGNATURE
This FUNCTION SELECTOR position will allow the operator to establish J-Box characteristics and perform a J-Box replacement using the FLTSs internal torque simulator.

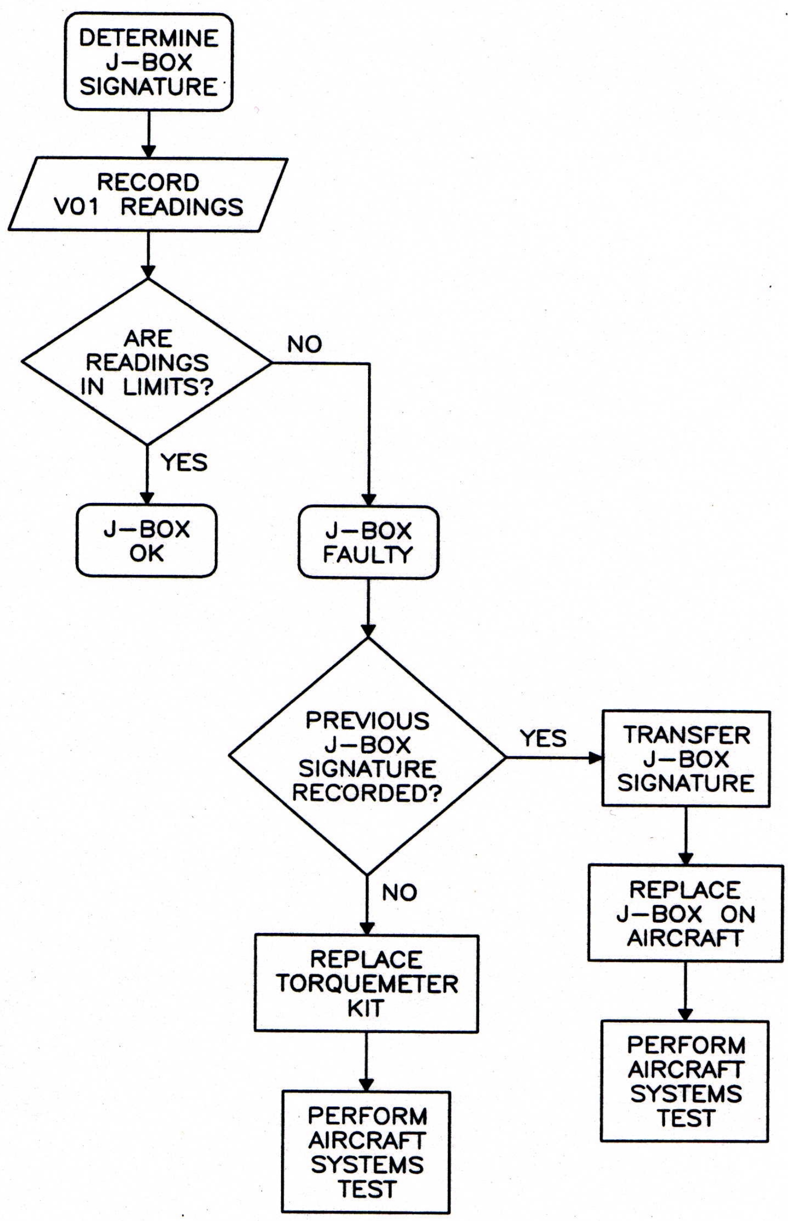
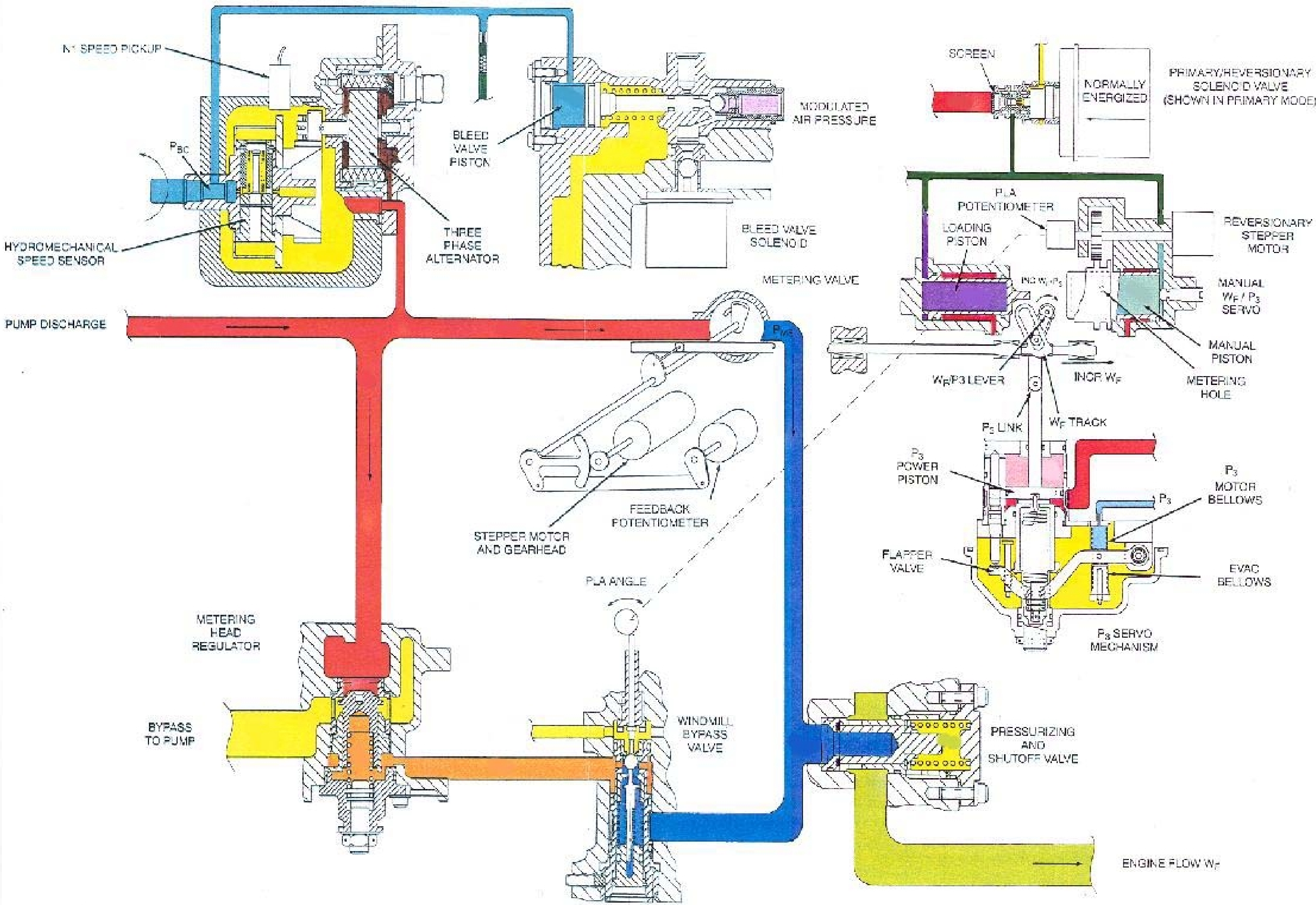
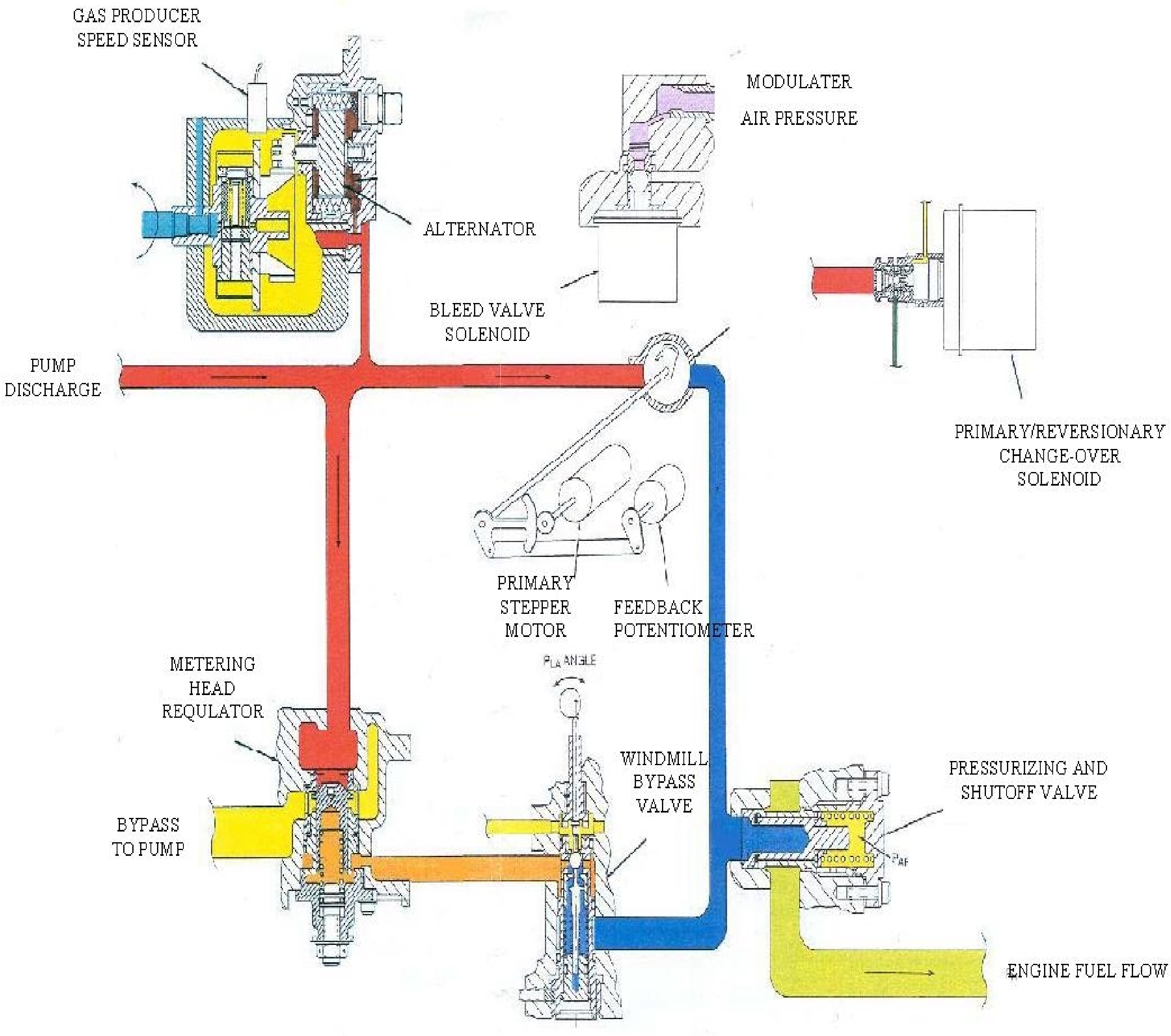


Figure Determine J-Box Signature



N1 SPEED PICKUP
P_{BC}
HYDROMECHANICAL SPEED SENSOR
BLEED VALVE PISTON
THREE PHASE ALTERNATOR
MODULATED AIR PRESSURE
BLEED VALVE SOLENOID
SCREEN
NORMALLY ENERGIZED
PRIMARY/REVERSIONARY SOLENOID VALVE (SHOWN IN PRIMARY MODE)
PLA POTENTIOMETER
LOADING PISTON
REVERSIONARY STEPPER MOTOR
METERING VALVE
MANUAL W_F / P_3 SERVO
MANUAL PISTON
METERING HOLE
PUMP DISCHARGE
P_{MF}
W_F/P3 LEVER
INCR W_F
P_3 LINK
W_F TRACK
P_3 POWER PISTON
P_3
P_3 MOTOR BELLOWS
FEEDBACK POTENTIOMETER
STEPPER MOTOR AND GEARHEAD
FLAPPER VALVE
EVAC BELLOWS
PLA ANGLE
P_3 SERVO MECHANISM
METERING HEAD REGULATOR
BYPASS TO PUMP
WINDMILL BYPASS VALVE
PRESSURIZING AND SHUTOFF VALVE
ENGINE FLOW W_F


GAS PRODUCER
SPEED SENSOR
MODULATER
AIR PRESSURE
ALTERNATOR
BLEED VALVE
SOLENOID
PUMP
DISCHARGE
PRIMARY/REVERSIONARY
CHANGE-OVER
SOLENOID
PRIMARY
STEPPER
MOTOR
FEEDBACK
POTENTIOMETER
METERING
HEAD
REQULATOR
PLA ANGLE
WINDMILL
BYPASS
VALVE
PRESSURIZING AND
SHUTOFF VALVE
BYPASS
TO PUMP
ENGINE FUEL FLOW

CHAPTER 5

ROTOR SYSTEM

ROTARY-WING HEAD AND CONTROLS

DESCRIPTION AND OPERATION

ROTARY-WING HEAD AND CONTROLS

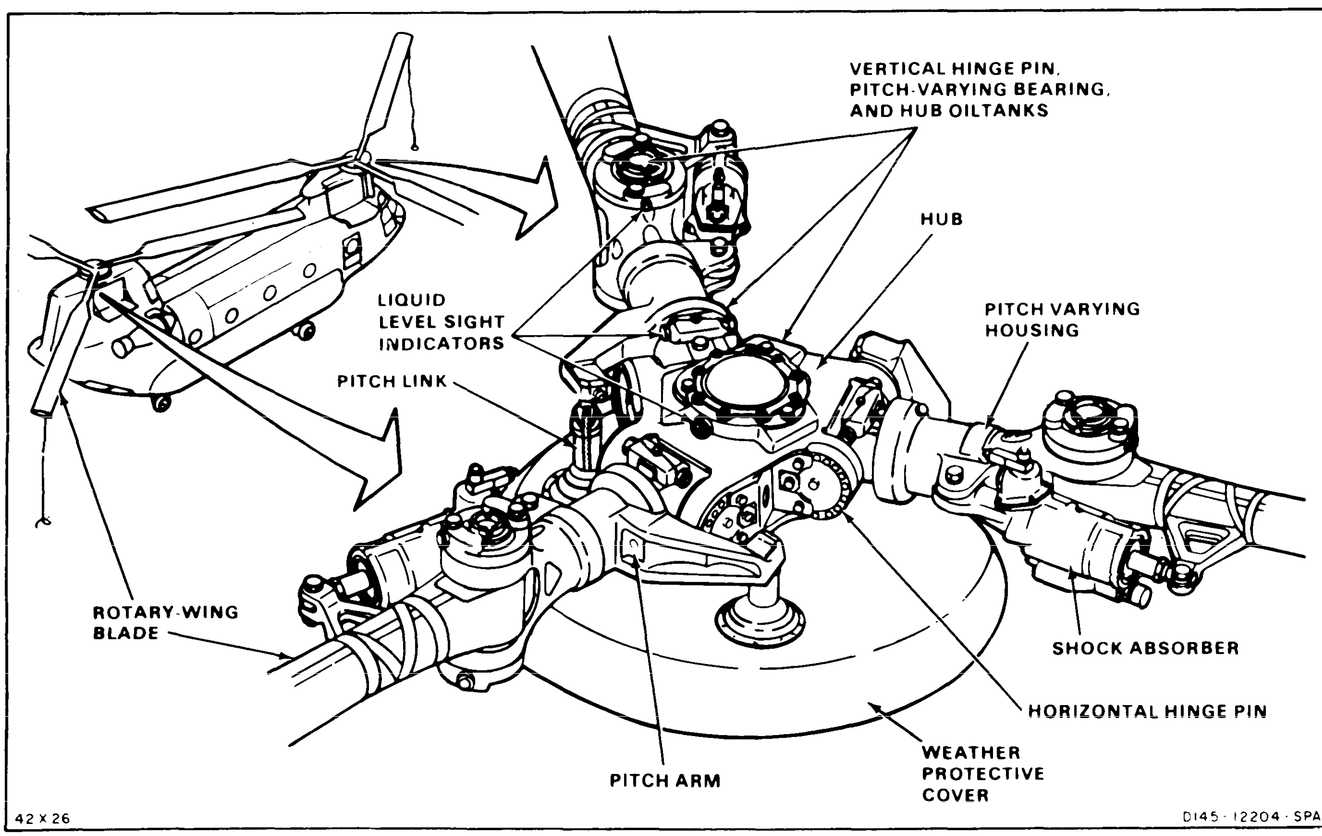
This rotary-wing head transmits torque from the forward or aft transmission rotor shafts to the rotary-wing blades. The rotary-wing controls transmit cockpit control movements to the blades. Three rotary-wing blades are attached to both the forward and aft rotary-wing heads. The aft blades turn clockwise and the forward blades turn counterclockwise, when viewed from above. Each rotary-wing head and controls consists of a rotor hub, three pitch-varying housings, three pitch-varying shafts with droop stops, three shock absorbers, a swashplate, three pitch links, a drive collar and drive arms, and a weather-protective cover.

ROTOR HUB

The rotor hub contains splines that mate with splines on the transmission rotor shaft. Pitch shafts are connected to the hub through the three horizontal pins. These pins ride in bearings supported by the hub lugs. Caps retaining the pins and bearings are secured by locking beams, The beams connect the leading cap of one pin with the trailing cap of the next pin.

PITCH-VARYING HOUSINGS

The pitch-varying housings are connected Internally to pitch-varying shafts by flexible, laminated steel tie bars. The laminated tie bar allows the pitch housing to rotate on the pitch shaft to change blade pitch. The tie bar is connected to the inboard end of the pitch shaft. The pitch arm on each housing is connected by a pitch link to a lug on the swashplate. The pitch link raises or lowers the pitch arm to rotate the housing on two roller bearings on the shaft. Outboard lugs on the housing contain bearings for the vertical hinge pin.

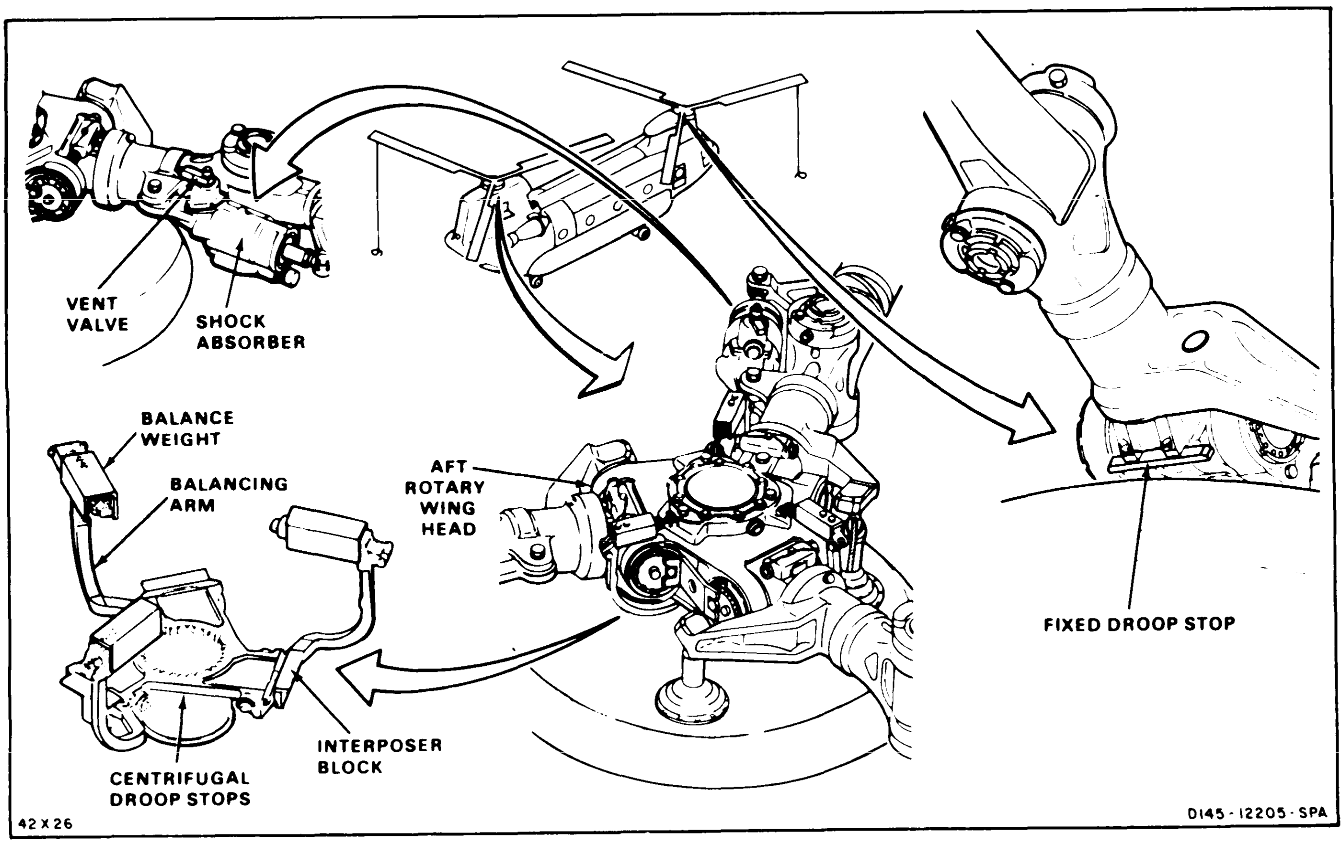


DROOP STOPS

The droop stops limit blade droop. Each pitch-varying housing is supported by a droop stop. Forward and aft heads have fixed droop stops. These are installed on the bottom of the pitch shaft to limit droop at zero rotor speed. These fixed droop stops rest directly against the hub. The centrifugal droop stop assembly is mounted on a splined plate under the aft rotor head. The droop stop contains three balancing arms. These are connected by springs to lugs on the hub oil tank. Interposer blocks on the balancing arms are positioned between fixed blocks and the hub. As rotor speed increases, the centrifugal droop stops swing out. This moves interposer blocks clear of the pitch shafts and allows more freedom for blade droop. As rotor speed decreases, the springs pull the arms in toward the hub. This positions the blocks between the hub and pitch shafts to reduce droop angle.

SHOCK ABSORBERS

Each head has three shock absorbers. They are connected between lugs on the pitch-varying housing and brackets on the blades. The shock absorbers limit lead and lag motion of the blades. Each shock absorber has a vent valve. The valve is opened for extreme cold weather operation. Changing the vent valve position allows the shock absorber to be used on forward or aft head.

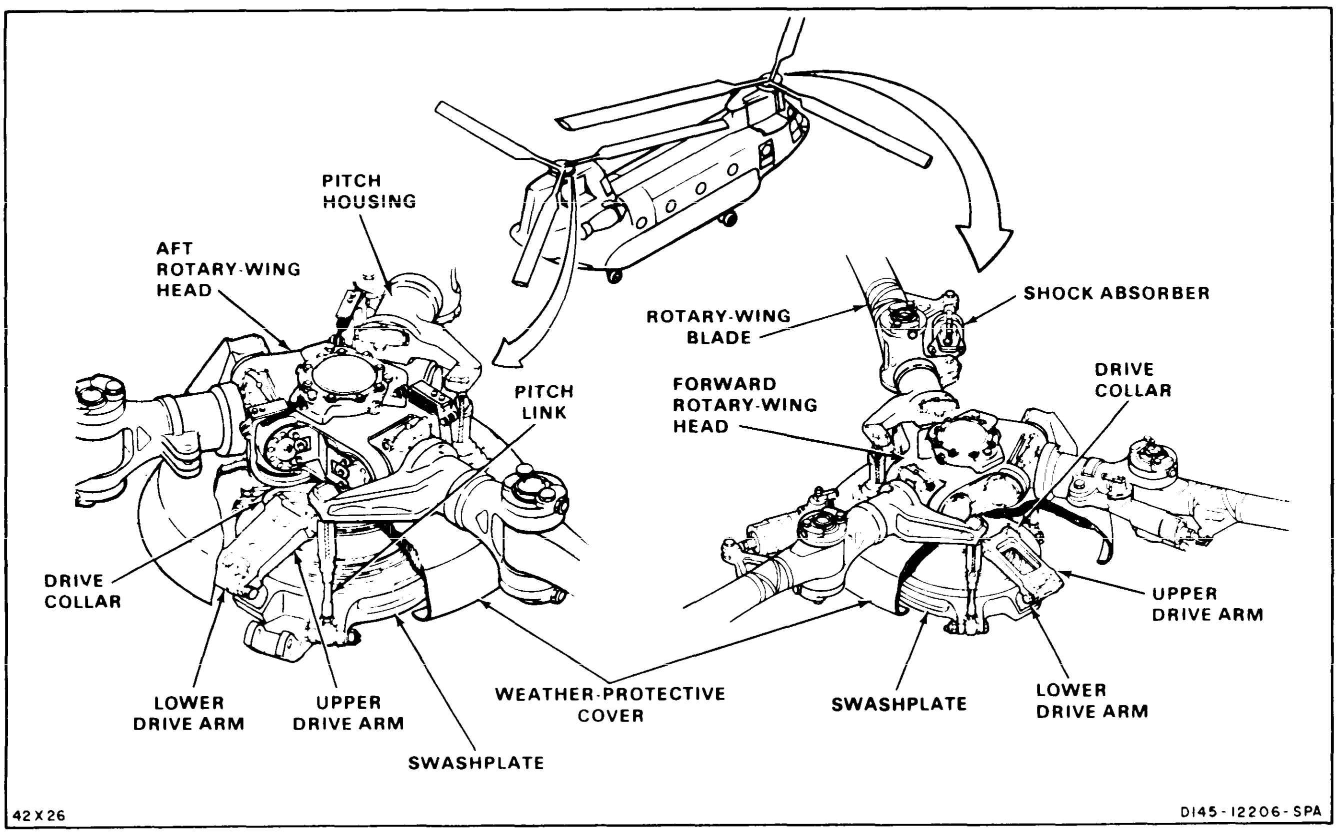


SWASHPLATES

The forward and aft swashplates transmit manual or automatic cockpit control movements to the rotary-wing blades. The swashplates can be tilted and moved vertically. This movement is transferred to the blades through the pitch links and pitch-varying housings. Forward and aft swashplates have aluminum rotating rings. The stationary ring on the aft swashplate is steel. On the forward swashplate this ring is aluminum. The stationary ring of each swashplate is mounted on a spherical bearing. This allows the swashplate to tilt in any direction. A ball bearing connects rotating and stationary rings. The swashplate is free to slide up or down on a slider shaft to change blade pitch angle. Lugs are provided on the rotating ring for connecting three pitch links and an upper drive arm. Drive arm lugs are located in two positions so the rotating ring can be used on forward or aft swashplate. Lugs on the stationary ring provide for connection of two servocylinders, fixed link, and logitudinal cyclic trim actuator. Two single interrupters and a double interruptor on the rotating ring, and a magnetic pickup on the stationary ring, are used for rotor balancing.

PITCH LINKS

The six pitch links are connected between the swashplates and pitch-varying housings. Tilting a swashplate up or down moves the pitch link and pitch arm in the same direction. This increases or decreases the blade pitch angle. Raising or lowering the swashplate on the slider shaft changes pitch on aiI three blades.



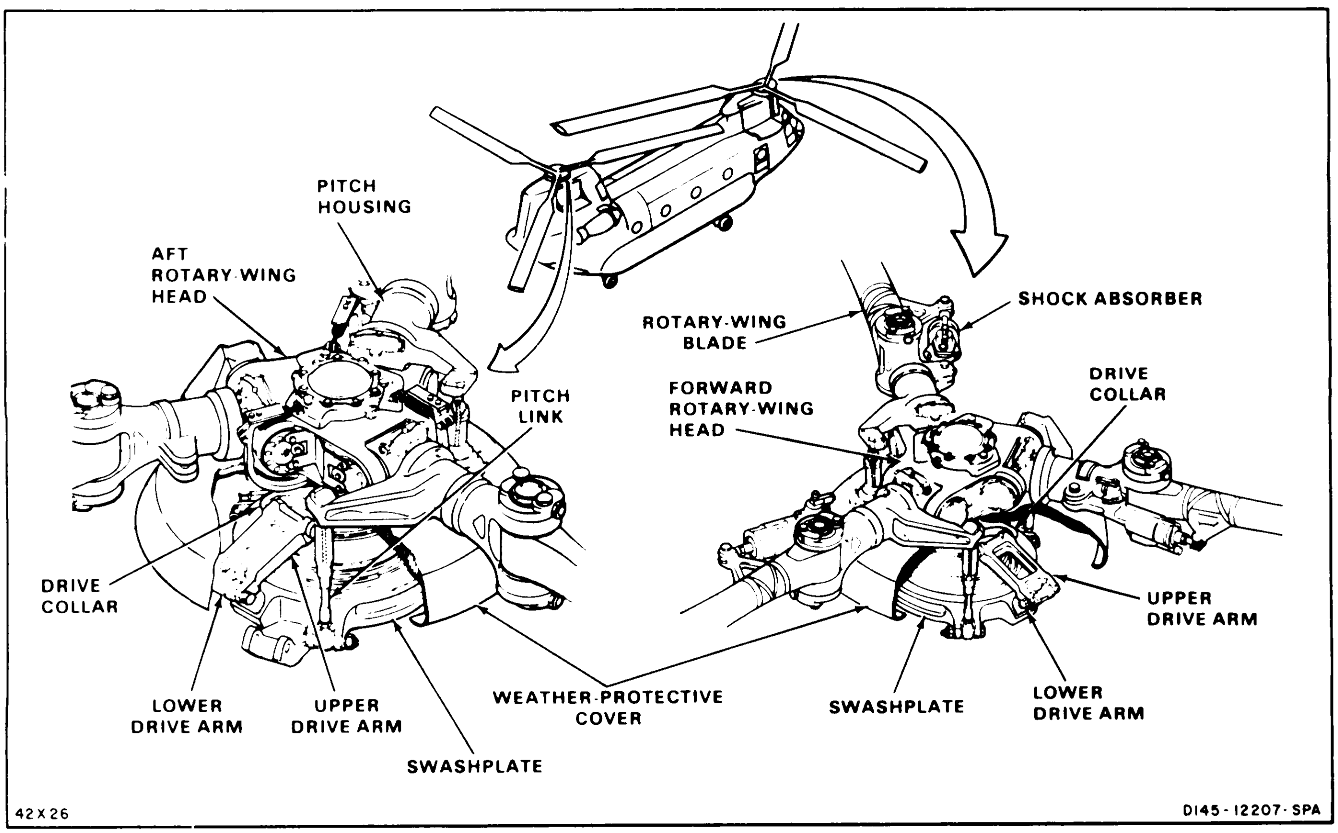
Three pitch links are installed on each rotary-wing head. Forward and aft pitch links are similar except for the angle between rod ends. Each pitch link is adjustable to change the pitch of an individual blade. Moving the turnbuckle toward the + mark makes the pitch link longer and increases blade pitch. A turn in the – direction shortens the pitch link and decreases blade pitch.

DRIVE COLLAR AND DRIVE ARMS

The drive collar transmits torque to the swashplate through the upper and lower drive arms. The drive arms are hinged to allow the swashplate to slide up and down on the slider shaft. The splined drive collars mate with splines on the transmission rotor shafts. A flange is located on the drive collar for installation of the weather-protective cover. Drive collar lugs are provided for connecting the upper drive arm. The upper drive arm is connected at the other end to the lower drive arm. Both connections are hinged. A ball spherical bearing on the lower drive arm is connected to the swashplate. This arrangement allows swashplate to tilt.

WEATHER-PROTECTIVE COVER

The weather-protective cover is bolted to the drive collar flange and turns with the collar and shaft. The cover provides weather-protection for the upper controls. Flexible boots protect the upper portion of the pitch links where they pass through the cover.

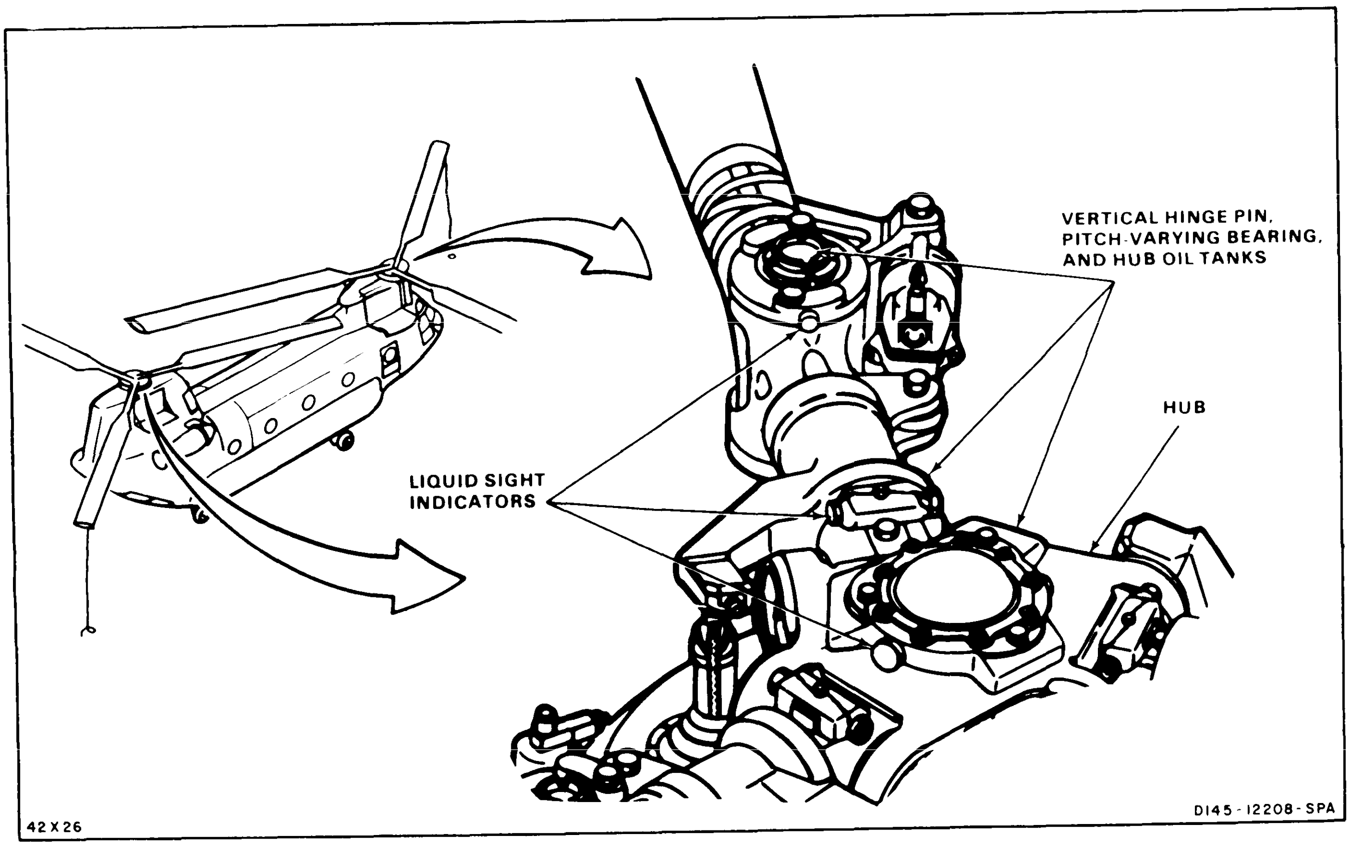


LUBRICATION SYSTEM

A single hub oil tank lubricates the horizontal pin bearings. Each pitch-varying housing has a pitch bearing oil tank and two vertical pin bearing oil tanks. The vertical pin tanks are connected to each other by an oil manifold tube. Sight indicators are provided for each tank, to check oil level. The swashplate is lubricated with grease.

SELF-RETAINING BOLTS

Bolts connecting upper controls and shock absorbers are the positive-retention or impedance types. These bolts have a pawl or lock ring to keep the bolt in place, even with the nut removed. Bolts are installed with bolt heads facing the direction of rotation (Task 1-14).



Rotor System

A. Rotor System Improvements

1. Vertical Hinge Pin Oil Tanks

    a. Composite material

    b. All tanks upper and lower interchangeable

2. Vertical Pin Oil Transfer Tube

3. Positive Locking for Horizontal Hinge Pin Cap

4. Position Retention Hub Nut

5. One Piece Drive Collar

6. Impedance Bolts Instead of Positive Retention Bolts

7. Fiberglass Rotor Blades

8. Lateral Balancing Capabilities - RADS-AT

9. Larger Bearing on Shock Absorbers

B. Description

1. Rotor Head and Rotor Head Controls

Lift is produced by a rotor system consisting of two fully articulated counter-rotating rotors. Each rotor has three fiberglass blades. The forward rotor is driven by the forward transmission through a rotor drive shaft. The aft rotor is driven by the aft transmission through a vertical drive shaft. The rotor head consists of a hub connected to three pitch-varying shafts by three horizontal hinge pins. These pins permit blade flapping. Stops on the top and the bottom of the hub limit the blade flapping motion. The aft rotor head is equipped with centrifugal droop stops which provide increased blade flapping angle for ground and flight operation. Covers are installed on the centrifugal droop stop operating mechanism. The covers prevent ice accumulation on the mechanism and ensures proper droop stop operation following flight in icing conditions. Mounted coaxially over the pitch-varying shafts are pitch-varying housings to which the blade leading and lagging. Each pitch-varying shaft is connected to the pitch-varying housing by a laminated tie bar assembly. The high tensile strength and low torsional stiffness of the tie bar retains the blade against centrifugal force and allows blade pitch changes about the pitch axis. Blade pitch changes are accomplished by three pitch-varying links connected from the rotating ring of the swash plate to the pitch-varying housing on each rotor blade. Cyclic pitch changes are accomplished by tilting the swash plate. Collective pitch changes are realized by vertical movement of the swash plate. Combined collective and cyclic pitch changes result from combined control inputs by the pilot. A direct action shock absorber is attached to the blade and to the pitch-varying housing. When the inboard end of the shock absorber is disconnected, the blade can be folded in either direction about the vertical hinge pin.

a. Specification - Rotor Heads

(1) Weight: Forward: 642.0 pounds

Aft : 664.0 pounds

(2) Dimensions, forward and aft: 15 in. high: 35 in. dia.

(3) Type of Lubricating Oil: MIL-L-7808

(4) Reservoir Capacity: Quarts

(a) Pitch varying housing and oil tank 0.44

(b) Rotary wing hub and oil tank 1.07

(c) Vertical hinge pin bearings and oil tank 0.62

b. Specifications - Swash plates

(1) Weight: Forward: 212.0 pounds

Aft: 333.0 pounds

(2) Dimensions: Forward: 40 in. long: 36 in. wide: 23 in. high

AFT: Same dimensions

(3) Rotary wing head controls cover

(a) Weight: 21.0 pounds

(b) Dimensions: 8 in. high: 40 in. dia.

2. Fiberglass Rotary Wing Blade

a. Location

(1) Three rotary wing blades are attached to

(a) The forward rotary wing head

(b) The aft rotary wing head

(2) Access to the rotary wing blades is made by positioning each blade over the cabin crown walkway.

(3) Forward and aft work platforms will be opened for access to the blade attaching points.

b. Function

(1) The rotary wing blade provides lift (thrust). Cockpit induced flight control inputs will change blade incidence to enable varying flight attitude and direction changes.

c. Specifications

(1) Weight: 357.0 pounds

(2) Dimensions: 330.5 in. span; 32 in. chord; 6 in. high

(3) Radius of Rotation: 360.0 ins.

d. Construction

(1) The fiberglass rotor blade presents a number of advantages over the metal blade.

(a) Fiberglass is non-corrosive

(b) Crack propagation is considerably slower due to the characteristics of the fiberglass composition.

(c) A significant improvement is surviving ballistic damage.

(d) The provisions for vibrex balancing are incorporated into the blade.

(2) The fiberglass rotor blade is a composite fiberglass, titanium and nomex core assembly.

(3) The main structural component is a D-shaped fiberglass spar.

(a) Leading edge elements are bonded to the front of the spar.

(b) A fairing assembly of nomex core with fiberglass covering is bonded to the trailing edge of the spar.

(4) The "D" spar structural elements consist of:

(a) Center and wrap around tension straps of unidirectional fiberglass that extend from the root, looping around the retention pin bore, to the tip.

(b) The straps are covered by multiple layers of cross-ply fiberglass to provide torsional stiffness.

(5) A composite kevlar shock absorber attaching bracket is bonded to the spar near the root end by Kevlar filament windings.

(6) A composite fiberglass sleeve lines the retention pin bore. Wear pads are bonded to the spar above and below the sleeve installation.

(7) The leading edge of the spar is covered by a titanium nose cap.

(8) A nickel erosion cap is bonded to the outboard 54 inches of blade tip.

(9) The fairing assembly consists of nomex honeycomb core covered with a skin of cross ply fiberglass laminates.

(a) The leading edge of the core and the fiberglass skin is bonded to the trailing edge of the spar.

(b) The trailing edge of the fairing assembly is reinforced by a wedge of unidirectional fiberglass that extends the entire span of the fairing assembly.

(c) The inboard end of the assembly is sealed with a Buns-N rubber closure rib.

(d) A stainless steel tip cover closes the forward outboard end of the blade. Buns N rubber sealant covers the end of the blade aft of the tip cover.

(e) A stainless steel trim tab is bonded to the trailing edge outboard of Station 239.

(10) Located in and aft of the spar at the outboard end, are the production tracking weights, which are used to establish chord and span production balancing.

(11) Ten vibrex balancing weights are attached to the tip cover along the pitch asix centerline. 81-TA-4048B

(12) Lightning protection is provided by aluminum wire mesh molded into the fiberglass skin at the blade tip and trim tab areas.

(a) A lightning protection strip extends from the inboard end of the titanium cap to the bonding cables attached to the rotary wing head.

(b) A splice strap bridges the gap between the protection strip and the titanium cap. This strip will unbound in the event of a lightning strike and indicates a requirement for blade lightning damage investigation.

(c) The titanium cap provides an electrical path from the wire mesh to the protection strip and bonding jumpers.

(d) Accelerometer blocks, installed at the forward rotor, Station 75, WL 40, BL 12L, and aft rotor, Station 590, WL 122, BL 10R, send a signal to the balancer.

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CHAPTER 6

DRIVE SYSTEM

DRIVE SYSTEM

DESCRIPTION AND OPERATION

TRANSMISSION

A. CH-47D Power Train System Improvements

1. 7500 HP @ 15.066 Engine RPM

2. All shafts free floating at transmission inputs

3. Integral lubrication systems

4. Auxiliary lubrication systems

5. Pressure and temperature switches added

6. Indicating debris screens added

7. Kevlar sumps on rotor and combiner transmissions

8. AGB deleted - direct assembly drive

9. Spare 12,000 RPM drive pad aft transmission

10. Hydraulic pump drive pad on forward transmission

B. Presentation

1. General Description

a. The power train system in the CH-47D consists of five transmissions and their associated drive shafts.

b. The transmissions are:

(1) Two engine transmissions

(2) One combining transmission

(3) One forward rotor drive transmission

(4) One aft rotor drive transmission

c. The drive shafts are:

(1) Two engine transmission quill shafts

(2) Two engine drive shafts.

(3) Seven forward synchronizing shafts

(4) Two aft synchronizing shafts

(5) One forward vertical drive shaft (part of the forward transmission)

(6) One aft vertical drive shaft

d. Each transmission has an independent oil lubrication system that is air cooled through a heat exchanger.

e. System condition monitors for oil pressure, temperature, and chip detection are found in either the cockpit master caution panel, the cabin maintenance panel, or the oil pressure and temperature indicators mounted on the cockpit instrument panel.

f. The aft transmission accessory section drives the No. 1 and No. 2 AC generators, the utility system hydraulic pump, the No. 2 flight controls hydraulic pump, the main oil pump and the cooling fan.

g. The drive system distributes the torque delivered by the two engines to the forward and aft rotary wing blades.

h. The reduction in gear ratio between the engine and 82-TA-4593A rotary wing blades is 66.96:1.

TRANSMISSION 1

TRANSMISSION DRIVE

1. Description

Transmits engine torque to the two rotor heads via transmissions and drive shafts.

2. Engine Transmission

a. Purpose

The engine transmissions are attached to the forward end of each engine. Power from each engine is supplied to the respective transmission by way of a quill shaft, which drives the spiral bevel pinion gear. The spiral bevel pinion gear drives the spiral bevel gear and shaft assembly where the direction of torque is changed approximately 90 degrees. A speed reduction of 1.23:1 occurs within the engine transmission.

Torque is transmitted by the engine shafts from the engine transmissions to the combining transmission.

The two engine transmissions are identical and can be used in either position by making a minor mechanical conversion.

b. Over-riding Sprag Clutch

Torque is then transmitted through a one-way drive, overriding (sprag) clutch to the output shaft. The sprag clutch permits the rotary-wing system to override the engine during auto-rotation or in the event of an engine failure.

3. Combining Transmission

a. Purpose

The combining transmission receives the torque delivered from both engine transmissions and distributes the combined torque to the forward and aft transmissions.

The torque from both engines is combined within the transmission by means of two spiral bevel input pinion gears and a single spiral bevel ring gear. The spiral bevel input pinion gears receive the torque from the engine transmissions and both gears drive the ring gear. A speed reduction of 1.77:1 occurs at this point. The ring gear is bolted to the aft drive shafts through forward and aft combiner output shafts. These output shafts are connected by a bearing mounted splined coupling.

4. Forward Transmission

a. Purpose

The forward rotor drive transmission transmits torque from the combining transmission to the rotary-wing head. Torque is transmitted within the transmission by a spiral bevel input pinion gear, which meshes with a spiral bevel ring gear. At this point, the direction of torque is changed from a horizontal to a vertical plane. The ring gear is bolted to the first stage sun gear. The sun gear, in turn, drives the first stage planet gears which mesh with a Stationary ring gear.

The non-rating ring gear causes the planet gears to revolve around the sun gear. The planet gears are attached to the first stage carrier which also revolves around the sun gear. The upper portion of the first stage carrier forms the second stage sun gear and it drives the second stage planet gears. These planet gears are attached to a second stage carrier and revolve in the same manner as the first stage planet gears and carrier.

The second stage carrier is an integral part of the rotor shaft, which is externally splined at the top to receive the forward rotary-wing head.

Three stages of speed reduction take place during the transmission sequence. The resulting overall reduction ratio is 30.72:1.

b. Hydraulic Pump

The No. 1 flight control hydraulic pump is mounted on and driven by the forward transmission.

c. Rotor Tachometer

The copilot rotor tachometer receives its indication signals from No. 1 generator permanent magnet section and the pilot from the No. 2 generator. Indicator power is provided by the No. 1 and No. 2 dc buses respectfully.

5. Aft Transmission

a. Purpose

The aft rotor drive transmission transmits torque from the combining transmission to the aft rotary-wing head. The torque is transmitted within the transmission by a spiral bevel ring gear. At this point, the direction of torque is changed from a horizontal to a vertical plane, and the direction of drive is opposite to the forward transmission. The ring gear is bolted to the first stage sun gear. The sun gear, in turn, drives the first stage planet gears, which mesh with a Stationary ring gear.

The non-rotating ring gear causes the planet gears to revolve around the sun gear. The planet gears are attached to the first stage carrier, which also revolves around the sun gear. The upper portion of the first stage carrier forms the second stage sun gear and it drives the second stage planet gears. These planet gears are attached to a second stage carrier and revolve in the same manner as the first stage planet gears and carrier.

The second stage carrier is splined to receive the aft rotary-wing (vertical) drive shaft. The top of the aft vertical drive shaft is splined to receive the splines in the aft rotary-wing head.

Three stages of speed reduction take place in the aft transmission, the same as in the forward transmission. The resulting overall reduction ratio is also 30.72:1.

b. Accessories Driven by the Aft Transmission

(1) Two ac generators, the No. 2 flight control hydraulic pump, and the utility system pump are mounted on and driven by the aft transmission.

6. Engine Drive Shafts

a. Purpose

The engine shaft assembly includes an engine shaft, and engine transmission adapter, a combining transmission adapter, and two flexible coupling packs.

The assembly transmits torque from each of the engine transmissions to the combining transmission. Each shaft is connected to the combining transmission. Each shaft is connected to the combining transmission and engine transmission by an adapter and plate assembly.

The shaft assemblies are serial-numbered and dynamically balanced as a unit. A hinged fairing encloses each shaft between the engine transmission fairing (bullet nose fairing) and the pylon.

7. Forward Sync Shafts

The forward sync drive shaft transmits torque from the combining transmission to the forward rotary-wing transmission. It also keeps the forward and aft rotors mechanically connected and in phase with each other.

This sync shaft extends from the combining transmission to the forward transmission and consists of seven sections of shafting (No. 1 through No. &), eight flex coupling splined adapter assemblies, and eight flexible plate packs. The shaft is supported by 6 bearing support assemblies placed between the forward and combining transmissions. The assemblies are interconnected by means of the adapter and flexible plate assemblies.

Shaft sections are located externally along the fuselage crown at water line +56.00, provided by hinged and removable covers along the top of the fuselage.

8. Aft Sync Shaft

The aft sync shaft transmits torque from the combining transmission to the aft rotary-wing drive transmission and consists of 2 sections. They are located in the aft fuselage section at waterline +56.00. The No. 8 section is connected to the aft end of the combining transmission. The No. 9 section is connected to the aft rotary-wing drive transmission by a flex pack and adapter. The shaft and adapter are balanced as an assembly and are marked by an index and serial number. The two shafts are connected in the center by an adapter and flex coupling plate assembly, which is supported by a bearing support assembly and support structure.

9. Forward Vertical Drive Shaft

The forward vertical drive shaft assembly extends upward through the forward pylon. It transmits torque from the forward rotary-wing drive transmission to the forward rotary-wing head and is integrally forged with the second stage planetary carrier in the forward transmission.

10. Aft Vertical Drive Shaft

The aft vertical drive shaft assembly extends upward through the aft pylon. It transmits torque from the aft rotary-wing drive transmission to the aft rotary-wing head. The base of the shaft is splined to match the splines of the aft transmission. The upper section of the shaft is splined to match the splines of the aft rotor head.

A thrust bearing and a housing, which is bolted to the canted deck at waterline +119.8, supports the shaft. The bearing is lubricated by oil from the aft transmission lubrication system. The slider shaft is mounted over the drive shaft and secured to the housing assembly.

A. <u>Description - Transmission Lubrication Systems</u>

The forward, aft, and combining transmissions each include independent main and auxiliary lubrication systems which operate concurrently. Refer to TM 55-1520-240-10, Table 2-3, page 2-75 for transmission oil system capacities, oil specifications, and servicing procedures.

1. Forward Transmission

The forward transmission lubrication system supplies lubricating oil to the gears and bearings in the forward transmission. Main system oil flows from the sump, through the main oil pump, oil filter, cooler, and a jet protection screen to jets from which the oil is discharged to the various gears and bearings. Auxiliary system oil flows from the auxiliary sump through the auxiliary oil pump, and the auxiliary system filter to separate AUX OIL jets. The main system filter has an impending bypass indicator. The bypass indicator extends if the pressure drop across the filter exceeds 15 to 18 psid, which may indicate a partially clogged filter. An oil cooler mounted on the aft end of the transmission around the input pinion cools main system oil. Air is forced through the cooler by a transmission-driven fan. Oil capacity 27.9 quarts.

2. Aft Transmission

The aft transmission lubrication system supplies lubricating oil to the various gears and bearings in the aft transmission and to the aft rotor shaft bearing. In addition, the main lubrication system circulates cooler oil through the two ac generators on the aft transmission. Transmission oil flows from the sump through the main lube pump, main filter, cooler, and the jet protection screen to jets where the oil is sprayed onto the various gears and bearings. In addition, after the oil leaves the jet protection screen, alternate paths route some of the lubricating oil to the aft shaft bearing and cooling oil to the generators. Auxiliary system oil flows the auxiliary sump through the auxiliary pump and filter to the various gears and bearings. Separate oil jets are utilized for each oil system. The auxiliary system does not lubricate the aft shaft bearing or the generators. An oil cooler mounted on the aft end of the transmission cools main system oil. Cooling air is drawn through the cooler by a transmission-driven fan. The main system filter has an impending bypass indicator. The bypass indicator extends if the pressure drop across the filter exceeds 15 to 18 psid, which may indicate a partially clogged filter. Oil capacity 43 quarts.

3. Combining and Engine Transmission Lubrication Systems

Combining transmission oil flows from the sump through the main pump, main filter, cooler, and jet protection screen to the various gears and bearings. Auxiliary system flows from the auxiliary reservoir through the auxiliary pump and auxiliary filter to the various gears and bearings. Separate oil jets are utilized for each oil system. Two scavenge pumps return the oil to the reservoir from the transmission sump. The combining transmission filter has in impending bypass indicator. If the pressure drop across the filter exceeds 15 to 18 psid, the bypass indicator will extend. This may indicate a partially clogged filter. Engine transmission oil flows from the reservoir through the pump, filter, cooler, and jet protection screen to the jets which spray the oil onto the various gears and bearings. A scavenge pump returns the oil from the transmission sump through in indicating screen and back to the reservoir. Engine transmissions do not have auxiliary lubrication systems. All engine transmission lubrication system components, except the jet protection screens and jets are on the combining transmission. The engine transmission filter has an impending bypass indicator. If the pressure drop across the filter exceeds 15 to 18 psid, the bypass indicator extends, which may indicate a partially clogged filter. The individual oil coolers for the combining and both engine transmission drive fan for cooling air. Oil capacities combining transmission 19 qts., engine transmission 11.1 qt.

4. Transmission Oil Pressure Indicating System

a. Transmission Main Oil Pressure Indicator

A transmission main oil pressure indicator on the center section of the instrument panel, indicates either the lowest main oil pressure in any one of the transmissions or only the oil pressure in the transmission selected by the pilot. The indicator is electrically connected to each transmission. AC power (115-volt) operates this unit. A circuit breaker for the indicator is on No. 1 power distribution panel and is marked XMSN OIL PRESS. Each transmission and aft rotor shaft bearing also incorporates a separate low pressure switch. These switches are connected to the XMSN OIL PRES caution light.

b. Transmission Main Oil Pressure Selector Switch

A transmission oil pressure selector switch is on the center section of the instrument panel. The switch positions are TEST, SCAN, FWD, AFT, MIX, LEFT, and RT. When the switch is set to TEST, the pointer on the transmission pressure indicator will drop to zero or below. In addition, the TEST nomenclature on the switch will be lighted. When the switch is set to SCAN, the SCAN nomenclature on the switch will be lighted and the lowest main oil pressure among all the transmission will be indicated. The nomenclature for that transmission will also be lighted. The remaining positions are used to select a particular transmission oil pressure indication. The nomenclature also lights when a transmission is individually selected. When selecting a particular switch position, be sure the switch is in detent. If the switch is not in detent, the pressure gage will indicate zero.

5. Transmission Main Oil Temperature Indicating System

a. Transmission Main Oil Temperature Indicator

A transmission oil temperature indicator on the center section of the instrument panel reads from -70° to +150°C. It indicates the highest oil temperature among all the transmissions or only the oil temperature of the selected transmission. Wires connect the indicator and amplifier to a temperature probe in the forward and aft transmission sumps and in each compartment of a three-compartment oil tank for the combining transmission and each engine transmission. The temperature probes in the three tank compartments measure oil temperature in the tank and may not immediately indicate a transmission problem. Loss of oil or low oil pressure may not be accompanied by a high oil temperature indication. Power to operate this unit is supplied by No. 1 115-volt ac bus through a circuit breaker marked XMSN OIL TEMP on No. 1 power distribution panel. Each temperature probe incorporates a high oil temperature switch which is independent of the temperature indicator and is triggered at 140°C, lighting the XMSN OIL HOT caution light.

b. Transmission Main Oil Temperature Selector Switch

A transmission oil temperature selector switch is on the center section of the instrument panel below the transmission oil temperature indicator. The switch positions are TEST, SCAN, FWD, AFT, MIX, LEFT, and RT. When the switch is set to TEST, the pointer on the transmission oil temperature indicator deflects full scale toward low temperature. In addition, the TEST nomenclature on the switch will be lighted. When the switch is set to SCAN, the SCAN nomenclature on the switch will be lighted. The highest oil temperature among all transmissions is indicated, and the nomenclature for that transmission will be lighted. The remaining positions are used for selecting a particular transmission oil temperature indication. The nomenclature also lights when a transmission is individually selected. When selecting a particular switch position, be sure the switch is in detent. If the switch is not in detent, the oil temperature indicator will indicate --70°C.

6. Transmission Warning Lights

a. Transmission Oil Caution Lights

Five transmission oil caution lights are on the master caution panel. The lights are marked XMSN OIL HOT, XMSN OIL PRESS, XMSN AUX OIL PRESS, and No. 1 and No. 2 ENG XMSN HOT. These lights, in conjunction with the transmission oil pressure and temperature indicators on the instrument panel alert the crew to impending transmission lubrication problems. The caution lights operate independently of the pressure and temperature indicators on the instrument panel. The XMSN OIL HOT light comes on when the main oil temperature in the reservoir of the forward, aft, combining, or either engine transmission exceeds 140°C. The hot transmission is identified by the oil temperature selector switch and indicator.

The XMSN OIL PRESS caution light comes on when main oil pressure drops below 20 psi in any transmission or aft rotor shaft pressure drops below 10 psi. The low-pressure system is identified by the transmission oil pressure selector switch and indicator on the instrument panel. If the XMSN OIL PRESS caution light comes on and the affected transmission cannot be determined using the selector switch, the condition may be caused by loss of aft rotor shaft oil pressure. Low oil pressure at the aft rotor shaft is indicated by the illumination of the AFT SHAFT light on the maintenance panel.

The XMSN AUX OIL PRESS caution light, which is activated by individual aux oil switches, comes on when auxiliary oil pressure drops below 20 psi in the fwd or aft transmission and 10 psi in the combining transmission. The transmission with the low pressure is identified by a lit AUX OIL PRESS indicating light on the maintenance panel.

The No. 1 and No. 2 ENG XMSN HOT caution lights come on if oil temperature in either engine transmission exceeds about 190°C. The lights are turned on by a thermo switch in each engine transmission. The thermo switch monitors oil temperature in the transmission, not in the reservoir. The thermo switch is part of a chip detector and temperature assembly in each engine transmission.

b. Transmission Chip Detectors

Chip detectors are installed in all transmission and aft rotor shaft thrust bearing lubrication systems. All chip detectors, except those in the engine transmission, are connected to the XMSN CHIP DET caution light on the master caution panel. Engine transmission chip detectors are connected to the ENG CHIP DET caution lights. All transmissions and the aft rotor shaft chip detectors are also connected to the TRANSMISSION CHIP DETECTOR indicators on the maintenance panel. When a chip detector is bridged by ferrous particles, the XMSN CHIP DET, or ENG CHIP DET caution light comes on. At the same time, the corresponding TRANSMISSION CHIP DETECTOR indicator on the maintenance panel will trip and change from an all-black indication to a black-and-white indication, identifying the transmission.

c. Transmission Debris Screens

There are six TRANSMISSION DEBRIS SCREENS latching indicators on the transmission section of the maintenance panel. There is one indicator for the forward, aft, and both engine transmission and two indicators marked LH and RH for the combining transmission. If the screen mesh is bridged by conducting debris, the corresponding DEBRIS SCREEN indicator will trip. The indicator display will change from all-black to black-and-white to indicate possible transmission component deterioration.

B. <u>Presentation</u>

1. Transmission

a. Engine Transmission Assembly

(1) Location

(a) An engine transmission is attached to the front of each power plant, in the aft pylon area, centering on Station 463, WL66, BL48R, and BL48L.

(b) Access to the engine transmission is made after the following is removed:

1 The engine air inlet screen

2 The engine transmission fairing

3 The engine drive shaft fairing

3 The engine drive shaft

(c) Oil Filler and Sight Gage Access

1 Engine and combining transmission. The oil filler and sight gages for the RH and LH engine transmissions and the combining transmission are accessible when the aft pylon leading edge fairings are opened.

a The oil filler is located on the combining transmission cover, Station 455, WL76, BL 0. The single filler services the RH, LH, engine transmission and the combining transmission sections of the reservoir. They are interconnected at the sight gage level.

b The sight gages for the RH, LH, engine transmissions, and the combining transmission, are located at identical levels in the combining transmission reservoir. The combining transmission sight gage is at the front of the reservoir, the right and left engine transmission sight gages on the side of the reservoir, facing the respective transmission.

(2) Function

(a) The engine transmission, bolted to the engine air inlet housing, receives engine torque, changes the drive direction 90°, and transmits the torque through the engine drive shaft to the combining transmission.

(3) Specifications

(a) Weight: 128.0 pounds (each)

(b) Dimension: 19 in. long; 16 in. wide; 16 in. high

(c) Type of Lubricating Oil: MIL-L-7808

(d) Reservoir Capacity: 6 quarts

(e) System Capacity: 11.1 quarts

(f) Transmission Oil Pressure

PSI Minimum Ground Idle		PSI Minimum		PSI Normal Operation	
Main Sys	Aux Sys	Main Sys	Aux Sys	Main Sys	Aux Sys
7	-	20	-	20-90	-

Maximum °C

(g) Transmission Oil Temperature 140°C (284°F) (at reservoir)

(190°-207°C) (375°-405°F)(at transmission)

(h) Temperature Warning

1 Transmission oil temperature switch closes at: 190° - 207°C

2 Reservoir oil temperature switch closes at:

135° - 145°C

(i) Lubrication Pump

1 Rated speed: 60002 RPM at 100% RPM

2 Rated flow (GPM): PRESSURE 6.0 SCAVENGE 18.0

(j) Lubrication Filter 30 Microns

1 Adjustable valve set to: 65 psi

2 Range of adjustment: 45-85 psi

3 Filter bypass valve operates when total pressure drop exceeds: 25-30 psid

4 Impending bypass indicator button extends when pressure differential across element exceeds: 15-18 psid

Thermonic lockout prevents indicator button activation if, or below: 115° ±10°F (46° ±5°C)

(k) Oil Cooler

1 Rated oil flow: 14 gpm

2 Temperature/pressure bypass valve

a Redirects oil to bypass cooler core when outlet temperature is: 160° +10°, -5°F (71° +5° - 2°C)

b Bypasses oil when core differential drop exceeds: 30 ±5 paid

(l) Oil Cooler Weight, RH 18 pounds
LH 20 pounds

Oil Cooler dimension, RH 3.75 in. high: 21 in. dia.
LH 3.75 in. high; 21 in. dia.

(m) Combining transmission fan weight: 13 pounds

(n) Combining transmission fan dimensions:

4.5 in. high; 12 in. dia.

(4) Construction

(a) The housing for the engine transmission is cast from magnesium alloy.

(b) The housing interior is coated with resin, the exterior with epoxy primer and coating.

(c) A cap and a support assembly, both magnesium allow castings, attach to the housing.

1 The bearings and lubrication passages for the level ring gear are located in the cap and the support assembly.

2 The oil jet for lubricating the sprag clutch and output shaft bearings is threaded into the cap.

(d) A support assembly for the bevel pinion gear cast from magnesium alloy is bolted to the housing.

1 The pinion gear is centered in the support assembly by a ball thrust bearing, a roller bearing, and a roller input bearing.

2 A magnesium alloy retainer is attached to the support assembly to secure the bevel pinion gear and bearings assembly.

(e) Shims are placed between the support and the housing to enable gear patterns to be established.

(f) The spiral bevel gear is supported by a roller bearing and a ball bearing forward to the gear teeth.

(g) These bearings are located in the bevel gear magnesium alloy support.

(h) Shims are fitted between the support and the main housing to permit gear pattern adjustment.

(i) The output end of the bevel gear is supported by a roller bearing which is attached to the housing, by an outer race flange.

(j) The spiral bevel pinion gear has 35 teeth. It is internally splined to receive the engine drive quill shaft.

(k) The spiral bevel gear has 43 teeth. The interior of the gear is machined to mount a sprag clutch and output shaft bearing set.

(l) The bevel gears and the output shaft are forged from a high tensile, carbonized chrome alloy steel.

(m) A sprag clutch fits between the bevel gear internal diameter and the output shaft. The design of the clutch permits the output shaft to freewheel if the shaft rpm exceeds that of the gear.

(n) The output shaft fits into and is driven by the sprag clutch.

1 The aft end of the shaft is supported by a double row tapered roller bearing, locked into the interior of the bevel gear.

2 The shaft is internally splined to accept the drive shaft adapter. A bolt extension serves as a stud to lock the adapter axially to the shaft.

(o) A magnesium allow retainer seats a viton-type fluroelastomer seal against the output shaft.

(p) A removable quill shaft is splined to fit the engine power output shaft, and at the opposite end, the bevel pinion gear. A vespel snubber fits between the quill shaft flange and the end of the pinion gear, to prevent axial interaction.

(q) The engine transmission can be built up to a left or right installation, depending on which way the build-up parts are installed.

(5) Operation

(a) The engine transmission receives its torque input directly from the engine to which it is attached.

(b) A quill shaft, driven by the engine power output shaft, applies torque to a spiral bevel gear set, which drives the output shaft through a sprag clutch.

(c) The bevel gear set reduces output shaft rpm by a ratio of 1.23:1 and changes the angle of drive by 90°.

(d) The sprag clutch permits the engine (N2) to drive the output shaft when rotor rpm is matched. When rotor rpm is faster than engine (N2) speed, the clutch allows a free wheel condition.

(e) The left and right engine transmission lubrication systems are independent of each other.

(f) Oil for each system is stored in a separate compartment of the combining transmission reservoir.

(g) The lubrication pumps are located in the combining transmission. Elements of independent left and right engine transmission oil pumps provide pressure and scavenge systems through external tubing.

(h) Pressure oil from the combining transmission mounted oil pump is directed internally to the main filter.

1 If pressure differential drop is less than 25-30 psid oil will be filtered.

2 Warning button extends when pressure differential drop is in the range of 15-18 psid.

3 The system pressure is regulated by adjustment of the pressure relief valve.

(i) The main oil filter is mounted on the aft side of the combining transmission.

1 The filter disposable element consists of a No. 42 and No. 100 aluminum wire mesh screen, containing a paper/fiberglass composition filter. The housing is aluminum alloy.

2 The No. 100 mesh inner screen has 0.015 inch openings which restricts migration of the composition filter. The No. 42 mesh outer screen protects the filter outer surface.

(j) A transfer tube routes oil to the cooler core. Air pulled through the collar fins by the fan reduces the temperature of the oil. The core will not receive oil due to bypass valve action if:

1 The core oil outlet temperature is 160° +10°, -5°F, or lower.

2 The core differential drop exceeds 20 ±5 psid.

(k) A separate cooler for each engine transmission is mounted above the combining transmission.

1 The two engine and the combining transmission coolers are attached together by bolted external flanges.

2 With the RH engine transmission cooler in the top position, the LH engine transmission cooler in the center position, the combining transmission attaches directly to the reservoir cover.

3 This cools the lubrication oil prior to being directed to the jets to spray the gears and bearings.

(l) A flexible hose transfer cooled oil to the airframe mounted inlet screen.

1 The low pressure warning switch taps into the inlet screen support.

2 The main pressure transducer taps into the inlet screen support.

3 The pressure transducer is mounted on the airframe structure behind the oil cooler assembly.

(m) Low oil pressure warning is displayed on the cockpit master caution panel and the cabin maintenance panel.

(n) The cockpit XMSN oil pressure indicator indicates the oil pressure. The indicator is electrically connected to the pressure transducer.

(o) An external hose carries oil to the engine transmission, where it flows through the oil galleries to the lubrication jets. Oil from the jets is directed at the gears and bearings.

(p) Drillings in the transmission housing provide an internal route for pressurized oil to the jets and bearing supports.

(q) Oil is scavenged from the engine transmission housing and returned through an external hose to the combining transmission.

(r) Prior to entering the lubrication pump, scavenge oil passes through the debris detection screen. Oil exiting from the pump is returned to one of the three sections of the Kevlar 49 combining transmission reservoir. Oil transfer ports between the compartments, permit full level equalizing.

(s) The debris detection screen for each transmission is mounted on the right and left sides of the combining transmission. The external scavenge line from each transmission housing connects to the screen housing.

1 Two stainless steel screens, a positive and a negative, are in each detector.

2 The screens are formed around woven polyester monofilaments. The No. 12 mesh openings are 0.060 inch.

3 All scavenge (return) oil is routed through the detector prior to being returned to the reservoir.

4 Electrically conductive particles bridging the positive to negative screen, activate the debris screen latching indicator on the maintenance panel.

(t) An oil temperature switch, combined with a chip detector, is mounted at the base of the transmission housing.

1 An oil over-temperature condition is indicated on the cockpit master caution panel (No. 1 or No. 2 ENG XMSN HOT).

2 Warning of metallic chip contamination is the transmission is made by the cockpit master caution panel and cabin maintenance panel latching indicator.

The indicator on the maintenance panel will identify the particular transmission.

(u) A combination temperature probe and overhead switch is mounted in the reservoir compartment for each engine transmission.

1 An oil over-temperature condition is indicated on the cockpit master caution panel, (XMSN OIL HOT) when the switch closes at 140°C.

2 An oil over-temperature condition is indicated on the maintenance panel latching circuit.

3 The temperature probe electrically activates the cockpit oil temperature gage.

(v) A breather-filter assembly mounted on the combining transmission reservoir cover, vents the transmission housing and permits oil replenishment.

1 A breather vent assembly is incorporated in each reservoir compartment.

2 External tubing connects the transmission breather with the reservoir to relieve case pressure.

b. Combining Transmission Assembly

(1) Location

(a) The combining transmission is located in the front of the aft pylon, centering on Station 463, WL 56, BL 0.

(b) Access to the combining transmission is made by opening the aft pylon leading edge fairing and removing the combining transmission fairing.

(c) Oil filler and sight gage access.

1 Engine and combining transmission. The oil filler and sight gages for the RH and LH engine transmissions and the combining transmission are accessible when the aft pylon leading edge fairings are opened.

a The oil filler is located on the combining transmission cover, Station 455, WL 76, BL 0. The single filler services for the RH, LH, engine transmission, and the combining transmission, sections of the reservoir. They are interconnected at the sight gage level.

b The sight gages for the RH, LH, engine transmissions and the combining transmission are located at identical levels in the combining transmission reservoir. The combining transmission sight gage is at the front of the reservoir, the right and left engine transmission sight gages on the side of the reservoir, facing the respective transmission.

(2) Function

(a) The combining transmission, with torque inputs from the right and left engine transmission, rotates the drive 90° and directs is through the synchronizer shafts to the forward and aft transmissions.

(3) Specification

(a) Weight: 416.0 pounds

(b) Dimensions: 35 in. long; 16 in. wide; 48 in. high

(c) Type of lubricating oil: MIL-L-7808

(d) Reservoir capacity: 14 quarts

(e) System capacity: 22.1 quarts

(f) Transmission oil pressure

PSI Minimum Ground Idle		PSI Minimum		PSI Normal	
Main Sys	Aux Sys	Main Sys	Aux Sys	Main Sys	Aux Sys
7	-	20	10	20-90	-

(g) Transmission oil temperature: Maximum °C

140(284°F)

(h) Temperature warning

Reservoir oil temp. switch closes at 285°F(140°C)

(i) Lubrication pump

1 Rates speed: 6002 rpm at 100% RRPM

2 Rated flow (GPM):

		Section	Main System	Aux System
a	Combining Trans.	Pressure	17.0	2.1
		Scavenge	20.0	-
b	Engine Trans.	Pressure	6.0	-
		Scavenge	18.0	-

(j) Lubrication filter: 30 microns

1 Adjustable valve set to: 85 psi

2 Range of adjustment: 60-110 psi

3 Filter bypass valve operates when total pressure drop exceeds: 25-30 psi

4 Impending bypass indicator button extends when pressure differential across element exceeds: 15-18 psi

4 Thermonic lockout prevents indicator button extension at, or below: 115° ±10°F (46°C ±5°C)

(k) Oil cooler

1 Rated oil flow: 14 gpm

2 Temperature/pressure bypass valve

a Redirects oil to bypass cooler core when outlet temperature is at or lower than: 160° + 10°, -5°F (71°C + 5° -2°C)

b Bypasses oil when core differential drop exceeds: 30 ±5 psi

(l) Auxiliary oil pump element

1 Bypass valve pressure relief set to: 45 psi

2 Rated speed: 6002 rpm

(m) Oil cooler weight: 21.5 pounds

(n) Oil cooler dimension: 4.5 in. high; 21 in. dia.

(o) Cooling fan weight: 13 pounds

(p) Cooling fan dimensions: 4.5 in. high; 12.0 in. dia.

(4) Construction

(a) The combining transmission casing consists of a main and an accessory housing, and a reservoir with a cover.

(b) The main and accessory housings are cast from magnesium allow. They are externally epoxy primed and coated, with the interior being resin treated.

(c) The reservoir is formed of twelve plies of Kevlar 49 and two plies of fiberglass type 181. The laminate lay-up uses 281, with type 285 being the alternate.

(d) The reservoir is divided into three sections, one section holding the oil for the combining transmission, and the remaining two sections containing oil for the left and right engine transmissions.

(e) The reservoir cover is cast from magnesium alloy. The finish is the same as is used on the main housing.

(f) The main housing has four steel bushed mounting pads attached by bolts to the fuselage.

(g) Viton type fluoroelastomer seals, mounted in cast magnesium allow seal retainers, attach to the right and left input pinion cartridge supports.

(h) The input pinion gears are supported by a ball thrust bearing and two roller bearings.

(i) The bearings are retained in a magnesium alloy cartridge, which is secured to the input gear by a lock-nut, and to the main housing by studs. The gear pattern shim is located between the housing and the cartridge.

(j) The collector gear is supported:

<u>1</u> By a ball bearing located between the gear bevel teeth and the fan drive gear.

<u>2</u> By a roller bearing located forward of the gear bevel teeth.

<u>3</u> By a roller bearing located at the output end of the gear.

(k) The collector gear and bearings aft of the bevel teeth are contained in a cartridge support, machined from magnesium alloy.

<u>1</u> The cartridge is attached to the main housing.

<u>2</u> The cartridge is secured to the collector gear bearings by a lock-nut.

<u>3</u> The gear pattern adjusting shim is located between the main housing and the cartridge.

4 A viton type fluoroelastomer seal, mounted in a cast magnesium alloy retainer, fits around the collector gear output shaft. The retainer is attached to the cartridge assembly.

(l) The pinion gears and the collector gear are forged from high tensile, carbonized, chrome allow steel.

(m) The pinion gear has 31 teeth, and is splined on the input end to receive the engine drive shaft adapter and plate.

(n) The collector gear has 55 bevel teeth. It has splines to receive:

<u>1</u> The fan drive Zerol bevel pinion gear.

<u>2</u> The aft synchronizing shaft adapter and plate assembly.

<u>3</u> The collector quill shaft. These drives splines are machined internally.

(o) The collector quill shaft, supported by the collector gear splines at the driven end, has a 14 ball bearing at the output end.

(p) The bearing is attached to the quill shaft by a locknut and is supported by the accessory housing.

(q) A viton type fluoroelastomer seal, located in a retainer attached to the accessory housing, seats against the quill shaft.

(r) The quill shaft is machined from a steel forging.

1 It is splined at either end. One set of splines fit the collector gear driving splines. The output and splines receive the forward synchronizing shaft adapter and plate assembly.

2 A set of spur teeth are machined into the quill shaft adjacent to the accessory housing bearing area, to drive the accessory gear train.

(s) The accessory drive spur gear is forged from steel

1 It is supported by two ball bearings

2 One ball bearing is pressed into the main housing, the outer bearing is retained within the accessory housing.

(t) The main and the auxiliary lubrication pump quill shafts are driven by identical gears meshing with the accessory drive spur gear.

(u) The lubrication pump spurs gears are forged from steel.

1 They are supported by two ball bearings.

2 One ball bearing is seated in a retainer attached to the pump.

3 The outer bearing is pressed into the accessory housing.

(v) The fan drive Zerol bevel pinion gear, machined from steel, is splined to the collector gear. It is held in position by a spacer, located between the gear bearings.

(w) Meshing with the fan pinion gear is a Zerol bevel gear, internally splined to receive the fan drive shaft. This gear is machined from steel.

(x) The Zerol bevel gear is supported by identical ball bearings.

1 The ball bearings are retained by a nut.

2 The bearings and Zerol gear are contained within a cartridge support machined from magnesium alloy.

3 A viton type fluoroelastomer seal mounted in a cast magnesium alloy retainer, seats against the gear shaft.

4 The seal retainer flange attaches the Zerol gear cartridge, which is inserted into the collector gear cartridge.

5 A nylon snubber fits on the top of the gear shaft to prevent fan drive shaft iteration.

(y) The fan drive shaft has an aluminum alloy tube riveted to identical steel flanged and splined ends.

1 It is a balanced unit.

2 It is 29.0 inches long by 2.0 inch diameter

(z) The auxiliary oil reservoir is an integral section of the main housing.

1 It is located directly beneath the Kevlar main reservoir.

2 It holds approximately four quarts of lubricating oil.

3 The auxiliary reservoir is filled by gravity with lubricating oil from the main reservoir.

(5) Operation

(a) The combining transmission is driven by each engine transmission through the connecting drive shaft.

(b) The pinion gear input from the drive shaft adapters drives the collector gear and collector quill shaft.

(c) The pinion and collector gear set reduces the output ratio to 1.7 to 1.

(d) The angle of drive is changed 90°.

(e) A spur gear machined into the quill shaft drives the accessory drive gear and subsequently the lubrication pump drive gears.

(f) The fan is driven by Zerol bevel gears driving the fan drive shaft.

(g) The combining transmission lubrication system is independent and self-contained.

(h) Oil is stored in a reservoir mounted on top of the main housing.

1 The reservoir is shared with the right and left engine transmissions.

2 There are three compartments. The front compartment supplies the combining transmission, the rear two supply the engine transmissions.

(j) The main oil pump is a four stage gyrotor unit. It provides lubrication and scavenging for the combining and left engine transmission.

(j) The auxiliary oil pump is also a multi-element gerotor unit. It provides:

1 Up to two hours of safe operation, if main system is inoperative.

2 Auxiliary oil pressure for the combining transmission.

3 Main oil pressure for the right engine transmission.

4 Scavenge oil return from the combining and right engine transmission.

5 If the main and the auxiliary lubricating systems both fail, up to 15 minutes of safe operation is still available.

(k) Oil to the main oil pump enters directly from the reservoir.

(l) Pressurized oil from the main oil pump is directed to the main filter.

1 Oil will be filtered if pressure differential drop is less than 25-30 psid.

2 When element pressure differential is 15-18 psid, the indicator button will extend.

3 A pressure relief valve is incorporated to provide pressure adjustment.

4 The main lubrication filter for the combining transmission is mounted on the cover of the reservoir, forward of the cooler.

5 The filter disposable element consists of a No. 42 and No. 100 aluminum wire mesh screen, containing a paper/fiberglass composition filter. The housing is aluminum alloy.

6 The No. 100 mesh inner screen has 0.015 inch openings which restricts migration of the composition filter. The No. 42 mesh outer screen protects the filter outer surface.

(m) Oil is routed through the reservoir cover, and into the oil cooler through a transfer tube. Air pulled through the collar fins by the fan reduces the temperature of the oil. The cooler core will not receive oil due to bypass valve action if:

1 The core outlet temperature is 160° +10°, -5°F or lower.

2 The core differential drop exceeds 30 ±5 psid.

(n) The fan is situated above the annular cooler.

1 Aluminum vanes, driven by the fan shaft, pull air through the cooler fins.

2 A baffle, centrally located within the cooler, directs the air axially through the fan, to exit through an exhaust duct.

(o) A three compartment cooler is attached to the reservoir cover.

1 The lower section of the cooler, cools combining transmission oil.

2 The center cooler section cools left engine transmission oil.

3 The upper cooling section cools the right engine transmission oil.

4 Transfer tubes direct oil to internal system. Flexible hoses connect the cooler externally.

5 All coolers incorporate a temperature-pressure bypass valve.

6 Armor plate, machined from 4340 steel, separates the left and right engine transmission cooler core sections.

(p) The cooler core is constructed of hollow fins which contain the lubricating oil. The fan directs air across the fin external surfaces, removing heat.

(q) A transfer tube returns cooled oil to the main housing where it is routed to the main inlet screen.

(r) The main inlet screen screws into the left side of the reservoir cover, has No. 40 mesh with 0.015 inch openings.

(s) A pressure transducer, mounted on the airframe behing the oil cooler assembly, is connected to the main oil pressure gallery in the reservoir cover.

(t) Main oil pressure is registered on the cockpit transmission oil pressure gage.

(u) A pressure switch is installed in the reservoir cover. Warning of low main oil pressure is displayed on the cockpit master caution panel and the cabin maintenance panel.

(v) Scavenge oil is routed through a debris detection screen, and by a chip detector, to be returned to the reservoir.

(w) Metal particles, activating the chip detector, will cause the cockpit master caution panel and the cabin maintenance panel lights to operate.

(x) Conductive particles, activating the debris indicating screen, will cause the cabin maintenance panel latching indicator to operate.

(y) The debris detection screens for the combining transmission are located at the lower front main housing.

<u>1</u> The detection screens are formed of 316, stainless steel. The screens are part of the pump scavenge system.

<u>2</u> There are two screens, an inner and an outer screen, in close proximity to each other, in each detector.

<u>a</u> One is wired to the positive side of the debris detection circuit, the other to the negative side of the circuit.

b Oil flowing through the screens, depositing electrically conductive particles between the screens, complete the circuit to operate the debris screen latching indicator on the maintenance panel.

(z) Oil from the auxiliary reservoir supplies the auxiliary element of the RH oil pump.

(aa) The auxiliary oil pump pressurizes the stainless steel mesh auxiliary filter in the main housing.

(ab) A bypass valve in the main housing regulates the auxiliary oil pressure to 45 psi.

(ac) A pressure switch in the main housing will cause the cockpit master caution panel and the cabin maintenance panel warning lights to operate in the event of low oil pressure.

(ad) The auxiliary lubricating oil is directed to the lubricator and jets.

(ae) Scavenge oil, passed through the auxiliary debris detector screen is returned to the reservoir.

(af) A temperature probe in the reservoir senses oil temperature and provides the cockpit oil temperature gage with this information. A switch in the probe closes at 140°C and activates the master caution panel capsule, (XMSN OIL HOT.), and the maintenance panel over temperature latching circuit.

(ag) A filler-breather is mounted on the reservoir cover above the combining transmission oil compartment.

(ah) Cooling air for the fan enters through the aft pylon fairing door opening, is drawn over the cooler fins by the fan, and exits through the fairing upper cover.

c. Forward Transmission Assembly

(1) Location

(a) The forward transmission is mounted to structure in the forward pylon, centered at Station 93, WL 56, BL 0.

(b) Access to the forward transmission is made by opening the forward pylon work platforms and removing fairings as required. The acoustic blanket and drip pan is removed over the cockpit entrance passage.

(c) Oil filler and sight gage access

1 The oil filler is located on the forward transmission upper cover between the forward and RH mounting legs, Station 82, WL 74, BL 8R.

(2) Function

Driven by the forward synchronizer shafting, the forward transmission changes the drive direction 81°. The vertical rotor shaft drives the rotary wing head.

(3) Specification

(a) Weight: 1186.0 pounds

(b) Dimension: 51 in. long; 20 inch. wide; 67 in. high

(c) Type of lubricating oil: MIL-L-7808

(d) Reservoir capacity: 18 quarts

(e) System capacity: 27.9 quarts

(f) Transmission oil pressure

PSI Minimum Ground Idle		PSI Minimum		PSI Normal Operation	
Main Sys	Aux Sys	Main Sys	Aux Sys	Main Sys	Aux Sys
7	-	20	20	20-90	-

(g) Transmission oil temperature: Maximum °C

140 (284°F)

(h) Temperature warning

Reservoir oil temp. switch closes at 285°F (140°C)

(i) Lubrication pump

1 Rated speed: 5334 rpm at 100% RRPM

2 Rated flow: 20 gpm

3 Pressure relief adjusted to: 60 psi

4 Range of adjustment: 30-90 psi

(j) Lubrication filter: 30 microns

1 Filter bypass valve operates when total pressure drop exceeds: 25-30 psid.

2 Indicator button extends when pressure differential across element exceeds: 15-18 psid.

3 Thermonic lockout prevents indicator button activation at, or below: 115° ±1-°F (46° ±5°C)

(k) Oil cooler

1 Rated oil flow: 19 gpm

2 Temperature/pressure bypass valve

a Redirects oil to bypass cooler core when outlet temperature is at, or lower than 160° +10°, -5°F (71° + 5° - 2°C)

b Bypasses oil when core differential drop exceeds: 30 ±5 psid.

(l) Auxiliary oil pump

1 Pressure relief valve set to: 80 psi

2 Rated speed: 3326 rpm

3 Rated flow: 1.5 gpm

4 Filter rating: 80 microns

(m) Oil cooler weight: 30.0 pounds

(n) Oil cooler dimension: 4.5 in. wide; 26 in. dia.

(o) Cooling fan weight: 19.0 pounds

(p) Cooling fan dimensions: 5 in. long; 18 in. dia.

(4) Construction

(a) The forward transmission casing consists of a main housing, an upper cover, and a sump. The planetary ring gear is located between the cover and the main housing.

(b) The main housing is cast from magnesium allow. It is externally epoxy primed and coated, with the interior being resin treated.

(c) The upper cover is machined from an aluminum allow forging.

1 Four mounting pads are machined into the supports and fitted with steel bushings.

2 Mounting lugs for the pivoting and swiveling actuators are machined and fitted with corrosion resistant bushings.

3 The upper controls yoke support lugs are machined and fitted with steel bushings.

(d) The sump is formed of ten plies of Kevlar 49 and two plies of fiberglass type 181. The laminate layup uses type Kevlar.

(e) A viton type fluoroelastomer input pinion seal is seated in a cast magnesium allow seal retainer, which is attached to the pinion cartridge support.

(f) The input pinion gear is supported by a ball thrust and a roller bearing at the input end. A roller bearing supports the shaft at the output end.

(g) A magnesium alloy cartridge, containing the ball and roller bearings, retained to the input pinion shaft by a lock-nut, is attached to the main housing with studs. The gear pattern is located between the cartridge and the housing.

(h) A flange on the race attached the pinion gear output end roller bearing to the main housing.

(i) The spiral bevel gear is supported by a ball duplex bearing at the lower end by a roller bearing at the base of the bevel teeth, and by a ball bearing at the gear and first stage carrier junction.

(j) The duplex double tow bearing is bolted to the main housing by the outer race flange. The center bearing is bolted to a magnesium alloy cast support, and the upper ball bearing is seated in the first stage carrier.

(k) The gear pattern shim for adjusting the bevel gear is located between the duplex bearing flange and the main housing.

(l) The spiral bevel pinion and the spiral bevel gear ball bearings are retained by lock-nuts.

(m) The spiral bevel pinion gear has 29 teeth. It has a key slot milled externally to drive the fan impeller, and is internally splined to receive the drive shaft adapter.

(n) The spiral bevel gear has 51 bevel teeth.

1 A 28-tooth spur sun gear is machined above the bevel tooth set.

2 A 38-tooth spur accessory drive gear is machined below the bevel tooth set.

3 A 44-tooth auxiliary lube pump forged from steel is keyed and locked to the lower end of the shaft.

(o) The spiral bevel pinion and bevel pinion gear are forged from a high tensile, carbonized chrome alloy steel.

(p) The first and second stage planet gears are machined from chrome alloy steel. A double row roller bearing is fitted to the center of the gear.

(q) The first stage planet carrier is forged from steel. Four bosses are machined to locate the planetary gears. The center of the carrier is splined to mount the second stage sun gear.

(r) The second stage sun gear is machined from chrome alloy steel. It is splined to the first stage planet carrier and secured by a lock-nut.

(s) The second stage carrier forms the base of the vertical rotor shaft.

1 It is forged from steel.

2 Six bosses are machined for mounting the planet gears.

3 Splines for driving the rotary wing hub and drive collar are machined into the upper end of the shaft.

(t) Two tapered roller bearings fit between the rotor shaft and the upper cover. They are secured with a lock-nut.

(u) Located between the main housing and the top cover is the planetary ring gear.

1 Machined from a steel forging, the gear has external flanges which bolt to the main housing and the upper cover.

2 Internal teeth mesh with the first and secondary stage planet gears.

(v) A slider shaft is attached to the upper cover by a flange around its base.

1 The shaft is machined from aluminum alloy.

2 A viton type fluoroelastomer seal is retained in the slider, seating against the rotor shaft, immediately above the tapered bearing lock-nut.

3 A synthetic rubber seal closes the top of the slider shaft.

(w) The accessory idler, main oil pump, and hydraulic pump gears are machined from steel forgings.

(x) The accessory idler gear, rotating around a ball bearing seated on the idler gear post, is retained by a lock-nut. The post is bolted to the main housing.

(y) The main lubricating pump gear is mounted in the main housing, supported by two ball bearings, and secured by a lock-nut. It is internally splined to drive the lubrication pump.

(z) The hydraulic pump gear is mounted in the main housing, supported by two ball bearings, and secured by a lock-nut. It is internally splined to drive the No. 1 flight control hydraulic pump.

(aa) A seal retainer seats a viton type fluoroelastomer seal against the hydraulic gear drive shaft.

(ab) The lubrication main pump fits into a machined cavity in the main housing. The pump quill shaft aligns with, and is driven by, the main lubrication pump gear splines.

(ac) The main lubrication pump is secured to the main housing. The main filter is attached to, and is an integral part of the pump.

(ad) The auxiliary lubrication pump gear is an integral part of the pump. The pump is seated in a machined cavity and secured by bolts.

(ae) A fan impeller aluminum alloy casting is splined to the bevel pinion input gear, and retained with a lock-nut.

(af) A cast aluminum diffuser and shroud assembly, bolted to the main housing, direct air into the impeller and to the collar.

(ag) The annular cooler attaches to the diffuser casing.

1 Oil inlet and outlet tubes connect the cooler to the main housing oil gallery.

2 A temperature/pressure bypass valve diverts oil from entering cooler core at an outlet temperature of 71° + 10° -5°C. If the pressure differential exceeds 30 ±5 psid, the cooler core pressure is relieved.

(ah) The cooler core consists of hollow aluminum fins through which the oil flows. Cooling air is forced over the fin external surface by fan operation.

(ai) A three piece aluminum alloy air inlet duct is fitted around the transmission input shaft adapter and plate assembly. It is attached to an annular flange on the Station 120 bulkhead.

(aj) The lubrication main oil pump is a positive displacement gerotor type.

1 An adjustable pressure relief valve is set to 60 psi, and covers a range of 30 to 90 psi.

2 The flow rate is 20 gallons per minute.

(ak) The main oil filter incorporates a pressure differential indicator that extends when 15-18 psi differential exists.

1 The filter disposable element consists of a No. 42 and No. 100 aluminum wire mesh screen, containing a paper/fiberglass composition filter. The housing is aluminum alloy.

2 The No. 100 mesh inner screen has .015 inch openings which restricts migration of the composition filter. The No. 42 mesh outer screen protects the filter outer surface.

3 The oil filter is a part of the oil pump assembly.

4 The filter incorporates a pressure regulator to adjust main oil system oil pressure.

(al) The inlet screen, auxiliary filter, main and auxiliary pressure switches and the main pressure transducer union, thread into the main housing lubrication gallery.

(am) The auxiliary pump pressure relief is set to do psi with a flow rate of 1.5 gallons per minute.

(an) Lubrication jets are attached to the main housing to lubricate and cool the gears, bearings, and planetary gear system.

(ao) The combination debris detection screen and chip detector is mounted in the sump.

1 The screen is stainless steel and utilizes a 12 mesh with a .060 inch opening. The screen is formed around a woven polyester monofilament.

2 All auxiliary oil is routed through the detector prior to entering the oil pump.

3 The detector incorporates a self-closing valve which permits the unit to be withdrawn from the sump with minimal oil loss.

4 The debris detector has a positive and negative screen. Ferrous particles, bridging the positive and negative screens, close the debris detection circuit, latching the maintenance panel debris screen indicator.

5 The chip detector is an integral part of the combination detector. When the .10 inch chip detector gap is closed by metallic contamination:

a The cockpit master caution panel capsule is activated.

b The cabin maintenance panel latching indicator is activated.

(ap) A temperature probe threads into the sump to register oil temp.

1 A combination aluminum breather-filler unit is mounted on the upper cover.

2 A sight gage, mounted on an aluminum extension, attaches to the side of the sump.

(aq) The upper cover and the main housing are drilled for lubrication passage to the jets and indicator switches.

(5) Operation

(a) The forward transmission is driven by the combining transmission. The torque transfer is accomplished by the forward drive shafting.

(b) The pinion spiral bevel gear receives its input from the forward drive shaft adapter, driving the bevel gear and two stage planetary gear set.

(c) The bevel and planet gear set reduces the ratio of the vertical rotor shaft to 30.72:1.

(d) The spiral bevel pinion and the spiral bevel gear change the angle of drive 81°. The vertical rotor shaft tilts forward 9°.

(e) A spur sun gear machined into the spiral bevel gear mates with the four first stage planet gears.

1 The first stage planet gears drive the carrier which rotates the six second stage planet gears.

2 The second stage planet gears, retained to the vertical rotor shaft rotate it to drive the rotary wing hub.

3 The rotor shaft is splined to mate with the upper controls drive collar and the rotary wing hub.

(f) A spur gear, machined into the lower end of the bevel gear, drives the accessory idler, main oil pump and hydraulic pump gears.

(g) The No. 1 flight control pump is driven by the hydraulic pump gears.

(h) A spur gear, splined to the bottom of the bevel gear, drives the auxiliary oil pump.

(i) The forward transmission lubrication system is independent, incorporating a main and auxiliary circuit.

(j) Oil is stored in the sump at the bottom of the transmission.

(k) The main oil pump draws oil through the sump mounted pump inlet screen.

(l) Pressurized oil is governed by the adjustable relief valve in the main oil filter which is an integral part of the pump.

1 The filter bypass valve operates when the pressure drop exceeds 25-30 psid.

2 The warning button exceeds when the pressure differential is 15-18 psi. Thermonic lockout will prevent actuation below 115°F ±10°F.

(m) The oil directed through the main housing to a transfer tube connecting to the cooler core.

1 The oil is cooled by fan driven air transferring heat from the core fin surface.

2 Bypass valve operation will prevent oil entry if:

a The core outlet temperature is 160° + 10°, -5°F, or lower.

b The core pressure differential drop exceeds 30 ±5 psid.

(n) The cooled oil enters the main housing through a transfer tube, and flows to the main inlet screen.

(o) The pressure switch is tapped into the main oil gallery at the exit side of the inlet screen.

(p) Low oil pressure warning is displayed on the cockpit master caution panel and cabin maintenance panel lights.

(q) The main oil pressure transducer, mounted on the airframe structure, Station 120, WL 68, BL 7L, taps into the main oil gallery adjacent to the pressure switch through a flexible hose.

(r) The oil pressure sensed by the transducer, is displayed on the cockpit XMSN oil pressure indicator, when selected.

(s) Pressurized oil is now directed to the lubrication jets to spray the bearings, gears, and planetary system.

(t) An auxiliary pump provides up to two hours of safe operation if the main lubrication system becomes inoperative.

(u) If both the main and the auxiliary lubrication system fail, up to 30 minutes of safe operation is still available.

(v) Auxiliary pump oil is drawn past the combination debris detection screen/chip detector.

(w) Indication of ferrous metal particles on the chip detector will activate cockpit master caution panel and the cabin maintenance warning latching indicator. Debris screen activation will operate the cabin maintenance panel warning latching indicator.

(x) Auxiliary pump oil is pressure regulated at the pump and is nonadjustable.

(y) Oil from the pump is routed through the auxiliary oil inlet screen and returned to the auxiliary oil gallery.

(z) The auxiliary pressure switch taps into the system at this stage.

(aa) Low oil pressure will actuate the cabin maintenance panel and the cockpit master caution panel warning lights.

(ab) The auxiliary pressure system oil is delivered to the jets to lubricate the bearings, gears, and planetary system.

(ac) A temperature probe in the reservoir registers oil temperature on the cockpit XMSN oil temperature indicator. A temperature switch in the probe will activate the cockpit master caution panel and the cabin maintenance panel warning latching indicator in the event of an oil overheating condition.

(ad) A breather filler assembly is attached to the main housing, to relieve case pressure and to permit replenishment of oil.

(ae) A slider shaft, located at the base of the vertical rotor shaft, guides swash plate motion. A combination seal and swash plate ball stop is attached to the top of the slider shaft.

(af) Cooling air for the fan enters the hinged intake screen at the rear of the upper forward pylon, is forced across the cooler fins by the fan, and exits through the exhaust screen above the fan.

d. Aft Transmission Assembly

(1) Location

(a) The aft transmission is located in the aft pylon just above the cabin ramp area, centered on Station 560, Wl 56, BL 0.

(b) Access to the aft transmission is made by opening the aft pylon lower cabin access doors, the pylon side access panels, and the aft work platforms.

(c) Oil filler and sight gage access.

1 The oil filler and sight gage for the aft transmission are accessible from the cabin ramp area.

a The oil filler is located on the forward right side of the transmission, Station 558, WL 50, BL 8R.

b The sight gage is located on the sump adjacent to the oil filler.

(2) Function

(a) With torque input from the aft synchronizing shafts, the aft transmission changes the angle of drive 94° and drives the aft rotor vertical shaft.

(3) Specification

(a) Weight: 982.0 pounds

(b) Dimension: 52 in. long; 34 in. wide; 35 in. high

(c) Type of Lubricating Oil: MIL-L-7808

(d) Reservoir Capacity: 40 quarts

(e) System Capacity: 44.0 quarts

(f) Transmission Oil Pressure

PSI Minimum Ground Idle		PSI Minimum		PSI Normal	
Main Sys	Aux Sys	Main Sys	Aux Sys	Main Sys	Aux Sys
7	-	20	20	20-90	-

(g) Transmission Oil Temperature. Maximum °C

140 (284°F)

(h) Temperature Warning

Reservoir oil temp switch closes at 284°F (140°C)

(i) Lubrication Pump

1 Rated speed: 5358 RPM at 100% RRPM

2 Rated flow:

a Pressure: 29.5 gpm

b Scavenge: 5.0 gpm

3 Adjustable pressure relief set to: 60 psi

4 Range of adjustment: 30-90 psi

(j) Lubrication Filter: 30 microns

1 Filter bypass valve operates when total pressure drop exceeds: 25-30 psid.

2 Impending bypass indicator button extends when pressure differential across filter exceeds: 15-18 psid.

3 Thermonic lockout prevents indicator button extension at, or below: 115° ±10°F (46° +5°C)

(k) Oil cooler

1 Rated oil flow: 29.5 gpm

2 Temperature/pressure bypass valve.

a Redirects oil to bypass cooler core when outlet temperature is at or lower than: 160° + 10°, -5°F (71° + 5° - 2°C)/

b Bypasses oil when core differential drop exceeds: 30 ±5 psid.

(l) Auxiliary oil pump

1 Bypass valve pressure relief set to: 70 psi

2 Rated Speed: 3326 RPM

3 Rated flow: 1.5 gpm

4 Filter Rating: 80 microns

(m) Oil cooler weight: 38.0 pounds

(n) Oil cooler dimensions: 10 in. wide; 17 in. diameter

(o) Oil cooling fan weight: 13.0 pounds

(p) Oil cooling fan dimensions: 7.0 in. wide; 12 in. dia.

(4) Construction

(a) The aft transmission major casing assembly consists of a main housing, an accessory housing, a sump, an upper cover, and the planetary ring gear.

(b) The main and accessory housings are cast from magnesium alloy. The housings are externally epoxy primed and coated, with the interior being resin treated.

(c) The sump is formed of ten plies of Kevlar 49 and two piles of fiberglass, type 181. The laminate lay-up uses 281 type Kevlar cloth.

(d) The upper cover, forged from aluminum alloy, has four transmission mounting pads machined and fitted with steel bushings.

(e) A seal retainer, cast from magnesium alloy, supports a viton type flouoroelastomer input pinion seal.

(f) The input pinion gear is supported by a ball thrust and a roller bearing at the input end. A roller bearing supports the pinion gear at the output end.

(g) The pinion input bearings are contained in a magnesium alloy cartridge support which is bolted to the main housing. The gear pattern shims fit between the housing and the cartridge.

(h) The pinion gear end bearing is bolted to the main housing by the race flange.

(i) The spiral bevel gear is supported by a ball duplex bearing at the lower end, by a roller bearing at the base of the bevel teeth, and by a ball bearing at the junction of the gear and the first stage carrier.

(j) The duplex bearing is bolted to the main housing by the race flange, the center bearing is bolted to a magnesium alloy support casting, and the upper ball bearing is recessed into the first stage carrier.

(k) The shims for establishing gear patterns for the bevel gear are located between the duplex bearing and the main housing.

(l) The accessory drive gear is supported by a roller bearing at the input end and by a ball bearing at the splined end.

(m) The accessory drive gear support bearings are bolted to a magnesium alloy cartridge support, which is bolted with gear pattern shims to the main housing.

(n) The pinion, bevel, and accessory drive gear ball bearings are retained by the inner race to the gear shaft by lock-nuts.

(o) The spiral bevel pinion gear has 29 teeth and is splined to receive the aft drive shaft adapter.

(p) The spiral bevel gear has 51 teeth.

1 A 28-tooth spur sun gear is machined above the bevel tooth set.

2 A 44 tooth spur gear, forged from steel, is keyed and locked to the lower end of the spiral bevel gear.

(q) The accessory drive gear has 36 bevel teeth and is splined to accept the main accessory drive spur gear.

(r) The spiral bevel pinion gear, bevel gear, and accessory drive (bevel) gear are forged from chrome alloy steel.

(s) The first and second stage planet gears are machined from chrome alloy steel. The gear rotates around double row roller bearings, fitted to the center of the gear.

(t) The first stage planet carrier is forged from steel. Four bosses are machined to locate the planetary gears. The center of the carrier is splined to mount the second stage sun gear.

(u) The second stage sun gear is machined from chrome alloy steel. It is splined to the first stage planet carrier and secured by a lock-nut.

(v) The second stage carrier is forged from steel.

1 Has six machined bosses for retaining the planetary gears.

2 Internal splines for driving the aft vertical drive shaft are machined into the carrier.

(w) A ball bearing, secured to the second stage carrier by a lock-nut, is located between the output spline area and the transmission top cover.

(x) Bisecting the main housing and the top cover is the planetary ring gear, machined from a steel forging. Bolts secure the external flanges to the main housing and top cover. Internal teeth mesh with the first and second stage planet gears.

(y) A double lip seal, held in a magnesium alloy retainer bolted to the top cover, seats against the aft vertical drive shaft to exclude moisture and contamination from the transmission.

(z) The main accessory drive spur gear is splined and secured by a lock-nut to the accessory drive (bevel) gear.

(aa) This gear, machined from a steel forging, is in line with, and drives all of the accessory section gearing.

(ab) The hydraulic pump idler and driver spur gears are machined from forgings. The gears are supported at both ends of the shaft by single row ball bearings, held in place by case pressure.

(ac) The hydraulic pump driver gear is internally splined to accept the No. 2 flight hydraulic pump, or the utility hydraulic pump.

1 A seal is seated in the main housing and secured by a retaining ring.

2 The seal lip material is a viton type fluoroelastomer.

(ad) Driven by the hydraulic pump gear, the generator and generator idler gears forged from chrome alloy steel, are supported by a single row ball bearing at each end.

1 The generator spur gear is internally splined to drive the No. 1 or No. 2 generators.

2 The ball bearings are retained by main and accessory housing pressure.

3 A viton type fluoroelastomer seal is retained in the accessory housing to contain the generator gear lubrication oil.

(ae) The lubrication pump spur gear is forged from steel.

1 Internally splined to drive the oil pump quill shaft, the gear is supported by a ball bearing at each end.

2 The bearings are supported and positioned by the main and accessory housings.

3 Oil leakage is prevented by the oil pump body and packing.

(af) The fan drive and idler gears are forged from steel.

1 The fan idler gear, driven by the main accessory drive gear, is supported by an internal ball bearing.

2 The ball bearing is secured to a shaft by a locknut. The shaft is flanged and bolted to the accessory housing.

3 The fan gear, splined at one end, is supported by a ball bearing at each end of the gear shaft.

4 The bearings are retained in recesses in the main and accessory housings.

5 A viton type fluoroelastomer seal is retained in the accessory housing to prevent oil leakage.

(ag) An annular cooler, with an external fan, is attached to the accessory case, centralized over the fan drive pad.

(ah) A fan drive quill shaft forged from steel, 13.8 inches long, by 1.2 inches diameter, is splined at both ends.

1 An annulus, machined to contain a packing, is located inboard of the splines.

2 A flange, to prevent excessive end float, is located inboard of the packings.

3 The quill shaft, identically machined at each end, is meshed with the fan drive gear and fan driving splines.

(ai) An air baffle, formed from aluminum alloy, is attached to the center of the cooler to form the inner air stream guide to the fan.

(aj) The cast aluminum oil cooler incorporates a temperature/pressure bypass valve which permits oil to bypass cooler core:

1 At oil temp. of 160°F +10°, -5°F or lower.

2 When core differential pressure drop exceeds 30 ±5 psid.

(ak) The cooler core is connected to the auxiliary housing lubrication gallery by external inlet and outlet oil transfer lubes.

1 The cooler core consists of hollow aluminum fins through which the oil flows.

2 Cooling air is forced over the external fin surface to dissipate heat, by the gear driven fan.

(al) The fan assembly, cast of aluminum alloy, has 12 blade impellers rotating on 2 sealed ball bearings. The impellers drive is splined to accept the fan drive quill shaft. A grease fitting permits lubrication of the ball bearings.

(am) The lubrication main oil filter consists of an aluminum base, bolted to the accessory housing, with a screw-on filter.

1 The filter incorporates a bypass indicator, a disposable filter element and a drain.

2 The filter disposable element consists of a No. 42 and No. 100 aluminum wire mesh screen, containing a paper/fiberglass composition filter. The housing is aluminum alloy.

3 The No. 100-mesh inner screen has .015 inch openings which restricts migration of the composition filter. The No. 42 mesh outer screen protects the filter outer surface.

(an) The main inlet screen, auxiliary filter, main and auxiliary pressure switches, and the main pressure transducer union, thread into the main housing lubrication gallery.

(ao) External tubes attach to fittings in the upper cover to pressurize the aft vertical shaft thrust bearing and return the oil to the system.

(ap) The main oil pump is a positive displacement gerotor type.

1 Drive is provided by a quill shaft splined to the input shaft.

2 An adjustable pressure relief valve, set to 60 psi, covers a range of 30 psi to 90 psi.

3 The flow rate at the pressure port is 29.5 gallons per minute; at the scavenge ports, 5 gallons per minute.

(aq) The auxiliary lubrication pump is a gerotor type.

1 The drive gear and pump shaft are integral.

2 The pressure relief valve is set to relieve at 80 psi with a rated flow of 1.5 gallons per minute.

(ar) Lubrication jets are attached to the main housing to direct main and auxiliary system oil to:

1 The pinion, bevel, and accessory bevel gears and bearings.

2 The two stage planetary system.

(as) The debris detection screen and chip detector is mounted in the sump.

1 The screen is stainless steel and utilizes a No. 12 mesh with an .060 inch opening. The screen is formed around woven polyester monofilaments.

2 All auxiliary oil is routed through the detector prior to entering the oil pump.

3 The detector incorporates a self-closing valve which permits the unit to be withdrawn from the sump with minimal oil loss.

4 The debris detector has a positive and negative screen. Ferrous particles, bridging the positive and negative screens, close the debris detection circuit, latching the maintenance panel debris screen indicator.

5 The chip detector is an integral part of the combination detector. When the 0.10 inch chip detector gap is closed by metallic contamination:

a The cockpit master caution panel capsule is activated.

b The cabin maintenance panel latching indicator is activated.

(at) A combination aluminum breather-filler unit is attached to the main housing. A sight gage, mounted on an aluminum extension, attaches to the sump.

(au) The upper cover, and the main and accessory housings are drilled for lubrication passage to the jets, accessory screens and indicators.

(av) A temperature probe threads into the sump to register oil temperature.

(5) Operation

(a) The aft transmission is powered by the combining transmission. Torque transfer is accomplished by means of the aft synchronizing shaft and adapters.

(b) A pinion spiral bevel gear is meshed with a spiral beval gear driving a two stage planetary gear set.

(c) The bevel and planetary gear set reduce rotation to a ratio of 30.72:1.

(d) The spiral bevel pinion and spiral bevel gear change the direction of drive 94°. The output drive assembly tilts forward 4°.

(e) A spur sun gear machined into the spiral bevel gear mates with four first stage planet gears.

1 The four first stage planet gears, locked from free rotation by the ring gear, drive the carrier.

2 The carrier, splined to a sun gear, locked from free rotation by the ring gear, drive the carrier.

3 The second stage planet gears rotate the carrier. Internal splines in the carrier match splines on the aft vertical drive shaft.

(f) An accessory drive gear is meshed with the bevel gear to drive the accessory gear train.

(g) The components driven by the accessory drive gear are, the No. 1 and No. 2 generators, the main oil pump, the No. 2 flight hydraulic pump, the utility hydraulic pump, and the cooling fan.

(h) The auxiliary oil pump is driven by a gear on the bottom of the spiral bevel gear.

(i) The auxiliary lubrication system will provide up to two hours of safe operation should the main system become inoperative.

(j) If the main and auxiliary systems both fail, up to 30 minutes of safe operation is still available. WARNING: The aft vertical shaft receives its lubrication oil from the main xmsn oil pump. With main lubrication oil pump inoperative, no oil is supplied to the aft vertical shaft thrust bearing acft must land as soon as possible.

(k) The aft transmission has an independent self-contained lubrication system.

(l) Oil is stored in the sump at the bottom of the transmission.

(m) The main oil pump consists of a pressure stage with three oil return (scavenge) stages.

(n) Oil is picked up from the sump through the inlet screen which has a No. 8.5 mesh with .098 in. openings by the pump.

(o) The pressurized oil is directed to the main oil filter. Pressure is regulated by the oil pump adjustable relief valve.

(p) The oil filter bypass valve operated when the internal pressure drop exceeds 25-30 psid. The warning button will extend when the pressure differential reaches 15-18 psid.

(q) Filtered oil is routed through the oil gallery to the oil cooler inlet transfer tube.

(r) The oil is cooled by fan driven air removing heat from the cooler fin surface. Bypass valve operation will prevent oil entry if:

1 The core outlet temperature is 160° +10°, -5°F, or lower.

2 The core pressure differential drop exceeds 30 ±5 psid.

(s) Oil from the cooler re-enters the auxiliary and main housing through a transfer tube to be passed through the main inlet screen.

(t) A pressure switch is tapped into the main oil gallery at the exit side of the inlet screen.

(u) Low oil pressure warning is displayed on the cockpit master caution panel and the cabin maintenance panel lights.

(v) The main oil pressure transducer, mounted on the airframe structure to the left of the transmission Station 557, WL 50, GL 30L, taps into the main oil gallery, via a flexible hose.

(w) Oil pressure sensed by the transducer is displayed on the cockpit XMSN oil pressure indicator, when selected.

(x) Pressure oil is routed to:

1 The oil jets to spray the bearings, gears, and planetary system.

2 The auxiliary housing to cool the two generators, and lubricate the gear train.

3 External tubing carries pressurized oil to the aft rotor shaft thrust bearing and returns it to the upper cover to gravitate to the sump.

(y) The rotor shaft thrust bearing housing mounts a pressure switch and a chip detector to monitor the status of the oil within the housing.

1 Low oil pressure will actuate the cockpit master caution panel and cabin maintenance panel warning lights.

2 Metallic particles bridging the chip detector will activate the cockpit master caution panel and cabin maintenance panel latching indicator.

(z) The scavenge elements of the pump pick up the oil on the exit ports of the oil cooled generators, draw it through the generator screens and return it to the sump.

(aa) The auxiliary pump draws oil through the combination detector screen/chip detector.

(ab) Metallic particles activating the chip detector cause cockpit master caution panel and the cabin maintenance panel-latching indicator to operate. Debris screen activation will operate the cabin maintenance panel-latching indicator.

(ac) Auxiliary pump oil pressure is internally regulated and the pump is nonadjustable.

(ad) The pressurized oil enters the auxiliary filter, and is then routed through the gallery to the lubrication jets.

(ae) The pressure switch taps into the auxiliary oil gallery.

(af) Low auxiliary oil pressure activates the cockpit master caution panel and cabin maintenance panel lights.

(ag) A temperature probe, sensing reservoir oil temperature, provides the cockpit XMSN oil temperature indicator with this data. A temperature switch in the probe will activate the cockpit master caution panel and the cabin maintenance panel-latching indicator in the event of an oil overheating condition.

(ah) A filler breather unit is mounted on the main housing to the left of the input shaft.

(ai) Cooling air for the fan enters the aft pylon fairing doors,

1 is drawn through the structure, ahead of, and around the aft transmission.

2 is drawn through the cooler fins.

3 exits through the compartment above the APU.

2. Transmission Indicating System and Maintenance Panel

a. Transmission Indicating System

(1) Operation

(a) Transmission temperature and main oil pressure indicators are installed in the cockpit center instrument panel, Station 50, WL4, BL 0.

(b) The main oil pressure indicator is powered by 115 VAC. A circuit breaker for the indicator is mounted on the No. 1 pdp.

(c) The indicator is electrically connected to a pressure transducer mounted adjacent to each transmission.

(d) The transducer is connected to each main oil pressure system by means of a flexible hose.

(e) A transmission oil pressure selector switch is mounted below each indicator.

(f) Operation of selector switch is as follows:

The switch positions are TEST, SCAN, FWD, AFT, MIX, LEFT, and RT. When the switch is set to TEST, the pointer on the transmission pressure indicator will drop to zero or below. In addition, the TEST nomenclature on the switch will come on. When the switch is set to SCAN, the SCAN nomenclature on the switch will come on and the lowest main oil pressure among all the transmissions will be indicated. The nomenclature for that transmission will also come on. The remaining positions are used to select a particular transmission oil pressure indication. The nomenclature lights also come on when a transmission is individually selected. If any one transmission oil pressure decreases below 20 psi, the nomenclature light for the affected transmission comes on and the XMSN OIL PRESS caution light comes on.

(g) The transmission main oil temperature indicator system is powered by 115 VAC, through a circuit breaker on the No. 1 pdp.

(h) The indicator is electrically connected to an INTERNAL amplifier and to temperature probes in the transmission sumps.

(i) A transmission main oil temperature switch is mounted below each indicator.

(j) The selector operates as follows:

The switch positions are TEST, SCAN, FWD, AFT, MIX, LEFT, and RT. When the switch is set to TEST, the pointer on the transmission oil temperature indicator deflects full scale toward low temperature. In addition, the TEST nomenclature light on the switch comes on. When the switch is set to SCAN, the SCAN nomenclature on the switch comes on, the highest oil temperature among all transmissions is indicated, ad the nomenclature for that transmission comes on. The remaining positions are used for selecting a particular transmission oil temperature indication. The nomenclature lights also come on when a transmission is individually selected.

b. Transmission Oil Caution Lights

(1) Operation

(a) The master caution panel is located on the center instrument panel, Station 50, WL 4, BL 0.

(b) Five transmission oil caution lights are on the master caution panel. The lights are marked XMSN OIL HOT, XMSN OIL PRESS, XMSN AUX OIL PRESS, and No. 1 and No. 2 ENG XMSN HOT. These lights, in conjunction with the transmission oil pressure and temperature indicators on the instrument panel alert the crew to impending transmission lubrication problems. The caution lights operate independently of the pressure and temperature indicators on the instrument panel. The XMSN OIL HOT light comes on when the main oil temperatures in the reservoir of the forward, aft, combining, or either engine transmission exceeds 140°C. The hot transmission is identified by the oil temperature selector switch and indicator.

(c) The XMSN OIL PRESS caution light comes on when the main oil pressure drops below 20 psi in the forward, aft, or combining transmission, or either engine transmission bearing. The light will also come on if pressure drops below 10 psi in the aft rotor shaft bearing. The low-pressure system is identified by the transmission oil pressure selector switch and indicator on the instrument panel. If the XMSN OIL PRESS caution light comes on and the affected transmission cannot be determined using the selector switch, the condition may be caused by loss of aft rotor shaft oil pressure.

(d) The XMSN AUX OIL PRESS light comes on when the auxiliary oil pressure drops below 20 psi in the forward or aft transmission, or below 10 psi in the combining transmission. The low pressure system is identified by the indicator on the instrument panel.

(e) The ENG XMSN HOT caution lights come on if oil temperature in either engine transmission exceeds 190° - 207°C. The lights are turned on by a thermo-switch in each transmission. The thermo-switch monitors oil temperature in the transmission, not in the reservoir. The thermo-switch is part of a chip detector and temperature assembly in each transmission.

c. The Maintenance Panel

(1) Operation

(a) The maintenance panel is on the right side of the cabin above the ramp, Station 518, WL 40, BL 50R. The panel is provided to assist in the identification of system conditions that may require servicing or other maintenance.

(b) The panel is divided into three sections: TRANSMISSION, HYDRAULICS, and ENGINE.

(c) The transmission section of the panel includes nine oil pressure lights, six chip detector magnetic latching indicators, six debris screen magnetic latching indicators, and five over-temperature magnetic latching indicators.

(d) The maintenance panel transmission indicators receive power from No. 1 dc bus through the MAINT PNL LTS circuit breaker on the XMSN section of No. 1 power distribution panel.

(e) Nine PRESS-TO-TEST oil pressure lights are on the TRANSMISSION section of the maintenance panel. Six lights marked MAIN OIL PRESS indicator low main oil pressure. Three lights marked AUX OIL PRESS indicate low auxiliary oil pressure. If main oil pressure drops below 20 psi in the forward, combining, or 10 psi in the aft shaft bearing, the corresponding light comes on. At the same time, the XMSN OIL PRESS light on the master caution panel comes on. If auxiliary oil pressure drops below 20 psi in the forward or aft transmission or 10 psi in the combining transmission, the associated AUX OIL PRESS caution light on the maintenance panel comes on. At the same time, the XMSN AUX OIL PRESS caution light on the master caution panel comes on. The AUX OIL PRESS caution lights on the maintenance panel are the only means of identifying the specific low-pressure auxiliary oil system. Low oil pressure at the aft rotor shaft is indicated by the illumination of the AFT SHAFT lights on the maintenance panel.

(f) Six CHIP DETECTOR magnetic latching indicators on the TRANSMISSION section of the maintenance panel. The indicators are marked FWD, COMB, AFT, AFT SHAFT, LH, AND RH. When the corresponding chip detector is bridged by ferrous particles, the associated chip detector indicator changes from all black to black-and-white. At the same time, the XMSN CHIP DET or ENG CHIP DET caution panel comes on.

(g) Chip detectors are installed in all transmission and aft rotor shaft thrust bearing lubrication systems. All chip detectors, except those in the engine transmission, are connected to the XMSN CHIP DET caution light on the master caution panel. Engine transmission chip detectors are connected to the ENG CHIP DET caution lights. All transmissions and the aft rotor shaft chip detectors are also connected to the TRANSMISSION CHIP DETECTOR indicators on the maintenance panel. When a chip detector is bridged by ferrous particles, the XMSN CHIP DET, or ENG CHIP DET, caution light comes on. At the same time, the corresponding TRANSMISSION CHIP DETECTOR latching indicator on the maintenance panel will trip and change from an all-black indication to a black-and-white indication, identifying the transmission.

(h) There are six TRANSMISSION DEBRIS SCREEN latching indicators on the transmission section of the maintenance panel. There is one indicator for the forward, aft, and both engine transmissions and two indicators marked LH and RH for the combining transmission. The indicators are electrically connected to screens of each transmission. If the screen mesh is bridged by conductive debris, the corresponding DEBRIS SCREEN indicator will trip. The indicator display will change from all-black to black-and-white to indicate possible transmission component deterioration.

(i) Five transmission oil OVERTEMP magnetic latching indicators are on the maintenance panel. Each OVERTEMP indicator is electrically connected to a temperature probe in the reservoir of each transmission. If oil temperature in the transmission reservoir exceeds 140°C, a switch in the probe closes. When the switch closes, the XMSN OIL HOT caution light comes on and the corresponding OVERTEMP latching indicator on the maintenance panel changes from all-black to black-and-white, identifying the hot transmission.

(j) A switch for testing the latching indicators is located at the lower RH corner of the maintenance panel.

1 The switch is spring-loaded to GRD position.

2 Momentarily setting the switch to TEST will activate all the indicators, displaying a black and white pattern.

3 Momentarily setting the switch to RESET will return all the indicators to the reset condition, which is a solid black display.

4 Master caution panel circuits are shared by the maintenance panel. Activation of the TEST switch will cause all caution panel capsules (which have maintenance panel duplicate indicators) to light up.

(k) There are three types of sensors used to operate the magnetic latching indicator.

1 The chip detector indicator circuit operates when ferrous metal closes the 0.10 inch chip detector gap.

2 The debris detector screen circuit operates when electrically conductive particles are between the positive and negative screens, completing the circuit.

3 The over-temp indicator circuit operates when the reservoir oil temperature exceeds 276°F - 292°F (135°C - 145°C). The temperature probe switch closes at this temperature. The thermal switch reopens when the oil temperature drops to 246°F - 262°F (119°C - 128°C).

(l) Electrical power is provided by the 28 VDC HYDRAULICS MAINT PNL circuit breaker located on the No. 1 PDP.

1 When a sensor provides a ground, the latching circuit winding is energized.

a This latches the indicator by means of a permanent magnet.

b Electrical power is not required to hold the circuit in the latched position.

c The latched display will be black and white.

2 The latched circuit is cancelled by the reset circuit winding being energized by the operation of the RESET switch. This returns the display to all black condition.

3 The nine push to test transmission oil pressure lights are powered from the same circuit breaker.

a Normally closed pressure switches are located at each transmission oil pressure gallery source.

b As the closed pressure switch completes the circuit, when electrical power is applied without the rotors turning the lights will come on.

c When the rotors are engaged, the pressure in the transmission oil systems open the pressure switches breaking the circuit. The oil pressure lights are not illuminated.

d If the oil pressure in any one of the nine oil circuits drops below the pressure required to close the switch, the maintenance panel light and the caution panel capsule will illuminate.

e The bulb circuit can be tested by pressing the spring loaded light lens. This grounds the bulb filament in lieu of the pressure switch circuit.

3. Transmissions Malfunctions Refer to TM 55-1520-240-10

a. Transmission Low Oil Pressure of High Temperature Indications

Developing trouble in the transmissions can be identified by high oil temperature or low oil pressure, as indicated by transmission temperature and pressure indicators and caution lights. If an abnormal temperature or pressure indication develops, closely monitor the caution lights. The XMSN OIL PRESS and XMSN OIL HOT caution lights operate independently of the pressure and temperature indicating system and come on when a low pressure or high temperature condition occurs. Additional information may be obtained by the flight engineer checking the maintenance panel.

b. XMSN OIL PRESS Caution Light On

(1) XMSN OIL PRESS selector - Select each position to identify the defective transmission. If low oil pressure is not indicated in any position, it shall be assumed that the defect is in the aft vertical shaft. The following steps are performed according to which component is defective:

(a) If the LEFT or RIGHT engine transmission is indicated, proceed as follows:

(2) ENGINE CONDITION lever (affected engine) - Adjust as required. If oil pressure is above zero, adjust N1 to 70% if not required for flight. If oil pressure is zero, move engine condition lever to STOP.

If engine is required for flight.

(3) Land as soon as possible.

If engine is not required for flight.

(4) Land as soon as practicable.

(a) If the FWD or MIX transmission is indicated, proceed as follows:

1 Altitude - Descend to minimum safe altitude

2 Airspeed - 100 KIAS or below

3 Land as soon as possible

(b) If the AFT transmission is indicated, proceed as follows:

1 Altitude - Descent to a minimum safe altitude

2 Airspeed - 100 KIAS or below

3 Electrical load - Reduce as much as possible

4 Land as soon as possible

(c) Aft vertical shaft

(5) Land as soon as possible.

c. XMSN OIL PRESS and XMSN AUX OIL PRESS Caution Lights On.

Land as soon as possible.

XMSN OIL HOT Caution Light On.

(1) XMSN OIL TEMP selector - Select each position to identify the defective transmission. The following steps are performed according to which transmission is defective:

(a) If the FWD or MIX transmission is indicated:

(2) Land as soon as possible.

(a) If the aft transmission is indicated, proceed as follows:

(3) Electrical load - Reduce as much as possible.

(4) Land as soon as possible.

d. No. 1 or No. 2 ENG XMSN HOT Caution Light On.

(1) ENGINE CONDITION lever (affected engine) - STOP

(2) Engine transmission - Check. The flight engineer will visually check the affected engine and engine transmission for fire.

(3) Land as soon as possible.

e. XMSN AUX OIL PRESS Caution Light On.

(1) XMSN OIL PRESS selector - Select each position to identify the defective transmission.

(2) XMSN OIL TEMP selector - Select each position to identify the defective transmission.

If pressure or temperature is abnormal in any transmission.

(3) Land as soon as possible.

If pressure and temperature are normal in all transmissions.

(4) Land as soon as practicable.

f. XMSN CHIP DET Caution Light On. If the XMSN CHIP DET caution light comes on, land as soon as possible.

g. Rotor Blades or Drive Failure.

If a rotor blade or drive shaft fails, land as soon as possible.

h. Rotor Tachometer Failure.

(1) If a rotor tachometer fails, proceed as follows:

DC ROTOR TACH (affected indicator) circuit breaker - In.

(2) If both rotor tachometers fail, proceed as follows:

(a) DC ROTOR TACH circuit breakers - In.

(b) Land as soon as practicable. Do not make any further changes in rotor speed. Practice auto-rotational descents shall not be performed and all maneuvers requiring use of the thrust control must be made as smoothly as possible to prevent rotor rpm droop or over-speed.

CHAPTER 7
HYDRAULIC SYSTEM

SECTION I
UTILITY HYDRAULIC SYSTEM
DESCRIPTION
AND
THEORY OF OPERATION

Utility Hydraulic System

A. Utility Hydraulic System Improvements

1. Modularization of Components

2. Cartridge-type components used in modules

3. Use of permaswage fittings

4. Use of Rosan fluid adapters

5. Isolation of systems

6. Power transfer units to operate flight control hydraulics from the utility system.

B. Description

1. The Utility Hydraulic System supplied hydraulic power for non-flight essential hydraulic systems. The systems are:

   a. Wheel Brakes

   b. Power Steering

   c. Swivel Locks

   d. Centering Cams

   e. Ramp Actuation Cylinders

   f. Cargo Door Motor

   g. Center Cargo Hook

   h. Cargo/Rescue Winch

   i. Engine Starters

   j. Power Transfer Units

   k. APU Start Circuit

   The utility hydraulic system incorporates a pressure control module which isolates the subsystems from each other. When a failure occurs in one subsystem that system can be isolated by switches in the cockpit and the remaining subsystems continue to operate normally. The APU Starting subsystem includes two accumulators, a 375 cubic inch accumulator accelerates the APU to Start, and a 25 cubic inch accumulator which maintains reservoir pressure throughout the Start cycle. The APU Starting subsystem also includes a two-stage hand pump for emergency charging the APU Start accumulators. Normally the APU accumulator is recharged by the APU motor pump after the APU is Started.

2. System Particulars

a. System Pressures

(1) 3,000 psi nominal - 3,350 psi APU operating

(a) Return side 50-90 psi

(2) 16 GPM nominal

b. Fluids used

(1) MIL-H-83282 (primary)

NOTE: Fire Retardant

(2) MIL-5606 (alternate)

(3) Fluids are compatible

(4) Operating temps.

(a) -65°F 275°F 125° Ambient

(5) Capacities

(a) Utility 5.60 gals.

(b) No. 1 & No. 2 flight control 2.40 gals. each

(6) Filling of system by:

(a) Three-position fill module

C. System Improvements

1. Modules

Standard hydraulic components that were distributed throughout the systems are packaged in single-housings as cartridges, which can be easily replaced in the module. A cartridge is a hydraulic component having a standardized outline with considerable interchangeability.

2. Swaging of lines

Mechanically swaged permanent connections are used in place of reconnectable fittings. The fittings are considered a permanent part of the tube assembly, thereby eliminating leak points.

3. Rosan Fluid Adapters

A fitting that is locked into the patent material by a serrated-locking ring. This allows tubing installation and removal with one wrench.

4. Fault Isolation

A hydraulic maintenance panel located on the aft RH side of the aircraft displays the vital parameters of the utility hydraulic system and the flight control hydraulic system.

5. On Demand Pressurization

The system is divided into five branches, the power steering and brakes, No. 1 engine Start, No. 2 engine Start, power transfer units-cargo hook-winch, and the ramp system. This gives the ability to isolate any or all branches when not in use. Prevents utility hydraulic loss due to leaks or bursts.

6. Power Transfer Units

The utility hydraulic system drives a hydraulic motor which is mechanically connected to a hydraulic pump in each flight control hydraulic system. Providing pressure for ground flight control check out.

D. Utility Hydraulic System Components

1. Reservoir/Cooler

Located in the aft pylon the reservoir/cooler provides a supply of hydraulic oil and a heat exchanger to cool the hydraulic oil. Contained in the reservoir cooler are level indicators, one on the reservoir and an LVDT for remove indication of the maintenance panel, a thermal switch to control fan operation, a temperature bulb for remote temperature indication on the maintenance panel, and a bleed and relief valve for system bleeding and system relief.

a. Location - aft Pylon W.L. + 72.0 accessible from R/H side aft pylon

b. Function

(1) Stores fluid for utility system

(2) Cools fluid

(3) Fluid is fed at approximately 55 psi when system is at 3,000 psi

c. Operation

(1) Return fluid flows through cooler first

(2) Fluid cooled by external fan

(3) To reservoir

d. Specification

(1) Air-cooled

(2) Capacity 6 quarts

(3) Pressurized, return side approximately 55 psi - piston ration 60-1

e. Components

(1) Relieve valve low pressure (145HS207-XX)

(a) Provides bypass around res./cooler

(b) Open to full flow at 25 psi

(c) Reseat at 20 psi

(2) Bleed relief valve

(a) Relieves excess pressure

(b) Valve fully open at 115 psi

(c) Reseats at 100 psi

(d) Valve is spring-loaded closed

(e) May be manually operated to bleed air or fluid

(3) Thermal Switch (A15HS015-SS)

(a) Closes when fluid temperature reaches 63°C.

1 Fan on

(b) Opens when temperature drops to 54°C

2 Fan off

(4) Temp bulb (1122153)

(a) Monitors reservoir fluid temperature

(b) Indication of hydraulic maintenance panel

(5) Fluid level transducer (LVDT)

(a) Signals maintenance panel indicator of fluid level

(b) Sight indicator

1 Visual level indication

(6) Accumulator 25 in^3 (114HS133-XX)

(a) Adjacent to reservoir cooler

(b) Maintains head pressure on reservoir

(7) Reservoir Cooler Fan

(a) Location-Aft pylon, on deck above reservoir

(b) Thermostatically controlled

(c) Temperature range 54°C to 63°C

(d) 115V 3-phase power #1 AC bus

2. Accumulators

There are five accumulators in the utility hydraulic system, three in the power system and two in the subsystems. The APU Start accumulator is self-displacing and supplies the power for starting the APU. It also can be used to power the subsystems in an emergency. It is located in the aft section RH side Station 555 in the transmission support structure. The bootstrap accumulator keeps pressure on the reservoir during APU Start to prevent pump cavitation. It is located in the aft pylon hydraulic equipment compartment.

a. Location - Station 555.0 right hand side, looking forward

b. Function

(1) Stores Start hyd. pressure for APU motor/pump

(2) Acts as a surge tank for utility system

(3) Uses return pressure to aid during APU Start

c. Operation

(1) With Start circuit energized, pressurized fluid flows to motor/pump for Startup.

(2) Pressure is maintained during Start model.

d. Specifications

(1) Weight 28.0 lbs.

(2) Overall length approximately 30.0 inches

(3) Will withstand a .50 cal. incendiary projectile

(4) 145 in^3 displacement high press. 145 in^3 low press.

(5) 375 in^3 nitrogen displacement

(6) Nitrogen pre-charge approximately 1800 psi

(7) Self-displacing using return pressure 50-150 psi

The APU Start module accumulator keeps pressure in the motor/pump signal line during APU acceleration to prevent the motor/pump from changing from a motor to a pump before the APU is at its rated speed. It is located in the aft section RH side Station 584.

The wheel-brake accumulator provides pressure to unlock swivel locks, removes surges and provides braking power to the wheel-brake when the utility system is not operating. It is located in the forward pylon LH side on the No. 1 hydraulic system reservoir/cooler structure. The swivel lock accumulator keeps pressure in the swivel lock and centering cam system when the utility system in not operating and dampen surges during operation. It is located on the power steering module RH side aft section Station 460.

3. Controllable Check Valves

There are two controllable check valves in the utility hydraulic system. One directs the APU Start accumulator pressure to the subsystems for emergency operation. It is located in the aft section RH side 82-TA-6102 Station 520. The other controllable check valve is in the bootstrap 79-TA-1313 accumulator line to maintain the pressure on the reservoir during APU Start. This controllable check valve must be opened to depressurize the utility hydraulic system. It is located in the aft section RH side Station 560.

4. Hydraulic Fill Module

The hydraulic fill module can be used to fill all three hydraulic systems from a single point, one at a time. It can be used to fill any system even during flight. It is located in the aft section RH side Station 510.

a. 3-way, 4 position valve, rotary selector

(1) Closed

(2) Utility fill

(3) No. 1 flight system

(4) No. 2 flight system

(5) Each position has detent

(6) Reservoir has filter, 0.0035 particles will be caught

(7) Reservoir capacity approximately 1 qt.

(8) Visual level indicator

NOTE: *Do not allow fluid level to go below site glass, air will be induced.

5. Hand Pump (Dual Stage)

A dual staging hand pump can be used to charge the APU Start accumulator when it is low. The pump stages at 2,200 psi, so the operation becomes easier at the higher pressures. It is located in the aft section RH side Station 527.

a. Used for pressurizing APU Start accumulator

b. Used for emergency operation subsystems

c. Emergency utility controllable check valve must be opened to operate subsystems.

6. APU Start Module

The APU Start module is the primary hydraulic control for APU Starting and motor/pump mode control. It contains a pilot solenoid valve, which is controlled by the ESU, that controls a pressure-operated valve. The pressure-operated valve controls the pressure to the motor/pump, also the signal line accumulator and the utility hydraulic system depressurization valve. It is located in the aft section RH side Station 584.

a. Location - Station 570.0 RBL 27.0 accessible from ramp area

b. Function

(1) Directs signal to APU motor/pump

(2) Directs start pressure to APU motor/pump

(3) Controls operating mode of APU motor/pump

c. Operation

(1) Place APU start switch in start position

(2) Solenoid operated valve directs pressure to start valve

(3) Pressure operated valve directs pressure to APU motor/pump

d. Specifications

(1) Operated 18-30 vdc

(2) Weight 4.65 lbs.

(3) Two-way valve

e. Components

(1) Solenoid operated start valve (145HS143-XX)

(a) Functions

1 Directs pressure to pressure operated valve

2 28 VDC from essential bus

(b) Operation

1 APU start switch in start pos.

2 Signals ESU (Electronic Sequence Unit)

3 Solenoid pilot valve directs pressure to Start valve

(c) Specifications

1 Contained in start module

2 28 VDC

3 Two-way valve

(2) Valve Engine Start (145HS552-XX)

(a) Location - installed in module assembly

(b) Function

1 Allows signal pressure to motor pump

2 Allows start pressure to motor pump

(c) Operation

1 Pressure is directed from solenoid pilot valve to pressure valve

2 Pressure operated valve directs pressure to APU motor/pump signal

(d) Specification

1 Pressure operated valve

2 Normally closed

(3) Accumulator 5 cu. in. (145HS656-XX)

(a) Function

1 Provides start signal to motor/pump

2 Acts a surge chamber

(b) Operation - Nitrogen pre-charge to 1,400 psi

(c) Specification

1 5 cu. in.

2 Screwed into module body assembly

(4) Depressurization and Check Valve 145HS660-XX

(a) Location contained in APU start module assembly

(b) Function

1 Depress 25 cu. in. accum. with depress controllable check valve open

2 Depress Start accum.

(c) Operation - Depress knob to accomplish above functions

(d) Specification

1 Check valve

2 Depressurization valve

3 Normally closed

7. Power Transfer Units

The power transfer units covert utility hydraulic power to flight control hydraulic power by fixed displacement motor, which is powered by utility hydraulic pressure, driving through a shaft a fixed displacement pump, which supplies hydraulic pressure to its respective flight control hydraulic system. The power transfer units are controlled by their respective switches in the cockpit. The No. 1 flight control hydraulic power transfer unit is located in the forward pylon RH side Station 140. The No. 2 flight control hydraulic power transfer unit is located in the aft pylon center Station 550.

a. Provides hydraulic pressure for ground checkout of flight controls from

(1) APU running

(2) Ground test unit

(3) One unit for each flight control system

(4) Utility and FCS fluid, not intermix

b. Receives pressure from utility system

(1) Motor is driven by pressure from utility system

(2) Fixed displacement motor

(3) Pressure in 3,300 psi nominal

(4) Pressure out (return) 150 psi nominal

(5) Flow in 5 gpm maximum, restricted to 3 gpm

c. Pump is spline driven by motor (fixed displ.)

(1) Pressure out (pump) 2,900 psi nominal

(2) Pressure into pump 60 psig

(3) Flow out of pump 3.5 gpm nominal

(4) Pump is driven by hydraulic motor

(5) Weight 12.3 lbs. max dry

d. Flow limiter (145HS142-XX)

(1) Limits flow from 11.5 gpm utility flow

(2) To 3.5 gpm flow through power transfer unit

e. Valve, pilot solenoid 3-way normally closed (145HS143-XX)

(1) Receives power from #2 DC bus 28-VDC

(2) Directs pressure to pressure operated valve

(3) Spool is positioned to allow pressure to utility motor

f. Pressure Operated Valve (145HS218-XX)

(1) Directs pressure to utility motor

(2) Return side has 1 gpm bleed at 3,000 psi

8. APU Motor/Pump

The APU motor/pump acts as a motor during the APU Starting cycle and as a pump, with an output of 3,350 psi, during APU operation. The switching from pump to motor to pump is controlled hydraulically through the APU Start control module and ESU.

a. Location

(1) Fwd END APU assembly

(2) Accessible from ramp area

b. Function

(1) Provides pressure for engine start

(2) Provides pressure for utility system operation

(3) Pump capability is

(a) Will provide 11.5 gpm at 3,350 psi

(b) Will provide 16.5 gpm at 3,000 psi

c. Operation

(1) Receives hydraulic signal from APU start module accumulator

(2) APU Start switch in start position

(3) Acts as motor to 90% APU speed

(4) Above 90% speed becomes pump for utility system (8216 RMP)

d. Specification

(1) Spline driven

(2) Shear torque - 1,270 lb-ins. minimum

(3) Constant delivery (motor mode) - APU Start

(4) Variable delivery (pump mode) - Utility system operation

(5) Weight 10.25 lbs.

9. Utility Hydraulic System Pump

The utility hydraulic system pump is a variable displacement pump that delivers hydraulic fluid at a nominal 3,000 psi. It is mounted on the RH side of the accessory drive section of the aft transmission.

a. Location - Aft transmission right-hand side, forward end aft XMSN

b. Function - Provides pressure to utility system, rotors turning

c. Operation

(1) Fluid is supplied from utility reservoir at approximately 50-90 psi

(2) Pump outlet pressure to utility system 2900-3100 psi 16.5 gpm

d. Specifications

(1) Pump turns approximately 5358 rpm - 100% rotor speed

(2) Horizontally mounted

(3) Variable delivery, piston-type pump

(4) Pressure range 2900-3100 psi - 16 gpm

(5) Coupling shear torque - 1650-2050 lb. ins.

(6) Weight 10.3 lbs. dry

10. Filters

Two identical filters are used in the utility hydraulic system one pressure, one return. The elements are five-micron and disposable. There is a filter contamination indicator mounted on the bottom of each filter bowl. This indicator also trips a switch which is connected to a warning light on the maintenance panel. The pressure filter is attached to the pressure control module aft section LH side, Station 534. The return filter is attached to the return control module aft section RH side Station 534.

a. Filter, high-pressure and return (145HS205-1)

(1) 5-micron filter - disposable

(2) Contamination indicator P 75 ±10 psid

(3) Will remove up to 97% of particles

(4) Power from No. 2 dc bus to light on maintenance panel

11. Oil Cooler Fan Assembly

The oil cooler fan is a three-phase AC fan. The fan is controlled by the thermal switch located in the reservoir/cooler. The fan assembly is mounted on the aft pylon thrust deck and ducted to the heat exchanger on the reservoir/cooler.

12. Pressure Control Module

The pressure control module contains the controlling components for five branches of the utility hydraulic system, left and right engine Start, power transfer units, brake system, and ramp system. Also contained in the module are the pressure filter, various check valves, the pressure transmitter, the pressure switch, and the high-pressure relief valve. The pressure control module is located on the forward left side of Station 534, former assembly, adjacent to the drive shaft.

a. Function

(1) Directs pressure from any one of 3 sources

(a) Ground hydraulic test unit

(b) APU motor pump (rotors off)

(c) Utility pump (rotors turning)

b. To utility subsystems

(1) Ramp

(2) Engine Start (2 each) (individual Start)

(3) Power steering/swivel locks

(4) Cargo hook

(5) Power assisted wheel brakes

(6) Power transfer units - ground check of light controls

c. Operation

(1) Engine Start 3,350 psi 11 gpm

(2) Utility system 3,000 psi 16 gpm

(3) Receives 28 VDC #1 and #2 DC bus

(4) Any subsystem may be isolated for troubleshooting and fault isolation purposes

(5) Weight 21.5 lbs.

d. Components

(1) Valve engine Start (2 each) 145HS552-XX

(a) Pressure actuated

(b) Normally closed

(c) Actuated by pressure through pilot solenoid valve

(d) Directs pressure to Starter motors

e. Valve Power Transfer Unit Motor (145HS204-XX)

(1) Normally open

(2) Pressure operated

(3) Directs flow to

(a) Power transfer units

(b) Cargo hook

(c) Cargo winch

f. Valve Pilot Solenoid 145HS143-1 L/H Engine

-3 R/H Engine

(1) Power from #1 DC bus 28 VDC L/H

(2) Power from #2 DC bus 28 VDC R/H

(3) Valves are not interchangeable, electrical connections are not the same

(4) Directs pressure to Start valves

g. Valve, Pilot Solenoid (Power Transfer Valve)

(1) Receives power from #1 DC bus 28 VDC

(2) Valve is normally open

(3) Directs flow to power transfer valve

h. Valve, Solenoid (145HS752-2)

(1) Receives power from #1 DC bus 28 VDC

(2) Valve is normally closed

(3) Directs pressure to ramp control valve

i. Valve, Solenoid (145HS742-3)

(1) Receives power from #1 DC bus 28 VDC

(2) Directs pressure to

(a) Power steering/swivel lock

(b) Power assisted wheel brakes

j. Filter, High Pressure (145HS205-XX)

(1) 5 micron filter

(2) Contamination Indicator P75 ±10 psi

(3) Will remove up to 97% of particles

(4) Power #2 bus 28 VDC light on maint pnl

k. Pressure Transmitter (145HS213-XX)

(1) Receives power #2 DC bus 28 VDC

(2) Sends electrical signal to pressure indicator

l. Pressure Switch (145HS214-XX)

(1) On decreasing pressure of approximately 1,800 psi or lower light will come on, on master caution panel

(2) On increasing pressure approximately 2,300 psi or higher, light will extinguish

(3) Nominal operating pressure of 2,000 psi

(4) Receives 28 VDC from essential bus

m. Relief Valve, High Pressure (145HS206-XX)

(1) Protection for module

(2) Relieves at 3,850 psi maximum, full-flow

(3) Reseat at 3,500 psi minimum

13. Return Control Module

The return control module is the central location for the return components, which includes the return filter, an APU motor/pump fail detector, a utility hydraulic pump fail detector, various check valves, and the ramp transfer cylinder. The main purpose of the return control module is to provide a source of return while keeping the subsystem isolated from each other.

a. Isolates return side of subsystems

b. Central location of return components

c. Pump fail indication 28 VDC #2 bus

(1) APU pump case drain

(2) Utility pump case drain

d. Components

(1) Filter (145HS205-1)

(a) 5-micron capability

(2) Relief Valve, Filter (145HS205.2)

(a) Pro-texts filter

(b) Cracks 130 ±15 psi approximate - reseats approximately 115 psi

(3) Differential pressure ind. (145HS205-XX)

(a) Warns of filter contamination P 75 psi ±10

(b) Receives power from #2 bus 28 VDC - Indication given on maintenance panel

(4) Check Valve (6 gpm) (145HS212-1)

(a) Isolates transfer cylinder in the event of leakage or failure

(5) Check valve (16 gpm) (145HS212-2) (2 each)

(a) Check valve is for filter

(b) Check valve prevents reverse flow through filter

(6) Pump Fail Indicators (145HS217-XX) (2 each)

(a) APU motor/pump

(b) Utility pump

(c) Power from #2 bus 28 VDC

(d) Warning light on maintenance panel

(7) Transfer Cylinder (145HS603-XX)

(a) Pertains directly to ramp operation

(b) Compensates for additional flow for ramp lowering

(c) Isolation of this function is maintained during ramp operation

(d) Mounted on return module assembly

<u>1</u> Operating pressure 60 psi - return pressure

14. Maintenance Panel (145E2056-XX)

a. Provides a means to monitor all hydraulic system functions

(1) Displays

(a) System pressures (all)

(b) System temperatures (all)

(c) Fluid levels (all)

(2) Warning lights

(a) Filter contamination (all)

(b) Pump failure (all)

(3) Power for level indicators

(a) Battery bus 28 VDC

(4) Power for fail and contamination lights - #2 bus 28 VDC

(a) #2 bus 28 VDC

15. APU Start System Hydraulic Operation

a. When the APU switch is placed to Start 28 VDC controlled by the ESU is applied to the APU pilot solenoid valve in the APU Start module.

b. The solenoid opens allowing the 300 psi pre-charge of the APU Start accumulator to enter the signal pressure line, which positions the motor/pump to the motor position. It also supplies the same pressure to the control port of the pressure-operated valve.

c. The pressure operated valve, which is a delayed opening type to allow the motor/pump to be correctly positioned, will open and allow the APU Start accumulator pressure to be applied to the motor pump.

d. The motor pump accelerates the APU until the APU Start accumulator is depleted. At which time the pressure trapped in the signal line keeps the motor/pump from shifting to a pump keeping the APU unloaded during acceleration.

e. At 90% rated speed, the ESU removes the 28 VDC from the APU pilot solenoid valve, which depressurizes the signal line, allowing the motor/pump to shift to the pump mode. This will provide utility pressure at 3,350 psi and recharge the APU Start accumulator.

16. Engine Start System Hydraulic Operation

a. When either engines start switch is placed in the motor or Start position 28 VDC from the DC essential bus is applied to the engine Start pilot solenoid valve, in the pressure control module, allowing the utility hydraulic pressure to be applied to the control port of the respective engine Start pressure operated valve.

b. The pressure-operated valve, which is a delayed opening type, will open allowing the system pressure to be applied to the respective engine Starter.

c. The Starter accelerates the engine to about 40% N1 where an overriding sprag clutch allows the engine to accelerate on its own.

d. Placing the engine start switch to off removes the 28 VDC from the engine start pilot solenoid valve, which closes, and removes system pressure from the pressure operated valve, allowing it to close, which removes the system pressure from the starter.

17. Malfunctions - TM 55-1520-240-10 (Emergency Procedures)

A. Utility Hydraulic Subsystem Improvements

1. Isolation of all subsystems by cockpit switches or manual control

2. Multiple hook system

3. Manual control valves for the winch

4. One switch for power steering and swivel locks

5. Brake accumulator added for brake application with utility system off

B. Ramp System

1. Description - Ramp System

a. Cargo Loading Ramp

The ramp provides a means of quickly loading and unloading troops and cargo. It can also be used to support portions of a cargo load which exceeds the longitudinal dimensions of the cargo floor. When used for additional cargo space, the ramp must be positioned so that the ramp floor is level with the cargo floor. In this situation, the weight of the cargo item resting on the ramp must not exceed 3,000 pounds or 300 psf.

b. Auxiliary Loading Ramps

Three auxiliary loading ramps are hinged to the aft-end of the ramp. When the ramp is lowered, these auxiliary ramps are unfolded to provide flush contact between the ramp and the ground. The auxiliary loading ramps can be positioned to accommodate various vehicle tread widths or butted together to facilitate winching of bulk cargo. When not in use, the auxiliary ramps are stowed in an inverted position on the floor of the ramp or removed. One of the auxiliary loading ramps when attached to the amp can also be used as a work platform. A collapsible support attached to the ramp can also be used as a work platform. A collapsible support attached to the ramp bottom allows the ramp to be positioned at any convenient height when used as a work platform.

c. Cargo Door and Ramp

The cargo door and ramp has two sections: an upper section, or cargo door, and a lower section, or ramp. The door retracts into the ramp when the ramp is being lowered and extends when the ramp is being raised. The door is an integral part of the ramp and only provides closure; therefore, references made to the ramp will be understood, to include the door and its related movements. The cargo door is jettisonable to provide an emergency exit. The cargo door and ramp is located at the aft end of the cargo compartment and is used for troop and cargo loading and unloading. In closed position, it conforms to the side contours of the fuselage. Internal locks in the ramp actuating cylinders prevent accidental opening and constitute the only locking mechanism for keeping the ramp closed. The ramp is hinged to the fuselage and opens rearward and downward to rest on the ground. When lowered to ground rest, the ramp inclines downward approximately 6.75° and maintains a uniform 78-inch overhead clearance of the cargo compartment. A continuous hinge runs the entire width of the aft upper edge of the ramp and holds the three auxiliary loading ramps. Power to operate the ramp is supplied from the utility hydraulic system.

2. Operation - Ramp System

a. Ramp Control Valve

Lowering and raising the ramp is controlled by a manually operated ramp control valve on the right side of the aft cargo compartment, between the floor and the overhead at Station 490. The ramp control valve has three marked positions, UP, STOP, and DN (down). The valve can be reached from the outside through a hinged panel on the aft fuselage.

b. Ramp Actuating Cylinders

Are hydraulically controlled, the raising of the ramp requires pressure. The lowering is by gravity, by allowing the hydraulic oil to flow out of the cylinders, therefore the ramp can be stopped and held in any position. The ramp-up locks are contained in the actuating cylinder and can only be released with hydraulic pressure.

c. Cargo Door and Motor

The motor, which extends or retracts the cargo door is actuated by the ramp sequence valve.

d. Ramp Control Sequence Valve

A mechanically operated sequence valve controls the sequence of cargo door and ramp operation. The valve is below the ramp control valve at the ramp hinge line. A plunger on top of the valve is manually pressed to hold the cargo door at full open during ramp operation. The plunger can be locked in the depressed position by rotating a retainer pin, which extends from the side of the valve.

e. Pressure Actuated Valve

Ramp operation is stopped during cargo door operation by a hydraulic pressure actuated valve. The valve is located near the ramp control valve. A plunger provides manual override of the valve if it sticks.

f. Hydraulic Hand Pump

A hand pump is mounted on the right side of the cabin below the maintenance panel. The pump is used to pressurize the APU accumulator. Besides Starting the APU, the charge in the APU accumulator can be used to open and close the ramp using the controllable check valve.

g. Controllable Check Valve

The controllable check valve is above the hand pump. The valve is marked EMERG UTIL PRESS, NORMAL, OPEN. At NORMAL, the valve allows fluid flow in one direction. The NORMAL position is used when the system is pressurized by the APU pump or the aft transmission pump. The OPEN position is used when the utility system must be pressurized from the APU Start accumulator or the hand pump.

C. Triple Cargo Hook

1. Description

Three external cargo hooks are provided for attaching external cargo. The hooks can be used with a single-load on one hook, two hooks in tandem (forward and aft hooks), or individual loads on three hooks, the tandem hook configuration provides improved load stability at higher airspeeds. With the triple hook system, up to three loads can be deposited at different locations during a single mission. The forward hook is at Station 249. The center hook is at Station 331. The aft hook is at Station 409.

All hooks have normal release modes, emergency release modes, and manual release modes. Normal release mode can be controlled by both pilot's or by the hoist operator. Emergency release of all hooks can be performed electrically by either pilot or manually by the hoist operator.

The structural limits for the cargo hooks are 17,000 pounds for the forward and aft, tandem 25,000 pounds, and the center 26,000 pounds.

2. Cargo Hook System

a. Components

(1) Cargo hooks

(a) Location

1 System has three hooks

2 One located at Station 240, bottom centerline (P/N 145ES102)

3 One located at Station 331, bottom centerline (P/N 145E5505)

4 One located at Station 409, bottom centerline (P/N 145ES102)

(b) Function

1 Provide means of carrying oversized loads

(c) Construction

1 Forward and aft hooks identical

2 Contains three switches - HOOK LOADED - HOOK OPEN-LINKAGE OPEN

3 Contains normal release relay

4 Contains release solenoid

5 Center hook contains two switches for hook open light

6 Also contains an emergency release solenoid

7 Center hook normal release is a hydraulic operation

(d) Operation

1 28-volts to release relay operates solenoid on forward or aft hook and opens hook

2 A load greater than 125 pounds operates hook loaded switch and lights a light on overhead panel

3 When hook open or linkage open, switch closes the hook open light on the caution panel comes on

4 Either or both switches to include the manual release on the center hook close when the hook is open and lights the caution panel light

(2) Dual hook relay box (P/N 145E2032)

(a) Location

1 At Station 270 right-side cabin area

(b) Function

1 Control normal release of cargo hook

2 Monitor forward and aft hook electrical connections and warns crew of hook release circuit problems

(c) Construction

1 Contains seven relays (pwr relay - fwd relay - ply - mid rel rly - aft rel rly - gnd rly - fwd capsule relay - aft capsule relay)

2 Has three warning lights - ARMED SW FAIL-RELEASE SW FAIL – GROUND RELAY ACTIVATE

3 Two electrical connectors

4 Metal box with removable cover

(d) Operation

1 Hook release relays are operated when a hook or hooks are operated.

2 The capsule relays operate when forward or afthook is open.

3 Power relay controls power in the box. It is energized when master switch is set to ARM. It lights the armed switch fail light.

4 Ground relay is energized when any hook release switch is activated. It supplies ground for aft or forward hook mounted release relay. Also supplies ground for ground relay activate light.

5 Release switch fail light comes on when any hook release switch operated.

(3) Emergency hook release relay box (P/N 145E2085)

(a) Location

1 Mounted in cabin at Station 270 left-side

(b) Function

1 Provide separate release circuits for cargo hooks to be used in emergencies

(c) Construction

1 Metal box with removable cover

2 Contains four relays

a Power relay

b A 10-second time-delay relay

c A forward hook relay

d An aft hook relay

3 Two voltage dropping resistors

4 The hook relays operate at 13.5 volts dc. They are rated to 35 volts

5 Two electrical receptacles

(d) Operation

1 Power is applied to the hook relays through the dropping resistors and the forward and aft hook release solenoids. This removes the ground from the dual hook fault light.

2 Power relay is energized by the emergency hook release switch and supplies voltage to all hook solenoids

3 Time-delay relay maintains power to release solenoids for 10 seconds

(4) Hoist/cargo hook control panel (P/N 145E2034)

(a) Location

1 Mounted on overhead panel

2 Right-side of panel

(b) Function

1 Provide pilot with control of hoist/winch

2 Provide pilot with control of hook release

(c) Construction

1 A master switch

a Double-pole double-throw toggle switch

b Marked OFF - ARM - RESET (momentary)

2 An emergency hook release switch

a Double-pole single-throw toggle switch spring-loaded off

b Marked - RELEASE ALL

c Has switch guard installed

3 A forward hook open light

4 An aft hook open light

5 A hook select switch marked as follows: FWD - MID - AFT - TANDEM - ALL

(d) Operation

1 Place arm switch ON supplies 28-volts DC to normal release relay box

2 Emergency switch applies 28-volts to all hooks for emergency release of all hook loads

3 Hook open light illuminates when the forward and/or aft hook opens

4 Selector switch connects hook normal release lines to be operated when hook release switches are operated.

(5) Hoist operators panel (P/N 145E2137)

(a) Location

1 Station 320 right-side of cabin

(b) Function

1 Provide connection for hoist operators grip control

2 Provides connection for inter-phone system

3 Provides switch for arming cargo hook release from grip control

4 Provides storage area for winch grip, grip cable assembly and inter-phone cable assembly

(c) Construction

1 Metal panel

2 Two wiring receptacles

3 Two toggle switches

a One for cargo hook arming (ARM - RMTE - RESET)

b One for inter-phone mike control (ON - OFF - MOM ON)

(d) Operation

1 Placing cargo hook switch to ARM supplies 28-volts to grip hook release switch.

2 Placing switch to reset allows center hook to close after a release

3 Placing hot mike switch ON allows operator to use inter-phone without depressing mike switch

4 Momentary ON allows operator to speak as long as he holds switch

(6) Center Hook normal release hydraulic solenoid valve (P/N 114HS114)

(a) Location

1 Located in drive shaft tunnel area at Station 334

(b) Function

1 Operate center hook open in normal release

(c) Construction

1 28-volt operated solenoid valve

2 Three-way valve

b. System Operation

(1) Cargo hook normal release system operates on 28-volts DC from the No. 2 DC bus through two circuit breakers. They are a 15 amp breaker marked "CARGO HOOK PWR NORMAL" and a 5 amp breaker marked "CARGO HOOK CONT RELEASE".

(2) Cargo hook emergency release system operated on 28-volts DC from the essential bus through two circuit breakers. They are a 20-amp breaker marked "CARGO HOOK EMERG REL PWR" an a 5-amp breaker marked "CARGO HOOK EMERG REL CONT".

(3) The forward or aft hook loaded lights illuminate if a load greater than 150 pounds is on the hooks.

(a) Voltage to the lights is supplied from the normal release control circuit breaker.

(b) Ground for the lights is supplied through the hook loaded switch to ground.

(4) A normal forward, aft, or tandem (fwd and aft) hook release operation follows:

(a) The normal release power circuit breaker supplies power to the normal release relay box. It is applied to one side of the GROUND RELAY ACTIVATE light and to A1 of the power relay. Also powers press-to-test of RELEASE SW FAIL and ARMED SW FAIL lights.

(b) Power from the control breaker is applied to master switch contacts 2 and 5. From contact 2 power continues through contact 3 to the hoist operator's panel and applies power to contact 11 of cargo hook remote switch.

(c) Power continues to contact 12 and to the normal release relay box and powers the forward and aft capsule relays.

(d) Placing master switch to ON applies powers to the following:

1 From contact 5 to 6 and operates hydraulic solenoid valve in utility system to pressurize system.

2 From contact 6 to the pilot's and copilot's cyclic stick cargo hook release switch.

3 Also to the normal release relay box and energizes the power relay.

4 When the power relay is energized, power is applied to the following:

a The ARMED SWITCH FAIL light and illuminates it

b To the "A" set of contacts of the fwd and aft release relays

c To the "B" set of contacts of the mid release relay

5 Arm switch voltage also continues through the box to the hoist operator's panel remote switch, contact 2 and 5. From contact 2 it goes back to the box and applies power to "A" contacts of ground relay and mid release relay.

(e) Placing hoist operator's cargo hook-switch to ARM supplies power to the grip hook release switch.

(f) Depressing any hook release switch, operates the following: (hook select switch in FWD)

1 Power is supplied through the select switch to the relay box and energizes the forward release relay

2 Power is also applied to the RELEASE SWITCH FAIL light and illuminates it

3 Power is also applied to the ground relay and latches itself through the "A" contacts. This provides a ground for the ground relay light and illuminates it through the "B" contacts.

4 When forward release relay energizes, power is applied through the "B" contacts and goes to the hook relay. The relay gets a ground through the ground relay "B" contacts.

5 This supplies power through the relay contacts to the solenoid, back to the relay to ground.

6 This operates the hook open and linkage open switches and supplies ground to capsule relay and illuminates the forward hook open light on master caution panel. This capsule relay is latched to hold the light on.

7 With hook unloaded, the overhead panel load light will go out.

(g) Placing either the hoist operator's panel or the master switch to reset will put the open light out, by removing power from its relay.

(5) Aft hook operation is identical except aft release relay is operated and the ground is supplied through the "C" contacts of the ground relay.

(6) Tandem operation operates both hooks at the same time.

(7) Center hook release operation is similar but the mid release relay is latched by its "A" contacts, it operates a hydraulic valve and the hook will close only when a reset has been performed.

(8) Release all operates all hooks as described

(9) Emergency hook operation follows:

(a) Power from the emergency power breaker is applied to the emergency hook release relay box, through the resistors to the forward and aft hook release solenoids, through the solenoids back to the box and energize the forward and aft hook relays. This arms the dual hook fault light circuit on the master caution panel.

(b) Power is also applied to C2 contact of relay K-1

(c) Power from the control circuit breaker is applied to the emergency release switch.

(d) When the switch is set to release all the following events occur:

1 28-volts is applied to control contact of the time delay relay and operates contacts

2 Power is also applied to the coil of K1 and its contact 12. The relay is energized.

3 When the relay operates, the power at C2 energizes all hook release solenoids. (Forward and aft directly and a solenoid in center hook that allows air charge to open hook)

4 It also applies power to the time-day relay to Start the timing

5 The 12 and 11 contacts supply voltage to the time-delay relay and latch the K1 relay. After the time out all hooks close (approximately 10 seconds).

c. Cargo Hook Caution Lights

The cargo hook caution lights are on the master caution panel. They are labeled FWD HOOK OPEN, MID HOOK OPEN, and AFT HOOK OPEN. A lit caution light indicates that the corresponding hook has opened. The lights can be extinguished by setting the CARGO HOOK MASTER switch to RESET or by setting the CARGO HOOK switch on the hoist operators panel to RESET.

d. Hook Loaded Advisory Lights

Two advisory lights marked HOOK LOADED are on the CARGO HOOK control panel. The lights are marked HOOK LOADED. When on, the light indicates that the corresponding (forward or aft) hook has a load of above approximately 150 pounds on it. The lights are turned on by sensors in the forward and aft hooks. Regardless of cargo hook MASTER switch position, the lights come on when hook load exceeds about 150 pounds.

e. Dual Hook Fault Caution Lights

A caution light labeled DUAL HOOK FAULT is on the master caution panel. This light provides continuous monitoring of the electrical continuity of the release solenoids in the forward and aft hook. When on, it indicates a loss of electrical release capability of the forward and/or aft hook in both normal and emergency modes. When the light is on, loads on the forward or aft hooks can only be released by the manual release system.

D. Cargo Winch

1. Description

A 3,000-pound capacity hydraulically operated which is mounted on the floor in the right forward cabin at Station 120. Hydraulic power to operate the winch is supplied by the utility hydraulic system. The winch is provided with 150 feet of 1/4-inch cable. It is capable of winching up to 12,000 pounds of cargo with the aid of pulley blocks. When used in hoisting mode, the load is limited to 600 pounds. The winch has two maximum reeling speeds: one for cargo loading (20 fpm) and one for hoisting (100 fpm). When the winch is used for cargo loading, a selector control level on the cable drum housing is moved to CARGO. When the switch is used for hoisting, the selector control lever is moved to RESCUE. A mechanical braking device automatically locks the cable drum when power is off, preventing loss of load control through cable pay out. If the winch cable load exceeds 3,200 pounds, an overload switch will automatically stop the winch. The free end of the winch cable is equipped with a metal ball, which locks into one end of a quick-disconnect device that is used to attach hooks to the cable. Both ends of the cable are painted red for 20 feet to alert the operator that the cable end is approaching. In CARGO mode, the winch will automatically stop when the cable is reeled out 150 feet and at 3 feet when the cable is reeled in. In RESCUE mode, the winch will stop when the cable is reeled in to Station 400.

2. Operation

a. Winch Controls

The winch can be controlled from the cockpit by switches on the overhead switch panel. It can also be controlled from the cargo compartment by switches on the winch/hoist control grip or mechanically by knobs on the control valves. The switches in the cockpit override the switches on the control grip, enabling the pilot to assume control of hoisting operations in an emergency. When operating from the cargo compartment, the winch/hoist control grip can be plugged into a receptacle on the auxiliary control panel at Station 95, the hoist operations panel at Station 320 or the receptacle at Station 502 by an extension cord. The winch can also be manually operated from the cabin. These controls are for emergency use only. The controls are mounted on the structure in the heater compartment. Instructions for manual operation of the winch are on the structure below the valves. Electrical power to operate and control the winch is supplied by the 28-volt No. 1 dc bus through two circuit breakers on the No. 1 power distribution panel. These two circuit breakers are marked HOIST CABLE CUTTER and HOIST CONT.

NOTE: The cable cutter arming device must be plugged into the receptacle on the auxiliary control panel at Station 95 and the cable speed selector lever must be at CARGO to complete the winch control circuit for cargo operations. The cable cutter-arming device must be plugged into the receptacle on the overhead above the utility hatch and the cable speed selector lever must be at RESCUE to complete the hoist control circuit for hoisting operations.

b. Winch Control Switches (overhead switch panel)

(1) Hoist master switch. A toggle hoist master switch is on the hoist control panel. The switch (labeled HOIST MASTER) has positions marked REMOTE, OFF, and PILOT. When the switch is at REMOTE, electrical power from the 28-volt No. 1 dc bus, through the HOIST CONT circuit breaker, energizes the winch-arming switch on the winch hoist control grip. Once this winch is pressed, the winch cable switch, also on the grip, is energized, allowing the winch reeling speed to be controlled at the hoist operator's Station. When the master switch is at PILOT, electrical power energizes the hoist control switch on the overhead switch panel, which gives the pilot control of the hoisting system. When the switch is at OFF, power is removed from the hoist control switches at both Stations.

(2) Hoist control switch. A spring-loaded, rheostat-type switch is provided for hoist control is on the hoist control panel. The switch (labeled HOIST) has positions marked OFF, IN, and OUT. When the hoist master switch is at PILOT, electrical power, from the volt No. 1 dc bus through the HOIST CONT circuit breaker, energizes the hoist control switch. Then the switch is moved to IN or OUT, the hoist brake release solenoid valve is energized open. The open valve applies hydraulic pressure through the hoist control valve to the winch to turn the cable drum in the appropriate direction. The speed of the cable is proportional to hoist control switch movement. When the switch is released the switch assumes the center-off position. In addition, the brake release solenoid valve is de-energized closed, which removed hydraulic pressure to brake the cable drum.

(3) Cable cutter switch. A cable cutter switch is on the left side of the hoist control panel. The guarded switch (labeled CABLE CUTTER) has positions marked ON and OFF. When the switch is at ON, electrical power from the 28-volt No. 1 dc bus through the CABLE CUTTER circuit breaker, detonates a ballistic cartridge in the cable cutter which cuts the cable. When the switch is at OFF, the cable cutter circuit is de-energized.

c. Winch Control Switches (control grip)

A portable pistol-shaped control grip contains a built-in microphone switch and a number of other switches used in hoisting, winching, and cargo hook operations. A receptacle for plugging in the extension cord is in the butt end of the grip. A hook extending from the side of the grip is used to hang the grip in its stowed position on the hoist control panel. The switches contained in the grip are as follows:

(1) Winch arming switch. The winch is armed for use by a trigger-type, spring-loaded switch. The location of the switch on the grip is the same as that of the trigger position on a handgun. When the switch is pressed, a circuit closes, arming the control circuits of the winch hydraulic motor. When the switch is released, the circuit open rendering the winch inoperable.

NOTE: The winch-arming switch must be pressed to operate the winch.

(2) Winch cable switch. Winch cable reeling is controlled by a rotary switch on the left side of the control grip. Action markings around the switch are IN, OFF, and OUT. The switch is spring-loaded to center OFF position. When the switch is moved in IN or OUT direction, a selector valve in the winch hydraulic system is electrically actuated, providing hydraulic pressure to turn the cable drum. The speed of the cable is proportional to cable switch movement in either direction.

(3) Cable cutter switch. A pushbutton switch on the upper shoulder of the control grip actuates the cable cutter. A metal guard marked CABLE CUTTER prevents accidental closing of the switch. When pressed, the switch closes a circuit, providing electrical current to fire a ballistic cartridge in the cable cutter. The firing propels a cutter which cuts the cable.

E. Wheel-brakes, Swivel Locks, Centering Cams, and Power Steering

1. Wheel-brake System

a. Brake System

The four wheels of the forward landing gear, and the two wheels of the aft landing gear, are equipped with self-adjusting disk brakes. Braking is accomplished on all wheels at all times. Both forward and aft brakes can be applied and brake pressure maintained by depressing the pedals. Hydraulic pressure is supplied by the utility hydraulic system.

b. Brake Pedals

When either the pilot's or copilot's brake pedals are depressed, pressure from the master brake cylinders go to a transfer valve in the brake lines. This allows independent braking by either pilot. From these transfer valves, pressure is directed through a parking brake valve to the forward and aft wheel brakes. The accumulator allows approximately 3 full brake applications when the system is not powered.

c. Parking Brake Handle

A parking brake handle is at the bottom left corner of the pilot's section of the instrument panel. The brake handle is mechanically connected to the parking brake valve. The parking brake handle is electrically connected to the PARK BRAKE ON caution light on the master caution panel. When the brake pedals are depressed and the parking brake handle is pulled OUT, pressure is trapped and maintained on forward and aft wheel brakes. At the same time, electrical power from the 28-volt No. 1 dc bus, through the CAUTION PNL circuit breaker, lights the PARK BRAKE ON caution light.

The parking brakes must be released by applying pressure to the brake pedals. This action automatically opens the parking brake valve, retracts the parking brake handle, and puts out the caution light.

d. Parking Brake Caution Light

A parking brake caution light is on the master caution panel on the console. This light is electrically connected to the parking brake handle. When the handle is pulled OUT, the light marked PARK BRAKE ON comes on. When the brake pedals are depressed and the handle goes in, the light goes out. Power to operate this light is supplied by the 28-volt No. 1 dc bus through the CAUTION PNL circuit breaker on the No. 1 power distribution panel.

e. Brakes and Steering Isolation Switch

The brakes and steering isolation switch is on the HYDRAULIC control panel on the overhead switch panel. It is labeled BRAKE STEER, ON and OFF. The switch isolates the brakes and steering hydraulic subsystem from the rest of the utility hydraulic system in the event of a leak in the subsystem. The normal position of the switch is ON. The switch is guarded to ON. Setting the switch to OFF, closes the power steering and brakes valves on the utility system pressure control module, isolating the brakes and steering the subsystem. With the switch at OFF, limited brake applications are available due to an emergency brake accumulator in the brake subsystem. Power to operate the isolation valve is from the 28-volt No. 1 dc bus through the BRAKE STEER circuit breaker on the No. 1 power distribution panel.

2. Swivel Locks, Centering Cams, and Power Steering

a. Steering and Swivel Lock System

The aft right landing gear is hydraulically steerable and electrically controlled by a control knob on the steering control box on the console. The three position SWIVEL switch, also on the STEERING CONTROL panel, controls operation of power steering and swivel locks. The switch positions are arranged so the power steering system cannot be energized and used with swivel locks engaged. Hydraulic power to operate the power steering actuator and the swivel locks is supplied by the utility hydraulic system through the utility system pressure control module and a separate power steering and swivel lock module. Electrical power to control the steering and swivel lock system is supplied by the 28-volt No. 1 dc bus through the BRAKE STEER circuit breaker on the No. 1 power distribution panel.

b. Power Steering Control Box

The power steering control box is on the aft end of the console. The box is marked STEERING CONTROL. It contains the SWIVEL lock control switch, the steering control knob, a fail-safe module and relay, and a servo-amplifier. The fail-safe module monitors the steering electrical circuits. A malfunction which could cause a steering hard-over will be detected by the fail-safe module and relay which disables the system and turns on the PWR STEER caution light.

c. Swivel and Steering Control Switch

The three-position steering and swivel control switch is on the STEERING CONTROL box in the console. The switch is labeled SWIVEL. The switch positions are labeled STEER, UNLOCK, and LOCK. Setting the switch to STEER applies 28-volt dc to the circuits in the power steering control box and arms the power steering actuator. Rotating the steering control knob with the SWIVEL switch at STEER will activate the power steering actuator and the aft right wheel will swivel when the power steering knob is rotated. Setting the SWIVEL switch to UNLCOK de-energizes the power steering circuits in the control box and the power steering actuator, while maintaining the swivel locks in the disengaged position. At UNLOCK, both aft wheels are free to swivel. Setting the SWIVEL switch to LOCK, energizes the swivel lock and centering cam control valve. Utility system pressure is directed to the lock port of the swivel lock cylinder and centering cam. The aft wheels will rotate to neutral trail position and the swivel lock will engage when helicopter weight is lifted from the rear wheels. AFCS heading hold is disabled at STEER and UNLOCK.

d. Control Knob

The power steering knob is on the right side of the power STEERING CONTROL panel. Index marks around the knot indicate degrees of knob rotation to LEFT and RIGHT in increments of 30°. These index marks do not represent wheel turn angle, they are reference marks only. The control knob is spring-loaded to zero turn angle. Power steering is accomplished by rotating the control knob a given amount in the desired direction. When the control knob is rotated, a servo valve on the power steering actuator regulates hydraulic pressure to extend or retract the actuator. A feedback variable resistor, also on the power steering actuator, stops actuator travel when the selected turn radius is reached.

e. Power Steering Caution Light

A power steering caution light is on the master caution panel on the console. The caution light is marked PWR STEER. The light indicates that power steering circuits have failed or the aft right wheel has exceeded turning limits. These limits are set at 58° for a left turn and 82° for a right turn. The aft right wheel is deflected an unequal number of degrees in one direction to produce an equal turn radius because of landing gear geometry. If turning limits are exceeded, an out-of-phase switch on the landing gear automatically closes the power steering solenoid valve, lights the caution light, and removes electrical power from the control box. To reenergize the power steering system, the landing gear must be returned within operating limits and the SWIVEL switch must be recycled.

CHAPTER 7
HYDRAULIC SYSTEM

SECTION II
FLIGHT CONTROL HYDRAULIC SYSTEM
DESCRIPTION
AND
THEORY OF OPERATION

Flight Hydraulics

A. Flight Control Hydraulic Improvements

1. Flight Control Hydraulic Separation and Redundancy

2. Integration of Actuators

3. Jam Proof Control Valves

B. Description

1. The flight control systems consist of two identical systems: No. 1 flight control system and No. 2 flight control system. The flight control systems are parallel in operation, hydraulically separated, and electrically integrated. They operate at approximately 3,000 psi, reduced to 1,500 psi for the integrated lower control actuators. The flight control systems power four dual integrated lower control actuators. Each flight control system powers one piston of each actuator.

   No. 1 flight control system is pressurized by a pump on the forward transmission. No. 2 system is pressurized by a pump on the aft transmission.

2. Components

   a. Reservoir Cooler (145H1602-2, 2 each)

      (1) Operation and components the same as the utility system reservoir cooler.

      (2) Capacity is approximately 2 qts.

   b. Power Control Modules (145H1201-4)

      The power control modules consist of pressure-operated valves and pressure-line and return-line filters. No. 1 system power control module is in the forward pylon. No. 2 system power control module is in the aft pylon. Each power control module also includes an accumulator. The accumulator dampens low frequency pressure surges and provides stored hydraulic power for peak loads.

      (1) Function of PCMs is to direct pressure and flow to either No. 1 or No. 2 flt boost system.

         (a) Operates on 3,000 psi at 7-8 gpm

         (b) Electrical power from No. 2 DC bus 28-VDC

         (c) Controlled by boost select switch on overload panel in cockpit

         (d) Weight 17.2 lbs. dry

         (e) No. 1 and No. 2 systems may be operated

            1 Both simultaneously

2 No. 1 or No. 2 independently

(2) Components of power control module

(a) Housing assy (145HS201-XX) contains PCM components

(b) Filter assy. high pressure (145HS205)

1 5-micron

2 Disposable element

3 Differential pressure indicator for contamination indicator

4 Removes all contaminants larger than 5-microns

5 Relief valve

a Opens 3,850 psi maximum full-flow

b Re-seats 3,500 psi min.

(3) Filter assy (return) 145HS205-XX

(a) 5-micron

(b) Disposable element

(c) Differential pressure indicator

(d) Relief valve

1 Cracks at 130 ±15 psi

2 Re-seats at 75 ±10 psi

(4) Accumulator 12 cu. in. (145HS656-XX)

(a) Takes up pressure surges in system

(b) Aids in providing head pressure on system

(c) Air charge approximately 1,400 psi

(5) Valve, pressure-operated (145HS204-XX)

(a) Spring-loaded to open position

(b) Pressure-operated to off position

(c) Directs flow to flight system

(6) Valve pilot, solenoid operated (145HS143-XX)

(a) Power for valve is from No. 2 bus 28-volt DC

(b) Normally closed

(c) Pressure is directed to valve from

1 Flight control pump

2 Power transfer unit

3 Ground support/equipment

(7) Pressure switch (145HS214-XX)

(a) Operating pressure

1 1,800 psi decreasing pressure light on master caution will illuminate

2 2,300 psi increasing pressure light will extinguish

3 Power from warning lights comes from essential bus 28-volt DC

(8) Pressure transmitter (145HS213-XX)

(a) Electromechanical device

(b) Takes in variable inlet pressures

(c) DC voltage is directly proportional to hydraulic pressure

(d) Directs electrical signal to maintenance panel

(9) Indicator, pump failure (145HS217-XX)

(a) Hydro-electrical-mechanical device

(b) Provides

1 Visible indication (button)

2 Electrical signal

3 Receives power from No. 2 DC bus 28-volt DC

4 Indication display on maintenance panel

c. Lower control, pressure control module 145H128-1

(1) Location

(a) System No. 1, Station 105, BL18 LH, WL40

(b) System No. 2, Station 95, between BL8 and BL18 LH, WL30

(2) Function

(a) Provides reduced pressure for ILCAs, with pressure relief protection.

(b) Provides pressure shutoff capability for ILCA extensible link sections.

(3) Specifications

(a) Pressure reduction - press. in. - 3,000, 1,450 to 1,550 psi out

(b) Return port designed for 50 to 100 psi operation

(c) Proof pressure - 4,500 psi on; pressure ports. 2,250 psi on return ports

(d) Fluid temperature range - minus 50 to 275 degrees F

(e) Flow - 3 U.S. gpm

(f) Mfg by Sterer Mfg. Co.

(g) Pressure reducer and solenoid are module-type, threaded into housing. Torque for both 120 to 140 in. lbs.

(h) Port identification

1 3,000 psi pressure in - P IN

2 1,500 psi pressure out to stick boost function - P OUT

3 Returned system - RTN

4 Extensible link pressure - P SAS

(4) Components

(a) Reducer/relief module (60610 steror)

1 Location - top of housing when installed in A/C

2 Operating pressure at:

a Pressure port - 2,800 to 3,350 psi

b Reducer port - 1,400 to 1,950 psid

c Return port - 50 to 150 psi

3 Reduced pressure range:

a Regulated pressure - 1,400 to 1,630 psid normal and 1,700 psid maximum

b Normal flow - 0.1 to 3.0 GPM

c Return leakage - 20 c.c. per minute

4 Relief valve

a Full flow - 3 GPM at 1,950 psid

b Reseat - 40 c.c. minimum at 1,700 psid

(b) Solenoid valve module type (60600-20 Sterer)

1 Location - bottom of unit when installed in A/C

2 Two-position, three-way port-type valve. Pressure port normally closed when de-energized

3 Operating range - 18 to 30-V DC

4 Electrical controlled by the AFCS selector switch on canted console

(5) Operation

(a) Solenoid De-energized

1 System pressure of 3,000 psi enters module through port P IN

2 Pressure is internally directed to the

a Closed (de-energized) solenoid valve

b Pressure reducer

3 Pressure acting on the large area and small area of the piston controls pressure output. Movement of the piston meters the fluid to control output pressure at approximately 1,400 to 1,700 psi.

4 Any pressure above 1,700 psi, at the outlet port, will unseat the relief valve and allow fluid flow into the return system.

5 With the solenoid valve closed (de-energized), the module P SAS port is connected to the RTN port through the solenoid.

(b) Solenoid energized

1 Relief/reducer same as solenoid de-energized

2 When energized the 1,500 psi pressure from the reducer is directed through the solenoid to the P SAS port. The internal return passage at the solenoid is blocked.

d. ILCA structural manifold 145H1282

(1) Location

(a) Closet area between Stations 95 and 120, between BL8 LH and BL18 LH about WL plus 10

(b) Two pieces mounted together

1 Thrust and yaw unit fwd

2 Roll and yaw unit aft

(2) Function

(a) Provides quick disconnect type fluid connections for the four ILCAs to allow removal with minimum loss of system fluid

(b) Provides structural attachments for the ILCAs

(c) Distribute pressurized fluid to the ILCAs boost and extensible link section

(d) Collect return fluid from the ILCAs

(e) Manufactured to prevent cracks from expanding from one system to another

(3) Specification

(a) Tubing parts are identified

1 Extensible link pressure port identified as P1SAS and P2SAS

2 Boost pressure port identified as P1 and P2

3 Return port identified as R1 and R2

(b) Manifold assembly made in two sections and attached together by huck bolts, to prevent dual system leakage caused from crack propagation

(c) Upper half of each manifold contains porting for hydraulics

(d) Upper half of each manifold contains porting for hydraulic system Number 1; lower half of each manifold contains porting for hydraulic system Number 2.

(e) Twelve check valves threaded into each manifold assembly

(f) Fwd and aft manifold are not interchangeable because of check valve location to match ILCAs

(g) Check valves are plunger-actuated to free-flow position when actuator and manifold are joined

(h) Approximate size is 3.5 in. thick, 10.5 in. high and 9.5 in. wide

(i) Proof pressure - 2,250 psi

(4) Operation

(a) Fluid from lower control manifold enters pressure ports, through open pressure check valves to ILCA

(b) Return fluid from ICLA passes through open return check valve to system return

(c) When ILCA is removed - check valves close, blocking ports within the manifold

e. Pump, flight control (145HS100-XX)

(1) Location: Forward transmission and aft transmission left-hand side

(2) Function:

(a) By selecting to operate either No. 1 or No. 2 or both. Pump or pumps will supply 3,000 psi to flight systems

(b) Fluid is supplied from flight control system reservoirs

(c) Pumps operate independent of each other

(3) Specifications

(a) Spline driven - shear angle 1,650 - 2,050 lbs.

(b) Variable delivery piston-type

(c) Weight 10.3 lbs. dry

f. ILCA (integrated lower control actuator)

(1) Location and access

(a) All ILCAs are located in the flight control closet area between Stations 95 and 120; and between BL 8 and 18 LH

(b) Accessible from the cockpit companion-way

(c) The ILCAs are attached to manifold

1 Pitch and roll - aft manifold

2 Thrust and yaw - forward manifold

(2) Function

(a) The BASIC ILCA has two basic functions

1 Provides hydraulic (boost) assist for the elimination of control friction forces and component weight

2 Converts the AFCS electrical input into a mechanical output using hydraulic actuation in three axis

(b) The thrust ILCA only provides hydraulic (boost) assist

(c) The ILCAs are designed with boost and AFCS control functions integrated in a single actuator package. Each function has dual redundancy. The Integrated Lower Control Actuators are designed in accordance with MIL-H-5440, Type II, MIL-C-5503, MIL-H-9775. Each unit consists of a dual hydro-mechanical power actuator with jam proof servo valves and a dual differential electro-hydraulic AFCS actuator, both with proportional input-output motion. Each hydraulic system isolated by separate manifolds and cylinders to provide crack propagation protection. The actuator provides cockpit control boost assist in pitch, roll, yaw, and thrust, and AFCS actuation in pitch, roll, and yaw.

(3) Specifications

(a) There are four ILCAs used in the flight control system:

1 PITCH ILCA 145H7300-13

2 ROLL ILCA 145H7300-14

3 YAW ILCA 145H7300-15

4 THRUST ILCA 145H7300-8

5 SPARE ASSEMBLY 145H7300-16

(b) Operating Fluid MIL-H-83282

(c) Operating pressure - 1,500 psi

(d) Proof Pressure - 2,250 psi

(e) Burst Pressure - 3,750 psi

(f) Temperature Rating - minus 50°F to plug 275°F

(g) Pitch, Roll, and Yaw actuators

1 Stall load dual-mode 390 lbs. at output (1,450 psid)

2 Main actuator stroke, plus-minus 2.25 in. at output, plus-minus 0.50 extensible link = 3.25 in.

3 Single-piston area 0.362 sq-in.

4 Velocity, dual mode, 80 lb. load = 7.35 in-sec. at output

5 Velocity, dual mode, no load = 8.37 in-sec. at output

6 Active valve stroke plus-minus 0.027 in.

7 Full flow - 1.05 cu-in. per second

8 Linkage ratio - input to valve - 2.68

9 Jam detent - 14.8 lbs. at input arm, 37.5 lbs. at valve arm

(h) Extensible Link

1 Stall load, dual mode, 570 lbs. at output

2 Stall load, single mode, 570 lbs. at output

3 Stroke, dual mode, plus-minus 1.0 in. at output

4 Stroke, single mode, plus-minus 0.5 in. at output

5 Piston area - 0.387 sq-in.

6 Full velocity, dual mode - 21 in-sec at output

7 Full velocity, single mode - 10.5 in-sec at output

8 Linkage ratio - 2.0

9 Dual extensible link stroke at output each way

a Pitch 0.340 plus-minus 0.060 in.

b Roll 0.440 plus-minus 0.060 in.

c Yaw 0.680 plus-minus 0.060 in.

10 Single extensible link stroke at output each way

a Pitch 0.17

b Roll 0.22

c Yaw 0.34

11 Single extensible link % of control travel or authority

a Pitch 12.5%

b Roll 13%

c Yaw 24%

12 Mechan Ratio - inches of cockpit control,

a Pitch 4.56 inches of actuator

b Roll 2.47

c Yaw 2.51

g. Thrust actuator

(1) Stall load, dual mode 350 lbs. at output (1,450 psid)

(2) Main actuator stroke plus-minus 2.25 in. at output

(3) Single piston area 0.362 sq-in.

(4) Velocity, dual mode, 80 lb. load - 3.68 in-sec at output

(5) Velocity, dual mode, no load - 4.35 in-sec at output

(6) Active valve stroke plus-minus 0.0188 in.

(7) Full flow - 0.525 cu-in. per second

(8) Linkage ratio - 20.83

(9) Jam detent - 1.8 lbs. at input, 37.5 lbs. at valve

h. ILCA jam sensor and indicator P/N 225530-1007

(1) Vendor Bertea Corp.

(2) Sensor located on each half of the dual ILCA manifold

(3) Actuates at 1,200 psig

(4) Normal pressure rating 3,000 psig

(5) Proof pressure rating 4,500 psig

(6) Burst pressure rating 7,500 psig

i. ILCA case relief valve 240060-101

(1) Vendor Bertea

(2) Located on all manifolds, two per ILCA, below check valve

(3) Torque to 15 to 20 in-lbs. for installation

(4) Cracking pressure 190 psi

(5) Reset pressure 150 psi

j. Pivoting Dual Actuating Cylinder (145H5500-XX)

NOTE: Forward and aft actuators NOT interchangeable.

(1) Location

(a) Forward pylon right side

(b) Aft pylon left side

(2) Function - provides mechanical assistance to flight controls by means of hydraulic boost.

(3) Operation - receives pressure from several sources

(a) Flight boost hydraulic system

1 No. 1 boost

2 No. 2 boost

3 Both

4 Power transfer units (ground check only)

5 Ground test unit (ground check only)

6 Pressure from flight boost pumps is directed through power control modules

7 Operating pressure is 8,000 psi 16 gpm

(4) Components

(a) Two cylinders, No. 1 system and No. 2 system

(b) Provides housing for pistons

(c) Two pistons

1 Pressure actuated

2 Provides motion to upper controls

(d) Two control valves - provides input pressure to pistons

(e) Two jam indicators - provides warning of jam condition in control valves

k. Swiveling dual actuating cylinder (145A6700-XX)

NOTE: Forward and aft cylinder ate not interchangeable.

(1) Location

(a) Forward pylon left side

(b) Aft pylon right side

(2) Function - provides mechanical assistance to upper controls by means of hydraulic boost.

(3) Operation and components same as pivoting dual actuator.

l. Power transfer units

The power transfer unit in each system allows ground checkout of the flight control systems with the rotors stopped. Each power transfer unit of a pump driven or a hydraulic motor which is pressurized by the utility hydraulic system. When the apu is running, the utility hydraulic system is pressurized by an apu-driven pump. The power transfer units are controlled by the POWER XFR switches on the HYDRAULIC panel in the overhead switch panel.

3. Operation

a. Hydraulic boost switch

A three-position center locked hydraulic boost switch is on the HYDRAULIC panel in the overhead switch panel. The switch is marked FLT CONTR. The switch positions are No. 1 ON, BOTH, and No. 2 ON. This switch can be used to turn off one of the flight control systems, provided the other one is operating. Turning off one of the flight control hydraulic systems disables the corresponding AFCS and causes the remaining AFCS to make full corrections. In addition, the respective AFCS OFF and HYD DLT CONTR caution lights will come on. Under normal flight conditions, with both No. 1 and No. 2 hydraulic boost system functioning, the hydraulic boost switch is set to BOTH ON. The switch shall be set to NO. 1 ON or NO. 2 to render the other hydraulic boost system inoperative following a malfunction in that system.

At BOTH, both solenoid valves are de-energized open and both flight control systems are pressurized. When the FLT CONTR switch is set to NO. 1 ON, the two-way solenoid valve on No. 2 power control module is energized closed. This causes No. 2 pressure-operated valve to close, depressurizing No. 2 system. When the FLT CONTR switch is moved to NO. 2 ON, the two-way solenoid valve on No. 2 power control module is de-energized open, and No. 2 system is pressurized. Simultaneously, No. 1 solenoid valve closes and No. 1 system is turned off.

b. Hydraulic Pressure Caution Lights

Two hydraulic pressure caution lights, one for each flight control system are on the master caution panel. The lights are marked NO. 1 HYD FLT CONTR, No. 2 HYD FLT CONTR. Each light is electrically connected to a pressure switch in the corresponding control module. Whenever hydraulic pressure drops below 1,800 psi in one of the flight control systems or the utility system, that system caution light comes on. The caution light goes off as increasing pressure approaches 2,300 psi. Caution light operation is independent of hydraulic pressure indicator operation. Power to operate these lights is supplied from the 28-volt DC essential bus through the CAUTION PNL circuit breaker on No. 1 power distribution panel.

c. Hydraulic Pressure Indicators

Two hydraulic pressure indicators, one for each hydraulic system, are on the maintenance panel. Each indicator is electrically connected to a corresponding pressure transmitter on each power control module. Power to operate these indicators is supplied from the 28-volt No. 2 DC bus through the HYDRAULICS PRESS IND circuit breaker on No. 2 power distribution panel.

3. Limitations and Malfunctions –

TM 55-1520-240-10
LIMITATIONS AND
EMERGENCY PROCEDURES

CHAPTER 8

INSTRUMENTS

SECTION I

ENGINE INSTRUMENTS

DESCRIPTION AND OPERATION

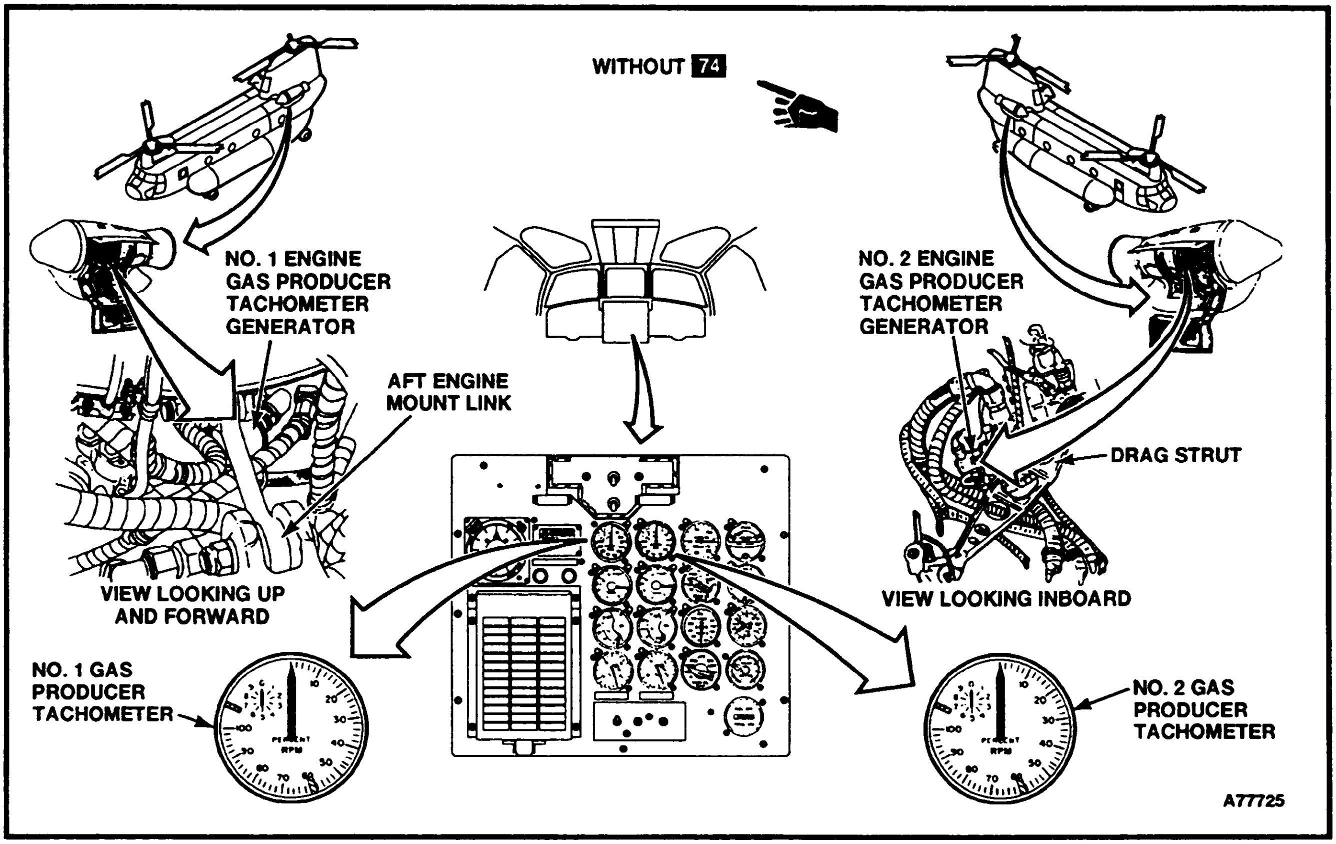
GAS PRODUCER TACHOMETER SYSTEM (WITHOUT 74)

Description:

The gas producer tachometer system is a synchronous system that measures engine compressor rpm. There is a separate system for each engine. Each system consists of an indicator and a tachometer generator. The generator is on the engine. The indicator is on the center instrument panel.

The gas producer tachometer indicator indicates compressor rpm as a percentage of maximum rated speed. The indicator is calibrated 0 to 110 percent rpm. Electrical connections are made through a connector at the rear of the clamp-mounted instrument.

The gas producer tachometer generator is a three phase ac generator mounted on the engine at the five o'clock position. It supplies voltage to the tachometer indicator at a frequency proportional to the speed of the engine compressor. Electrical connections are made through a connector in the side of the generator.



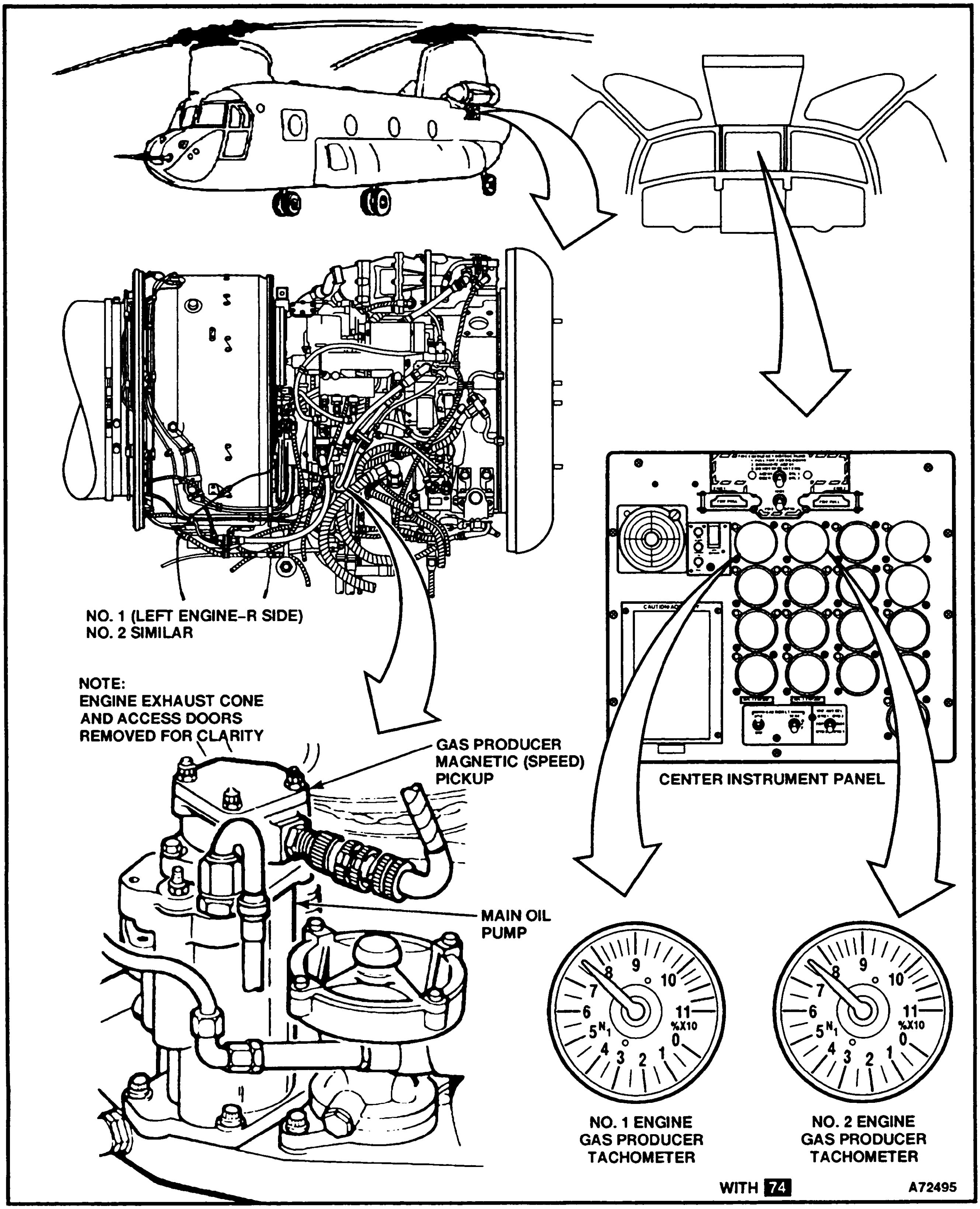
GAS PRODUCER TACHOMETER SYSTEM (WITH 74)

Description:

The gas producer tachometer indicating (N1) system measures engine compressor rpm. There is a separate system for each engine. Each system consists of an indicator and a magnetic (speed) pickup. The magnetic pickup is mounted on the engine. The indicator is mounted on the center instrument panel.

The gas producer tachometer (N1) indicator shows compressor rpm as a percentage of maximum rated speed. The indicator is calibrated 0 to 110 percent (%) rpm. Electrical connections are made through a connector at the rear of the instrument.

The only powerplant-mounted equipment is a magnetic pickup. The magnetic pickup gives a signal frequency that is proportional to gas producer speed. Electrical connections are made through a connector on the side of the magnetic pickup.


NO. 1 (LEFT ENGINE-R SIDE)
NO. 2 SIMILAR
NOTE:
ENGINE EXHAUST CONE
AND ACCESS DOORS
REMOVED FOR CLARITY
GAS PRODUCER
MAGNETIC (SPEED)
PICKUP
MAIN OIL
PUMP
CENTER INSTRUMENT PANEL
NO. 1 ENGINE
GAS PRODUCER
TACHOMETER
NO. 2 ENGINE
GAS PRODUCER
TACHOMETER
WITH 74
A72495

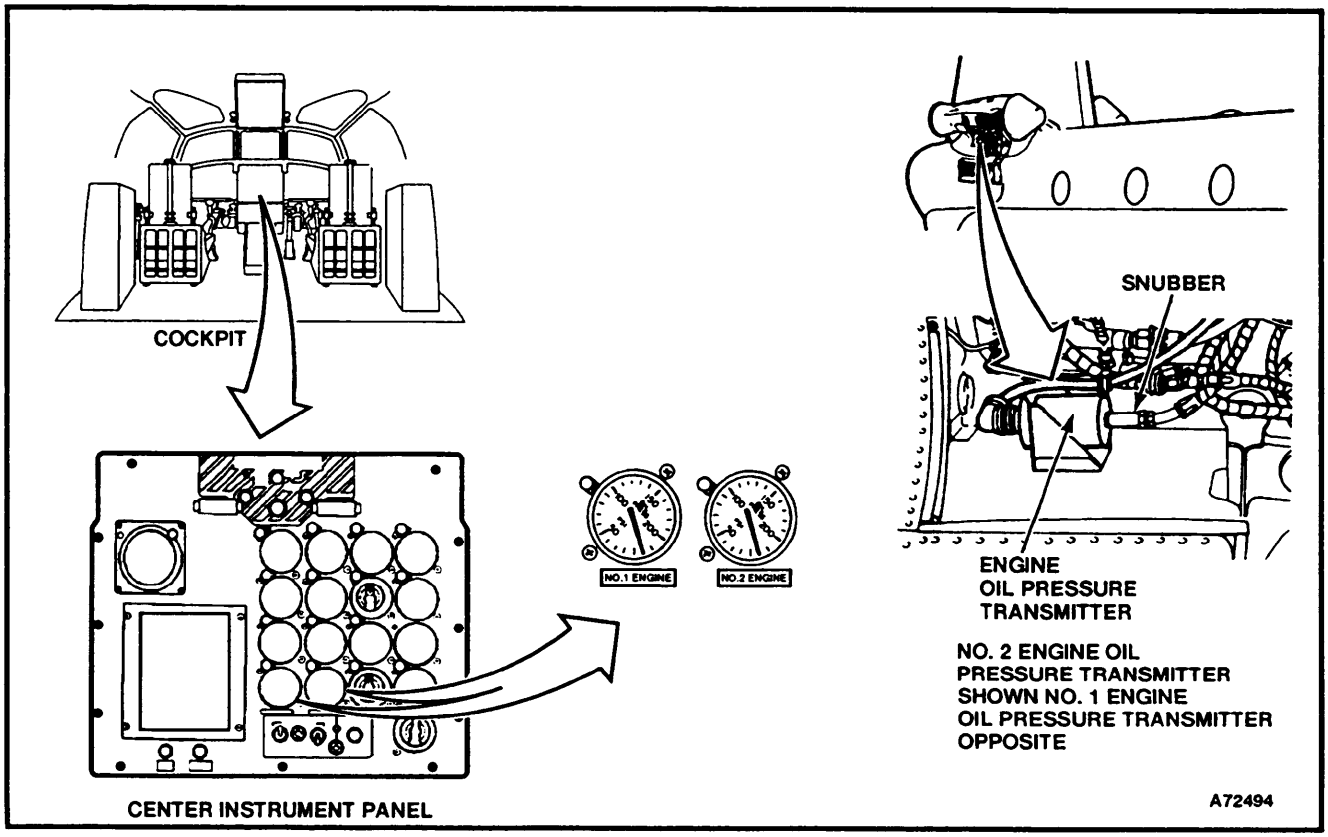
ENGINE OIL PRESSURE INDICATING SYSTEM

Description:

The engine oil pressure indicating system is a differential pressure synchro system. It measures and indicates the pressure of oil circulating within the engine. There is a separate system for each engine. Each system consists of an indicator and a pressure transmitter synchro. The transmitter is located in the engine nacelle. The indicator is on the center instrument panel.

The engine oil pressure indicator, a synchro receiver, indicates oil pressure as psi. The indicator is calibrated from 0 to 200 psi. Electrical connections are made through a connector at the rear of the clamp mounted instrument.

The transmitter, a synchro transmitter, is linked to the engine oil system through a flexible hose, coupling and snubber. Pressure is applied to a diaphragm in the transmitter causing the transmitter rotor to turn. This causes a change in the stator voltage in the indicator, that causes the stator rotor to turn, moving the pointer to the correct pressure indication. The snubber reduces the effect of pressure surges on the system. A zero adjustment is included on the transmitter.



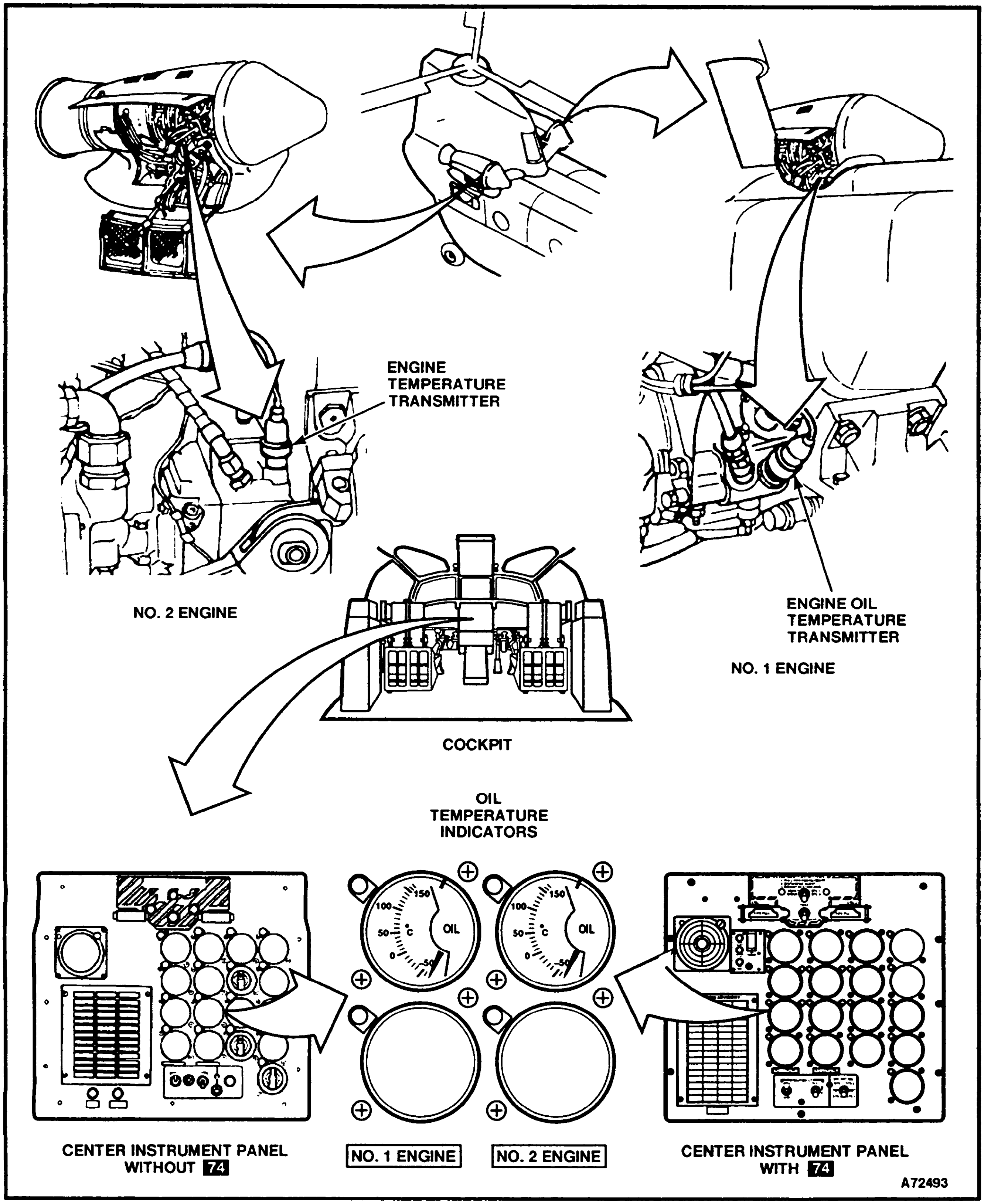
ENGINE OIL TEMPERATURE INDICATING SYSTEM

Description:

The engine oil temperature indicating system is an electrical resistance thermometer system. It measures and indicates the temperature of the oil circulating in the engine. There is a seperate system for each engine. Each system consists of an indicator and a temperature bulb. As oil temperature varies, bulb resistance varies, causing the indicator pointer to move a distance proportional to the temperature change.

The temperature bulb senses and transmits engine oil temperature signals to the indicator. The bulb is calibrated to provide 90.38 ohms resistance at 0°C (32°F). It is located at the 4 o'clock position, screwed into a lube fitting, on the engine.

The indicator is clamp-mounted on the center instrument panel with electrical connections provided through an electrical connector at the rear of the indicator. The indicator is calibrated from -70°C to +150°C.


ENGINE
TEMPERATURE
TRANSMITTER
NO. 2 ENGINE
ENGINE OIL
TEMPERATURE
TRANSMITTER
NO. 1 ENGINE
COCKPIT
OIL
TEMPERATURE
INDICATORS
150
100
50
°C
0
-50
OIL
CENTER INSTRUMENT PANEL
WITHOUT 74
NO. 1 ENGINE
NO. 2 ENGINE
CENTER INSTRUMENT PANEL
WITH 74
A72493

TORQUE INDICATING SYSTEM (WITHOUT 74)

Description:

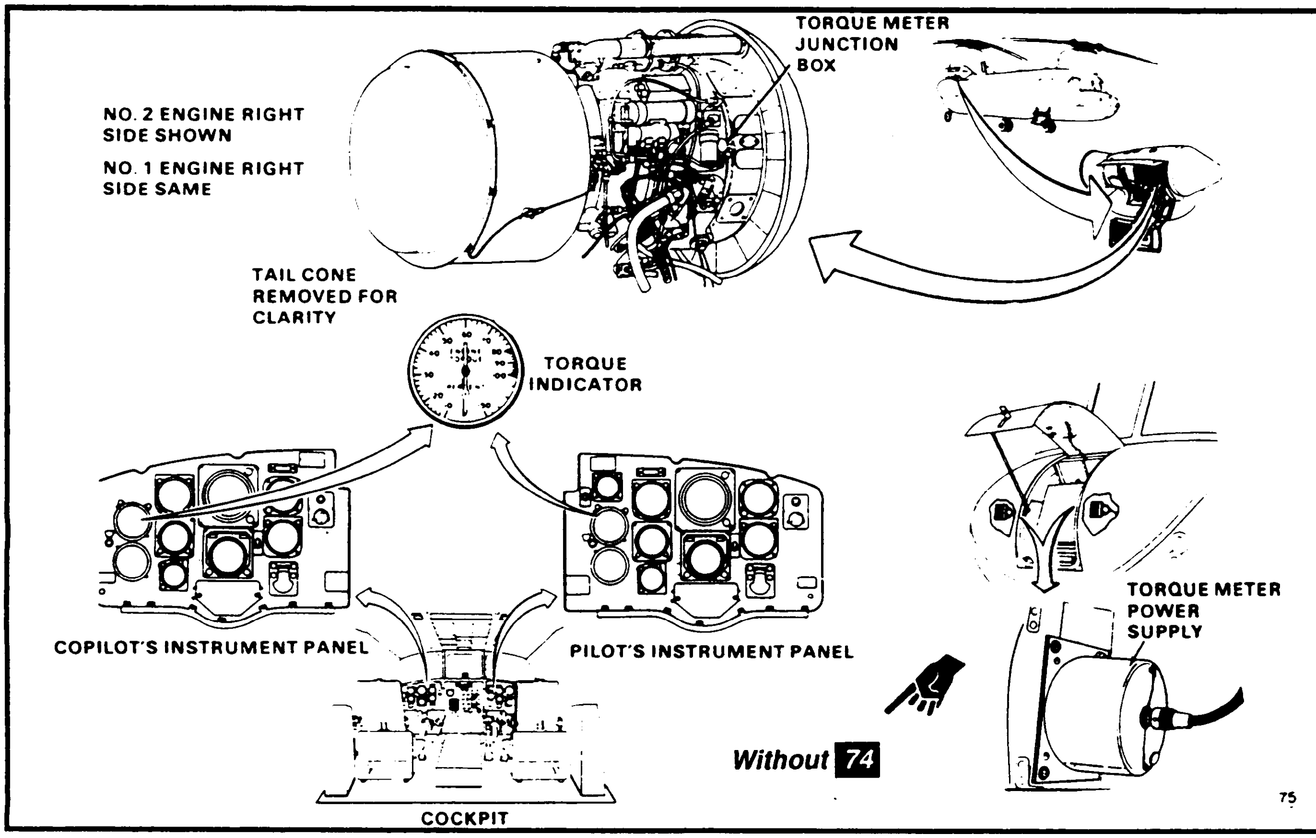
The torque indicating system, which monitors engine power output, is a ratio system. It measures and indicates the amount of engine torque. The system consists of an engine-driven power shaft, a head assembly and a junction box on each engine, a dual torque indicator on each pilot's instrument panel, and two power supplies in the nose compartment.

The head assembly and the power shaft make up a transformer. The head assembly contains the single primary and two secondary windings of the transformer. The power shaft is the core of the transformer. The junction box provides interconnection between system components. The head assembly, power shaft, and junction box make up a calibrated set. If one part is bad, all three must be replaced with a matched set.

A signal from the torquemeter power supply is applied to the primary winding in the head assembly. With no engine torque developed, equal signals are coupled to the secondary windings. When engine torque is developed, the power shaft is distorted, and unequal signals are coupled to the secondaries. The signals from the secondaries are rectified in the indicator and moves the pointer to show percentage of rated torque.

The indicator is calibrated 0 to 150 percent and has two numbered pointers, one for each engine. Electrical connections are provided through two connectors at the rear of the clamp-mounted indicators.

The torquemeter power supply is a solid-state inverter that converts dc voltage to ac voltage for use by the engine torque sensor (head assembly).



TORQUE INDICATING SYSTEM (WITH 74)

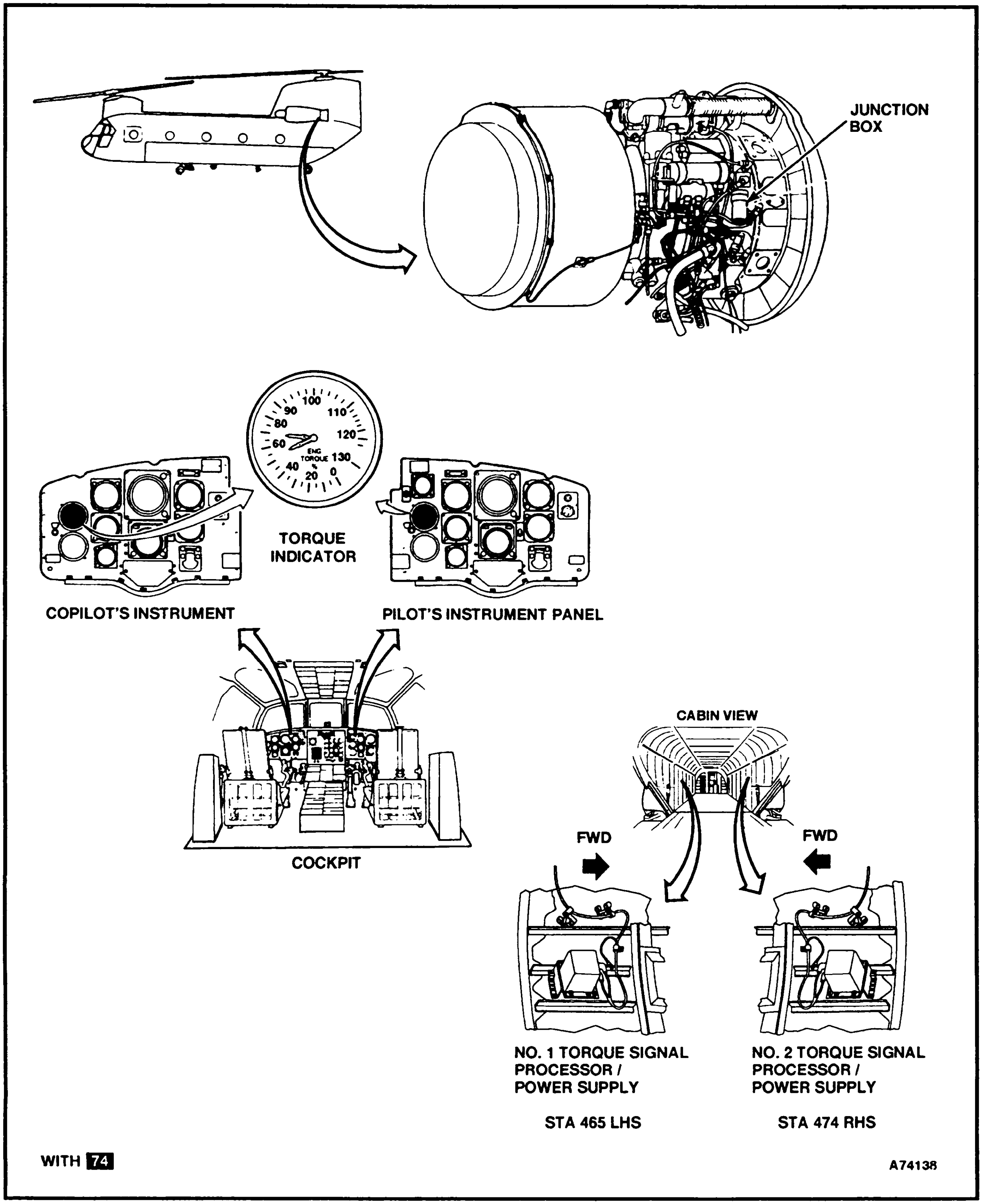
Description:

The torque indicating system, which monitors the engine power output, is a ratio detector system. It measures and indicates the amount of engine torque. The system consists of two dual torque indicators on each pilot's instrument panel, an engine driven power shaft, a head assembly and a junction box on each engine, and two separate torque signal processor/power supply units. The torque signal processor/power supply units are mounted in the aft cabin ceiling at left hand sta 465 and right hand sta 474.

The torquemeter head provides an electric torque signal that is proportional to the twisting motion of the power shaft. That signal is transmitted through a cable to the junction box. The junction box is mounted on the engine inlet housing. It provides operating power for the torquemeter head and receives signals from the head and sends them to the torque signal processor/power supply. The engine driven power shaft, head assembly and junction box make up a matched assembly. If one component is bad, all three must be replaced with a matched set.

The torque signal processor/power supply provides a 6 kHz constant current signal to the torquemeter head. It processes the signal coming from the junction box and sends this signal to cockpit torque indicator and engine digital electronic control unit (DECU).

The torque indicator is calibrated 0 to 150 percent. It has two pointers each marked with the number of its respective engine. Electrical connections are provided through connectors at the rear of each indicator. The indicator is hermetically sealed.


JUNCTION BOX
100
90
110
80
120
60
ENG TORQUE %
130
40
0
20
TORQUE INDICATOR
COPILOT'S INSTRUMENT
PILOT'S INSTRUMENT PANEL
COCKPIT
CABIN VIEW
FWD
FWD
NO. 1 TORQUE SIGNAL PROCESSOR / POWER SUPPLY
STA 465 LHS
NO. 2 TORQUE SIGNAL PROCESSOR / POWER SUPPLY
STA 474 RHS
WITH 74
A74138

FUEL FLOW INDICATING SYSTEM

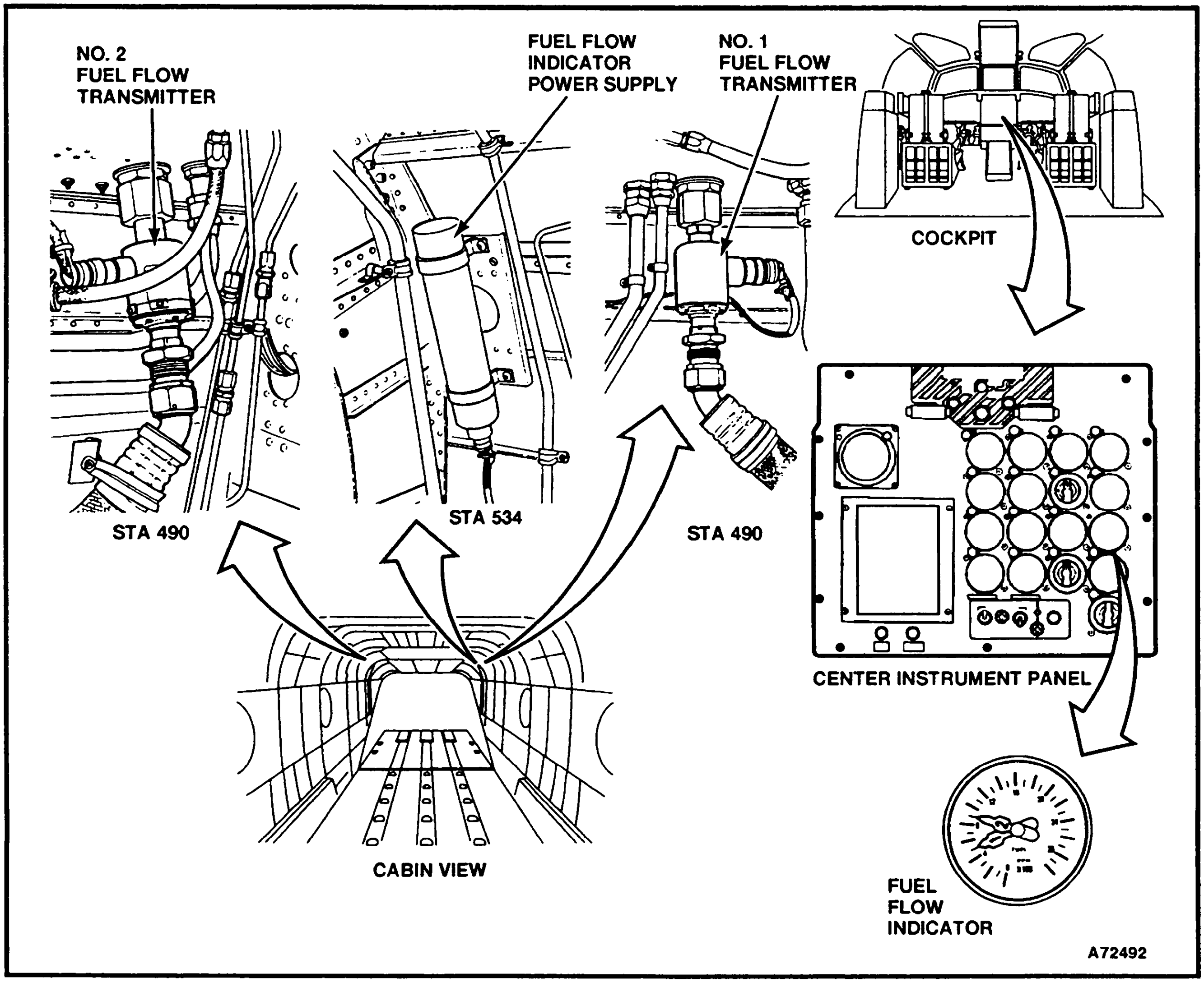
Description:

This system consists of a fuel flow indicator, a power supply, and two transmitters, one for each engine.

The fuel flow indicator, clamp-mounted on the center instrument panel indicates fuel flow in pounds per hour (PPH). The power supply provides power to both transmitters, which are located below the engine disconnect shelves, both sides, aft cabin.

The fuel flow indicator power supply furnishes power to the transmitter motor, the rotor of which is an impeller. The impeller is driven at a constant angular velocity. As fuel passes through the impeller it picks up the angular velocity of the impeller. The fuel strikes a spring restrained stator causing the stator to rotate in proportion to the flow rate. The change in angular rotation is measured by a synchro connected to the stator.

The synchro signal is applied to a receiver synchro in the fuel flow indicator and displays the fuel flow rate in pounds per hour (PPH).



FLIGHT INSTRUMENT

1. Pitot System

   Two electrically-heated pressure heads are on tubes, mounted on the aircraft nose, one on each side of center.

   a. Port Pitot Tube

      The left pressure head supplies dynamic pressure to the copilot's airspeed indicator, and No. 1 AFCS unit.

   b. Starboard Pitot Tube

      The right pressure head supplies total pressure to the pilot's airspeed indicator and to No. 2 AFCS unit.

2. Pitot Anti-Ice

   The pressure head heating elements are controlled by an ANTI-ICE PITOT Switch on the overhead panel. Power is obtained from No. 2 AC bus bar via the PITOT HEAT circuit breakers in No. 2 PDP. The switch also controls the heating system for the yaw ports via a yaw PORT HEAT circuit breaker on No. 2 PDP.

3. Static System

   Two unheated static ports are located on the cabin fuselage at Station 236, one to port and the other to starboard. The static ports are connected by common tubing to the two airspeed indicators, vertical speed indicators, altimeters, and AFCS units.

4. Airspeed Indicator

   There are two airspeed indicators. These indicators are in the upper left portion of the pilot's and copilot's instrument panels. The difference between dynamic pressure and static pressure as measured by the pitot static system is introduced into these instruments, and indicated as airspeed in knots.

5. Vertical Velocity Indicator

   The vertical velocity indicator on both pilot's and copilot's instrument panel indicates rate of climb, based on the rate of change of atmospheric pressure. The indicator is a direct-reading pressure instrument requiring no electrical power for operation.

6. Barometric Altimeter

a. Description

An AIMS altimeter is provided for the pilot. A pneumatic counter-drum-pointer type altimeter is installed for the copilot. The pilot's altimeter is a pneumatic counter-drum-pointer type which is a self-contained unit consisting of a precision pressure altimeter combined with an altitude encoder. The display indicates and the encoder transmits through the transponder, simultaneously, the altitude of the helicopter. Altitude is displayed on the altimeter by a 10,000-foot counter, and a 100-foot drum. A single pointer indicates hundreds of feet on a circular scale with 50-foot center markings. Below 10,000 feet, a diagonal warning symbol will appear on the 10,000 foot counter. A barometric pressure setting knob is provided to insert the desired altimeter setting in inches of Hg. A vibrator powered by No. 2 dc bus is contained in the altimeter and requires a minimum of 1 minute warm-up prior to checking or setting the altimeter. If dc power to the altitude encoder is lost, a warning flag placarded CODE OFF appears in the upper left instrument dial. The flag indicates that the altitude encoder is inoperative and that the system is not reporting altitude to ground Stations. The CODE OFF flag monitors only the encoder function of the altimeter. It does not indicate transponder condition. The AIMS altitude reporting function can be inoperative without the CODE OFF flag showing, as in case of transponder failure or improper control settings. It is also possible to get a good Mode C test on the transponder control with CODE OFF flag showing. Display of the CODE OFF flag only indicates an encoder power failure or a CODE OFF flag failure. In this event, check that dc power is available and that the circuit breakers are in. If the flag is still visible, radio contact should be made with a ground radar site to determine whether the AIMS altitude reporting function is operative. The remainder of the flight should be conducted accordingly.

The copilot's altimeter is a pneumatic counter-drum-pointer type which displays altitude in the same manner as the pilot's altimeter. It also incorporates a barometric pressure setting knob and an internal vibrator powered by the No. 2 dc bus. A minimum of 1 minute of vibrator operation is required prior to setting or checking the altimeter. At ambient pressure, both altimeters should agree, within $\pm$70 feet of the field elevation when the proper barometric pressure setting is set in the altimeter. If the internal vibrator of either altimeter becomes inoperative due to dc power failure, the pointer drum may momentarily hang up when passing from 9 through 0 (climbing) or from 0 to 9 (descending). This will cause a lag of magnitude which will depend on the vertical velocity of the aircraft and the friction in the altimeter.

b. Operation

(1) Preflight Operation - Altimeter

If the AIMS altimeter encoding function is to be used during a flight, perform the following steps prior to takeoff:

(a) Be sure the AIMS ALT and IFF circuit breakers on No. 2 power distribution panel are in.

(b) Set the pilot's altimeter to the field barometric setting.

(c) Check the pilot's altimeter indicates within $\pm$70 feet of field elevation. If the altimeter error is greater than $\pm$70 feet, do not use the altimeter for IFR flight.

(2) In-flight Operation - Altimeter

Operate the AIMS altimeter encoding function as follows:

(a) Be sure the IFF set is on and set to the proper code.

(b) Be sure the altimeter is set to the local altimeter setting.

(c) Set the M-C (mode C) switch on the IFF control panel to ON.

(d) Check that the red CODE OFF flag is not visible in the pilot's altimeter.

7. Radar Altimeter (AN/APN-209A)

a. Description

Radar altimeters are provided for the pilot and copilot. The altimeters provide a continuous indication of the height of the helicopter above the surface from 0 to 1,500 feet. Altimeter indications are reliable with pitch and roll attitude up to 45°. Altitude is displayed by a dial and pointer and by a digital display. Each altimeter has HI and LO caution lights. The caution lights on each altimeter can be set independently of the other altimeter. The caution lights are set by rotating the LO SET and HI SET knobs until the L index and H index on the perimeter of the altimeter are at the desired altitudes. If the helicopter descends below the low index setting or rises above the high index setting, the corresponding HI or LO caution light will come on. If helicopter altitude exceeds 1,500 feet, pitch or roll angle exceeds 45°, or the system is unreliable, the following will occur. The OFF flag will appear, the pointer will move through 1,500 feet behind the dial mask, and the digital display and LO and HI caution lights will be out.

If power to the system is lost, the following will occur. The OFF flag will appear, the digital display and caution lights will go out, and the pointer will remain at the last valid indication when power was lost. The altimeters have a self-test feature. Pressing the PUSH-TO-TEST knob will cause the pointer and digital display to indicate between 900 and 1,100 feet. If LO set and HI set are indexed below 900 feet, the LO caution light goes out, and the HI caution light comes on. The radar altimeter receives power from the 28-volt No. 2 dc bus through RAD ALT circuit breaker on the No. 2 power distribution panel.

b. Controls and Function

CONTROLS/ INDICATOR	FUNCTION
LO SET knob	Either pilot's LO SET knob applied power to the altimeter system. LO set index on both altimeters can be set independently. Both LO set indices must be masked to turn the set off.
HI SET knob	Sets position of HI set index and tests altimeter system when pressed.
LO SET index	Indicates altitude trip point for LO caution light.
HI SET index	Indicates altitude trip point for HI caution light.
Indicator pointer	Indicates absolute altitude from 0 to 1,500 feet.
Digital indicator	Provides direct reading four digit indication of absolute altitude from 0 to 1,500 feet.
LO caution light	Comes on when helicopter descends below altitude on LO set index.
HI caution light.	Light comes on when helicopter rises above altitude on HI set index.
OFF flag	Flag is displayed when power is removed from set or when indications are unreliable.
RAD ALT display	On right side of both instrument panels. Controls light intensity of digital display and HI and LO caution light.

c. Operation

(1) Starting

(a) RAD ALT circuit breaker - Check in.

(b) Rotate the LO SET knob on the pilot's altimeter until the LO index is at 100 feet. Rotate the HI set knob until the HI index is at 800 feet. Allow 1 minute for warm-up.

(c) Check for the following indications:

1 The pointers indicate between 0 and 3 feet.

2 The digital displays indicate between 0 and 3 feet.

3 LO caution light is on.

4 HI caution light is off.

5 OFF flag not in view.

(2) Testing

(a) Press and hold the PUSH-TO-TEST knob. Check for the following indications:

1 OFF flags not in view.

2 Pointers indicate between 900 feet and 1,100 feet.

3 Digital displays read between 900 feet and 1,100 feet.

4 LO caution light is off.

5 HI caution light is on.

(b) Release the PUSH-TO-TEST knob. Check that all indications return to those specified in step (1).

(c) Rotate the RAD ALT dimming control from BRT to DIM. Check that the digital display dims and goes out. Check that the LO caution light dims but does not go out completely.

(d) Repeat on copilot's instrument.

NOTE:
The LO caution light may appear to go out. However, the light will be visible with night vision goggles. In bright daylight, it may be necessary to shaft the indicator to verify operation of the dimming control.

(3) In-flight operation

CAUTION: When operating over dense foliage, the radar altimeters will indicate the altitude to the tops of the trees. When operating over sparse foliage, the altimeters may indicate the altitude between the ground and about half the average tree height, depending on ground speed. When external cargo is carried, the radar altimeter may occasionally indicate the distance between the bottom of the helicopter and the load.

(a) Set RAD ALT dimming control to desired digital display light level.

(b) Set HI and LO indexes as desired. If HI or LO indexes are not desired, set the LO index at 0 feet or the HI index above 1,500 feet.

8. Attitude Indicators

a. Description

Two attitude indicators are on the instrument panel for use by the pilot and copilot. The attitude indicators have been specifically tailored for the flight characteristics of a helicopter by the inclusion of an electrical trim capability in the roll axis in addition to the Standard pitch trim. Normal flight attitudes of helicopters, defined by fixed amounts of roll as well as pitch, are easily trimmed into this indicator, and optimum operation of the helicopter in an attitude such as hover is facilitated. Degrees of pitch and roll are indicated by movement of a universally mounted sphere painted optical black and light gray to symbolize earth and sky, with a horizon line separating the two colors. To adjust the miniature aircraft in relation to pitch, use the lower knob. The pitch adjustment range is about 20° nose up and 20° nose down minimum. To compensate attitude in the roll axis, use the upper knob. The roll adjustment range is about 8° minimum in either direction.

The indicator incorporates integral lighting. The attitude indicator gyros receive power from 115-volt No. 1 and No. 2 ac bus through two circuit breakers marked PILOT VGI and COPLT VGI. The PILOT VGI circuit breaker is on No. 1 power distribution panel. The COPLT VGI circuit breaker is on No. 1 power distribution panel. Both the pilot's and copilot's attitude indicators should erect within 30 to 90 seconds after electrical power is applied.

b. Pilot and Copilot Attitude Indicator (VGI) Switch

A VGI switch is on the instrument panel below each attitude indicator. VGI switch positions are marked NORM and EMER. When the switch is at NORM, each attitude indicator operated from a separate gyro. If either the pilot's or the copilot's gyro fails, signaled by the OFF flag on the indicator, manual switching to the remaining gyro is accomplished by moving the respective VGI switch to EMER. The switching of the gyros from NORM to EMER operation is accomplished by a gyro transfer relay. Failure of the gyro will also result in failure of the associated AFCS. The VGI switch receives power from the 28-volt No. 2 dc bus through a CONT VGI circuit breaker on No. 2 power distribution panel.

9. Turn and Slip Indicator (4-Minute Type)

Each turn and slip indicator is controlled by an electrically actuated gyro. Power for the gyros is obtained from the 28-volt dc bus through two circuit breakers marked TURN & SLIP. The pilot's circuit breaker is on No. 2 power distribution panel. The copilot's circuit breaker is on No. 1 power distribution panel. The instrument has a pointer (turn indicator) and a ball (slip indicator).

10. Magnetic Compass

The magnetic compass is mounted between the top of the instrument panel glare shield and the overhead switch panel. It is a direct reading instrument. It includes a compass card mounted on a magnetic element in a liquid-filled bowl.

11. Free-Air Temperature Gage

The free air temperature gage is on the exterior of the pilot's eyebrow window. The unit is calibrated in degrees from -70° to 50°C.

12. Cruise Guide Indicator System (See Flt Controls)

a. Description

The cruise guide indicator system gives the pilot, a visual indicator of actual loads imposed on critical components of the helicopter dynamic system. The system allows the pilot to achieve maximum helicopter utilization under various conditions of payload, altitude, airspeed, ambient temperature, and center-of-gravity. The system consists of strain gages bonded to fixed links in the forward and aft rotor controls, an indicator, a signal processor unit in the aft pylon, a signal conditioner unit in the forward pylon, and interconnecting wiring. The system measures alternating stress loads and displays the larger of the two signals. The system is powered by No. 2 28-VDC bus through the CRUISE GUIDE circuit breaker on the No. 2 power distribution panel.

b. Cruise Guide Indicator

The cruise guide indicator is on the pilot's instrument panel. Three bands are displayed on the dial face of the indicator. Operation in the red-and-yellow striped band shall be avoided. Immediate corrective action must be taken to reduce stress. This can be accomplished by lowering thrust, reducing airspeed, releasing back pressure on the cyclic stick, or by reducing the severity of the maneuver.

c. Cruise Guide Indicator Test Switch

The cruise guide indicator test switch is on the pilot's instrument panel, on the left side of the indicator. It is a three-position switch, spring-loaded to center. The switch is marked CGI TEST, FWD, and AFT. When the switch is moved from center position to each test position, the pointer should indicator within the white test band. The white test band indicates proper system operation.

NOTE:
Do not test the cruise guide system with rotors turning. False indications will result.

The test circuit tests the circuits from the strain gages to the indicator. However, separation of the bond of the strain gage to a link will not be detected by the test function. The narrow white line towards the high end of the avoid band is used for calibrating the indicator during bench test.

d. Limitations

(1) Airspeed limitations with an operative cruise guide indicator are per the following indicator displays (not to exceed 170 KIAS):

(a) Needle must be kept in green band.

(b) Transient needle excursions into the yellow band are permissible but should be minimized.

(c) Needle excursions into the red/yellow band are to be avoided.

(2) Airspeed limitations with an inoperative cruise guide indicator are per the airspeed limitations shown in T55-1520-240-10.

(a) Flight at 98% rotor rpm with an inoperative cruise guide indicator is prohibited.

(3) The following airspeed limitations apply with an operative or inoperative cruise guide indicator:

(a) Maximum airspeed in sideward flight is 45 knots.

(b) Maximum airspeed in rearward flight is 45 knots.

(c) Maximum crosswind or tailwind for hover is 45 knots.

CHAPTER 9

ALTERNATING CURRENT (AC) POWER DISTRIBUTION SYSTEM

A. Introduction AC Power System

1. Power source system improvements

   a. Primary power

      (1) 2-40 KVA oil-cooled brush-less generators

      (2) Driven by aft transmission

      (3) Provides electrical power for flight operations

   b. Secondary power

      (1) 1-20 KVA air-cooled brush-less generator (brush-type can be used)

      (2) Mounted on and driven by the APU

      (3) Provides electrical power for ground operations

   c. External power

      (1) Provides power for maintenance activities

2. Distribution system improvements

   a. Consists of:

      (1) Separate feeder lines from each generator

      (2) 2-power distribution panels (PDP)

      (3) 2 AC buses No. 1 and No. 2

   b. Operation

      (1) Normal operation, each bus is powered by its respective generator

      (2) Single generator operation, both buses are powered through a bus cross-tie circuit

      (3) APU or external power modes, both buses are powered through the cross-tie circuit

3. Bus control and power transfer circuitry improvements

   a. Ensure only one power source can be connected to a bus

   b. Controls priority of power application

      (1) Main generator power has priority over:

         (a) APU power

         (b) External power

      (2) APU power has priority over external power

4. General

Primary electrical power is provided by two Lucas 40 KVA AC brushless generators which produce 200-volt 400-Hz 3-phase (115-volt single-phase) power. The AC generators are driven by the aft transmission and are cooled by oil from the aft transmission. Each AC generator energizes an associated 28-volt 200-ampere air-cooled transformer rectifier unit (TRU) which produces the main DC power supplies. A 24-volt battery is provided for initiating APU Starting and supplies emergency DC power for essential services if both TRUs fail. Warning of AC generator or TRU failure or malfunctioning is given on a master caution panel in the cockpit.

On the ground AC power can be supplied by a 20 KVA air-cooled generator driven by the APU or AC and DC external supplies can be connected via sockets in a receptacle on the forward left fuselage. If AC external power is used, DC power is supplied via the TRU. If Dc external power only is used, the AC generators must be driven to provide AC power or external AC power must be connected.

Normally the electrical installation can be considered to comprise two similar but independent AC and DC generating systems, No. 1 and No. 2. Each system has the capacity to supply the electrical requirements of the aircraft; if an AC generator or a TRU fails, power re-distribution is effected by the automatic closure of AC or DC cross ties, respectively, and no services are lost. The two systems are widely separated in the aircraft to minimize system losses due to battle damage.

Elements of the No. 1 and No. 2 electrical systems are in waterproof compartments at the forward end of left and right fuselage pods respectively. The majority of the cockpit breakers are on No. 1 and No. 2 power distribution panels (PDP) in the cockpit.

5. Generators and Generator Control

a. Each main AC generator is manually controlled by its TEST/OFF RESET/ON switch on the overhead panel. With a generator switch at ON, and provided that the output is satisfactory, as associated contactor closes and connects the generator to its AC 3-phase bus bar. At OFF RESET, the generator is de-energized and disconnected from the bus. The position is also used to reset a generator. The TEST position is provided to allow the generator to be energized but disconnected from the bus to determine whether the AC produced is of proper frequency and voltage.

b. Main generators (P/N 179-60500-4)

(1) Location

(a) No. 1 on left side of aft transmission

(b) No. 2 on right side of aft transmission

(2) Function

(a) Provides 3-phase 400 hz power to the distribution system

(b) Each generator is capable of providing total AC electrical requirement

(c) Provides input to its respective generator control unit (GCU) through the use of six current transformers in the grounding and main feeder line circuits.

(3) Specifications

(a) Weight - 30 pounds

(b) Rating - 40 KVA continuous

(c) Terminal load - 115 amps at 117 volts

(d) Overload - 45 KVA for 5 minutes

- 60 KVA for 5 seconds

(e) Short circuit capacity - 260 amps for 5 seconds at 380 to 420 hz

(f) Normal operating speed - 10,800 to 12,600 rpm

(g) Shear shaft - 1,900 inch-pounds

(4) Construction

(a) 3-sections

1 Permanent magnet generator (PMG)

2 Main generator exciter

3 Main generator stator/rotor

(b) 3-current transformers - monitoring shorted feeder lines, overload, under-load, under-frequency, and differential ground return faults.

(c) Cast metal housing

1 Mounting flange

2 Internal cooling oil passages

(5) Operation

(a) Electrical

1 Self-excited generator

2 PMG section used for

a Frequency sensing

b Control voltage for exciter through GCU

c Output approximately 40 volts @ AC 12,000 rpm

3 Rotor exciter provides input to main generator rotor winding

4 Main generator stator output

a Distribution system

b GCU for voltage sensing (regulation)

c Output 115 volts 400 hz @ 12,000 rpm AC

5 Current transformers output to GCU for feeder line short detection, over-voltage, under-voltage, under-frequency, and differential ground return faults.

a 6 incorporated in the 3-phases

1) 3 ground fault detection

2) 3 for main feeder line faults

(b) Cooling

1 Cooling oil supplied by aft transmission lube system

2 Oil flow maintained by aft transmission main lube pump

3 Pressure

a Operating - 30 psi

b Minimum - 20 psi

4 Flow rate - 5 gpm nominal

5 Enters rear of generator, lubes rear bearing and PMG stator

6 Enters main generator shaft, lubes

a PMG rotor

b Main generator rotor and stator

c Rotor shaft splines

d Drive splines

e Front bearing

6 Oil returned to aft transmission by the scavenge section (one for each generator) of the main lube pump.

c. Generator control unit (P/N 179-70500-5)

(1) Location

(a) GCU No. 1 LH electrical compartment

(b) GCU No. 2 RH electrical compartment

(2) Function

(a) Monitors main generator for:

1 Under-voltage

2 Over-voltage

3 Under-frequency

4 Feeder line shorts

(b) Regulates generator output voltage

(c) Energizes exciter

(d) Controls connection of generator to distribution system

(e) BITE

1 Indicates:

a Feed line shorts

b Generator failure

c Black no failure

d Striped failure black or white

e 95% confidence level

(3) Specifications

(a) Weight - 3 pounds

(b) High under-frequency limit - 330 $\pm$5 hz for 3 to 5 seconds

(c) Low under-frequency limit - 320 $\pm$5 hz instantaneous

(d) Low over-voltage limit - 123 $\pm$1.5 volts for 3 seconds

(e) High over-voltage limit - 180 volts .115 seconds

(f) Under-voltage (Startup) - 110 $\pm$2 volts

(g) Under-voltage (operations) - 102 $\pm$2 volts for 5 to 7 seconds

(h) Feeder line short limit - 30 $\pm$6 amps phase to ground

(i) Under-frequency monitoring is locked out until frequency is greater than 350 hz on Startup

(4) Construction

(a) Aluminum case

(b) Three circuit boards

1 Frequency sensing and control logic

2 Current sensing and power supply

3 Voltage sensing and voltage regulator

(c) Two relays

1 Excitation control relay (ECR)

2 Generator contactor relay (GCR)

(d) Field output transistor

(5) Operation

(a) Voltage regulation

1 Maintained at 115 $\pm$2.5 VAC through 0 to 40 KVA load

2 Regulated by controlling current to exciter field

3 Output voltage decreases, exciter current increases

4 Each output phase rectified and summed

5 High output phase rectified

6 Compared to accurate DC level

7 When voltage out of tolerance regulator action commanded

8 Current to exciter through exciter control relay

(b) Voltage sensing - over-voltage

<u>1</u> Sense and timing network each phase

<u>2</u> Average of all over 123.5 ±1.5 Starts timing

<u>3</u> Delay inversely proportional to over-voltage

<u>a</u> 1223.5 over-voltage trips in 3 seconds

<u>b</u> 180 volt over-voltage trips in .115 seconds

<u>4</u> GCR and ECR latch. Reset by generator control switch

(c) Voltage sensing - under-voltage

<u>1</u> Sample of each phase

<u>2</u> Any phase less than 102 ±2 Starts to 5 to 7 second timer

<u>3</u> Longer than 5 to 7 seconds logic latches GCR and ECR

<u>4</u> Reset by generator control switch

<u>5</u> During run-up sense amp trip level modified. No fault until voltage exceeds 110 ±1

(d) Under-frequency protection

<u>1</u> Detected from PMG frequency

<u>2</u> Under 330 HZ Starts 3 to 7 second timer

<u>3</u> Over 3 to 7 seconds trips GCR

<u>4</u> Fault corrects, generator on

<u>5</u> Under 320 HZ, no delay

<u>6</u> Automatic recovery

<u>7</u> Modified during Start up until above 350 HZ

<u>8</u> Under-voltage fault inhibited

(e) Differential current protection

1 Monitors current flow of each phase

2 Current differential of any phase 30 $\pm$6 amps trips and latches GCR and ECR

3 Generator switch to reset

4 Monitors line current for regulation purposes

5 Limits to 260 - 350 amps

(f) Logic operation

1 Under-frequency

a High under-frequency

(1) Logic 0 = Fault

(2) Logic 1 = No Fault

b Low under-frequency

(1) Logic 0 = No Fault

(2) Logic 1 = No Fault

2 Under-voltage

a Logic 0 = No Fault

b Logic 1 = Fault

3 Over-voltage

a Logic 0 = No Fault

b Logic 1 = Fault

4 Differential current

a Logic 0 = Fault

b Logic 1 = No Fault

5 High field current

a Logic 0 = Fault

b Logic 1 = No Fault

6 Control switch State

a Logic 0 = switch "OFF/RESET"

b Logic 1 = switch "ON" or "TEST"

d. Generator Caution Lights

Two amber generator caution lights are on the master caution panel. The lights are marked NO. 1 GEN OFF and NO. 2 GEN OFF. These lights come on whenever the generators are inoperative. The lights are controlled by the main generator contactors when the generator control switches are in either the ON or OFF RESET position. In the TEST position, the lights are controlled by the generator control switch and will go out if generator output is the proper frequency and voltage. Current to operate the lights is supplied from the 28-volt dc essential bus through a CAUTION PNL circuit breaker on the No. 1 power distribution panel.

6. APU Generator and Generator Control

a. APU generator (P/N 31161-001)

(1) Location

(a) Mounted on APU in aft section of helicopter

(2) Function

(a) With APU operating and only source of power supplies all power requirements of helicopter

(3) Specifications

(a) 20 KVA air cooled

(b) Brush or brush-less

(c) Weighs 48 pounds

(d) No lubrication or servicing necessary

(e) Replaceable shaft

(f) Built in cooling fan

(g) 3 Generators in one

1 Permanent magnet generator

a AC for frequency sensing

b DC for generator control

2 Exciter Generator

a Provides main generator excitation

b Regulates main generator output

3 Main Generator

a Supplies 115/205 single and 3-phase, 400 HZ output

b 56 Amps per phase

c Feeds to No. 1 AC bus and cross-ties to No. 2

(4) Construction

(a) Phase rotation A, B, C (CCW at drive end)

(b) Self-cooled by built in fan

(c) PMG rating

1 33 to 36 volts DC at DC terminal

2 PN to minus - minus 28 volts DC

3 A + to minus - minus 28 volts DC

4 Rated at 1 amp

(d) Shaft shear load 1000 to 1400 inch-pounds

(e) Consists of three generators

1 Permanent magnet generator

a Aft section of generator

b AC terminals: P1 and PN

(1) No load - 20 VAC minimum

2 Exciter Generator

a Center section of generator

b A+ to A-, 4 to 8 volts DC

c F1 to A-, 3 to 14 volts DC

3 Main AC generator

a Output terminals, T1, T2, T3

b Ground terminals T4, T4, T6

(5) Operation

(a) Permanent magnet generator (PMG)

1 Self-contained miniature generator

2 Supplies AC and DC as soon as generator Starts turning

3 Supplies Dc for initial excitation of main generator

4 Supplies operating voltage to control unit and generator switch

5 Supplies AC for frequency sensing

(b) Exciter section

1 Supplies Dc voltage to main generator field

2 Output regulated by control panel

(c) Main generator

1 Has rotating field

2 Supplies AC voltage to APU generator contactor

b. APU generator control unit (P/N 114ES249-13)

(1) Location

(a) Right electrical compartment

1 Voltage regulation

2 Over and under-voltage

3 Under-frequency

4 Differential current

(2) Specifications

(a) 3 - phase output maintained at 112.5 to 117.5 volts

(b) Under-frequency protection activated when generator frequency drops below 345 HZ

(c) Under-voltage protection is activated when voltage falls below 100 volts

(d) Over-voltage of 132 volts for more than 3 seconds removes the generator from the line

(3) Construction

(a) Generator control panel consists of two basic assemblies

1 Control panel

2 Conversion plug

(b) Conversion plug

1 Located on left hand connector plug of control panel

2 Plug makes proper connection within control for proper generator (brush or brush-less)

a Black conversion plug to control brush type generator

b Red conversion plug to control brush-less generator

(c) Control Panel

<u>1</u> Is main assembly and contains all active electronic components.

<u>2</u> Component contains four circuit boards

<u>a</u> Voltage regulator board - “D”

<u>b</u> Overvoltage and undervoltage board - “C”

<u>c</u> Underfrequency board - “B”

<u>d</u> Overvoltage and undervoltage sensing board - “A”

<u>3</u> Unit contains five relays which are chassis mounted

<u>A</u> KST relay - start relay

<u>B</u> KLC relay - line connector relay

<u>C</u> KFR relay - gen field relay

<u>D</u> KUF relay - underfrequency relay

<u>E</u> KUV relay - undervoltage relay

<u>4</u> Also mounted on chassis are some diodes, resisters, and capacitors

(5) Operation

(a) Underfrequency protection

<u>1</u> Less than 345 HZ removes generator from line

<u>2</u> Locked-out on start-up to 360 HZ

<u>3</u> 10 to 15 second time delay

(b) Undervoltage protection

<u>1</u> Samples the average of the 3 phases

<u>2</u> Less than 100 volts starts 5 to 7 second timer

3 Disconnects generator from line

4 Locked out on start-up until voltage over 104

(c) Over-voltage protection

1 Samples each phase

2 Voltage greater than 132 for 3 seconds

3 Disconnects exciter voltage

4 Delay inversely proportional to over-voltage

5 3 seconds maximum at 132 volts

6 .115 seconds at 180 volts

(d) Differential current protection

1 Samples current through 6 transformers

a Three in feeder line

b Three in ground return line

2 Difference of 33 amps

a Disconnects generator from line

b Inhibits excitation voltage

(e) Voltage regulation

1 Maintained at 115 $\pm$2.5

2 Control by amount of current to exciter

3 Output of generator decreases, exciter current increases

c. Current transformers (P/N 50252-000)

(1) Location

(a) Three mounted in APU compartment

(b) Three mounted in No. 2 PDP

(2) Function

(a) Provide feeder line short circuit (feeder fault) signals for the control panel

(b) Induced signal sent to generator control unit

(3) Specifications

(a) All units identical and interchangeable

(b) Two connections on each one

(c) Each forward transformer connected to its corresponding aft transformer

(d) All are connected to control panel

(4) Construction

(a) Coil of wire, donut shaped case with two mounting lugs

(b) Two connections for output to control unit

(c) Generator feeder line passes through center

(5) Operation

(a) Normal operation

1 Current flow in generator feeder lines and generator ground lines induces voltage in current transformers

2 Current flow in output equal to the ground feeder

3 Transformer output voltages cancel each other

(b) Operation with fault

1 Current flow in feeder line shorted

2 No voltage in forward current transformer

3 Current flow in ground line increased

4 Higher induced voltage

5 Voltage energizes circuit in control panel

d. Contactors

(1) Location

(a) 2 contactors for main operation of generator in No. 2 PDP

1 APU slave relay (K4) (MS 24149-D1)

2 APU generator contactor (K3) (AO7ES117-1)

(2) Function

(a) To control application of generator power to the bus

(b) To lockout external power

(3) Construction

(a) K3 contactor has 3 sets of 3 phase contacts

(b) Has connector which connects to helicopter wiring

1 Ke A1-B1-C1 are main feeders and feed to control unit

2 A2-B2-C2 to K1 then to No. 1 AC bus

3 A3-B3-C3 to No. 2 AC bus

(c) Connector controls coil operation and keeps ground power off while APU generator on

(d) APU slave relay has 2 sets of contacts

(e) Both relays operated on 28 volts DC

(4) Operation

(a) APU slave relay is energized when generator ready, this arms the control switch and locks out external power by energizing K5, X-Y contacts, and also arms the AC cross-tie circuit

(b) APU generator contactor closes when APU generator switch set to on and connects generator to the AC bus.

e. Electric control panel

(1) Location

(a) Located on overhead panel in cockpit

(2) Function

(a) Allows generator to be connected to bus

(3) Construction

(a) Metal panel with quarter-turn fasteners

(b) Switches mounted to panel

(c) Plastic panel mounted on plate

(4) Operation

(a) Placing appropriate switch to "ON" connects source to bus

(b) Placing switch to test checks source for proper operation

(c) Switch to "OFF/RESET", after fault, resets GCU and allows generator on line if fault corrected

f. System operation

(1) APU generator operating and no other source of AC power

(2) Generator power normal - 28 volts output from pin "A" of control unit

(3) This voltage routed through Gen. 1 and Gen. 2 contactors

(a) Prevents APU generator power from being applied when either generator on the line

(4) K4 becomes energized and control voltage routed through A1-A2 of K4 to control switch

(5) Also applies 28 volts K5 X-Y and arms cross-tie

(6) Switch to on, control voltage routed to A-B coil on K3

(7) This connects 3-phase AC to No. 1 AC bus

(8) Power is routed through No. 1 AC bus-tie through K4 contacts to the No. 2 AC bus

7. Power distribution panels

   a. Location

      (1) No. 1 located in cockpit to the left and behind copilot (P/N 145E2106)

      (2) No. 2 located in cockpit to the right and behind pilot (P/N 145E2108)

   b. Function

      (1) Transfer and distribute AC power

      (2) No. 1 feeds left side of helicopter

      (3) No. 2 feeds right side of helicopter

      (4) Contains contactors, current transformers, circuit breakers, and auto-transformers

   c. Construction

      (1) Metal box structure

      (2) Sloping front has hinged cover with circuit breakers

   d. Operation

      (1) Connects power source to AC buses

      (2) Supplies 3 phase and single-phase AC to helicopter

      (3) Converts 115 volts to 26 volts

8. AC External Power

External AC power (200 volt 400-HZ) can be connected via a socket in the AC power receptacle adjacent to the left electrical compartment. If the applied power is acceptable, the power monitor will allow power to be applied to the airframe; if not, the power monitor will not allow to be applied to the airframe. With neither AC generator online, an external power contactor closes to connect the AC external power to No. 2 3-phase AC bus-bar and, via No. 1 AC BUS TIE circuit, to No. 1 3-phase AC bus-bar. If either main or APU generators are brought on line, AC external power is automatically prevented from being connected to the bus bar.

a. External power monitor (P/N 179-60550)

(a) Left electrical compartment

(2) Function

(a) Monitors ground power unit for:

1 Frequency

2 Over-voltage

3 Under-voltage

4 Phase sequence

(3) Specifications

(a) Weighs 2.5 pounds

(b) Input power - 115 volts, 400 HZ, 3-phase AC

(c) Output - 22 to 30 volts DC (external power in spec)

(4) Construction

(a) Metal case cover

(b) 5 printed circuit boards

1 Power supply

2 Under-voltage timer

3 Voltage sensor

4 Frequency sensor

5 Over-voltage timer

(c) Base plate

(d) 3-phase power transformer

(e) Relay

(5) Operation

(a) Power application

1 B and C phase to external contactor power supply

2 Develops 22 to 30 volts DC

3 Generates Start enable signal for 18/26 volt DC power supply

4 Supplies 18 volts for monitor operating

5 26 volts to monitor K1 relay

(b) Under-voltage detection

1 Monitors three input lines

2 Over 102.5 volts applies logic 0 to and gate GA1

3 One or all phases below 102, Starts under-voltage timer (inversely proportional to magnitude of under-voltage)

4 Trips monitor K1 relay

(c) Under-frequency detection

1 Monitors B phase

2 Below 370 applies logic 0 to GA2, Starts under-voltage timer

3 Operation continues as for under-voltage

(d) Over-voltage detection

1 Monitors all phases

2 Over 125 volts, disables under-voltage phase A

3 Over-voltage timer Starts (inversely proportional to over voltage)

4 Continues as above

(e) Over-frequency detection

1 Operates at 425 HZ

2 Same action as for under-frequency

(f) Phase sequence detection

1 Contained in 18/26 volt power supply

2 Phase not ABC - BCA - CAB, power supply disabled

b. Current transformers (P/N 179-60500-6)

(1) Location

(a) No. 1 located in No. 1 PDP

(b) No. 2 located in No. 2 PDP

(2) Function

(a) Provide signals to GCU for differential fault protection

(3) Construction

(a) Three individual windings in one package

(b) Air core transformers

(c) Each core marked for its phase

(d) Electrical connector for connection to GCU

(4) Operation

(a) Current flowing through feeder induces voltage in transformer

(b) Voltage routed to GCU ground fault detection circuits

c. Electric control panel

(1) Location

(a) Located on overhead panel in cockpit

(2) Function

(a) Allows generator to be connected to bus

(3) Construction

(a) Metal panel with quarter turn fasteners

(b) Switches mounted to panel

(c) Plastic panel mounted on plate

(4) Operation

(a) Placing appropriate switch to "on" connects source to bus

(b) Placing switch to "test" checks source for proper operation

(c) Switch to "off/reset" after fault, resets GCU and allows generator on line if fault corrected

9. System Operation

With both AC generators on line, each supplies its associated AC bus bar. If either generator fails or is switched off, its contactor opens to disconnect it from its bus bar; simultaneously the contactor connects the bus bar with the serviceable 3-phase AC bus bar, via the AC BUS TIE circuit breaker of that bus bar, to maintain supplies to all AC services. Each AC BUS TIE circuit breaker protects its respective bus bar against faults (eg: short circuits) occurring in the other 3-phase bus bar. With an AC BUS TIE circuit breaker open the services supplied from the defective bus bar are lost.

a. No. 1 generator operating only

(1) K1 operates and feeds No. 1 AC bus

(2) Prevents APU slave relay from operating

(3) Prevents K5 A-B terminals from operating

(4) Allows K5 X-Y terminals to operate

(5) Feeds No. 2 bus through No. 1 AC bus tie breaker

b. No. 2 generator operating only

   (1) K2 operates feeds No. 2 AC bus

   (2) Prevents APU slave relay from operating

   (3) Prevents K5 A-B terminals from operating

   (4) Allows K3 X-Y terminals to operate

   (5) Feeds No. 1 bus through No. 2 AC bus tie breaker

c. No. 1 and No. 2 generator operating

   (1) K1 operates feeds No. 1 AC bus

   (2) K2 operates feeds No. 2 AC bus

   (3) K3 X-Y and K5 X-Y operate

   (4) Arms cross-tie circuit

   (5) Prevents APU or external power

d. APU generator operating only

   (1) K4 operates. This allows:

      (a) K5 X-Y to operate

      (b) K3 A-B to operate

   (2) No. 1 AC bus fed through K3 and K1

   (3) No. 2 AC bus fed from No. 1 through N0. 1 AC bus tie and K5

   (4) Prevents external power

e. External power operating only

   (1) K5 A-B operates, feeds No. 1 bus through K5 and K2

   (2) K3 X-Y operates, feeds No. 1 AC bus through No. 2 bus tie and K3

SECTION II

DIRECT CURRENT (DC) POWER
DISTRIBUTION SYSTEM
DESCRIPTION
AND
THEORY OF OPERATION

1. Distribution System Improvements

    a. Separate feeder lines from each TRU

    b. 2 Power distribution panels

    c. 5 DC buses

2. Bus control and power transfer circuitry improvements

    a. Ensure only one power source can be connected to a bus

    b. Controls priority of power application

        (1) External power has priority over:

            (a) TRU power

            (b) Battery power (except for battery bus)

3. General

    a. The No. 1 and No. 2 TRU, powered from their associated 3-phase bus bars, supply 28-volt (nominal) DC to No. 1 and No. 2 DC bus bars respectively. If either TRU fails, DC cross-tie circuits operate automatically to connect the bus bars and ensure the continuation of supplies to meet all DC requirements. The 24-volt NI CAD battery, which is connected to the battery bus bar and switched battery bus, supplies essential DC power and provides power for initiating APU Starting DC power can also be supplied from and external power source via a receptacle on the forward left fuselage.

    b. No. 1 and No. 2 DC sources are identical. Each has a DC power supply (transformer-rectifier) and a reverse current cutout relay. Each transformer-rectifier converts 200-volt 3-phase AC power to 28-volt DC and can supply up to 200 amperes. Each reverse current cutout relay protects its associated transformer-rectifier. The AC input power to each transformer-rectifier is from its associated AC bus.

    c. Five DC buses

        (1) Battery bus

        (2) Switched battery bus

        (3) Essential bus

        (4) No. 1 DC bus

        (5) No. 2 DC bus

d. Control and transfer circuits

(1) DC buses powered according to power source available

(2) Battery only source, three buses powered

(3) External power, one TR or both TRs four buses fed by that source, one by battery

4. DC power sources

a. Transformer-rectifiers

(1) Main source of DC power

(2) Powered by 115 volts, 3-phase AC

(3) Each TR supplies its respective DC bus

b. Battery

(1) Charge maintained by charger when 115 volts AC available

(2) Supplies battery bus

(3) Supplies switched battery bus when No. 1 DC bus not powered

(4) Supplies essential bus when No. 1 bus not powered

c. External power

(1) When applied has priority over TRs

(2) Supplies power to No. 1, No. 2 essential and switched battery bus

5. Five DC buses

a. No. 1 DC bus

(1) Supplied by No. 1 TR

(2) Supplies power to left side of helicopter

b. No. 2 DC bus

(1) Supplied by No. 2 TR

(2) Supplies power to right side of helicopter

c. Essential bus

(1) Supplied by battery when only source (battery switch on)

(2) Supplied by No. 1 TR when operating

(3) Supplied by No. 2 TR if No. 1 not operating

d. Switched battery bus

(1) Supplied by battery when only source

(2) Supplied by No. 1 TR when operating

(3) Supplied by No. 2 TR if No. 1 not operating

e. Battery bus

(1) Always supplied by battery

6. Control and transfer circuits

a. Control application of power sources to buses

b. Cross-ties buses as required by conditions

7. Components

a. Transformer-rectifier (P/N 28VS200Y-9)

(1) Location

(a) No. 1 in left electrical compartment

(b) No. 2 in right electrical compartment

(2) Function

(a) Convert 3-phase AC to 28 volts DC

(3) Specifications

(a) Supplies up to 200 amps

(b) Supplies 300 amps for 5 minutes

(c) Supplies 500 amps for 1 minute

(d) 1.5 volts AC maximum ripple voltage

(e) Self-cooled by build-in fan (AC operated)

(f) Positive and negative output terminals

(g) Quick-disconnect AC input connector

(h) Six rectifiers in each half-wave circuit

(4) Construction

(a) Weight - 17.0 lb. maximum

(b) Height - 7.0 inches

(c) Width - 7.625 inches

(d) Depth - 11.250 inches

(e) Cylindrical metal housing

(5) Operation

(a) 200V, 3-phase, AC sent through R.F. filter to 3 transformer input windings

(b) R.F. filter prevents radio noise

(c) Transformer converts 200V, 3-phase AC, to 48.5 volts, 3-phase AC

(d) Six output windings in transformer

(e) Rectifiers convert 48.5 volt AC to 28 VDC

(f) Condenser or pi-network filter smoothes out AC ripple to maximum 1.5 volts AC

(g) Output voltage not directly regulated (regulations of input voltage indirectly regulates output)

b. Reverse current cut-out relay (P/N A700AQ-4)

(1) Location

(a) No. 1 (K3) located in No. 1 PDP

(b) No. 2 (K4) located in No. 2 PDP

(2) Function

(a) Protects transformer-rectifier

(b) Remains energized if TR voltage at least 0.85 volts greater than bus

(3) Operation

(a) 28 VDC applied to APP and GEN terminals

(b) APP operates main contactor coil

(c) Closes main contacts and 28 VDC to BATT terminal and to bus

(d) 28 volts DC to IND terminal to power TR fail relay

c. Battery (P/N BB432/A)

(1) Location

(a) Located in left electrical compartment

(2) Function

(a) Supplies 24.7 volts DC to:

1 Battery bus

2 Switched battery bus

3 Essential bus

When no other source of DC available

(3) Specifications

(a) Voltage - 24.7 volts DC

(b) Rating - 11 amp-hours

(c) Retains charge for long idle periods

(d) Modified for charger connection

(e) -65°F to +165°F temperature range

(4) Construction

(a) 19 cells

(b) Metal case with two vent tubes

(c) Metal top with gasket and four latches

(d) Nickel-cadmium plates

(e) Potassium hydroxide electrolyte - 30% by weight

(f) 1.240 to 1.320 specific gravity

d. Battery charger (P/N 145ES014)

(1) Location

(a) Located in left electrical compartment

(2) Function

(a) Monitor the following on the battery:

(1) Overheating

(2) Defective temperature sensor

(3) Battery cell imbalance

(b) Charge the battery

(3) Specifications

(a) Input: 115 volts AC, 3-phase

(b) Output: Charge voltage to maintain battery at 80% of charge

(c) Charge proportional to battery state full charging up to 80% than gradual charging after

(4) Construction

(a) Metal housing

(b) Contains fault indicator

(c) Has reset button for resetting fault indicator after a fault has been corrected

(5) Operation

(a) Charger is supplied with 115 volts AC

(b) AC reduced and rectified for use within charger

(c) Charger has circuit that connects to lights for:

1 Battery charging (less than 80% charge)

2 Charge complete (more than 80% charge)

(d) Monitors battery temp. and shuts charger down when temperature exceeded

(e) Monitors battery charge state and maintains 80% charge

(f) Charger has monitor for charger over-temp.

(g) Fault indicator trips on charger over-temp.

(h) Reset with pushbutton when fault corrected

e. Electrical control panel

(1) Location

(a) Located on overhead panel

(b) Contains battery ON-OFF switch

(2) Function

(a) To connect battery to switched battery bus, essential bus, and battery bus

(3) Construction

(a) Metal panel with quarter-turn fasteners

(b) Switches mounted to panel

(c) Plastic panel mounted on plate

(4) Operation

(a) Battery switch ON connects battery to:

1 Switched battery bus

2 Essential bus (when battery only DC source)

9. System Operation

a. Battery bus control - when battery plugged in bus hot

b. Switched battery bus control

(1) Battery plugged in, switch OFF or ON, bus powered by battery through contacts A2-A3 of K10

(2) Battery plugged in, switch ON, No. 1 and No. 2 TRs on, bus powered by No. 1 DC bus through essential bus control circuit breaker, A1-A2 of K2 and A1-A2 of K10

(3) Battery plugged in, switch ON, No. 1 TR on only same as (2) above

(3) Battery plugged in, switch ON, No. 2 TR on only bus powered by No. 2 DC bus through A1-A2 of K8 to No. 1 DC bus then same as (2) above

c. Essential bus control

(1) Battery plugged in, switch ON, no TRs on, bus powered by battery through B3-B4 of K2

(2) Battery plugged in, switch ON, either or both TRs on bus powered by No. 1 DC bus through A1-A2 of K2

d. No. 1 DC bus control

   (1) Powered by No. 1 TR through GEN-BATT terminals of No. 1 RCCO (Ke)

   (2) Powered by No. 2 TR when No. 1 fails, through cross-tie relay contacts A1-A2

e. No. 2 DC bus control

   (1) Powered by No. 2 TR through GEN-BATT terminals of No. 2 RCCO (K4)

   (2) Powered by No. 1 TR when No. 2 fails through cross-tie relay contacts A1-A2 (K8)

f. External DC power

   (1) When applied disconnects TR by action of K9 and powers all buses, except battery bus, through A1-A2 of K7

10. Transformer-rectifier caution lights

Two amber transformer-rectifier caution lights, on the master caution panel are marked No. 1 RECT OFF and No. 2 RECT OFF. These caution lights are controlled by the reverse-current cutouts and TRU failure relays. Whenever one of the transformer-rectifiers fails, either through a fault in the transformer-rectifier or a bus fault, the respective caution light comes on. The reverse-current cutout prevents current flow through the disabled transformer-rectifier, current to operate the lights is supplied by the 28-volt DC essential bus through the CAUTION PNL circuit breaker on the No. 1 power distribution panel.

11. Battery system malfunction caution light

A battery system malfunction caution light is on the master caution panel on the console. Marked BATT SYS MAL, this light comes on when the battery charger has stopped charging the battery. This can be caused by an overheated battery or battery charger, battery cell imbalance, or an output short or open circuit. Current to operate the light is supplied by the 28-volt DC essential bus through the CAUTION PNL circuit breaker on No. 1 power distribution panel.

12. Battery maintenance lights

Located in the No. 1 sys electrical compartment are two battery charging lights (green in color). One indicates the battery is charging (under 80% charge), the other indicates the battery is charged (over 80%).

LIGHTING SYSTEMS - LESSON

1. Introduction

   a. Internal lighting

      The primary lighting for the cockpit and cabin includes cockpit and cabin general lighting, console lighting, instrumental integral lighting, and cockpit lights. A secondary source of lighting for the cockpit is provided by 8 floodlights. Three emergency exit lights, troop warning lights and crew call lights are in the cabin. Maintenance lights are provided to facilitate the reading of oil level gages.

   b. External lighting

      The external lighting consists of navigation lights, anti-collision lights, formation lights, landing lights. Master switches for the landing lights are on their associated pilot's lighting panel.

2. Cockpit Instrument Panel Lighting

   a. Overhead panel lights

      The overhead switch panel has integral lighting. Power to operate and control the overhead panel lights is supplied by the No. 1 AC bus through a circuit breaker marked DVHD PNL on the lighting section of the No. 1 power distribution panel.

      The overhead panel lights dimming rheostat is on the left lighting control panel of the overhead switch panel. The rheostat adjusts the angle of light. The rheostat is marked OVERHEAD PANEL LIGHTS. It controls the light level from BRT to DIM and OFF.

   b. Pilot's and copilot's flight instrument lights

      All flight instruments and placards on both pilot's and copilot's instrument panel receiving lighting. The horizontal situation indicator, rotor tachometer, magnetic compass, attitude indicator (VGI), AIMS altimeter, radar altimeter, and rotor tachometer for both pilot and copilot have integral lighting. The remaining instruments are externally lit by lighting posts adjacent to the instruments. Power to operate and control the pilot's flight instrument lights is supplied by the 26 volt No. 2 lighting transformer through the PILOT INSTR LIGHTING circuit breaker on No. 2 power distribution panel. Power to operate and control the copilot's flight instrument lights is supplied by the 26-volt No. 1 lighting transformer through the COPLT ISNTR LIGHTING circuit breaker on the No. 1 power distribution panel.

      The pilot's flight instrument lights dimming rheostat is on the right lighting control panel of the overhead switch panel. The copilot's flight instrument dimming rheostat is located on the left lighting control panel of the overhead switch panel. The rheostats are marked PILOT, COPILOT FLT.

LTS: both provide lighting control of the flight instruments from BRT to DIM and OFF.

c. Center section instrument panel

The center section instrument as well as the fire warning panel are lighted. Power to operate and control and center section lights is supplied by the No. 3 AC bus through a circuit breaker marked CTR INSTR on the No. 2 power distribution.

The center section instrument lights dimming rheostat is on the right lighting control panel of the overhead switch panel. The rheostat is marked CTR SECT INST LTS. The center section instrument dimming rheostat provides full control of the lighting from BRT to DIM and OFF, for the center section instruments.

d. Console lights

Lighting is provided for all control panels on the console. Power to operate and control the console lights is supplied by the 26 volt AC lighting transformer through a circuit breaker, marked CONSOLE on the LIGHTING section of the No. 1 power distribution panel.

The console lights dimming rheostat is on the left lighting control panel of the overhead switch panel. The rheostat is marked CONSOLE LTS. The console lighting is controlled by the console dimming rheostat from BRT to DIM to OFF.

3. <u>Cockpit Secondary Lighting</u>

a. Dome lights

Two cockpit dome lights attached to the overhead structure adjacent to the overhead switch panel are provided. Each dome contains a white and red lamp, which can be selected individually. Power to operate and control the dome lights is supplied by the DC essential bus through a COCKPIT DOME circuit breaker on the LIGHTING section of the No. 2 power distribution panel. When the cockpit dome lights are on white, the master caution panels cannot be dimmed. If the white dome light is selected while the caution lights are operating on DIM, the caution lights will automatically switch to BRIGHT mode.

A three-position switch on the left lighting control panel of the overhead switch panel selects the function of the dome light. The switch is marked DOME SELECT switch positions, WHITE, RED, and OFF.

The dome lights dimming rheostat is on the left lighting control panel of the overhead switch panel. When WHITE or RED is selected on the dome lights select switch, the dome lights dimming rheostat is operable through a range from DIM to BRT. The dome lights dimming rheostat is marked DOME LIGHTS.

b. Pilot's and Copilot's Utility Lights

Two utility lights, connected to individual flexible cords, are mounted in two retaining sockets on either side of the overhead switch panel above the pilot and copilot. The lights are detachable and can be moved about to take care of special lighting situations. Each utility light has a rheostat switch as an integral part of its assembly. This switch, located on the aft part of the light, regulates the intensity of the light from OFF to BRT. A white button on the light housing, opposite the switch, is used for flashing the light. By selecting the color desired on the barrel of the light, red or white light will be emitted. The utility light receives power from the 28-volt No. 2 DC bus through a COCKPIT DOME circuit breaker on the LIGHTING section of the No. 2 power distribution panel.

c. Floodlights

Ten floodlights provide a secondary source of light. Eight are under the glare shield and two on the cockpit bulkhead. Six of the eight floodlights under the glare shield light the instrument panel; the other two light the console. The two overhead floodlights light the overhead switch panel. Power to operate and control the floodlights is supplied by the 28-volt DC essential bus through a circuit breaker, marked INST FLOOD on the LIGHTING section of No. 2 power distribution panel.

The floodlights dimming rheostat is on the lower right lighting control panel of the overhead switch panel. With the floodlight selection switches ON, the rheostat is used to turn the floodlights ON or OFF to control them from DIM to BRT.

Three floodlight selection switches are on the lower right lighting control panel of the overhead switch panel. Each two-position switch is labeled for the area the floodlights will light: FLOOD LTS CONSOLE, INST PNL, and OVHD PNL. By placing any one switch ON, the associated floodlights will light when the floodlight-dimming rheostat is turned toward BRT. Moving the switch to OFF de-energizes the floodlight circuit.

d. Emergency Floodlights

If the pilot's flight instrument lights have been turned on, loss of 28-volt No. 1 DC bus, or loss of 115-volt AC from the No. 1 AC bus, will cause the floodlights to automatically come on. All floodlights except the two on the console will function automatically in the BRIGHT mode. The console floodlights can be turned on by selecting the console floodlights switch to ON and adjusting the floodlight-dimming rheostat. Simultaneous dimming control of all floodlights can be regained by setting the three floodlight selection switches ON, turning the floodlight dimming rheostat to BRT, and turning the pilot's flight instrument dimming rheostat to OFF. Floodlight intensity can be controlled by the floodlight-dimming rheostat.

4. Cargo Lighting

a. Cabin and ramp lights

Five cabin and ramp lights are in the cabin, attached to the overhead structure. Each light contains a white and red lamp, which can be selected individually. Power to operate and control the cabin and ramp lights is supplied by the 28-volt DC switched battery bus through a CABIN & RAMP circuit breaker on the LIGHTING section of the No. 1 power distribution panel.

b. Emergency exit lighting

Three emergency exit lights are in the cargo compartment close to each of the three primary emergency exits; the main cabin door, the emergency exit opposite the main cabin door, and the ramp emergency exit. The lights come on whenever a loss of power on the switched battery bus occurs or during a landing when 3 to 4g are exceeded as sensed by an inertia switch. The lights may also be used as portable lamps by removing them from their housing and by rotating the handle, marked PULL EMERGENCY LIGHT, 45° from its normal position. Power to operate the emergency exit lights is supplied by two, internal, 1.25-volt, nickel-cadmium batteries. Power to operate and control the charging, monitoring, and test circuit use supplied by the 28-volt DC switched battery bus through the CABIN & RAMP circuit breaker on the LIGHTING section of the No. 1 power distribution panel. The emergency exit lights system is controlled by the emergency exit lights control switch on the overhead panel.

The EMER EXIT LTS control switch is on the lower left lighting control panel of the overhead switch panel. The switch has three marked positions: ARM, TEST, and DISARM. When the switch is moved to ARM, the emergency exit lights stay off, the batteries are charging, and the charge indicator lights come on. The circuit monitors electrical failures and landings in excess of 3 to 4g. The light from the charge indicator lamps is seen emitted through two pinholes at the base of the main light reflector. If the emergency exit light comes on during landing, an entry on DA Form 2408-13 is required.

When the switch is set to TEST, the main light comes on, powered by the batteries. When the switch is set to DISARM, the main light on the emergency exit lights stays off, the batteries are not charging, and the charging indicator lamps stay off.

c. Cabin and ramp light switches

The control panel for the cabin and ramp light switches are located below the ramp control valve. A three-position toggle switch labeled RED, OFF, and NVG. A rotary toggle switch labeled DIM and BRT adjusts light level under RED light or NVG light conditions.

d. Emergency troop alarm and jump lights

Two emergency troop alarm and jump light boxes are in the cargo compartment. The forward box is on the bulkhead above the avionics equipment shelves and the aft box is on the left side of the fuselage above the ramp at Station 575. Each box has an electric bell in the center with a red light fixture on one side and a green light fixture on the other side. The emergency troop alarm and jump lights have several functions. The emergency troop alarm can be used to notify passengers and crew with pre-determined signals in time of emergency. The jump lights can be used to notify the flight engineer during airborne delivery operations, and also to alert the troop commander during paratroop drop missions. Power to operate and control the emergency troop alarm and jump lights is supplied by the essential DC bus through two circuit breakers labeled TROOP ALARM BELL and JUMP LT, on No. 2 power distribution panel.

A two-position toggle switch on the TROOP WARN panel of the overhead switch panel is labeled TROOP ALARM with positions marked OFF and ON. Moving the troop alarm switch to ON rings the bell continuously at both Stations until the switch is moved to OFF.

A three-position toggle switch on the TROOP WARN panel of the overhead switch panel is labeled TROOP JUMP LTS with positions marked GREEN, OFF, and RED. When the switch is set to GREEN, the green lights on the emergency troop and jump light box, at both Stations, and the troop jump lights on the overhead switch panel come on. When the switch is set to RED, the red lights come on. OFF position turns off both sets of lights. The red and green troop jump lights can be dimmed, while operating at night, by setting either CABIN AND RAMP LIGHTS control switch to RED ON.

Two troop jump lights on the TROOP WARN panel on the overhead switch panel are provided to give the pilots a visual indication of the troop jump light selected. One light is provided for each color selection and comes on when the respective light is selected. The lights dim when the CAUTION LIGHTS switch on the console is moved to DIM.

e. Forward transmission oil level check lights

The forward transmission floodlight provides light to check the oil level of the transmission. The floodlight is near the sight gage on the transmission. Power to operate and control the oil level check light is supplied by the 28-volt DC switched battery bus through an OIL LEVEL CHECK circuit breaker on the LIGHTING section of the No. 1 power distribution panel.

One oil level check light switch is provided for the oil check light for the forward transmission. It is a two-position switch marked OIL LEVEL CHECK LT SW, ON-OFF. The switch is inside the cockpit on the canted bulkhead at Station 95 above the pilot's seat.

5. <u>Exterior Lighting</u>

a. Position lights

Three position lights are installed on the helicopter. On the right side of the fuselage is a green light; on the left, red, and on the aft pylon, white. Power for the position lights is supplied by the 28-volt No. 2 DC bus through a circuit breaker marked POS on the LIGHTING section of the No. 2 power distribution panel.

A three-position toggle switch on the left LTG control panel of the overhead switch panel controls the position lights. The switch is marked POSITION LIGHTS DIM-BRT-OFF.

b. Formation lights

Five electro-luminescent panels on the top of the fuselage, increase the night formation capability of the helicopter. Three panels, which form an equilateral triangle, are aft of the forward pylon. Two panels are on the aft pylon aft of the anti-collision light. The five panels are controlled by a switch on the overhead switch panel. Power to operate and control the formation lights' system is supplied by the 115-volt bus, 1 AC bus through the FORM circuit breaker on the LIGHTING section of the No. 1 power distribution panel.

The formation lights control switch is on the left LIGHTING control panel of the overhead switch panel. The rotary switch has three positions; OFF, DIM, and BRT. When the switch is OFF, the formation lights' system is de-energized.

c. NVG lights

NVG formation lights are on each side of the forward pylon. Two NVG formation lights on each side of fuselage. Two NVG formation lights are also on aft pylon. One next to the anti-collision light, and one on vertical panel at the rear of the aft pylon.

Anti-collision lights

Two red strobe anti-collision lights are on the helicopter. One is on top of the aft pylon; the other is on the fuselage underside. Power to operate the anti-collision lights is supplied by the 28-volt No. 2 DC bus through two circuit breakers labeled ANTI-COL TOP and BOT and the LIGHTING section of the No. 2 power distribution panel.

Two toggle switches are on the right lighting control panel of the overhead switch panel. The two-position switches marked ANTI-COLL LTS TOP and BOTTOM. Each switch has ON and OFF positions. When the switch is moved to OFF, the anti-collision lights are de-energized.

d. Landing Searchlights

Two controllable 450-watt quartz landing-search lights are mounted on the bottom of the fuselage. Each light is operated independently by a filament switch, a control switch, and a position switch. Each light can be extended or retracted into the fuselage. Each can be stopped at any desired position in its extension arc of 90 degrees. It will rotate in a horizontal plane to the left or right. It will continue to turn in either direction as long as the searchlight control switch is displaced. Power to operate the landing-search light lamp is supplied by the 28-volt No. 1 and No. 2 DC buses through circuit breakers marked SLT FIL on each power distribution panel. The pilot's circuit breaker is on the No. 2 power distribution panel. The copilot's circuit breaker is on the No. 1 power distribution panel.

The pilot and copilot's searchlight filament switches are on the respective thrust-control rod switch bracket. Both switches have two positions, OFF and ON. The switches turn on the landing-search light lamp, before or after extension. The switches get power from the 28-volt No. 1 and No. 2 DC buses through the SLT FIL circuit breakers on each power distribution panel.

Searchlight control switches are on the overhead lighting control panel. The pilot's searchlight control switch is on the right lighting control panel. The copilot's searchlight control switch is on the left lighting control panel. The control switch allows the position switch on the thrust control rod to become operational and also to retract the landing-search light. If the searchlight is any angle off center when the searchlight control switch is moved to RETR, the searchlight will automatically rotate to point forward and then will retract flush with the fuselage. The control switch is a two-position toggle switch with positions marked ON and OFF. The switches receive power from 28-volt No. 1 and No. 2 DC buses through circuit breakers marked SLT CONT on each power distribution panel. The pilot's circuit breaker is on the No. 2 power distribution panel. The copilot's circuit breaker is on the No. 1 power distribution panel.

A five-position momentary switch is on each thrust control. When the filament and control switches are ON, the searchlight can be controlled up and down or left and right. The searchlight position switch gets power from the 28-volt No. 1 and No. 2 DC bus through the SLT CONT circuit breaker on each power distribution panel. The pilot's circuit breaker is on the No. 2 power distribution panel. The copilot's circuit breaker is on the No. 1 power distribution panel.

The landing-search light can be used for two separate functions: as a landing light or a searchlight. To cover a wide area with the searchlight use the searchlight position switch on the thrust control. The searchlight may be extended and stopped at any angle up to 90 degrees in a vertical plane and rotated 360 degrees about its vertical axis.

CHAPTER 10
FUEL SYSTEM

FUEL SYSTEM
DESCRIPTION
AND
THEORY OF OPERATION

FUEL SYSTEMS

A. Description

1. Fuel Supply System

The fuel supply system furnishes fuel to the two engines, the heater, and the APU. Two separate systems connected by cross-feed and a pressure refueling lines are installed. Provisions are available within the cargo compartment for connecting internal ferry fuel tanks to the two fuel systems. Each fuel system consists of three fuel tanks contained in a pod on each side of the fuselage. The tanks are identified as forward auxiliary, main, and aft auxiliary tanks. During normal operation, with all booster pumps operating, fuel is pumped from the auxiliary tanks into the main tanks, then from the main tanks to the engine. A simplified fuel flow diagram is engraved on the fuel control panel. When the fuel is consumed in an auxiliary tank, the fuel pump is automatically shut off and a check valve closes to prevent fuel from being pumped back into that tank. Should a fuel pump fail in an auxiliary tank, the fuel in that tank is not usable. However, should both booster pumps fail in a main tank, fuel will be drawn from the main tank as long as the helicopter is below 6,000 feet pressure altitude. Fuel is delivered to the APU from the left main tank and to the heater from the right main tank. Fuel system switches and the auxiliary tank low pressure caution lights are on the fuel control panel of the overhead switch panel, the fuel line pressure caution lights are on the master caution panel and the fuel flow meter is on the center instrument panel. The single point pressure refueling panel and nozzle adapter are on the right side above the forward landing gear.

2. Type of Fuel

JP4
JP5
JP6
JP8

3. Fuel Capacities

Left Main	- 278 gals.
Right Main	- 274 gals.
Left Fwd Aux	- 122 gals.
Right Fwd Aux	- 119 gals.
Left Aft Aux	- 118 gals.
Right Aft Aux	- 117 gals.

4. Single-point Pressure Fueling System

   a. Operating and connecting point in fwd right inter-tank area.

   b. High level shutoff valve control maximum fuel level in each tank.

   c. Pre-check panel allows operational check of high level shutoff valves.

   d. System will accept up to 300 gals/min and 55 psi.

e. Fuel quantity indicators available for observing amount of fuel delivered.

f. System operated on 28-volts DC from switched battery bus.

g. Inverter provides AC power for fuel quantity when in refuel mode.

h. Switch for refuel station located on overhead level.

5. Fuel Quantity System

a. System contains ten capacitance type fuel quantity probes

(1) Three probes in each main tank

(2) One probe in each aux tank

b. Main tank center probes have thermistor for low level warning

c. Two indicators and selector switches

(1) One set in center instrument panel

(2) One set in refueling station pre-check panel

d. System contains fuel quantity switch box for transferring signals between cockpit and refuel station.

e. Inverter in system to power refueling station indicator

f. Indicator has two readouts

(1) Digital readout for total fuel remaining

(2) Pointer readout for fuel remaining in any selected tank

g. Fuel quantity operated on 115-volts AC from No. 1 bus and 28-volts DC from the switch battery box.

B. <u>Presentation</u>

1. Components

a. Fuel pumps (P/N 114P4111)

(1) Location

(a) Eight fuel pumps in system

<u>1</u> One each aux tank (4 total)

<u>2</u> Mounted in fwd end of tank

3 Two in each main tank (4 total)

4 Mounted in each end of tanks

(2) Function

(a) Provide positive fuel pressure to engines.

(b) Evacuates pressure-fueling manifold through operation of the jet pump.

(3) Specifications

(a) Single Stage impeller type pump

(b) Motor rated at 0.30 HP @ 10,3000 rpm

(c) Thermally protected

(d) Operate on three phase 115 volts AC

(4) Operation

(a) Left side pumps powered by 115 volts 3-phase from No. 1 AC bus

(b) Right side pumps powered by 115 volts 3-phase from No. 2 AC bus

(c) Operation is controlled by DC through relays

(e) Aux pumps controlled by thermistors to prevent operation when aux tank fuel depleted.

b. Fuel Pump Control Relay Boxes (P/N 145E2195)

(1) Location

(a) Two boxes in system

1 One on left side of cabin Station 340

2 One on right side of cabin Station 340

(b) Left box controls left pumps.

(c) Right box controls right pumps.

(2) Function

(a) Control application of AC power to fuel pumps

(3) Construction

(a) Metal box structure with cover

(b) Each box contains four relays

(c) Relays are DC operated

(d) Relays have three sets of main contacts for pump AC connections

(4) Operation

(a) Each relay in left box supplied three phase AC from No. 1 AC bus

(b) Each relay in right box supplied three phase from No. 2 AC bus

(c) DC from No. 1 DC bus connected to individual pump switch on overhead panel for left pumps

(d) DC from No. 2 DC bus connected to individual pump switch on overhead panel for right pumps

(e) Selecting a main tank pump switch supplies 28 volts DC to relay

(f) Relay closes and AC voltage supplied to pump

(g) Selecting an aux pump switch supplies 28 volts DC to fuel pump thermistor control

(h) With full tank, voltage continues to relay box and closes pump relay

c. Shutoff and Cross-feed Valves (P/N 114PS401)

(1) Location

(a) Total of four valves in system

1 One in each engine main fuel line

2 Two in cross-feed fuel line

(b) Engine valves are located at Station 498 left and right side

(c) Cross-feed valves are located at Station 504 left and right side

(2) Function

(a) Engine valves provide means of stopping fuel flow to engines.

(b) Cross-feed valves provide means of supplying fuel to either engine from either fuel system.

(3) Construction

(a) Valves are thermally protected

(b) Can be operated manually

(c) Contain circuits for indicating malfunction (switch and valve not same position

(d) Remain in last selected position when power fails

(e) DC motor operates at 18 to 30 volts

(4) Operation

(a) Engine valves operate on 28 volts DC.

<u>1</u> No. 1 valve from No. 1 bus

<u>2</u> No. 2 valve from No. 2 bus

(b) Cross-feed valves operate on 28 volts DC from No. 1 DC bus

(c) Placing cross-feed switch to open applies 28 volts DC to each valve

(d) Engine valves are wired through fire pull handles

(e) Engine valves are normally open

(f) Pulling fire handle applies 28 volts to selected valve and closes it.

d. Pressure Switches (P/N 114PS407)

(1) Location

(a) Total of six pressure switches

(b) One for each aux pump

<u>1</u> Station 250 left and right inter-tank area for fwd aux pumps

2 Station 380 left and right inter-tank area for aft aux pumps

(c) Main fuel system pressure switch on Station 502 left and right side of ramp area

(2) Function

(a) Aux pump switches indicate pump pressure under 10 psi on fuel control panel in overhead panel (does not indicate which pump, only left or right side pump fail)

(b) Main fuel system pressure switch provides indication on master caution panel of fuel pressure less than 10 psi

(3) Specifications

(a) Pressure switch is normally closed

(b) Switch closes at 10 psi or less

(4) Operation

(a) Main pressure switch has 28 volts DC supplied from caution panel

(b) With fuel pressure less than 10 psi, switch is closed and provides ground for light

(c) With pressure greater than 20 psi, no ground for light

(d) Aux pump pressure switch for left side powered by 28 volts DC from No. 1 DC bus

(e) Aux pump pressure switch for right side powered by 28 volts DC from No. 2 DC bus

(f) Operation is same as main switch, only light is on overhead panel

e. Thermistor Control Unit (P/N 114ES224 & 472580-011)

(1) Location

(a) Three control units in fuel system

(b) One for low fuel level warning light system

1 Located in fwd right side of console

(c) Two units in aux pump DC control voltage

1 Mounted above pump relay control boxes left and right side of cabin

(2) Function

(a) Low level control unit activates warning light on caution panel.

(b) Aux pump controls interrupt DC power to aux pump relays.

(3) Construction

(a) Contain elements of bridge circuit

(b) Contain relays

(4) Operation

(a) Low level control operates on 28 volts DC from No. 1 DC bus.

(b) When thermistor on main tank capacitance unit is uncovered, caution light on panel is supplied 28 volts to light capsule.

(c) Pump control unit operates on 28 volts DC.

(d) When both thermistors on aux pump are uncovered, DC control voltage to pump relay is interrupted.

(e) When both thermistors are covered, completes control circuit to pump relay.

f. Control Switches and Lights

(1) Location

(a) Fuel pump, cross-feed, and refuel Station control switches mounted on fuel control panel on overhead panel.

(b) Aux pump low pressure warning lights on fuel control panel.

(c) Main fuel pressure warning light on master caution panel.

(d) Low fuel level warning on master caution panel.

(e) Main engine fuel and cross-feed valves indicator lights located below respective valve.

(2) Function

(a) Pump switches control each pump for normal operation of fuel pumps and manual fuel management.

(b) Cross-feed switch allows fuel from either system to supply either engine.

(c) Refuel Station switch provides power to refuel Station pre-check panel when on, and closes refuel gate valves in aft inter-tank areas when off.

(d) Aux pump warning light indicates pressure from pump is 10 psi or less.

(e) Main fuel pressure warning light indicates pressure from main pumps is 10 psi or less.

(f) Low level warning light indicates 370 ±50 lbs. of fuel remains in the main fuel tank.

(g) Valve lights indicate valve operation. If they remain on, indicates a valve malfunction.

g. Fuel Quantity Indicator (P/N 114ES224)

(1) Location

(a) One located in cockpit center instrument panel

(b) One located in pre-check panel fwd right inter-tank

(2) Function

(a) Indicate fuel remaining in fuel system

(3) Construction

(a) Contains two servo amplifiers

(b) Two servo motors

(c) Elements of bridge circuits

(d) Calibration potentiometers

(e) Provides two types of readout

1. Digital readout for continuous reading of total fuel remaining in 50 lb. increments.

2. Pointer readout for total fuel in selected tank in 50 lb. increments. Remains hidden until tank selected.

(4) Operation

(a) Cockpit indicator operates on 115 volts AC from No. 1 AC bus.

(b) Refueling Station indicator operates on 115 volts AC from system inverter.

(c) Operates on capacitance-bridge principle.

(d) Servo motor drives to balance bridge and operate pointer and digital readout.

(e) Signals supplied by tank units through selector switch.

h. Fuel Quantity Selector Switch (P/N 114ES224)

(1) Location

(a) One located in cockpit center instrument panel

(b) One located in pre-check panel fwd right inter-tank

(2) Function

(a) Provide means of selecting individual tank for reading fuel remaining

(b) When set to total, reads fuel remaining in all tanks

(3) Construction

(a) Has seven positions

(b) Left fwd - left main - left aft

(c) Right fwd - right main - right aft

(d) Total is center position

(e) Two types of switches available

1 -2 switch is spring-loaded to center position

2 -4 switch remains in position selected

(4) Operation

(a) Placing switch to desired position connects tank unit(s) to indicator to provide reading.

i. High Level Shutoff Valves (P/N 114PS478)

(1) Location

(a) Six valves in system

(b) One located in each fuel tank

(2) Function

(a) Provide means of shutting off fuel flow, from single point fueling, when tank is full

(b) Main valves also stop flow from aux tanks when fuel being transferred from aux to main

(3) Construction

(a) Each valve has two floats and two solenoids

(b) Floats shutoff sense lines when tank is full creating a back pressure that Closes the valve

(c) Solenoids used to check operation. Mechanically raise floats to stop flow

(4) Operation

(a) Power to operate solenoids supplied by 28 volt switched battery bus

(b) Normal operation, fuel level raises floats

(c) Closes off sense lines to pressure fueling valve

(d) Valve closes and fuel flow to tank stops

(e) Operating valve switch lifts float to close sense line

(f) Main tank valve has drain tube that causes tank level to drop lower than aux tank valves

(g) This allows aux pumps to feed main tanks only after this lower level is reached

j. Pre-Check Panel (P/N 114ESS53)

(1) Location

(a) Located in right fwd inter-tank area

(2) Function

(a) Provide means to check high level shutoff valves (primary and secondary)

(b) Fuel quantity monitored from here (during refuel)

(c) Control fueling of helicopter from single-point refueling Station

(3) Construction

(a) Metal panel containing the following:

1 Nine switches

2 Fuel quantity selector switch

3 Fuel quantity indicator

4 Refuel valve indicator light

5 Work light

6 Power on light

(4) Operation

(a) Power for pre-check panel from 28 volt switched battery bus

(b) Power applied to panel when refuel Station switch turned on

(c) Turning pre-check panel switch on causes the following to occur:

1 28 volts operates aft inter-tank area shutoff valves to open and lights indicator lamps

2 All high level shutoff valve switches armed

3 28 volts supplied to fuel quantity indicator inverter

4 Power supplied to fuel quantity switch box

5 Power light comes on

6 Power supplied to work light switch

(d) With high level shutoff valve control switches in flow, fuel flows to tanks

(e) Placing all tests to primary or secondary off, operates respective solenoid and stops fuel flow to all tanks (approximately 4 seconds)

(f) Each tank can be controlled by individual switch

k. Refuel shutoff valves (P/N 114PS494)

(1) Location

(a) Two valves in system

(b) One in aft left inter-tank area

(c) One in aft right inter-tank area

(2) Function

(a) Allow refueling of aft aux tanks

(b) Prevent cycling of fuel in aft tank system when in normal operation

(3) Construction

(a) Construction similar to engine and cross-feed valves

(4) Operation

(a) Valves are operated by 28 volts DC from switched battery bus

(b) For normal operation the valves are closed

(c) Power goes through refuel Station switch, OFF, to pre-check panel and to valves

(d) Placing refuel switch to ON and pre-check panel power switch to ON, operates valve to open

(e) Placing either switch to OFF closes valve

l. Jet Pump (114PS413)

(1) Location

(a) Inside of main tank fwd access panel

(2) Function

(a) Evacuate fuel from fuel cross-over line in floor

(3) Specification

(a) Motive flow - 30 psig from 3/8 dia line

(b) Flow rate - .50 gpm minimum flow rate

(4) Construction

(a) Aluminum material

(b) Check valve operation

(c) One half pound

(5) Operation

(a) Works in conjunction with boost pump to evacuate pressure refueling lines

m. Vent System

(1) Location

(a) In each fuel tank

(2) Function

(a) To allow air to enter fuel tank during normal fuel usage, as well as, allow air to escape during pressure refueling.

(b) In the event of fuel tank inversion, the system's crashworthiness allows tank to vent.

(3) Specification & Construction

(a) Aluminum tubing routed within tank so that spillage through the vent system is at a minimum, irrelevant of tank orientation.

(b) Two vent boxes are an integral part of plumbing at top of tank

1 The function of the box is to keep vent system open to atmospheric pressure by trapping sloshing fuel as a result of different orientations of the fuel cells during flight maneuvering.

2 Aluminum material

(c) Vent system is open to atmospheric pressure at two places per tank

1 Open vent line routed through frangible fitting located on aft access panel of fuel tank.

2 Through drain valve in bottom of tank via second poppet drain valve.

2 Second poppet drain valve allows for closing off access to vent system from bottom of tank during water landing.

n. Fuel Quantity Switch Box (P/N 114E2255)

(1) Location

(a) In cabin area Station 232 overhead

(2) Function

(a) To switch fuel quantity signals from cockpit to refuel Station when refuel Station selected on overhead panel

(b) Disconnects AC voltage from cockpit indicator

(3) Construction

(a) Metal box with cover

(b) Contains three relays

(3) Placing refuel Station switch to on puts 28 volts DC from switched battery bus through pre-check panel to switch box.

o. Inverter (P/N MS16057-3) Solid State

(1) Location

(a) Located in cabin right side Station 283 WL38

(2) Function

(a) Supply AC voltage to fuel quantity indicator at refuel Station

(3) Specifications

(a) Input voltage 23 to 34 volts DC

(b) Output 115 volts AC $\pm$2.5 volts

(c) Single-phase 400 $\pm$ 7 HZ

(d) Output steady two seconds after input applied

(4) Construction

(a) 4.5 inches by 5 inches by 7 inches

(b) Solid state - no moving parts

(c) Weighs approx. 5 pounds

(5) Operation

(a) Operates on 28 volts from switched battery bus

(c) Output - 115 volts 400 HZ single-phase to pre-check panel fuel quantity indicator.

p. Thermistor

(1) Location

(a) Ten thermistors in fuel system

(b) Two on each aux pump

(c) One on each center tank fuel quantity tank unit

(2) Function

(a) Aux pump thermistors control pump operation

1 When fuel reaches lower unit, it shuts pump off. When fuel covers upper unit, it allows pump operation.

2 Prevents fuel-washing action on lower unit from cycling pump.

(b) Main tank thermistors control low level warning light in master caution panel.

(3) Operation

(a) When fuel in main tanks is low enough to uncover thermistor, it warms and changes resistance.

(b) Change causes transistor switch to cut-off and deactivate relay, lighting warning light.

(c) When both thermistors on pumps are uncovered, the action is the same as low level warning.

q. Fuel quantity tank units (114PS471 & 114PS472)

(1) Location

(a) Ten units in fuel quantity system

(b) One in each aux tank (four total)

(c) Three in each main tank (six total)

(2) Function

(a) Provides signal to fuel quantity indicating system

(3) Construction

(a) Two cylindrical tubes, insulated from each other, to form a capacitor.

(4) Operation

(a) Air and fuel act as dielectric and capacitance changes as amount of fuel decreases.

(b) This change is reacted on by servo that drives indicator as it balances bridge.

2. System operation

a. Airframe fuel system

(1) Fuel pumps supplied 115V AC 3-phase power

(2) Power controlled by relays in each circuit

(3) Operation for left fwd main pump follows:

(typical for all main pumps)

(a) 28 volts DC from No. 1 DC bus to overhead panel

(b) 115 volts AC from No. 1 AC bus to relay box on left side of cabin.

(c) Placing left fwd main pump switch to ON, directs DC to relay box and closed relay.

(d) AC voltage then applied to main left fwd pump.

(e) Fuel pumped to left engine through engine shutoff valve.

(f) Valve is open and DC power is applied from engine No. 1 fuel shutoff valve circuit breaker, No. 1 DC bus to No. 1 fire handle.

(g) Pulling handle powers close side of valve and stops fuel flow to engine.

(h) Pressure switch will be open and left fuel pressure warning light will be out.

(i) Fuel pressure below 10 psi will cause light to come on.

(j) Fuel supply may be directed to No. 2 engine through cross-feed valves.

(k) Operated on 28 volts DC from No. 1 DC bus.

(l) Operating switch on overhead panel to open operates valves to open position.

(m) This will put right fuel pressure warning light out.

(4) Operation for left fwd aux pump follows:

(typical for all aux pumps)

(a) 28 volts DC from No. 1 DC bus to overhead panel.

(b) 115 volts AC from No. 1 AC bus to relay box on left side of cabin.

(d) Placing left fwd aux pump switch to ON, directs voltage to left hand pump thermistor control unit.

(e) If both thermistors on fuel pump are covered, voltage continues through control unit to relay boxes and closes relay.

(e) AC voltage then applied to fwd aux pump.

(f) When both thermistors are uncovered, pump control voltage does not continue through control unit.

(g) Fuel will then be transferred to main tank if high level shutoff valve floats are down.

(h) Bus voltage also applied to aux pressure warning light.

(i) With pressure over 10 psi, in pressure switch, no path for warning light ground.

b. Single-point pressure fueling

(1) Power supplied from switched battery bus.

(2) Voltage to overhead panel and pre-check panel

(a) On overhead panel to refuel station switch

(b) At pre-check panel, to refuel shutoff valves, close side.

(3) When refuel switch is ON, voltage to pre-check panel power switch

(4) Turning power switch to ON causes following:

(a) Refuel valves open

(b) Fuel quantity switch box operated

1 Switches signal to pre-check panel

2 Disconnects AC to cockpit indicator (if powered)

(c) Inverter powered - supplies AC to fuel quantity indicator

(d) All shutoff valve test switches armed

(e) Power light on

(f) Panel light switch armed

(5) High-level shutoff valves may be checked individually or collectively.

(6) Fueling can be controlled with switches and watching fuel quantity indicator.

c. Fuel quantity indication system

(1) Power supplied by No. 1 AC bus for indicator.

(2) 28 volts DC for fuel quantity control from No. 1 DC bus.

(3) Tank units provide signals to selector switch.

(4) Switch in total, all signals to indicator.

(5) Drive servo-motor to balance bridge and give total fuel remaining on digital readout.

(6) Switch to individual tank, provides signal to indicator.

(7) Drives pointer on indicator to indicate fuel remaining in tank selected.

(8) Low level warning illuminated when approx. 370 lbs. fuel remain in tank.

CHAPTER 11

FLIGHT CONTROLS SYSTEM

SECTION I

FLIGHT CONTROLS SYSTEM

DESCRIPTION AND OPERATION

Flight Controls

A. Description

1. The helicopter is controlled by changing the pitch of the blades either collectively or cyclically. Pitch changes are made by the pilot's movement of the flight controls which include a thrust control, a cyclic control stick, and directional pedals. The pilot's controls are interconnected with the copilot's controls.

   Flight control movements are transmitted through a system of bell-cranks, push-pull tubes, and actuators to a mixing unit just aft of the cockpit, next to the forward transmission. The control movements are mixed to give the correct lateral cyclic and collective pitch motions to the rotors through dual hydraulic actuators. These boost actuators are under each swash plate. Each set of dual actuators is normally powered by both flight control hydraulic systems.

2. Vertical Control

   Vertical control is achieved by collective pitch (thrust); moving the thrust control up increases the pitch of both rotors equally.

3. Lateral and Directional Control

   Roll control is achieved by tilting the rotors laterally by an equal amount in the same direction using the cyclic stick. Yaw control is achieved in the natural sense by tilting the rotors laterally in opposition by an equal amount using the yaw pedals.

4. Differential Collective Pitch

   Longitudinal control is achieved by differential collective pitch (DCP); moving the cyclic stick forward decreases the pitch of the forward rotor and increases that of the aft rotor and vice versa. A differential airspeed hold (DASH) system ensures that a positive stick gradient is maintained throughout the speed range. Longitudinal cyclic trim is incorporated to enable the aircraft to be flow throughout the speed range in a substantially level attitude, thereby reducing drag and stress on the rotor shafts.

B. Thrust Control

Either thrust control is used to apply equal pitch simultaneously to both rotors, thus controlling ascent and descent of the helicopter. Raising thrust control increases pitch. Lowering thrust control decreases pitch. An integrated lower control actuator (ilca) is installed between the thrust control and the mixing unit. This actuator assists the pilot in moving the thrust control. A cockpit control driver actuator (ccda) is also installed in the thrust control system. This actuator responds to signals from the AFCS and increases or decreases collective pitch on the blades to maintain a constant altitude. In addition, a balance spring is installed that counteracts the downward imbalance of the thrust control. A detent capsule establishes a ground operation detent to reduce droop stop pounding. A viscous damper in the thrust control system improves control feel. The thrust control is also electrically linked to the power turbine actuator through the droop eliminator system. An upward movement of the thrust control electrically increases the power turbine governor speed setting to compensate for inherent engine droop and maintain engine speed as rotor loads are increased. A downward movement of the thrust control electrically decreases the power turbine governor speed setting. Mounted on each thrust control is an auxiliary switch bracket containing a searchlight control switch, a searchlight filament switch, and the two engine beep trim switches.

C. Thrust Control Brake Switches

A trigger switch under each thrust control grip controls the magnetic brake of the collective cockpit control driver actuator (ccda) in the flight control closet. Pressing the switch applies electrical power to release the magnetic brake in the actuator. The thrust control can then be freely moved. With barometric or radar altitude hold selected, squeezing the trigger disables altitude hold. The AFCS will hold the altitude at the time the trigger is released. When the switch is released, the magnetic brake is applied, holding the thrust control in position. Current is supplied to the thrust control magnetic brake from the essential dc bus through the THRUST BRAKE circuit breaker on the No. 2 power distribution panel. Should the magnetic brake malfunction, the magnetic brake will slip at a predetermined force between 7 and 20 pounds.

D. Cyclic Control Sticks

Each cyclic control stick is used for lateral and longitudinal control of the helicopter. Moving the stick to the right tilts both rotor disks equally to the right and causes the helicopter to roll to the right in flight. Moving the stick to the left causes the opposite movement. Moving the stick forward simultaneously decreases pitch of the forward rotor blades and increases pitch of the aft rotor blades, causing a nose-down helicopter attitude in flight. Moving the stick aft causes the opposite movement resulting in a nose-up attitude. Two integrated lower control actuators (ilcas), one for lateral control and one for longitudinal control, are installed to assist the pilot in moving the stick. In addition to these actuators, viscous dampers are installed. One damper is for longitudinal control and one for lateral control to improve control feel.

Located on the pilot's and copilot's cyclic control stick grips are a centering device release switch, an AFCS trim switch, a cargo hook release switch, inter-phone transmitter trigger switch, and a flare dispenser control switch.

E. Cyclic Grip Switches

1. Centering Device Release Switches

The centering device release switches, marked CENTERING DEVICE RELEASE, are on each cyclic control stick. The button switch is used to simultaneously release the force feel trim magnetic brakes for the lateral, the longitudinal, and the directional flight controls and disengages bank angle, heading hold and heading select functions when AFCS is operating. A centering spring and a magnetic brake for each control provide a sense of force feel to hold the control in a trim position. However, the pilot can override the force manually while maneuvering the helicopter. When the switch is pressed, electrical power is applied to release the magnetic brake switch centering spring assumes a new trim position where the control forces are nulled. Releasing the switch removes electrical power and applies the magnetic brakes; the centering springs are retained in their new positions. Power to operate the magnetic brakes is supplied by the 28-volt switched battery bus panel. The magnetic brake for longitudinal control is in the longitudinal cockpit control driver actuator.

2. AFCS Trim Switches

The AFCS trim switches are on each cyclic control stick. The switches are used to make small changes in pitch (airspeed) and roll attitude while the AFCS is operating. The switches are spring-loaded to center off position. Moving the switch forward or aft from center off position commands an increase (forward) or decrease (aft) in airspeed by driving a trim motor in the longitudinal ccda. Moving the switch left or right commands the roll ilca to bank the helicopter in the selected direction without moving the stick. Pumps to drive the pitch trim motor is from the 115-volt No. 1 AC bus through the COLL DRIVER ACT circuit breaker on the No. 1 power distribution panel.

F. Directional Pedals

The directional pedals are used for directional control of the helicopter during flight and while taxiing with the forward gear off the ground. When the right pedal is displaced forward, the forward rotor disk tilts to the right and the aft rotor disk tilts to the left. The opposite action occurs when the left pedal is displaced forward. An integrated lower control actuator is installed to assist the pilot in moving the pedals. The pedals are adjusted individually fore and aft by depressing a lever mounted on the pedal support and moving the pedal to a new position before repositioning the lever. A balance spring is installed to stop pedal creep. A viscous damper is installed to reduce control sensitivity.

G. First and Second Stage Mixing Units

The mixing complex combines a first stage mixing unit above the controls closet area and a second sage mixing unit aft of the forward transmission mounting structure. The pitch, roll, yaw, and collective control movements accumulated from the cockpit controls and controls closet, are integrated by the mixing complex and reduced to two control outputs, lateral cyclic and collective pitch, which are transmitted from the second stage mixing unit to the forward and aft swash plates.

H. Tunnel and FWD and Aft Pylon Control Runs

Integrated control movements are transmitted to the forward upper boost actuators and via push-pull tubes in the tunnel fairing, bell cranks, and links in the aft pylon to the aft upper boost actuators.

I. Rotor Head Controls

1. Swash Plates

The lateral axis of each fixed swash plate is controlled by the left and right upper boost actuators. The fore and aft axis is controlled by two links, one link is of fixed length, the other link is a longitudinal cyclic trim (LCT) actuates both links pivot on a hinged yoke. This four-point mounting ensures that the required fore and aft tilt on the swash plate is maintained for any pitch, roll, yaw, or collective input from the cockpit controls.

2. Swash Plates and Pitch Change Rods

The rotor disks are controlled conventionally via fixed and rotating swash plate assemblies control pitch change rods to each blade pitch change arm on the rotor head.

J. Longitudinal Stick Position Indicator

A cyclic stick longitudinal position indicator, fitted below the AIR CONTROL handles to the right of the canted console, is mechanically linked to a pitch input bell crank. The indicator, calibrated in inches and marked F (forward), N (neutral), and A (axial) displays cyclic stick position forward or aft of a neutral datum point. The indicator is rigged to display netural position (N) when the aircraft is in a free air hover with a neutral cg and AFCS engaged.

K. Longitudinal Cyclic Trim Actuators

The LCT actuators are positioned aft of the fixed links on the yoke controlling each fixed swash plate that extension of an actuator causes its associated rotor disk to tilt forward. The programming of the LCT is normally controlled automatically through the AFCS but manual control is available by setting the CYCLIC TRIM AUTO/MANUAL switch to MANUAL and operating the associated switches in the desired sense. CYC TRIM indicators on the center instrument panel indicate the position of the associated actuator. When the aircraft is on the ground the actuators must be set to GND on the indicators; this sets the plane of the disk normal to the next to minimize droop stop pounding. Speed restrictions are imposed if the actuators are not functioning. With the CYCLIC TRIMAUTO/MANUAL switch set to AUTO, the LCT actuators are supplied through the CYCLIC FWD ACT (No. 1 PDP) and CYCLIC TRIM AFT (No. 2 PDP) circuit breakers from the No. 1 and No. 2 DC bus bars, respectively. With the switch set to MANUAL, power is supplied through the TRIM MAN (No. 1 PDP) circuit breaker from the No. 1 DC bus bar.

L. Cruise Guide Indicator System Description

1. The cruise guide indicator system gives the pilot, a visual indication of actual loads imposed on critical components of the helicopter dynamic system. The system allows the pilot to achieve maximum helicopter utilization under various conditions of payload, altitude, airspeed, ambient temperature and center-of-gravity. The system consists of strain gages bonded to fixed links in the forward and aft rotor controls, an indicator, a signal processor unit in the aft pylon, a signal conditioner unit in the forward pylon, and interconnecting wiring. The system measures alternating stress loads and displays the larger of the two signals. The system is powered by No. 2 28-VDC bus through the CRUISE GUIDE circuit breaker on the No. 2 power distribution panel.

2. Cruise Guide Indicator

The cruise guide indicator is on the pilot's instrument panel. Three bands are displayed on the dial face of the indicator. Operation in the red-and-yellow striped band shall be avoided. Immediate corrective action must be taken to reduce stress. This can be accomplished by lowering thrust, reducing airspeed, releasing back pressure on the cyclic stick, or by reducing the severity of the maneuver.

3. Cruise Guide Indicator Test Switch

The cruise guide indicator test switch is on the pilot's instrument panel, on the left side of the indicator. It is a three-position switch, spring-loaded to center. The switch is marked CGI TEST, FWD, and AFT. When the switch is moved from center position to each test position, the pointer should indicate within the white test band. The white test band indicates proper system operation.

NOTE: Do not test the cruise guide system with rotors turning. False indications will result.

The test circuit tests the circuits from the strain gages to the indicator. However, separation of the bond of the strain gage to a link will not be detected by the test function. The narrow white line towards the high end of the void band is used for calibrating the indicator during bench test.

M. Flight Control System Changes From CH-47C to CH-47D

1. Longitudinal Stick Position Indicator

a. Location

(1) The longitudinal stick position indicator is on the right hand side of the canted console, centered at Station 55, WL-7, BL 9 R.

(a) The indicator assembly, cable support tube and operating cable extended from Station 58, WL-8, BL 9 R, forward to Station 40, and aft to Station 56, WL-26 BL 24 R, pilot's pitch bell crank attaching point.

(b) Access to the longitudinal stick position indicator is gained by removing:

1 The access panel from the RH side of the canted console.

2 The pitch control stick boot and the adjacent floor access panels.

b. Function

The stick position indicator references the position of the longitudinal pitch control stick relative to the neutral rig position.

c. Specification

d. Construction

(1) Consists of a cable supported in a tube assembly?

(a) Connected to the telescoping rod at the input end.

(b) Terminates in an indicator tube at the panel end.

(2) The telescoping rod is attached:

(a) To the cable/tube assembly by means of a swivel assembly.

(b) To the pilot's pitch bell crank by a rod end.

(3) The indicator is indexed to show the stick position by means of a pointer within the transparent polycarbonate tube. A removable cap contains a lamp for illumination.

e. Operation

(1) Longitudinal motion of the pilot's pitch control stick results in a corresponding movement of the pilot's pitch input bell crank.

(2) The longitudinal stick position indicator, attached to the pitch input bell crank, references the relative motion of the pitch control stick from the neutral stick position.

N - Hover Position Crosswind

2. Flight Controls Pallet Installation, Station 95.0

a. Location

(1) The pallet containing the thrust and yaw secondary controls is mounted on Station 95, WL-17 to WL-10, BL 8 L to BL 18 L airframe structure.

(2) Access to the pallet installation is made by removing the Station 95 to Station 120 closet panel and blanket assemblies.

b. Function

(1) The thrust and yaw pallet assembly contains secondary controls that provide:

(a) Artificial feel (centering spring, magnetic brake).

(b) Control position balancing (balancing springs)

(c) Control centering trim (magnetic brake).

(d) Controls dampening (viscous damper).

(e) Thrust 3° detent position (detent capsule).

(f) Droop elimination (droop elim. potentiometer)

(g) Precise control position information for No. 1 and No. 2 AFCS. (Control position transducers)

(3) A thrust cockpit control driver actuator (CCDA) to provides inputs to the thrust axis on a command from No. 1 AFCS. This signal trims the thrust to maintain a selected altitude.

c. Specification

d. Construction

(1) The controls pallet assembly is mounted on the Station 95 airframe structure.

(2) It can be removed for servicing any of the components attached to it without disturbing the rigging settings.

(3) The pallet is constructed of aluminum honeycomb core with alum skin.

(4) Two control links from the cockpit transfer bell cranks extend up to attach to the thrust and yaw, idler bell cranks on the pallet.

(5) The idler bell cranks provide lower attaching points for the:

(a) Centering spring

(b) Control position transducers

(c) Viscous damper linkages

(d) Droop eliminator potentiometer

(e) Thrust detent arm

(f) Thrust CCDA linkage.

(6) The yaw centering spring attaches directly to the magnetic brake.

(7) The yaw CPT attaches to a support bracket at the bottom of the pallet.

(8) The thrust viscous damper arm is attached to a link connected to the idler bell crank.

(9) The yaw viscous damper connects to the yaw centering spring and magnetic brake through a link.

(10) The dampers are bolted to the pallet structure.

(11) The droop eliminator potentiometer pivots on a support mounted on the pallet structure.

(12) The thrust detent is mounted on a support in the center of the pallet.

(13) The thrust CCDA is mounted on the pallet structure. A link connects the CCDA arm to the idler bell crank.

(14) The yaw balance spring attaches to the idler bell crank and to an adjustable strap at the top end.

(15) The magnetic brake consists of:

(a) An electromagnetic coil

(b) Brake and clutch discs

(c) A spring

(d) A gear cluster

(e) A gear shaft

(f) A crank arm

(g) A housing

(h) The arm is held in position by the brake and clutch discs through spring pressure.

(i) When 28-VDC is applied to the coil the spring pressure is removed. The arm is free to move to a new position.

(16) The thrust CCDA consists of an:

(a) output arm

(b) housing

(c) magnetic brake

(d) servo motor

(e) synchro control transformer

(f) servo amplifier

(g) output clutch

(h) duplex clutch

(i) gear train

(j) planet gears

e. Operation

(1) The pallet assembly contains

(a) the centering springs

(b) the balancing springs

(c) the magnetic brakes

(d) the viscous dampers

(e) the thrust detent capsule

(f) the droop eliminator potentiometer

(g) the control position transducers (CPT)

(h) the cockpit control driver actuator (CCDA)

(2) Artificial feel, required due to normal feel being lost due to hydraulic assist, is provided by:

(a) yaw centering spring

(b) yaw magnetic brake

(3) The centering spring is compressed in the neutral position to a specific pre-load for a particular axis.

(a) The centering spring trim position is controlled by the Centering Device Release Switch mounted on the Cyclic Control Stick.

(b) When the switch is depressed, the magnetic brake holding the centering spring trim is released, and the centering spring re-references to a new trim position as the switch is closed, re-engaging the magnetic brake.

(4) The magnetic brake is normally on.

(a) To release the magnetic brake, the Centering Device Release Switch is depressed applying 28-VDC to the internal coil to release spring pressure on the brake.

(b) The release of the magnetic brake permits the centering spring to assume a new trim position in pitch roll or yaw axis.

(5) The balancing springs are required to balance the pitch, roll, and yaw controls around the neutral position.

(a) The thrust balancing spring counteracts the downward imbalance of the thrust controls.

(b) The springs are attached to straps which permit adjustment to set the controls:

1 to correct for minor thrust control unbalance above the ground operation detent.

2 to correct for breakout force inconsistencies.

(6) A viscous damper is installed in each axis to dampen the motion between the pilot's controls and the hydraulic assist when the magnetic brake is released. If controls are out of trim and centering device is depressed - prevents abrupt movement of controls to trim position.

(7) A thrust detent capsule is required to provide a detent at the 3° position to prevent droop stop pounding during ground operation. The detent is operated by a striker bolt mounted on a bracket attached to the thrust idler.

(8) A droop eliminator potentiometer is provided to counter lag in the engine response to power requirement changes, caused by thrust control movement.

(9) Control position transducers are attached to the yaw transfer bell crank. Two linear variable differential transducers within the CPT sense pilot induced control motion. One LVDT sends the motion signal to No. 1 AFCS computer, the other LVDT advises No. 2 AFCS computer of the controls motion.

(10) The thrust CCDA is driven by a command from No. 1 AFCS.

(a) The thrust CCDA maintains a selected altitude by trimming the thrust axis of the flight controls.

(b) The thrust CCDA also includes a magnetic brake which holds the thrust lever in a selected position.

(c) The magnetic brake is normally on. The brake is released by the depression of the Thrust Control Brake Trigger mounted on the thrust control levers. This permits the thrust control lever to be moved to a new position and held by the magnetic brake as the trigger switch is released.

(d) A slip clutch is installed to permit the drive arm to slip between 7-20 pounds with the magnetic brake engaged.

(11) Two idler bell cranks apply control motion to the thrust and yaw secondary controls mounted on the Station 95 pallet.

(12) Links attach the idler bell cranks to the cockpit transfer bell cranks

3. Flight Controls Pallet Installation Station 120.0

a. Location

(1) The pallet containing the pitch and roll secondary controls is mounted on the Station 120, WL-17 to WL-10, BL 8 L to BL 18 L airframe structure.

(2) Access to the pallet installation is made by removing the Station 95 to Station 120 closet panel and blanket assemblies.

b. Function

(1) The pitch and roll pallet assembly contains secondary controls that provide:

(a) artificial feel (centering spring, magnetic brake)

(b) control position balancing (balance springs)

(c) control centering trim (magnetic brake)

(d) controls dampening (viscous damper)

(e) precise control position information for No. 1 and No. 2 AFCS (control position transducers)

(2) A pitch cockpit control driver actuator (CCDA) serves two functions:

(a) The actuator is controlled by the cyclic beep switch to trim the longitudinal pitch axis of the flight controls.

(b) The magnetic brake section is released by the Centering Device Release Switch to reposition the cyclic control stick. Disengaging the switch permits the control stick to be held by the magnetic brake in the new trim position.

c. Specification

d. Construction

(1) The controls pallet assembly is mounted on the Station 120 airframe structure.

(2) It can be removed for servicing any of the components attached to the pallet without disturbing rigging settings.

(3) The pallet is constructed of aluminum skin with aluminum honeycomb core.

(4) Two control links from the cockpit transfer bell cranks extend up to attach to the pitch and roll idler bell cranks on the pallets.

(5) The idler bell cranks provide lower attaching points for the:

(a) centering springs

(b) control position transducer

(c) viscous damper linkages

(6) The roll centering spring attaches directly to the magnetic brake.

(7) The pitch centering spring attached to the CCDA.

(8) The pitch and roll CPTs attach to a support bracket at the bottom of the pallet.

(9) The pitch and roll viscous damper arms are attached to links extending up from the respective idler bell cranks.

(10) The pitch and roll axis viscous dampers bolt directly to the pallet assembly.

(11) The pitch CCDA is mounted on the pallet structure, the arm is attached to the pitch centering spring.

(12) Pitch and roll balance springs attach to the idler bell crank at one end and an adjustable strap mounted on the pallet structure at the top end.

(13) The pitch CCDA consists of an:

(a) Output arm

(b) Housing

(c) Magnetic brake

(d) Trim motor

(e) Gear train

(f) Planet gears

e. Operation

(1) The pallet assembly contains:

(a) The centerline springs

(b) The balancing springs

(c) The magnetic brakes

(d) The viscous dampers

(e) The control position transducer (CPT)

(f) The pitch cockpit control driver actuator

(2) Artificial feel, required due to normal feel being lost due to hydraulic assist, is provided by:

(a) A pitch and roll centering spring

(b) A pitch CCDA

(c) A roll magnetic brake

(3) The centering spring is compressed in the neutral position to a specific pre-load for a particular axis.

(a) The centering spring trim position is controlled by the Centering Device Release Switch mounted on the cyclic control stick.

(b) When the switch is depressed, the magnetic brake holding the centering spring trim is released, and the centering spring re-references to a new trim position as the switch is closed, re-engaging the magnetic brake.

(4) The magnetic brake is normally on.

(a) To release the magnetic brake, the centering device release switch is depressed applying 28-VDC to the internal coil to release spring pressure on the brake and clutch discs.

(b) The release of the magnetic brake permits the centering spring to assume a new trim position in pitch roll or yaw axis.

(5) The CCDA in pitch axis serves two functions.

(a) The actuator is controlled by the cyclic beep switch to trim the longitudinal pitch axis of the flight controls.

(b) The magnetic brake section is released by the centering device release switch to reposition the cyclic control stick. Disengaging the switch permits the control stick to be held by the magnetic brake in the new trim position.

(6) The balancing springs are required to balance the pitch and roll controls around the neutral position.

(a) The springs are attached to straps which permit adjustment to set the controls:

<u>1</u> Around the pitch and roll control stick and directional pedals neutral position.

<u>2</u> To correct for breakout force inconsistencies.

(7) A viscous damper is installed in each axis to dampen the motion between the pilot's controls and the hydraulic assist when the magnetic brake is released.

(8) Control position transducers are attached to the pitch and roll transfer bell cranks. Two linear variable differential transducers within the CPT sense pilot induced control motion. One LVDT sends the motion signal to No. 1 AFCS computer, the other LVDT advises No. 2 AFCS computer of the controls motion.

(9) Two idler bell cranks apply control motion to the pitch and roll controls mounted on the Station 120 pallet.

(10) Links attach the idler bell cranks to the cockpit transfer bell cranks.

4. Intermediate Bell Crank Installation

a. Location

(1) Two intermediate bell cranks, in thrust and yaw axis, attached to the ILCA output arms, rotate about a shaft secured to the aircraft structure at Station 100, WL-37, BL 11 L to BL 15 L. The pitch and roll intermediate bell cranks attach to a bracket at Station 119, WL-37, BL 11 L to BL 15 L.

(2) Access to the ILCA actuators and intermediate bell cranks is made by:

(a) Removing the Stations 95 to 120 control closet backup panel.

(b) Removing the forward transmission drip pan.

b. Function

(1) The intermediate bell cranks transfer the pitch, roll, yaw, and thrust control motion from the ILCA actuators to the first stage mixing unit.

c. Specification

d. Construction

(1) The identical aluminum alloy thrust and yaw bell cranks, situated above the ILCA actuators, connect to the first stage bell cranks by direct links.

(2) The pitch and roll aluminum alloy are similar, but not identical. They are positioned above the ILCA actuators and connect directly to the first stage bell cranks by a single link.

e. Operation

(1) Operation of the ILCA output arm in either of the four axis by the boost actuator or the extensible link will cause the intermediate bell crank to actuate the first stage bell crank.

5. First stage Mixing Installation

a. Location

(1) The first stage mixing linkage bell crank pivot point is at Station 116, WL-51, BL 11 L to BL 15 L.

(2) Access to the mixing control linkage is made by:

(a) Removing the Station 95 to 120 control closet backup panel.

(b) Opening the forward work platforms on the LH side.

b. Function

(1) The first stage mixing provides differential control mixing.

c. Specification

d. Construction

(1) The first stage mixing unit consists of two bell cranks containing two small bell cranks.

(2) The two internal bell cranks pivot on ball bearing shafts.

(3) The aluminum thrust and yaw bell cranks pivot on bearings which are centered on steel mounting shafts.

(4) The shaft is secured in airframe structure brackets. Spacers on the shaft hold the bell cranks in correct alignment.

e. Operation

(1) The first stage mixing has two large bell cranks with four small bell cranks to provide differential control mixing.

(2) The ILCA output control motion in four axis, pitch, roll, thrust, and yaw, is converted to two differential control outputs by the first stage mixing unit.

(3) The two upper first stage output bell cranks consist of:

(a) A pitch thrust axis

(b) A roll yaw axis

6. Forward Pylon Controls Installation

a. Location

(1) The forward pylon controls are located in the forward pylon area.

(a) Control links extending forward from the second stage mixing complex attach to the forward pylon control bell cranks located at Station 92, WL-59, BL 13 L (for the swiveling actuator) and BL 13R (for the pivoting actuator).

(2) Access to the forward upper controls, longitudinal cyclic trim actuator, fixed link and mounting yoke is made by opening both forward work platforms.

b. Function

(1) Control inputs from the second stage mixing unit operate:

(a) On the LH side, a bell crank which moves the control rod to the swiveling actuator control valve, resulting in a hydraulic reaction.

(b) On the RH side, a bell crank which operates the pivoting actuator control valves resulting in proportional hydraulic reaction.

c. Specification

(1) Dual pivoting and swiveling actuator.

(a) Type of operating oil: MIL-H-83282

(b) Operating pressure: 3,000 psi

d. Construction

(1) The support assemblies for the pivoting and swiveling actuator control bell cranks attach to the forward transmission housing.

(2) The pivoting and swiveling actuators mount to lugs machined in the forward transmission upper cover.

e. Operation

(1) A connecting link extends forward from the LH second stage output bell crank to the forward pylon controls bell crank.

(a) A connecting link attaches the bell crank to the forward swiveling actuator control valve.

(b) A connecting link extends from the RH second Stage output bell crank to the second stage walking beam.

(c) A connecting link extends forward to attach to the forward pylon controls bell crank.

(d) A connecting link attaches the bell crank to the pivoting actuator control valve.

(2) Operation of the linkage results in dual actuator control valve displacement causing cylinder extension or retraction.

7. Longitudinal Cyclic Trim Controls, Forward

a. Location

(1) The forward longitudinal cyclic trim actuator, the fixed link and the yoke to which they are attached, are located in the forward pylon, at Station 108, WL-76, BL 8 L, mounted on the forward transmission.

(2) Access to the forward long cyclic trim controls is made by opening the forward work platforms.

b. Function

(1) The Fwd actuator is controlled by AFCS input, but can be switched to manual operation.

(2) The Fwd actuator, in conjunction with the dash actuator, controls stick gradient and provides a level fuselage during flight.

c. Specification

d. Construction

(1) The Fwd electromechanical actuator and steel fixed link are attached:

(a) At their upper ends to the Stationary swash plate.

(b) At their lower ends to the long cyclic yoke.

(2) The attaching bolts are the positive retention type.

(3) The titanium yoke rotates on a shaft supported on the upper cover of the forward transmission.

(4) The fixed link is strain gaged for cruise guide indication operation.

(5) The fixed link and Fwd actuator have an adjustable rod end bearing for rigging.

e. Operation

(1) Without an input from AFCS, the fixed link, Fwd actuator and yoke move in conjunction with the Stationary swash plate.

(2) With an AFCS input, the Fwd actuator retracts or extends changing the swash plate and the rotary wing blade incidents.

(3) Normal Fwd actuator operation is controlled by the AFCS when the switch is in AUTO.

(a) If the Fwd actuator fails to extend or retract, as shown on the cyclic trim indicator, MANUAL mode can be selected.

(b) In MANUAL mode, the actuator can be controlled by the FWD actuator control switch, using the airspeed indicator and the cyclic trim indicator.

8. Cruise Guide Indication System

a. Location

(1) The indicator and test switch is located on the pilot's instrument panel.

(2) A strain gaged fixed link at the forward and aft upper controls.

(3) A signal processor for the aft strain gaged link mounted in the aft pylon at Station 582, WL 122, BL 13 R.

(4) A signal conditioner controlling the forward fixed link signals, mounted in the forward pylon at Station 120, WL 58, BL 13 R.

b. Function

(1) The cruise guide indication system provides a visual indication of actual loads imposed on critical dynamic components during various flight conditions.

c. Specifications

d. Construction

(1) The forward and aft steel fixed links are not interchangeable.

(2) Strain gages, bonded to each fixed link, attach to connectors through shielded cable.

(3) The fixed link has an adjustable rod end bearing for rigging purposes.

e. Operation

(1) The pilot monitors the cruise guide indicator which will advise him of the rotor loads imposed.

(2) The cruise guide indicator dial has three bands.

(a) Normal Flight - green band

(b) Transient Flight - yellow band

(c) Avoid Flight - red/yellow band

(d) Transient operation is permitted in the yellow zone, but corrective action should be taken to reduce stress and return the pointer to the green band.

(e) Operation in the red and yellow striped band shall be avoided.

<u>1</u> Immediate action must be taken to reduce stress by:

<u>2</u> Lowering Collective Pitch

<u>3</u> Reducing Airspeed

<u>4</u> Releasing back pressure on the cyclic stick

<u>5</u> Or reducing the severity of the maneuver

(3) The CGI test switch has three positions, spring-loaded to center. When the switch is moved to FWD or AFT test positions, the pointers should indicate within the white band on the CGI dial.

(a) The test position develops a test signal that is amplified and sent to the indicator. The needle moving to the white test band verifies system serviceability.

(b) The test switch should not be used with rotors turning as false indications could result.

(4) The signal circuits work in the following maneuver:

(a) An increase or decrease of the load on the forward or aft fixed link unbalance the strain gage bridge circuit.

(b) This sends a signal, proportional to stress, from the forward link to the signal conditioner, and from the aft link to the signal processor.

(c) The signal from the forward link is then routed through the first and second stage amplifiers, then to the peak to peak detector in the signal processor.

(d) Both the aft and the forward peak to peak signals are compared and the peak detector selects the highest amplitude signal.

(e) This signal is routed through the driver circuit to the CGI meter.

(f) The CGI meter then displays a readout that is proportional to actual rotor load.

SECTION II

ADVANCED FLIGHT CONTROL SYSTEM

DESCRIPTION AND OPERATION

AFCS

A. Advanced Flight Control System - Description

The CH-47D Advanced Flight Control System (AFCS) stabilizes the helicopter about all axes. It automatically maintains desired airspeed, altitude, bank angle, and heading. Two complete systems are installed. With both systems operating, each system operates at half gain. If one (1) system fails, the remaining system operated at three (3) quarters gain to compensate for the failed system. The AFCS receives power from four AFCS circuit breakers (1AC, 2DC) located on the No. 1 and No. 2 power distribution panels.

The AFCS consists of the following components:

1. Cockpit control panel

2. Two (2) AFCS computers

3. Three (3) integrated lower control actuators (ILCA)

4. Two (2) differential airspeed hold (DASH) actuators

5. Two (2) longitudinal cyclic trim (LCT) actuators

6. Two (2) magnetic brakes (yaw and roll), a longitudinal cockpit control drive actuator (CCDA) and a collective cockpit control driver actuator.

7. Three (3) control position transducers (CPT)

B. Automatic inputs from the AFCS enter the flight control system by two means. One, in series, between the cockpit controls and the rotors, through the ILCA and the differential airspeed hold (DASH). These signals do not move the cockpit controls. Secondly, in parallel, with the collective controls through a collective cockpit control driver actuator (CCDA). These signals move the cockpit collective control.

The advanced flight control system provides the following modification and additions to the stability augmentation system (SAS) installed in earlier model CH-47 helicopters.

1. Continuous pitch attitude and, in the long term, airspeed hold referenced to the longitudinal control position throughout the flight envelope.

2. Long term bank angle and heading hold in level flight and bank angle hold about any stabilized bank angle in turning flight.

3. A stable longitudinal positive control gradient from maximum rearward to maximum forward flight speeds.

4. Vernier beep trim of bank angle and airspeed.

5. Radar and barometric altitude hold.

6. Coupled heading selected through the HSI bug error.

7. Cockpit control position transducers (control switch pick-offs) in the longitudinal, lateral, and directional control system to improve maneuverability.

8. The mechanical detent switches on the lateral and directional controls have been replaced by electronic signals derived from control position signals supplied to the AFCS.

9. Automatic longitudinal cyclic trim positioning to the ground mode when either aft wheels are on the ground.

AFCS - 1

1. Stabilization

   The AFCS provides rate stabilization in pitch, roll, and yaw and gives improved control response. Failure or de-selection of one system automatically increases the gain in the other system through the ILCA cross-feed-backs. Although in severe situations the reduced mechanical authority limits may be reached, in normal situations the enhanced response of the remaining system is practically as effective as that with both systems working.

2. Hold Facilities

   In addition to rate stabilization in pitch, roll, and yaw, the three channels plus the collective channel are capable of taking information from other sources to give airspeed, bank angle, turn-to-heading, heading and altitude holds.

3. AFCS Components and Sensors

   AFCS is a dual system with a single control panel, each system consists of an identical AFCS computer unit and a cyclic trim indicator. The control panel is located on the center console. The AFCS computer units are located in the cabin electronic compartment. The cyclic trim indicators are located on the center instrument panel.

1 - AFCS Controls and Indicators

Control/Indicator	Marking	Function
On AFCS Control Panel		
AFCS system selector switch	SYSTEM SEL-OFF/1/BOTH/ 2/OFF	Used to select or turn-off one or both AFCS units.
Barometric altitude hold engagement push button	BARO ALT	Selects the output of the altitude transducer in No. 1 AFCS unit as the signal source for altitude hold. When selected on, the ENGAGED caption on the button illuminates.

1 - AFCS Controls and Indicators (Cont'd)

Control/Indicator	Marking	Function
<u>On AFCS Control Panel</u> (Cont't)		
Radar altitude hold engagement push button	RAD ALT	Selects the radar altimeter signal as the signal source for altitude hold. When selected on, the ENGAGED caption on the button illuminates.
Heading select engagement push button	HDG	Use to provide automatic turn-to-heading selected on either pilot's HSI in conjunction with the associated MODE SELECT panel. When selected, the ENGAGED caption on the button illuminates.
LCT actuators control source selector switch	CYCLIC TRIM-AUTO/ MANUAL	Selects either automatic control by the AFCS units or manual control by the AFCS control panel FWD and AFT EXT/RET switches.
Forward LCT actuator manual control switch	CYCLIC TRIM-FWD EXT/RET	Used to manually extend or retract the forward LCT actuator.
Aft LCT actuator manual control switch	CYCLIC TRIM-AFT EXT/RET	Used to manually extend or retract the aft LCT actuator.

1 - AFCS Controls and Indicators (Cont'd)

Control/Indicator	Marking	Function
On Caution/Advisory Panel		
No. 1 and No. 2 AFCS Unit Caution Lights	No. 1 AFCS OFF No. 2 AFCS OFF	Illuminate when associated AFCS unit is turned off by SYSTEM SEL switch position or a hydraulic, electrical, vertical gyro, or internal logic failure occurs. Both lights may come on momentarily accompanied by a slight pitch transient when the SYSTEM SEL switch is set to BOTH following AFCS off flight. This indicates that the dash actuator is running at a reduced rate to null an airspeed error signal developed during AFCS off flight.
On Center Instrument Panel		
Cyclic trim indicators	AFT CYC TRIM-EXT/ RET/GND/KNOTS	Displays aft LCT actuator position.
	FWD CYC TRIM-EXT/ RET/GND/KNOTS	Displays forward LCT actuator position.
On Cyclic Stick Grips		
Centering Device release push button	CENTERING DEVICE RELEASE	Used to release yaw pedals, lateral cyclic and longitudinal cyclic magnetic brakes and provide a heading hold and attitude hold disengage signal to the AFCS unit.

1 - AFCS Controls and Indicators (Cont'd)

Control/Indicator	Marking	Function
On Cyclic Stick Grips		
Beep trim switch		Provides trim control of the longitudinal pitch axis through the longitudinal cockpit control driver actuator (CCDA) when the switch is moved fore or aft. Provides AFCS generated bank angle changes when the switch is moved left or right.
On Thrust Lever Grips		
Thrust brake release switch	THRUST BRAKE TRIGGER	Used to release the magnetic brake in the collective cockpit control driver actuator (CCDA). When pressed, the switch also provides a signal to No. 1 AFCS unit to disengage altitude hold.

4. AFCS Sensor Inputs

The following list contains the flight related sensor signals supplied to or located within the AFCS units for development of actuator command signals. The list also contains the sensors, the AFCS unit that receives the input and the function of that input.

1 - AFCS SENSOR INPUTS

Sensor	AFCS Unit	Function
Left Pitot tube	No. 1	Provide ram air pressure to AFCS unit airspeed transducer.
Right pitot tube	No. 2	Provide ram air pressure to AFCS unit airspeed transducer.

1 - AFCS SENSOR INPUTS

Sensor	AFCS Unit	Function
Static ports	Both	Provide static air pressure to AFCS unit, altitude and airspeed transducers.
No. 1 Side-slip ports	No. 1	Provide side-slip differential air pressure to AFCS unit side-slip transducer.
No. 2 Side-slip ports	No. 2	Provide side-slip differential air pressure to AFCS unit side-slip transducer.
Copilot vertical gyro	No. 1	Provide pitch and roll attitude signals to AFCS.
Pilot vertical gyro	No. 2	Provide pitch and roll attitude signals to AFCS.
Directional gyro (gyro compass)	Both	Provide heading signals to AFCS.
Pilot or copilot HSI	Both	Provide heading select signal as directed by pilot or copilot mode select panel.
Radar altimeter	No. 1	Provide altitude signal for RAD ALT hold.
Dual longitudinal, lateral, and directional control position transducers (CPT)	Both (one section to No. 1 and one section to No. 2)	Longitudinal cpts provide longitudinal cyclic stick position signals. Lateral cpts provide lateral cyclic stick position signal. Yaw cpts provide pedal control positions.

1 - AFCS SENSOR INPUTS (Cont'd)

Sensor	AFCS Unit	Function
<u>Logic Discrete Sensor Signals</u>		
Swivel lock switch	Both	Provide signal when aft wheels are locked.
Copilot vertical gyro valid	No. 1	Provide signal when gyro is not powered.
Pilot vertical gyro valid	No. 2	Provide signal when gyro is not powered.
No. 1 hydraulic pressure switch	No. 1	Provide signal when No. 1 hydraulic system is not pressurized.
No. 2 hydraulic pressure switch	No. 2	Provide signal when No. 2 hydraulic system is not pressurized.
Left landing gear ground contact switch	No. 1	Provide signal when left rear gear is in ground contact.
Right landing gear ground contact switch	No. 2	Provide signal when right rear gear is in ground contact.
Cyclic Grip Centering Device Release Switch	Both	Provide signal when cyclic stick and pedal magnetic brakes are released by pilots.
Thrust Grip Thrust BRAKE TRIGGER Switch	No. 1	Provide signal when thrust stick magnetic brake is released by pilots.
Radar Altimeter	No. 1	Provide signals when altitude signal not valid and when altimeter self-test initiated.
Cyclic grip beep trim switch	Both	Provide signal for bank angle change.

1 - AFCS SENSOR INPUTS (Cont'd)

Sensor	AFCS Unit	Function
Engine condition control	Both	Provide signal to disable AFCS unit BITE when either engine condition lever moved out of STOP.
<u>AFCS Unit Sensors</u>		
Airspeed, baro-altitude, and side-slip transducers		Convert applied air pressures to analog signals.
Yaw rate gyro		Converts yaw rate of change into an analog signal.
Vertical accelerometer		Converts vertical accelerations into an analog signal.
<u>AFCS Unit Logic Discretes</u>		
Lateral, Longitudinal, and pedal detents		Provide signal when associated control is moved more than ±0.10 inches.
Low Frequency Clock		Provides reference for digital synchronizer.
Power Supply Voltages		Provides signal when internal power supply levels are correct.

5. AFCS Output Components

The following list contains the flying control actuators that are controlled by AFCS.

NO. 1 AFCS Output Components

Component	AFCS Unit Control	Function
Pitch, roll, and yaw ILCAs	No. 1 controls the upper extensible links of the ILCAs. No. 2 controls the lower extensible of the ILCAs.	Pitch ILCA provides axis stability. Roll ILCA provides roll axis stability, roll attitude hold, bank angle turns during automatic turn-to-heading, and control response quickening. Yaw ILCA provides yaw axis stability, heading hold, and control response quickening.
DASH Actuator	No. 1 controls the upper actuator. No. 2 controls the lower actuator.	The DASH actuator provides airspeed and pitch attitude hold, positive stick gradient and control augmentation.
Collective control driver actuator	No. 1	Provides altitude hold and thrust lever reference position when altitude hold is disengaged.
Forward Longitudinal Cyclic Trim (LCT) actuator	No. 1	Provides relatively constant fuselage attitude as forward speed or altitude changes. Reduces fuselage drag and rotor shaft stresses.
Aft longitudinal cyclic Trim (LCT) actuator	No. 2	Same as Forward LCT

6. AFCS Output Feed-backs

The following list contains the flying control actuator feed-backs into AFCS.

FEEBBACKS TO AFCS

Feedback Source	Type of Feedback	To AFCS Unit
Pitch, roll, and yaw ILCA extensible links	1 LVDTs on each link	Lower actuators
	1 Dual LVDT connected to summing output of both links	1 LVDT to No. 2 Upper actuators
		1 LVDT to No. 1
		1 summing total to both
DAST actuator	1 variable resistor on each actuator	Upper dash actuator resistor to No. 1. Lower dash actuator resistor to No. 2.
Forward LCT actuator	Variable resistor	No. 1
Aft LCT actuator	Variable resistor	No. 2

7. No. 1 and No. 2 AFCS Units

The AFCS units receive and process flight related sensor signals to develop command signals for electro-hydraulic and electromechanical actuators in the flight controls. The resultant actuator movements are transferred to the upper boost controls which convert all control movements into swash plate motion. This motion controls the pitch of the rotor blades, thereby, controlling aircraft speed, altitude, and attitude. The AFCS unit in each system controls one-half of the three dual extensible links, one actuator section of the DASH dual actuator and one longitudinal cyclic pitch (LCT) actuator; No. 1 unit controls the forward actuator while No. 2 unit controls the AFT actuator. No. 1 AFCS unit also controls the collective cockpit control driver actuator. Each actuator provides a feedback position signal to its related AFCS unit.

8. AFCS Control Panel

The AFCS control panel contains seven switches for control of the various AFCS functions. The SYSTEM SEL switch engages or disengages No. 1, No. 2, or both AFCS systems to the flight controls. The switch provides the signal for pressurizing the extensible links and activating the dash actuator of the selected system. When only one AFCS system is engaged, certain functions controlled by the disengaged AFCS system continue. These are the cyclic trim functions for each system and the barometric and radar height hold functions for the No. 1 system. When neither AFCS system is engages, only the cyclic trim functions continue.

9. Pitch Axis Stability

Pitch stabilization is achieved by deriving a rate signal from each vertical gyro pitch attitude output, which is compensated by yaw rate and roll attitude to activate the pitch extensible link. When the aircraft is on the ground, the system gain is halved to optimize ground stability.

10. Roll Axis Stability

Roll stabilization is achieved by developing a roll rate signal from each vertical gyro and processing it to activate the roll extensible link. Additionally, control response is improved by the lateral movement of the cyclic stick being sensed and generating an appropriate command for the extensible link to optimize the mechanical input to the flying controls.

11. Yaw Axis Stability

Yaw stabilization is achieved by processing signals from the rate gyro and side-slip transducer within each AFCS unit. Above 40 knots the rate gyro signal is modified to provide coordinated turns; at airspeeds above 60 knots the responsible progressively reduced. The command is fed to the haw extensible link. When the haw peals are moved from their trimmed position the pilot input is assisted in a manner similar to that for the roll channel.

12. Airspeed (Pitch Attitude) Hold

a. Dash Actuator

The DASH actuator consists of two electro-mechanical linear actuators mounted end-to-end on a single shaft in the pitch axis of the flying controls. The upper half is controlled by No. 1 AFCS unit and the lower half by No. 2. The DASH actuator has a control authority of 50% of the flying control range but its rate of movement is slow, about 5 seconds for full travel in the event of a runaway. Its movement is controlled in response to airspeed, pitch attitude, and stick position so that airspeed is maintained for a given stick position. The stick position input is disconnected via landing gear squat switches when the aircraft is on the ground.

b. Collective CCDA

The Collective CCDA is an electromechanical actuator consisting of an output arm, housing, magnetic brake, servo motor, synchro control transformer, servo amplifier, output clutch, duplex clutches, gear train planet gears and related parts.

The actuator operates in either a stabilizing or synchronizing mode. The stabilizing mode maintains altitude hold. In this mode the No. 1 AFCS unit energizes and releases the magnetic brake. The AFCS unit also energizes the simplex clutch connecting the servo-motor through the gear train to the output arm and the duplex clutch driving, the feedback synchro gearing. Command signals from the AFCS unit drive the servo motor to maintain selected altitude. The synchro transmitter provides feedback signals to the AFCS unit.

13. Roll Attitude Hold

Each AFCS unit roll channel processes signals from lateral movements of the stick trimmer and from its vertical gyro to generate roll attitude hold commands to the roll extensible link. Error signals between units are compared to ensure that the two systems remain synchronized with each other. The control logic disengages the bank angle hold when:

a. A pilot's centering device button is pressed.

b. The cyclic stick is moved out of its trimmed position (more than 0.10 inches).

c. If the AFCS HDG button is engaged.

Attitude hold does not engage if the roll rate is greater than 1.5° per second.

14. Heading Hold

The yaw channels of each AFCS unit take an input from the directional gyro to maintain heading within 2°. The control logic disengages the heading hold when:

a. The swivel switch is set to UNLOCK or STEER.

b. A cyclic TRIM REL button is pressed.

c. At speeds above 40 knots, lateral stick trim is used, the stick is moved laterally from its trimmed position, or turn-to-heading is engaged.

d. The yaw pedals are moved from their trimmed position.

Heading hold cannot be resumed until the yaw rate is less than 1.5 per second; additionally at speeds above 40 knots, it cannot be resumed until the bank angle and yaw rate is less than 1.5°.

<u>WARNING:</u> The directional gyro signal has a permanent input to the AFCS. The compass system is not to be slowed with AFCS engaged unless the swivel switch is set to UNLOCK.

15. Altitude Hold

No. 1 AFCS unit provides altitude hold through the collective CCDA. Two buttons on the AFCS panel select the source of the altitude hold signal: the BARO ALT button selects a signal from an altitude transducer within No. 1 AFCS unit, or the RAD ALT button selects a signal from the radar altimeter system. When altitude hold is engaged, the AFCS uses the signal representing altitude at time of selection as the reference. Deviations from this altitude cause the AFCS unit to generate an error signal, initiating a command signal that drives the collective CCDA which moves the collective pitch control to maintain selected altitude. Vertical damping of the command signal is provided by an accelerometer in No. 1 AFCS unit. During coordinated turns, a bank angle signal is used to offset the normal accelerometer signal and to provide a collective command which maintains altitude in the turn. The altitude hold is released by disengaging the appropriate altitude pushbutton; it may be released temporarily to permit altitude changes by pressing the THRUST BRAKE TRIGGER, the altitude when the trigger is released then becomes the reference altitude. When RAD ALT is selected as the reference for altitude hold, a radar altimeter valid signal must be received before the AFCS initiates an altitude hold command.

NOTE: The RAD ALT signal is rendered invalid when the radar altimeter TEST button is pressed.

The BARO ALT hold accuracy is ±25 feet in stabilized flight with transients to ±50 feet during turns up to 20° bank or airspeed changes up to ±20 knots. The RAD ALT hold accuracy is ±5 feet in hover and low speed transitional flight.

WARNING: Use of RAD ALT over rough water or land results in a hard ride and, in the latter case, does not take account of rapidly rising ground ahead of the flight path.

16. Automatic Turn

With a HDG CMD button on a MODE SELECT panel engaged, the bank angle and heading holds are automatically disengaged and the aircraft rolls into a coordinated turn towards the heading selected on the appropriate HSI. The heading error signal from the HSI is modified by airspeed and an input from the vertical gyro to command a standard rate turn. When approaching the selected heading, the aircraft automatically rolls out of the turn and the heading is held. The heading can subsequently be changed by adjusting a select heading knob on the same HSI. To disengage the turn-to-heading, release the HDG button on the AFCS panel. The HDG button on the AFCS panel does not latch unless the airspeed is above 40 knots and HDG CMD has been engaged. If HDG CMD is selected by the other pilot the AFCS HDG button unlatches and must be reset. Control logic in the system disengages the hold if the airspeed falls below 40 knots or if the centering device release button is pressed.

17. Control Response Quickening

a. Control Position Transducers

(1) Dash Actuator

Connected to the summing amplifier is the resultant longitudinal CPT signal. This signal passes through a landing gear switch activated logic switch. With the aircraft on the ground, the logic switch is opened preventing DASH actuator response when the cyclic stick is moved longitudinally. With the aircraft airborne, the logic switch is closed connecting the CPT signal through two paths to a summing amplifier. These paths provide for longitudinal control augmentation. One path is direct. The other path, a higher gain path, is through a velocity limit circuit. This circuit limits the rapid signal increase that occurs with quick stick movement and which would otherwise result in over response. The output of this summing amplifier is the resultant longitudinal CPT signal.

(2) Roll and Yaw Channels

Directional pedal movement signals from the yaw CPT are used by the AFCS units to quicken the aircraft's response to directional pedal control movement by the pilot. This signal is also used to develop a directional pedal logic discrete. The signal is summed with the side-slip transducer signal before being summed with the heading and stability signals.

The lateral CPT signal is connected through a lead-lag network to the command summing amplifier. This signal is used to quicken lateral control response. The CPT signal is also used to develop the roll out of detent discrete. Out of detent occurs when the cyclic stick is moved laterally more than $\pm$1.10 inch from trimmed position. This condition disables heading hold-above 40 knots, and roll attitude hold functions.

18. Positive Stick Gradient

The AFCS unit commands the DASH actuator to perform its function by comparing aircraft pitch attitude and airspeed with the longitudinal cyclic stick position. The longitudinal CPT provides the AFCS units with a proportional relationship between stick position and airspeed. The result which is a positive stick gradient.

19. Longitudinal Cyclic Trim

Reduces flap-back to relieve bending stresses particularly on rear rotor shaft.

In its automatic mode of operation, airspeed and altitude signals are processed by the AFCS units and used to position the two LCP actuators; the forward is controlled by the No. 1 AFCS unit, the aft by the No. 2 AFCS. When the aircraft clears the ground, the actuators retract from their ground position. At sea level, beyond 60 knots, the forward and aft actuators remain retracted, positioning the rotor disc planes relative to their masts by 1.2° and 3.25° respectively. From 60 knots to 150 knots, the actuators increase cyclic pitch linearly to 4° forward on both rotors. With increasing altitude, the LCT program is advanced. Provided that the AFCS units are receiving electrical power, LCT automatic operation continues. Driving signals are routed through the AUTO/MAN switch on the AFCS panel. Setting the switch to MAN disconnects signals from both AFCS units and permits manual operation of the LCT.

20. Electrical Power Supplies and CBs

AC and DC electrical supplies are required for operation of the AFCS. Selecting a system off disengages most of the AFCS outputs to the flight controls, however, the AFCS continues to follow up inputs. The AFCS can be isolated only by pulling the relevant circuit breakers.

Both units have built in test equipment for ground maintenance purposes; it cannot, however, be operated unless both ECL are at stop.

CIRCUIT BREAKERS

Circuit	Markings	Location
No. 1 AFCS unit (Two circuit breakers)	AFCS No. 1 - DC AFCS No. 1 - AC	No. 1 PDP
No. 2 AFCS unit (Two circuit breakers)	AFCS No. 2 - DC AFCS No. 2 - AC	No. 2 PDP
LCT Actuators (Three circuit breakers)	TRIM MAN - DC CYCLIC FWD ACT - DC CYCLIC TRIM AFT - DC	No. 1 PDP No. 1 PDP No. 2 PDP
Thrust - CCD Actuator (Three circuit breakers)	COLL DRIVE ACT - AC COLL DRIVER ACT - AC THRUST BRAKE - DC	No. 1 PDP No. 2 PDP No. 1 PDP
Longitudinal - CCD Actuator (Same circuit breaker used by collective - CCD Actuator)	COLL DRIVE ACT - AC	No. 1 PDP
Left Landing Gear Switch (Same circuit breaker used by No. 1 AFCS unit)	AFCS No. 1 - DC	No. 1 PDP
Right Landing Gear Switch (Same circuit breaker used by No. 1 AFCS unit)	AFCS No. 2 - DC	No. 2 PDP

A. AFCS AVIM Maintenance Concept

Fault isolation is logically accomplished by utilizing troubleshooting/system performance procedures provided by AFCS built-in-test-equipment (BITE) and the AFCS line test set. All BITE functions are controlled from the front panel of the AFCS unit. When the BITE identifies a system failure, the test process will stop and a display will indicate the failed test. A failed test can be bypassed to complete the test series. The test process is continuous unless a failure is detected. If the recognized failure is internal to the AFCS unit, as indicated on the AFCS unit instruction decal, a removal and replacement of the unit is performed. If the recognized failure is associated with an AFCS component or sensor external to the AFCS unit, further fault isolation is accomplished utilizing the AFCS line test set.

The AFCS Line Test Set provides the capability to check the AFCS interface to the extent required to isolate system malfunctions to associated components, sensors and/or aircraft wiring. The test set shall interface with the aircraft AFCS unit connectors and shall replace the AFCS unit during testing. The test set shall interface with the following components:

1. Cockpit Control Driver Actuator (CCDA) Thrust

2. Dual Longitudinal (Pitch) Control Position Transducer (CPT)
3. Dual Lateral (Roll) Control Position Transducer (CPT)
4. Dual Directional (Yaw) Control Position Transducer (CPT)
5. Pitch Integrated Lower Control Actuator (ILCA)
6. Roll Integrated Lower Control Actuator
7. Yaw Integrated Lower Control Actuator
8. HSI
9. Forward Longitudinal Cyclic Pitch Actuator (LCP)
10. Aft Longitudinal Cyclic Pitch Actuator (LCP)
11. Dual Differential Airspeed Hold (DASH) Actuator
12. AFCS Control Panel
13. Cyclic Mag. Brake
14. Thrust Mag. Brake
15. Vertical Gyro
16. Roll Beep Trim
17. Radar Altimeter
18. Landing Gear Switches
19. Swivel Lock Switch
20. Barometric Altitude (Static Input)
21. Hydraulic Pressure

1. AFCS Management

a. Normal Operation

Before the AFCS can be selected, AC and DC electrical supplies must be on line with the appropriate circuit breakers made, both pilot's vertical gyros run up and the attitude indicators OFF flags clear and No. 1 and No. 2 flight control hydraulic systems pressurized. Before Starting the engines and rotors, ensure that the compass is aligned, the LCT switch is set to AUTO and then check selection of the AFCS by switching to BOTH for 10 seconds then to OFF to ensure that the DASH actuators are correctly positioned. Extinction of the AFCS 1/2 captions on the MASTER CAUTION panel should follow system selection.

The aircraft should be taxied with the AFCS selected off and flown with both systems on. A functional test of each system should be carried out in the hover after the first take-off each day.

b. Flight With One System Selected Off

When a system is selected off, the associated extensible link hydraulic actuators are centered; if any actuator is not already in its central position an abrupt attitude change results. Maximum airspeed is restricted to 100 knots and stabilization is slightly impaired due to reduction in overall AFCS effectiveness; limits are reached sooner due to the increased gain of the operating system.

WARNING: The effect of an actuator runaway can no longer be countered by the other system.

c. Reselecting One System In Flight

When a system is selected off, its associated DASH actuator freezes, it is important therefore to return to the airspeed/attitude at disengagement and to hold it for twenty seconds before making a reselection.

WARNING: If the system is not reselected in flight, reselection is not to be made on the ground until the rotors have stopped.

2. Malfunctions

a. AFCS Failures

Malfunctioning of the AFCS normally disturbs the aircraft and may be indicated by illumination of an AFCS caption. Restore the aircraft to a safe flight attitude using the flying controls in the normal sense and increase altitude if necessary to obviate risk of ground collision during subsequent flight.

Unless control of the aircraft is difficult to maintain, both systems should remain selected on. If it should be necessary to identify the malfunctioning AFCS unit, select each system off in turn; abrupt attitude changes will occur when selecting between systems. The 20-second interval between selections and appropriate speed limitations are to be observed. However, if an AFCS caption has illuminated, deselect the failed system to prevent unexpected reengagement. Some malfunctions may be alleviated by deselecting the associated hold.

Airspeed with one system failed is 100 knots, maximum.

b. DASH Actuator Failure

Failure of the DASH results in degraded longitudinal control characteristics. If the position of the cyclic stick is abnormally forward, avoid high nose attitudes.

c. LCT Actuator Failure

Failure of the LCT actuators to move correctly is displayed on their respective indicators. Selection of the LCT to MANUAL should enable normal flight to continue, however, speed restrictions apply if the actuators cannot be fully extended.

d. Malfunctions That Will Illuminate AFCS Caption

Source	Functions Lost
Internal to AFCS Unit Defective Power Supplies Defective Low Freq Clock	None, remaining AFCS assumes sole authority. Response to large input may be reduced due to lower system authority. One DASH actuator section is disabled which may lead to abnormal stick position during landing.
External to AFCS Unit Loss of hydraulic system pressure No valid vertical gyro signal	
Loss of AC or DC power (only if operable power system does not cross-tie)	If associated system circuit breakers opened, loss of automatic LCT actuator programming during flight and upon landing will occur. Opening No. 1 system circuit breakers will also disable altitude hold.

e. Input and Output Malfunctions That Will Not Illuminate AFCS Caption

Input/Output Failure Mode	Indication	Pilot Response
Directional Gyro		
Open	(a) Heading Select Mode: Won't roll out on selected heading. (b) Heading Hold Mode: No heading hold	HDG Switch - OFF Swivel Lock - UNLOCK. Fly heading manually.
Drifting	(a) Heading Select Mode: (b) Heading Hold Mode: Undesired heading changes occur	HDG push button - OFF Swivel Lock - UNLOCK Lock prior to landing. Use directional pedals to eliminate yaw inputs.
Directional CPT		
Open	Slow directional response to inputs in hover	Isolate AFCS with malfunctioning directional cpt and note for maintenance action. Continue to operate on both systems.
Hardover	Direction Pedals offset	Balance controls manually.
AFCS Yaw Logic Failure		
	Heading hold won't release during pedal inputs - sluggish control response. Pedal offset when new heading selected. Yaw kicks when activating magnetic brake with new heading. Heading hold will not release during stick turns in forward flight.	Swivel lock - UNLOCK Lock prior to landing or - apply magnetic brake and hold prior to, and during pedal displacement.

Input/Output Failure Mode	Indication	Pilot Response
Vertical Gyro		
Pilot's (pitch or roll axis open or tumbling)	Pitch attitude change; reduced stability.	Observe AI to confirm faulty system.
	No roll attitude hold; reduced stability.	Select No. 1 AFCS (pilot VGI) or No. 2 AFCS (copilot VGI)
		Pull pilot's (or copilot's) attitude indicator circuit breaker.
Copilot's (pitch or roll axis open or tumbling)	Same	
AFCS Roll Logic Failure	Sluggish response. Tendency to maintain original initial roll attitude. Won't lock on to new bank angle. Heading hold will not release above 40 knots.	Activate and hold magnetic brake prior to and during turns.
Dash Actuator		
Static	Degraded A/S hold. Degraded pitch attitude hold. Longitudinal stick position not correct for given airspeed.	Exercise caution during approach to hover due to abnormal position.
Dynamic (hardover)	Rapid change in pitch attitude. Longitudinal stick position not correct for given airspeed.	Override longitudinal control inputs to check pitch rate and regain level flight. Limit airspeed to 120 KIAS. Exercise caution in approach to hover due to abnormal control position.
Longitudinal CPT Failure	Similar to dynamic DASH failure.	Same as dynamic DASH failure.

Input/Output Failure Mode	Indication	Pilot Response
Pitch CCDA Actuator		
Static	Possible loss of longitudinal magnetic brake function. No pitch axis beep control.	Override longitudinal position and forces.
Dynamic	Slow longitudinal stick position driving motion. Possible loss of magnetic brake function.	Override longitudinal position and forces.
Heading Synchrometer (Bug command)	Constant turn (overshoot selected heading) or no turn when commanded.	HDG switch - OFF. Retrim to level attitude and re-engage. If condition persists leave at OFF.
Thrust CCD Actuator Failure		
Altitude Hold OFF	Possible loss of magnetic brake function. Thrust lever tends to creep.	Override (maintain hand on thrust control).
Altitude Hold On Static	No altitude hold.	Altitude hold - OFF.
Dynamic (Hardover)	Thrust lever driven up or down. altitude. Rapid change in power.	Override thrust lever Rapid change in motion. Altitude hold- OFF. Revert to normal thrust control action.
Altitude Hold Baro/ RAD Sensor Failure		
Static (Go Dead)	No altitude hold.	Altitude hold - OFF.
Dynamic (Hardover)	Thrust lever drive up or down. Rapid change in altitude. Rapid change in power.	Pilot override thrust lever motion (maintain hand on thrust control). Altitude hold - OFF
Altitude Hold Accelerometer Signal Failure	Poor altitude hold characteristics. Overshoots above and below selected setting.	Altitude hold - OFF

Input/Output Failure Mode	Indication	Pilot Response
Analog Synchronizer Signal Failure	Altitude drift drift is excessive.	Activate magnetic brake to resynchronize altitude hold, or - altitude hold - OFF if
Altitude Hold Accelerometer Signal Failure	Poor altitude hold characteristics. Overshoots above and below selected setting.	Altitude hold - OFF.
Analog Synchronizer Signal Failure	Altitude drift	Activate magnetic brake to resynchronize altitude hold, or - altitude hold - OFF if drive is excessive.

CHAPTER 12
UTILITY SYSTEMS

SECTION I
WINDSHIELD AND ANTI-ICING SYSTEM
DESCRIPTION
AND
THEORY OF OPERATION

WINDSHIELD ANTI-ICING SYSTEM

DESCRIPTION

The windshield anti-icing system operates independently on the three cockpit windshields. The pilot's and copilot's windshields have anti-icing and anti-fogging systems. The center windshield has an anti-fogging system only.

The total system consists of the three windshields, three switches on the overhead **panel, and three relays and control boxes behind the nose dynamic absorber. Each windshield is made of laminated layers with an imbedded temperature sensor. The inner surface of the outside layer is a transparent heating element. When the switch is operated, current passes through the transparent element, heating the windshield.**

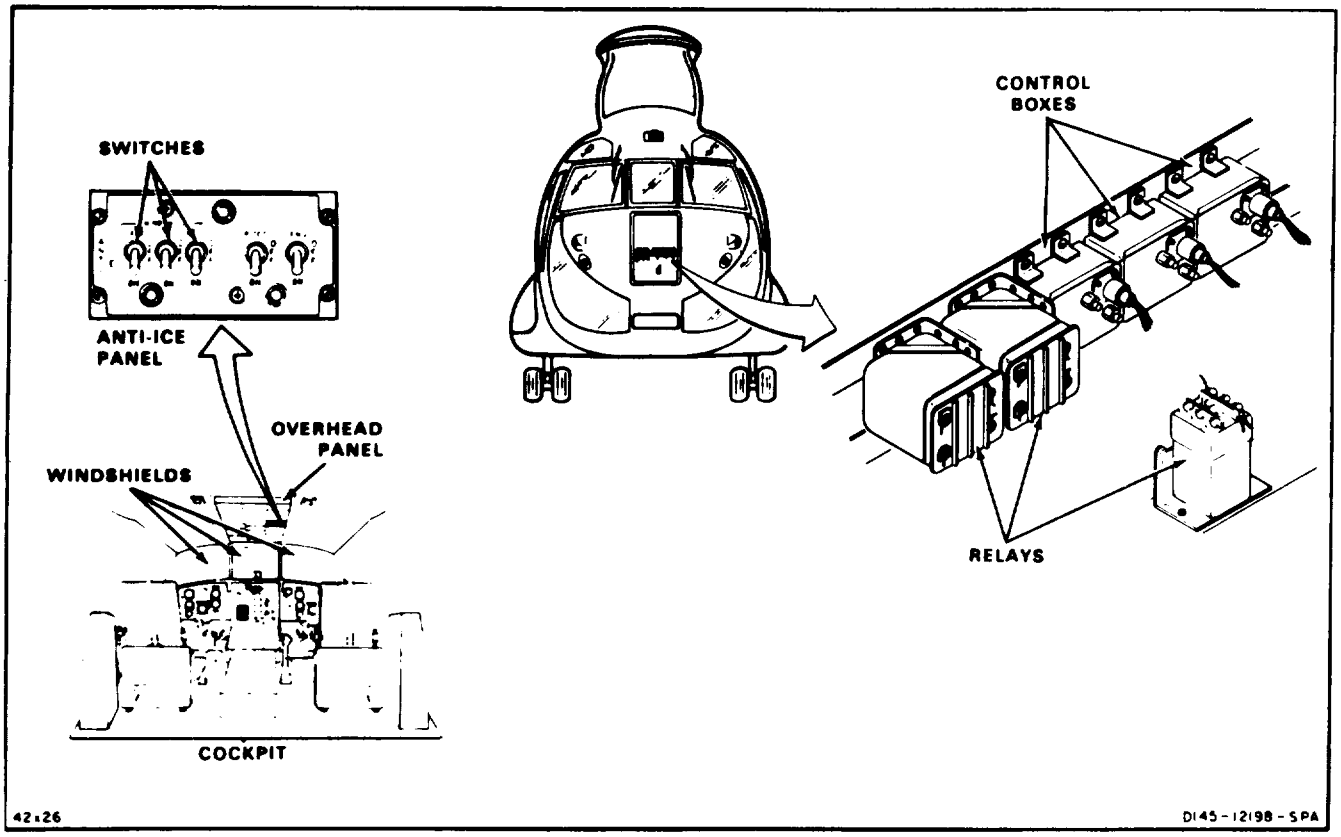
Electrical circuits for the three windshields are identical, except that the cut-in temperature for the center windshield is lower.

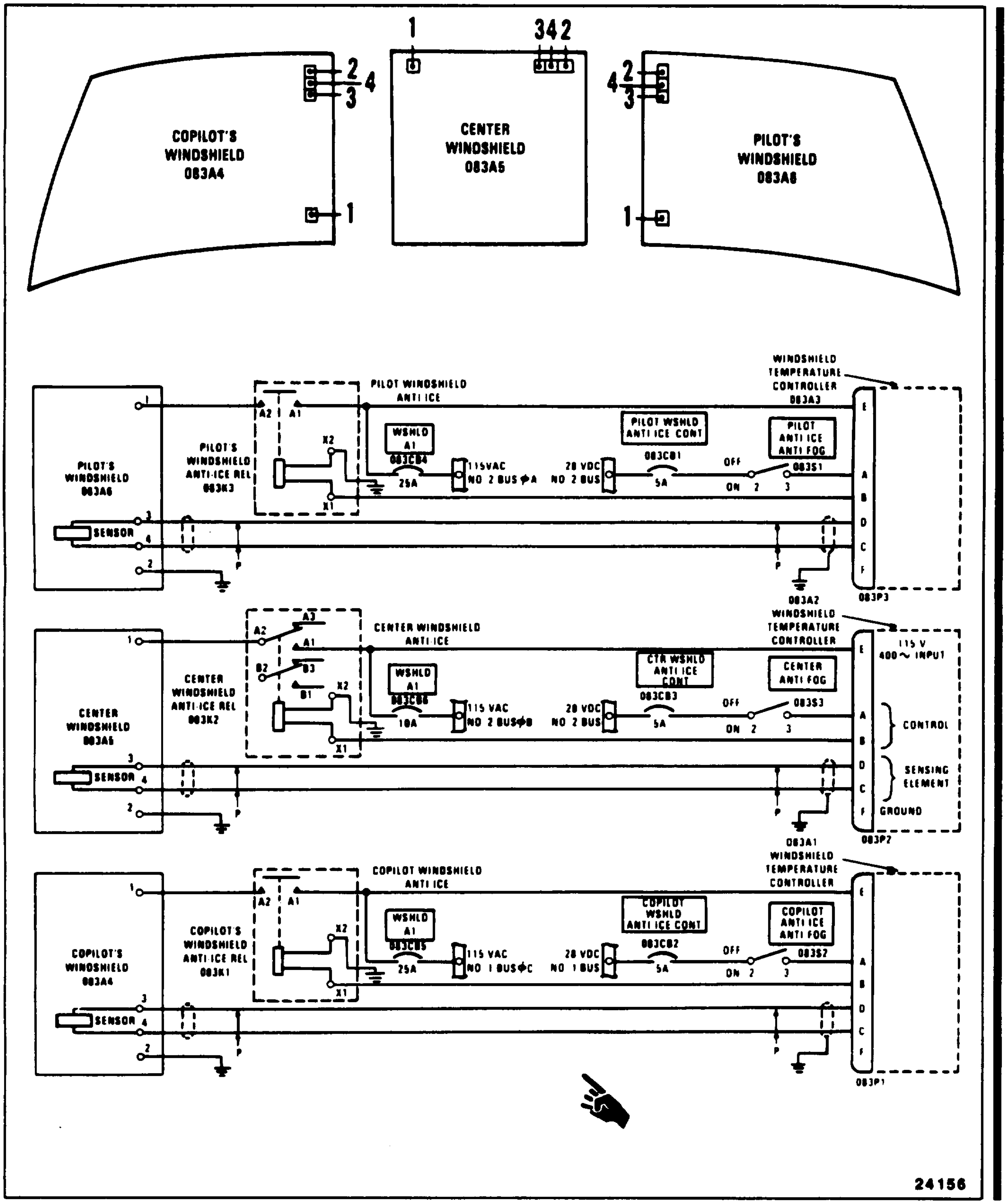
THEORY OF OPERATION

When any of the windshield switches on the ANTI-ICE overhead panel is moved to ON, 28 volts dc **is applied to the** temperature controllor **for the associated windshield. If the temperature of the windshield, as sensed by an** imbedded sensor, is below **90°F (32°C) (pilot's or copilot's windshield) or 80°F {27°C) (center windshield),** relay K1 In the controller **is energized, applying 115 volts ac to the** heating element **in the windshield,**

As windshield temperature increases, resistance within the sensor also increases. When the temperature reaches 110°F (43°C), sensor resistance is high enough to reenergize the anti-ice power relay, **cutting off power to the** heating element. **When the windshield cools, the** sensor **reenergize the** relay **and current flows again to the** heating element.

Power for the pilot's and center windshield comes from the No. 2 ac bus. **Power for the copilot's windshield comes from the No. 1** ac bus. **Temperature control of the pilot's and center windshield is through the No. 2** dc bus. **Control of copilot's windshield temperature is through the No.** 1 dc bus.




COPILOT'S WINDSHIELD 083A4
CENTER WINDSHIELD 083A5
PILOT'S WINDSHIELD 083A6
PILOT WINDSHIELD ANTI ICE
PILOT'S WINDSHIELD ANTI-ICE REL 083K3
WSHLD A1 083CB4 25A
115VAC NO 2 BUS φA
28 VDC NO 2 BUS
PILOT WSHLD ANTI ICE CONT
083CB1 5A
PILOT ANTI ICE ANTI FOG
083S1
OFF
ON
WINDSHIELD TEMPERATURE CONTROLLER 083A3
083P3
SENSOR
083A2 WINDSHIELD TEMPERATURE CONTROLLER
CENTER WINDSHIELD ANTI ICE
CENTER WINDSHIELD ANTI-ICE REL 083K2
WSHLD A1 083CB6 10A
115 VAC NO 2 BUSφB
CTR WSHLD ANTI ICE CONT
083CB3 5A
CENTER ANTI FOG
083S3
115 V 400 ~ INPUT
CONTROL
SENSING ELEMENT
GROUND
083P2
083A1 WINDSHIELD TEMPERATURE CONTROLLER
COPILOT WINDSHIELD ANTI ICE
COPILOT'S WINDSHIELD ANTI-ICE REL 083K1
WSHLD A1 083CB5 25A
115 VAC NO 1 BUSφC
28 VDC NO 1 BUS
COPILOT WSHLD ANTI ICE CONT
083CB2 5A
COPILOT ANTI ICE ANTI FOG
083S2
083P1
24156

SECTION II

FIRE DETECTION AND EXTINGUISHING SYSTEMS DESCRIPTION AND THEORY OF OPERATION

FIRE DETECTION SYSTEM

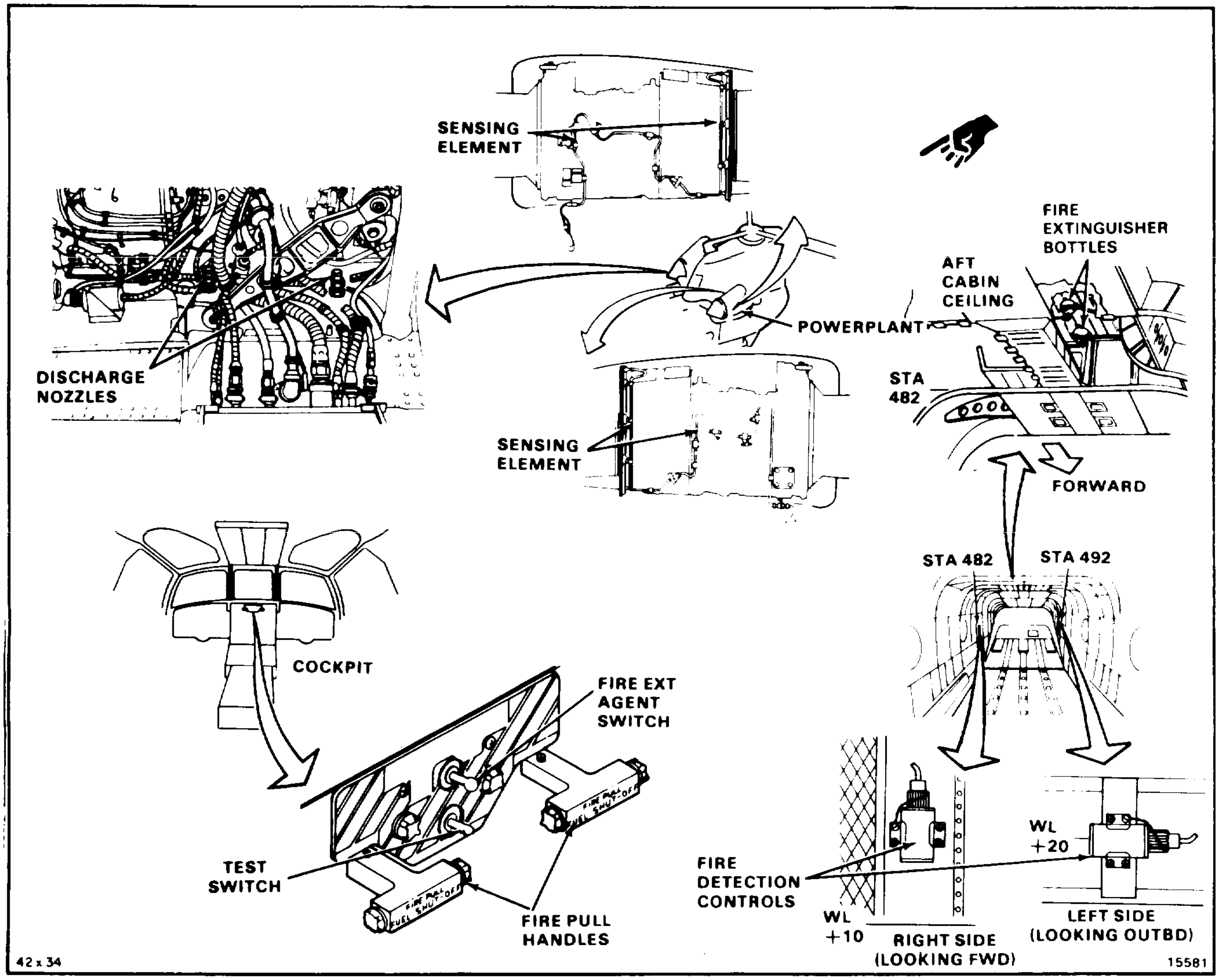
DESCRIPTION

The fire detection system consists of a fire detection loop routed around each engine, a control unit for each of the two loops, and a test switch and indicator lights in the cockpit.

Each fire detection loop consists of three sensing elements joined by connectors. Each element consists of a thin metallic tube with a wire running through the center, insulated from the tubing by a salt imbedded in a ceramic matrix. The resistance of the insulating salt drops and the salt becomes conductive at about 575°F (300°C). The tubing is connected to ground. The central wire is connected to the control unit. The three elements have a combined length of about 19 feet.

The two control units are mounted in the cabin at sta 482 left and right. Each unit contains an ac-powered magnetic amplifier and a dc test circuit. Each unit is connected to its respective fire detection loop. The units are sealed, and maintenance is limited to replacement.

A fire indicating light for each engine is located in the respective fire extinguisher handle on the cockpit center instrument panel. A test switch between the fire pull handles allows the light and electrical circuits to be checked.



THEORY OF OPERATION

Under normal conditions, the circuit within the magnetic amplifier of a control unit is in balance and no current flows to the warning lights. When the engine compartment temperature around the sensing element reaches about 575°F (300°C), indicating a fire, the insulating material between the sensing element tubing and the internal wire becomes conductive, allowing current to pass through the control unit to the appropriate warning light in the cockpit.

When the test switch on the center instrument panel is operated, 28 volts dc is delivered to the control units. Within each control unit, a relay operates to ground the system, lighting the warning lamps in the fire pull handles.

FIRE EXTINGUISHING SYSTEM

DESCRIPTION

Two containers filled with fire extinguishing agent are mounted in the base of the pylon, between the engines. In case of an engine fire, extinguishing agent within the containers can be discharged independently to the affected engine from the cockpit.

The system includes the two fire extinguishing agent containers, four discharge nozzles (one to each engine from each bottle), controls and switches in the cockpit, and associated tubing, wiring, and circuit breakers.

Each container is a metal sphere that holds a three-pound charge of non-toxic extinguishing agent. The agent is pre-charged with nitrogen at 600 psi, monitored by a gage on the bottle. Separate lengths of tubing lead from the bottle to each engine, ending in a pair of discharge nozzles in each engine compartment. The two containers share the nozzles at each engine. The discharge paths are kept separate by a double check valve tee where the tubing from each container joins.

Discharge of extinguishing agent to the engines is controlled by two pull handles, one for each engine, and a toggle switch on the center instrument panel. Pulling a handle shuts off fuel to that engine and arms the circuit to the containers. Selecting one of the containers with the switch discharges extinguishing agent from that container to the affected engine. The remaining container may be discharged into the same or the opposite engine as required.

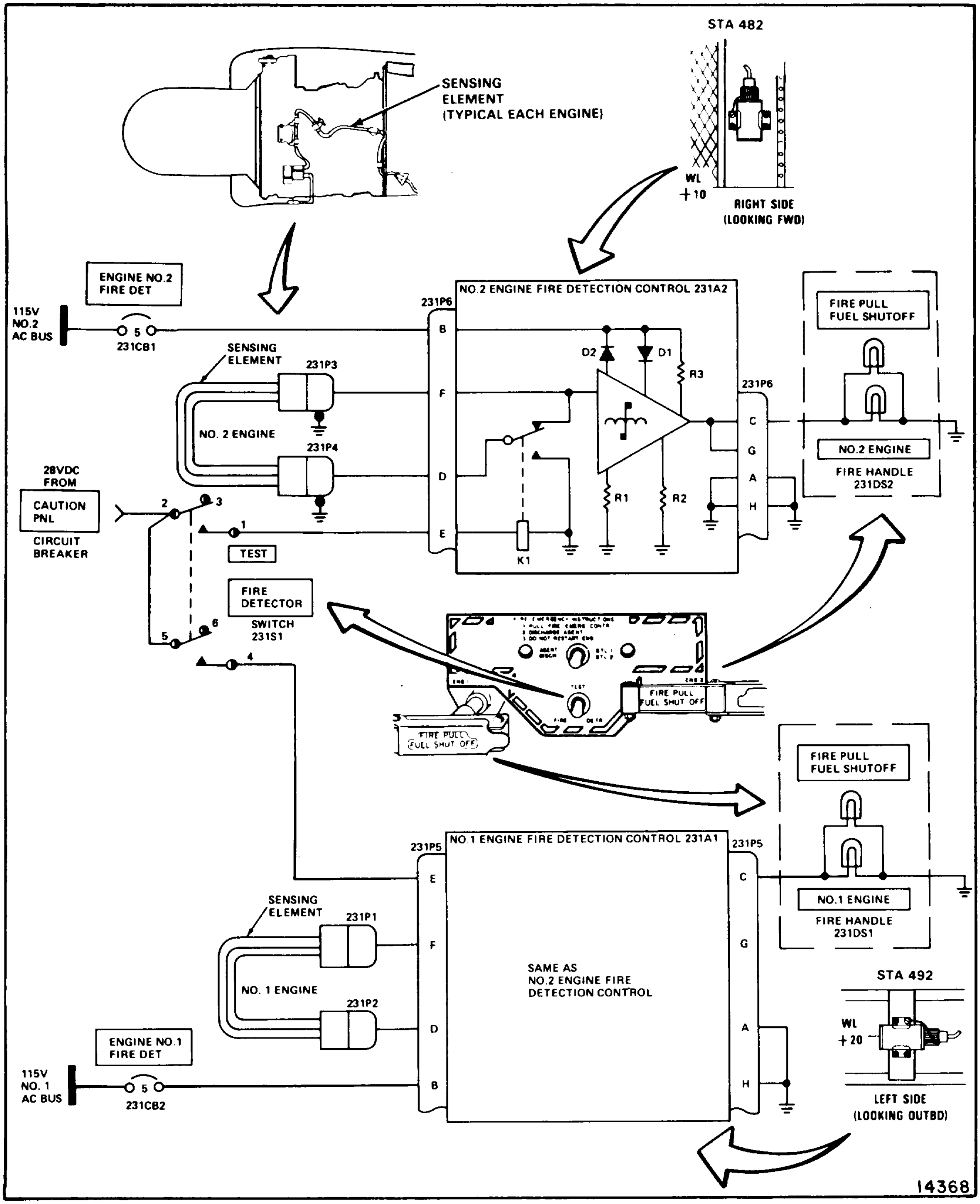
Electrical power for the system is supplied from the 28 volt dc no. 1 or no. 2 flight essential bus through circuit breakers in the no. 1 and no. 2 power distribution panels.

THEORY OF OPERATION

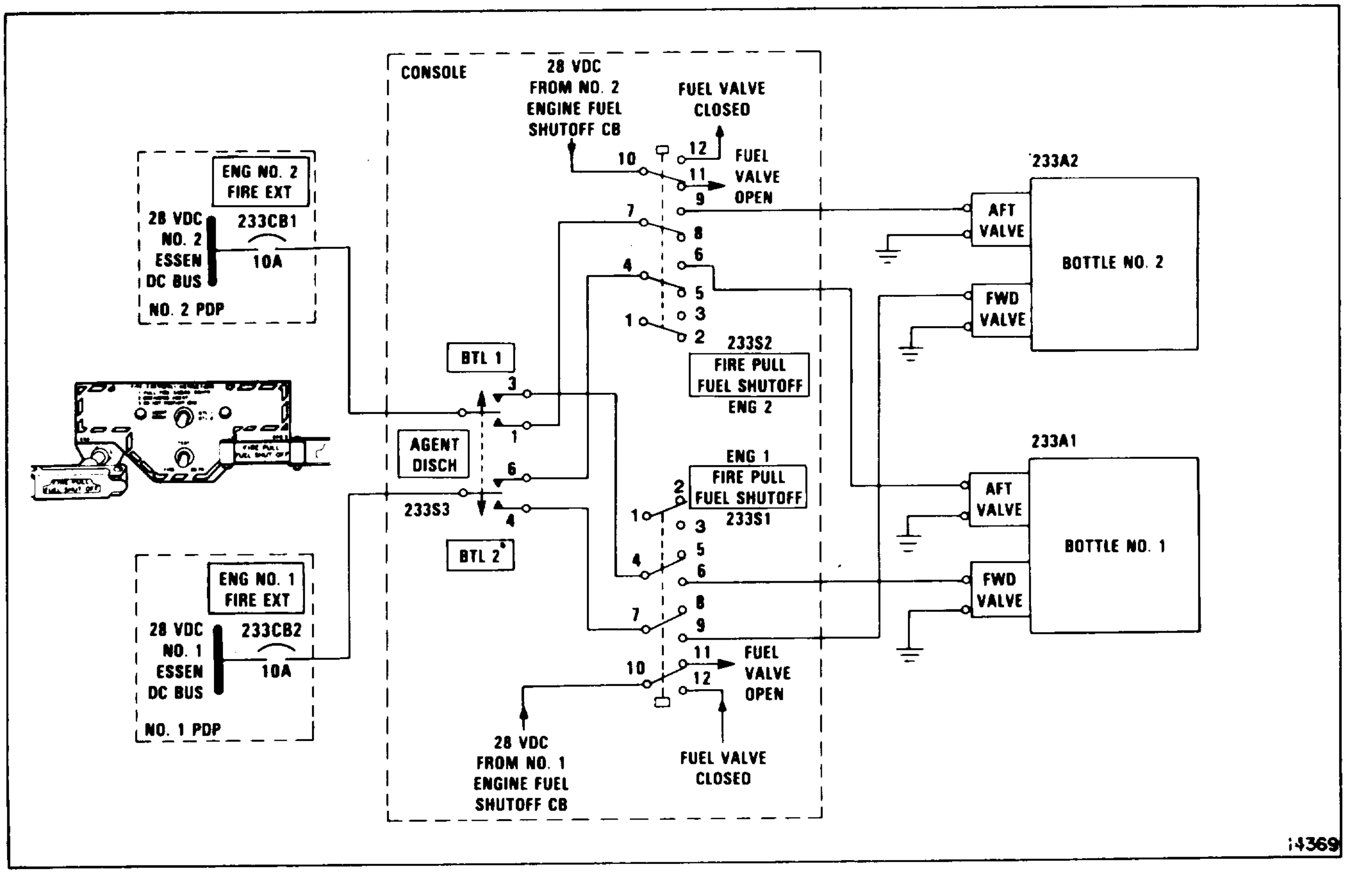
When the fire detection system lights the warning lamps in either fire pull handle, the extinguishing system for the affected engine can be armed for operation by pulling out the lighted handle. When this is done, the following sequence of events occurs:

a. Current from the 28 volt dc flight essential buses is directed by a switch through the engine fuel shutoff circuit breaker to close the engine fuel valve. This shuts off fuel to the affected engine.

b. At the same time, the selector switch between the fire pull handles is armed. When the switch is operated to select a container, an explosive cartridge at that bottle is fired. This breaks a brittle retaining disc, releasing extinguishing agent from the bottle through the tubing to the two discharge nozzles at the affected engine.



STA 482
SENSING
ELEMENT
(TYPICAL EACH ENGINE)
WL
+10
RIGHT SIDE
(LOOKING FWD)
ENGINE NO.2
FIRE DET
115V
NO.2
AC BUS
5
231CB1
SENSING
ELEMENT
231P3
NO. 2 ENGINE
231P4
231P6
NO.2 ENGINE FIRE DETECTION CONTROL 231A2
D2
D1
R3
R1
R2
K1
231P6
FIRE PULL
FUEL SHUTOFF
NO.2 ENGINE
FIRE HANDLE
231DS2
28VDC
FROM
CAUTION
PNL
CIRCUIT
BREAKER
TEST
FIRE
DETECTOR
SWITCH
231S1
FIRE PULL
FUEL SHUTOFF
231P5
NO.1 ENGINE FIRE DETECTION CONTROL 231A1
231P5
SENSING
ELEMENT
231P1
NO. 1 ENGINE
231P2
SAME AS
NO.2 ENGINE FIRE
DETECTION CONTROL
NO.1 ENGINE
FIRE HANDLE
231DS1
STA 492
WL
+20
LEFT SIDE
(LOOKING OUTBD)
ENGINE NO.1
FIRE DET
115V
NO. 1
AC BUS
231CB2
14368


CONSOLE
28 VDC
FROM NO. 2
ENGINE FUEL
SHUTOFF CB
FUEL VALVE
CLOSED
FUEL
VALVE
OPEN
ENG NO. 2
FIRE EXT
28 VDC
NO. 2
ESSEN
DC BUS
233CB1
10A
NO. 2 PDP
233A2
AFT
VALVE
BOTTLE NO. 2
FWD
VALVE
233S2
FIRE PULL
FUEL SHUTOFF
ENG 2
BTL 1
AGENT
DISCH
233S3
BTL 2
ENG 1
FIRE PULL
FUEL SHUTOFF
233S1
233A1
AFT
VALVE
BOTTLE NO. 1
FWD
VALVE
ENG NO. 1
FIRE EXT
28 VDC
NO. 1
ESSEN
DC BUS
233CB2
10A
NO. 1 PDP
FUEL
VALVE
OPEN
28 VDC
FROM NO. 1
ENGINE FUEL
SHUTOFF CB
FUEL VALVE
CLOSED
14369

CHAPTER 13
ENVIRONMENTAL CONTROLS

SECTION I
ENVIRONMENTAL SYSTEM DESCRIPTION AND THEORY OF OPERATION

DESCRIPTION

The environmental system provides heat and ventilation for the helicopter. The system consist of a heater and fan mounted between an air inlet duct and exhaust pipe, an ignition unit, control switches, a temperature controller and thermostat, cockpit and cabin ducting, and fuel delivery components.

The heater is located in a compartment on the right forward end of the cabin, ahead of the cabin door. It is capable of 200,000 btu/hr output.

A fuel control unit draws fuel from the right side fuel system and controls the pressure and flow to the heater combustion chamber.

The fan draws air from outside through the air inlet duct and forces it through the heater. Some air is mixed with fuel and ignited in the heater combustion chamber and other air is heated and sent through the duct network. The fan can also supply fresh air for ventilation. Exhaust gases are sent through the exhaust pipe and discharged outside, above and aft of the air inlet.

The ignition unit supplies a high voltage current that produces a continuous spark in the heater combustion chamber to ignite the fuel and air mixture. Unburned fuel is drained overboard.

The thermostat maintains a steady temperature in the cabin by causing a relay in the temperature controller to open or close as cabin temperature fluctuates. In this way, the controller controls the electrical circuit to the heater fuel system, interrupting or resuming fuel flow, as required.

The heater system is protected from overheating by three thermostatic switches. A differential air pressure switch shuts down the heater when there is not enough air for safe operation.

Switches on the overhead panel control heater operation. A temperature controller adjusts the cabin thermostat setting. Push-pull controls in the cockpit regulate air flow through the ducting.

THEORY OF OPERATION

The heater and fan are both controlled by a control switch and a start button on the cockpit overhead panel. The switch has three positions, labeled OFF, VENT BLOWER ONLY, and HEATER ON. The button is spring-loaded and is labeled HEATER START. When the switch is set to HEATER ON and the button is pressed and released, the system is set in operation as follows:

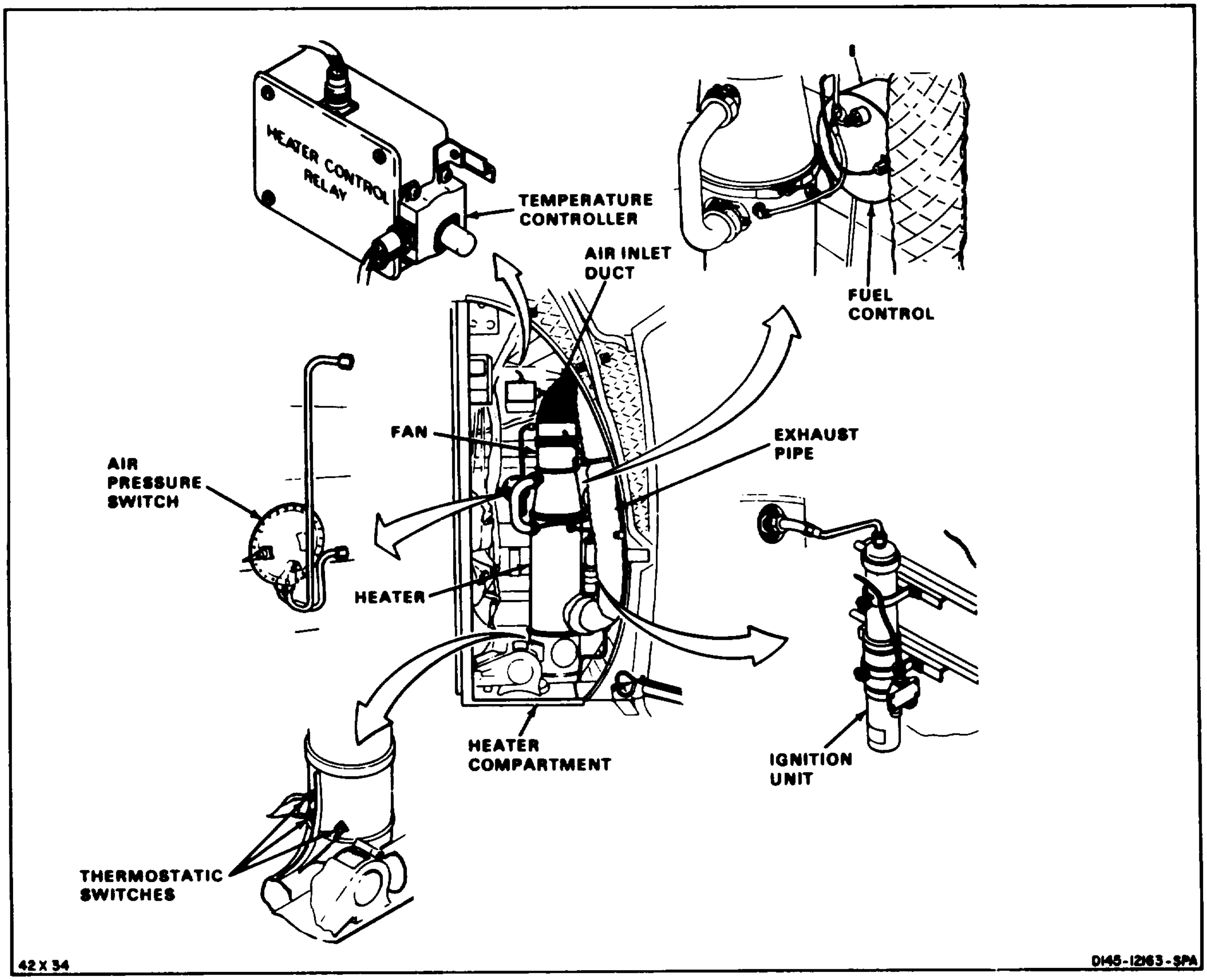
a. **Relay 082K3** is energized by 28 volts from the No. 2 dc bus through the normally closed (NC) contacts of overheat switch 082A5. This action energizes **relay 082K2** and **fan relay 082K1,** connecting 115 volt 3-phase ac from the No. 2 ac bus to the heater fan.

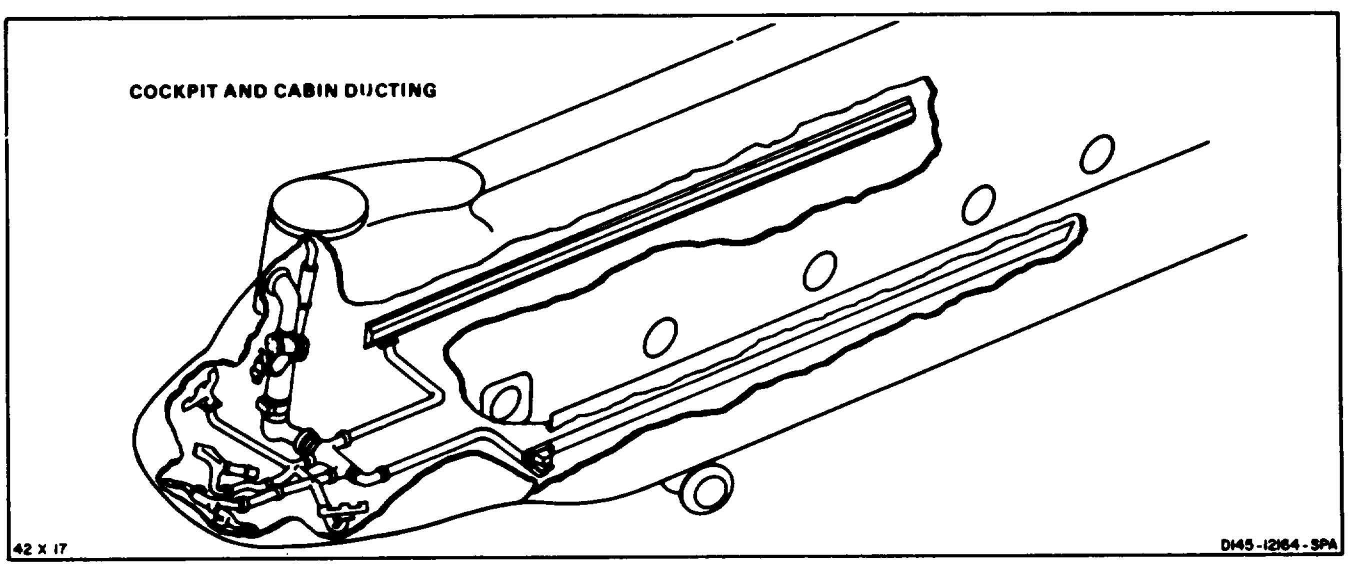
b. When the fan has been in operation of 10 seconds, **time-delay (TD) relay 082K4** and **air pressure switch 082A4** close. The delay allows time for the fan to purge the heater of combustible vapor and to build up enough air pressure to activate the switch. The closed TD relay and switch allow voltage to close **relay 082K5,** operating **master fuel valve 082L1,** the **fuel pump** (located in **fuel control unit 082A2)** and **ignition unit 082A3.** The closed relay also connects power to the **temperature controller** and **thermostat** (See step e.).

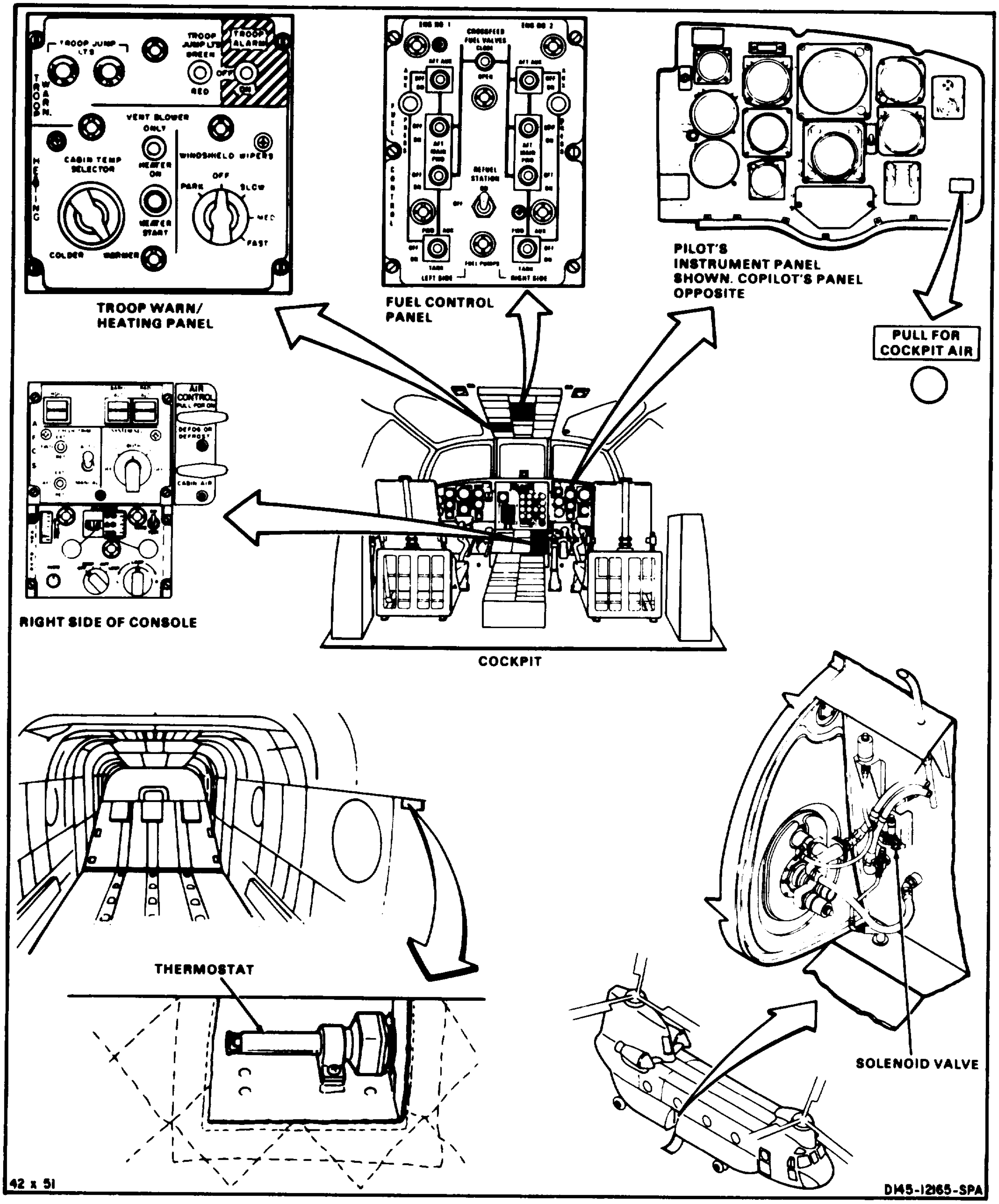
c. The open master fuel valve unit allows fuel to be delivered from the boost pump in the right main tank to the fuel control unit. In the fuel control unit, the fuel passes through a **filter,** a **pressure regulator** and a **pump.** The pump raises fuel pressure to 100 psi, controlled by a **pressure relief valve,** and delivers it through a **solenoid valve** to the heater. The solenoid valve is energized through the temperature controller and thermal cycling switch (See step e.).

d. Fuel enters the heater combustion chamber, where it is atomized by a spray nozzle and mixed with air provided by the fan through the combustion air tube. The mixture is ignited by a spark plug supplied with high tension voltage from the ignition unit. The remainder of the pressurized air flows around the combustion chamber, picking up heat as it does. The heated air is then distributed through ducting to the cockpit and cabin. Air flow direction and volume is controlled by manual operation of valves in the ducting.

e. The temperature of the heated air is controlled by the combined action of **CABIN TEMP SELECTOR switch 082S1, temperature controller 082A1,** and **cabin thermostat 082S4.**


HEATER CONTROL RELAY
TEMPERATURE CONTROLLER
AIR INLET DUCT
FUEL CONTROL
FAN
EXHAUST PIPE
AIR PRESSURE SWITCH
HEATER
HEATER COMPARTMENT
IGNITION UNIT
THERMOSTATIC SWITCHES
42 X 34
D145-12163-SPA


COCKPIT AND CABIN DUCTING
42 X 17
D145-12164-SPA


TROOP WARN/
HEATING PANEL
FUEL CONTROL
PANEL
PILOT'S
INSTRUMENT PANEL
SHOWN. COPILOT'S PANEL
OPPOSITE
PULL FOR
COCKPIT AIR
RIGHT SIDE OF CONSOLE
COCKPIT
THERMOSTAT
SOLENOID VALVE
42 x 51
D145-12165-SPA

The switch is on the cockpit overhead panel. The controller is in the heater compartment on the side of the HEATER CONTROL RELAY box at sta 95. The thermostat is on the left side of the cabin at sta 335.

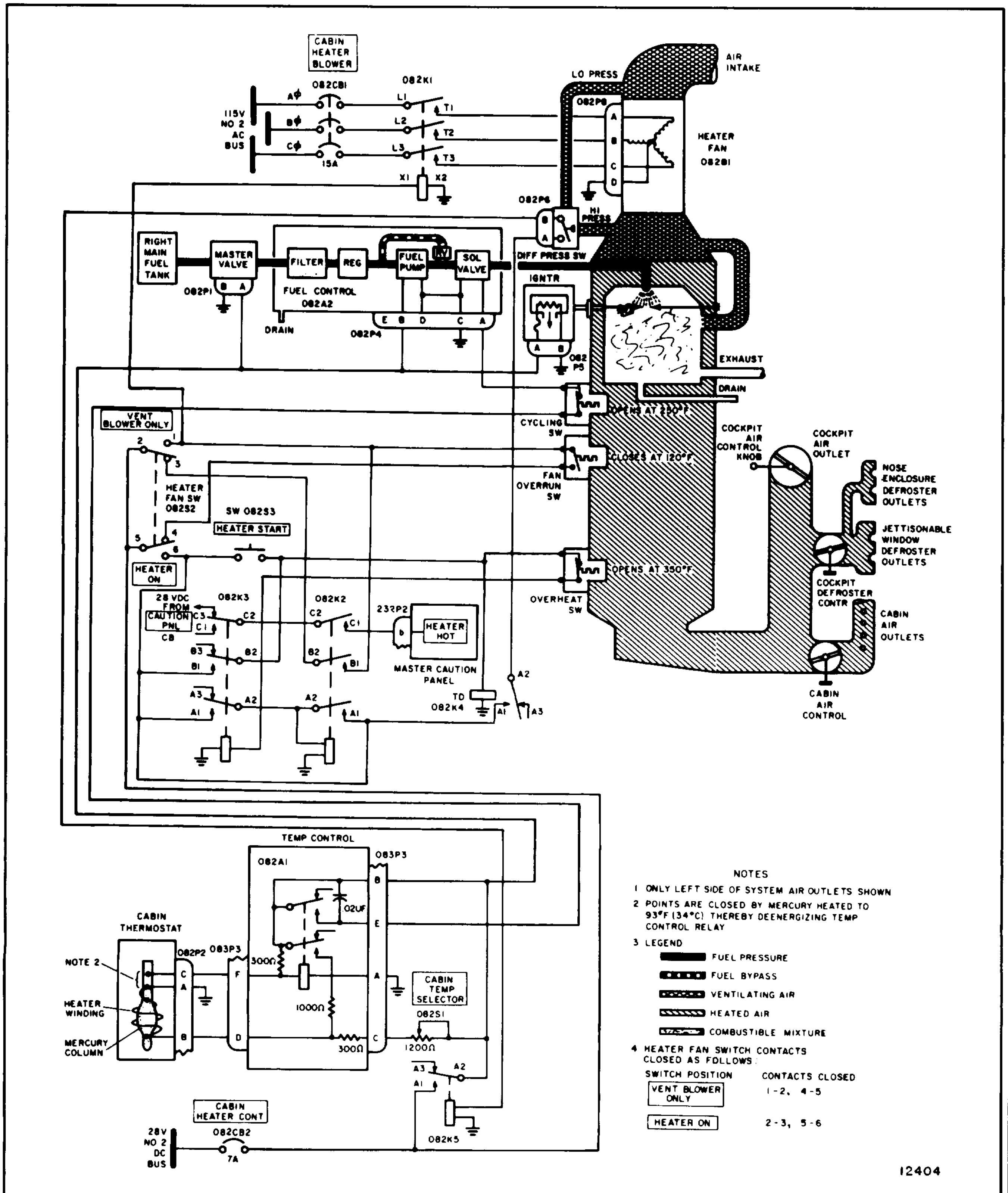
f. Power is provided through the switch to the controller and thermostat when **relay 082K5** is energized (See step b.). At the same time, power passes through the controller and **thermal cycling switch 082A7** to open the solenoid valve in **fuel control 082A2,** permitting fuel to be delivered to the heater as described in step c.

g. The cabin thermostat consists of a column of mercury surrounded by a heater winding. Current passes through the variable retsistor within the temperature controller to heat the winding. When the winding raises the temperature of the mercury to 93°F (34°C), it opens contacts within the temperature controller relay. This removes power from the solenoid valve within the fuel control, shutting off fuel to the heater. It also removes power from the heater winding, allowing the mercury column to cool and contract. When this happens, the relay contacts open, power is restored to the fuel solenoid valve, and the heater starts.

h. Protection for the heater is provided by three thermal switches at the base of the heater. **Cycling switch 082A7** interrupts the circuit to the fuel control solenoid valve when temperature of the air leaving the heater goes over 250°F (121° C). **Overheat switch 08285** is a backup switch that functions if the cycling switch fails. It opens to deenergize **relay 082K3** whenever air in the transition assembly below the heater exceeds 350°F (177°C). This shuts off the heater, but lets the fan continue to operate. At the same time, the HEATER HOT caution light on the master caution panel comes on. When this happens, the heater cannot be operated again until the transition assembly has cooled below 250°F (121°C. At that time, the heater can be started again by pressing the HEATER START button. **A fan overrun switch 08286** keeps the fan operating after the heater has been shut down until the temperature within the heater drops below 120°F (49°C). If the temperature rises to 120°F (49°C) again, the overrun switch will close and the fan will come on again. This cycling will continue until the temperature stays below 120°F (49°C).

i. Additional heater protection is provided by **diffferential air pressure switch 082A4,** on the sta 95 bulkhead. This switch shuts down the fuel and ignition systems by deenergizing **relay 082K5** if air pressure through the fan drops below 1.25 to 1.75 inches of water

j. When the switch on the cockgit overhead panel is set to VENT FAN ONLY, only those contacts within the switch that energize the heater fan are dosed. The blower then forces unheated ventilating air through the ducting.



NOTES

1 ONLY LEFT SIDE OF SYSTEM AIR OUTLETS SHOWN
2 POINTS ARE CLOSED BY MERCURY HEATED TO 93°F (34°C) THEREBY DEENERGIZING TEMP CONTROL RELAY
3 LEGEND
   - FUEL PRESSURE
   - FUEL BYPASS
   - VENTILATING AIR
   - HEATED AIR
   - COMBUSTIBLE MIXTURE
4 HEATER FAN SWITCH CONTACTS CLOSED AS FOLLOWS

SWITCH POSITION	CONTACTS CLOSED
VENT BLOWER ONLY	1-2, 4-5
HEATER ON	2-3, 5-6

12404

HEATING AND VENTILATING SYSTEM

1. Description

   a. Provides heated and unheated air

   The air conditioning is a heating and ventilation system which circulates either fresh or hot air to maintain the cockpit and cabin areas at selected temperatures.

   b. Fuel for the system

   The main fuel solenoid valve is connected to a tapping in the right main engine fuel feel line located at Station 380 between the right main tank and aft auxiliary tank fuel pods. The solenoid valve controls the flow of fuel to the heater fuel control unit.

   c. Blower

   The blower consists of a fan, motor, and housing. It introduces air into the heater for heating or cooling purposes and, when ventilation is selected, introduces fresh air through the heater into the system ducting. The blower is in the heater compartment between the heater adapter assembly and the air inlet duct.

   d. Heater

   (1) Location

   The heater assembly is in the forward cabin right equipment compartment between Station 120 and Station 95. An acoustical blanket secured by hook and pile tape covers and shuts off the compartment from the rest of the forward cabin area.

   (2) Purpose

   The heater and heater fuel system provides and controls heated air for the aircraft. The system consists of a blower fan which draws air into the heater fuel system which feeds and controls fuel to the heater, an ignition system for ignition of the fuel and air mixture in the combustion chamber, a heater assembly, where the air may be heated, thermal control and selector switches, and electrical wiring which provides a means of selecting and controlling the cabin air temperature and provide overheat protection.

   e. Ducting

   (1) Ducting is located in the cockpit and the cabin area.

   (2) Purpose

   To distribute fresh air or heated air to provide comfortable level of temperature to the crew and passengers.

2. System Operation

a. Master function switch

(1) Location

Overhead panel in the cockpit.

(2) Purpose

To control the air conditioning system

(3) VENT Blower Only

(4) HEATER ON

(5) OFF

b. Heater Start button

(1) Location

Overhead panel in the cockpit

(2) Purpose

To provide a means of starting the heater

c. Temperature selection control

(1) Location

Overhead panel in the cockpit

(2) Purpose

The temperature selector is a rotary variable resistor which controls the current to the temperature controller to maintain selected cabin air temperature.

d. Cabin thermostat

(1) Location

The cabin thermostat is on the left side of the cabin structure at Station 352.

(2) Purpose

The cabin thermostat is a mercury-filled temperature operated switching device. The mercury expands and contracts with change in cabin air temperature to provide operating control of the relay in the temperature controller.

e. Cockpit air knob

(1) Location

There are two cockpit air controls. Each control is made from a sheathed push/pull single core cable, running from a control handle at the lower corner of the pilot and copilot's instrument panels.

(2) Purpose

Each control is routed to the respective cockpit air outlet flap valve on each side of the cockpit floor console and just forward of the cockpit floor.

f. Air control handles

(1) Location

Cockpit Defrost and Cabin Heater Controls. These controls are mounted just right of the center cockpit floor console. The marking on the panel is AIR CONTROL PULL FOR ON and for two controls are marked DEFOG or DEFROST and CABIN AIR.

(2) Purpose

To give the cockpit-crew a means of regulating cockpit or cabin airflow.

g. Cargo compartment heat controls

(1) Location

Under the heater ducts on the left and right sides of the cargo compartment.

(2) Purpose

To give the cabin-crew a means of regulating the airflow into the cabin.

h. Heater caution light

(1) Master caution caption

HTG HOT caption comes on at 177°C (350°F)

(2) Overheat switch 177°C (350°F)

Should the temperature of air in the heater transition assembly rise to 350°F, overheat switch releases a relay. This shuts off the entire system except for the blower.

(3) Re-Start

The heating system cannot be operated again until the heater temperature has returned to normal and the HTG START button is pressed.

i. <u>The 121°C (250°F) cycling switch</u>

a. Location

In the transition assembly where the air leaves the heater.

b. Purpose

A cycling effect is provided by the 250°F cycling switch. This switch interrupts the circuit to the fuel control solenoid valve when the temperature of air leaving the heater exceeds 250°F (121°C).

c. The 49°C (120°F) blower overrun switch.

(1) Purpose

After the heater is shutoff, blower overrun switch A6 keeps the blower in operation until the temperature of the heater falls below 120°F (49°C). When the heater control switch is at VENT, the blower forces unheated ventilating air through the system ducting.

d. Heater ignition unit vibrator.

(1) Location

The ignition unit is on the cabin bulkhead at Station 95 on the lower right side of the heater compartment.

(2) Purpose

The ignition unit consists of a relay, condenser, and noise filters in a housing with a vibrator, ignition coil, and junction box mounted externally. The unit converts 28-volt dc to a high voltage oscillating current, which produces a continuous spark at the spark plug in the heater combustion chamber. The vibrator contains a spare set of contacts which can be selected, by operation of a switch on the unit junction box, to continue operation of the ignition unit in event of failure of the vibrator main contacts.

CHAPTER 14
HOISTS AND WINCHES

SECTION I

CARGO HANDLING SYSTEM
DESCRIPTION
AND
THEORY OF OPERATION

DESCRIPTION

The cargo handling system consists of a hydraulically-operated winch and cable, a cable cutter, tackle blocks, and a remote-control grip and safety harness. Stowage bags in the heater compartment are provided for the cable cutter and tackle blocks when not in use. System power and control is provided through various hydraulic valves and electrical switches and receptacles.

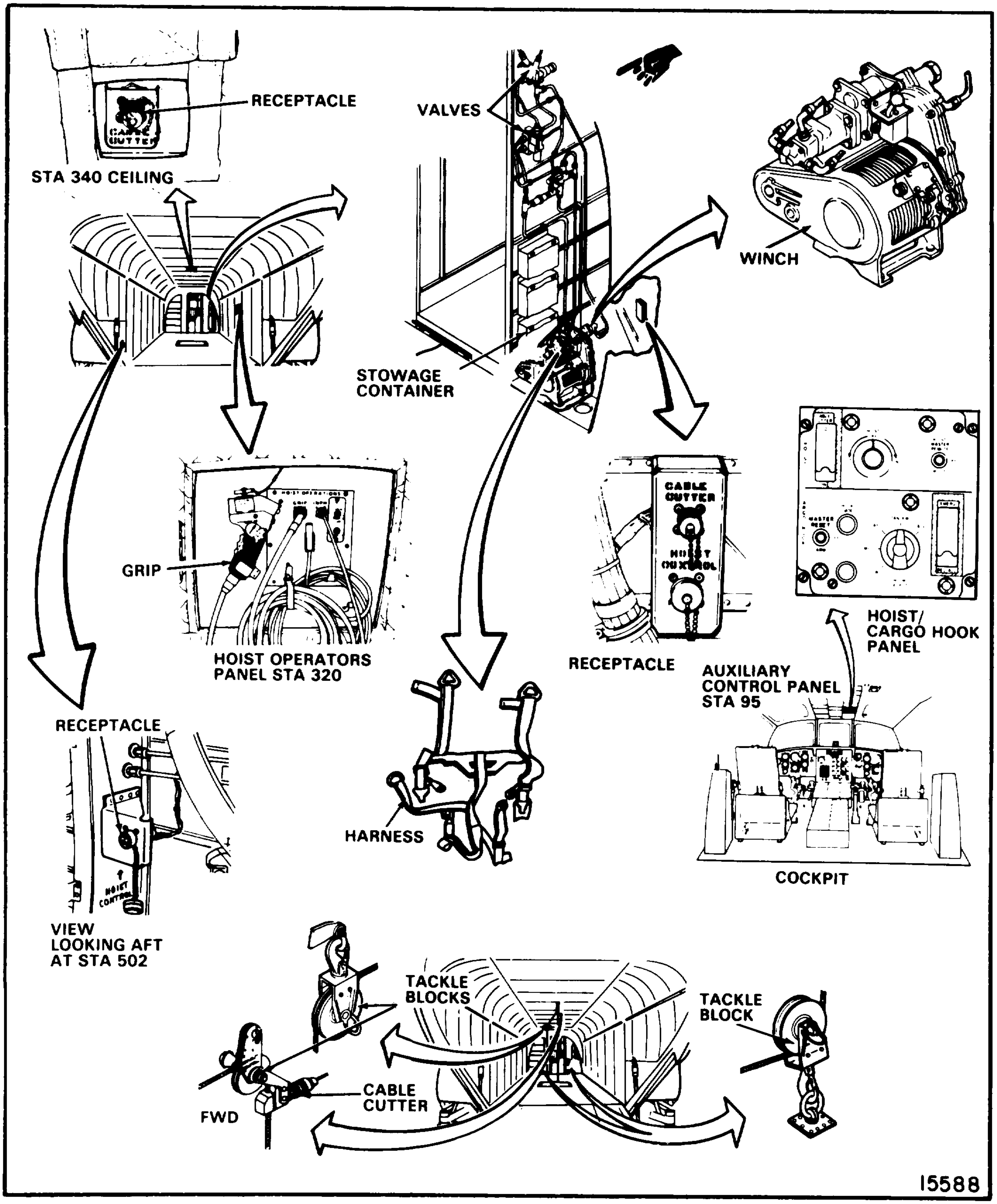
The heart of the cargo handling system is the winch, mounted to the floor of the heater compartment at the right forward corner of the cabin. It is powered by hydraulic pressure from the utility hydraulic system. By changing cable routing, the winch can be used to perform several different functions:

- Loading cargo into the cabin through the open cargo door
- Carrying or bringing on board cargo through the open rescue hatch while in the air
- Personnel rescue operations
- Parachute static line retrieval

Refer to TM 55-1520-240-10 for information on setting up the system to perform these functions.

The winch has 150 feet of 1/4 inch steel cable. It has a 3,000 pound load capacity at a reel-in speed of 20 feet per minute for cargo loading through the cargo door. For hoisting operations through the rescue hatch, it can lift 600 pounds at a reel-in speed of 100 feet per minute. For cargo loading, the effective winch capacity can be increased by reeving the cable through the cable blocks as described in TM 55-1520-240-10.

The winch system can be operated from either the cockpit or the cabin. Cockpit operation is by the HOIST panel on the overhead console. Cabin operation is by a control grip that can be plugged into an operator's panel at sta 320 or receptacles at sta 95 or 502. If power is lost during operation, a winch-mounted brake will automatically lock the cable. During rescue operations, the cable is reeved through a cable cutter that is plugged into a receptacle above the rescue hatch. During cargo operation, the cable cutter is stowed in the stowage container and connected to a stowage receptacle in the heater compartment at sta 95.



RECEPTACLE
CABLE CUTTER
STA 340 CEILING
VALVES
WINCH
STOWAGE CONTAINER
GRIP
HOIST OPERATORS PANEL STA 320
CABLE CUTTER
HOIST CONTROL
RECEPTACLE
HOIST/ CARGO HOOK PANEL
AUXILIARY CONTROL PANEL STA 95
RECEPTACLE
HARNESS
COCKPIT
VIEW LOOKING AFT AT STA 502
TACKLE BLOCKS
TACKLE BLOCK
CABLE CUTTER
FWD
15588

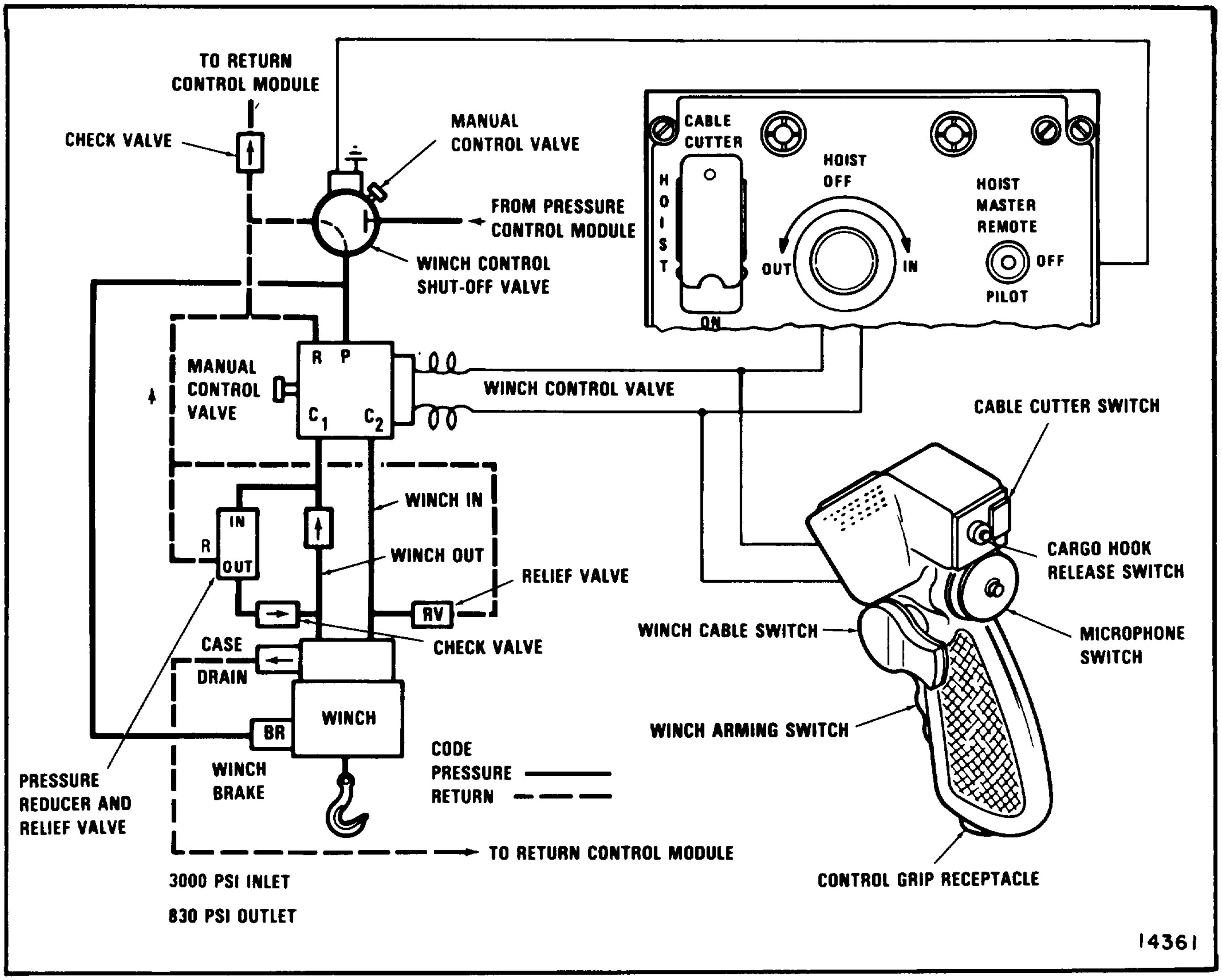
THEORY OF OPERATION

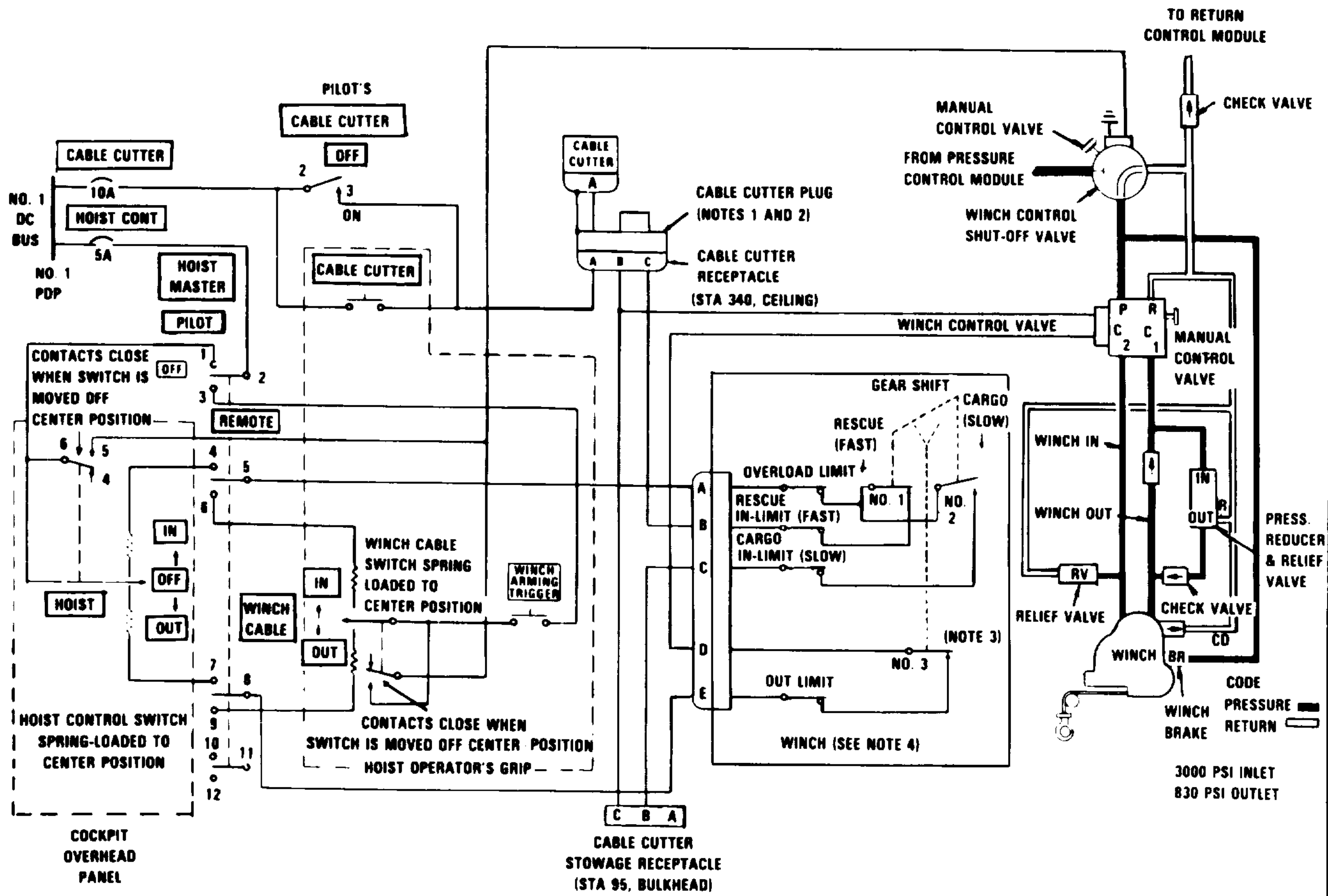
The hoist system can be operated from the cockpit or from any of three locations in the cabin. System operation is identical regardless of which location is used. Operation described here is from the cockpit overhead panel, with the winch shifting lever at RESCUE. The control locations in the cabin can be used when the HOIST MASTER switch on the cockpit overhead panel is at REMOTE.

1. **Placing the HOIST MASTER** switch **to PILOT connects 28-volt dc from the bus to the spring-loaded center-off HOIST** rotary switch. **The rotary switch has a set of contacts that close whenever the switch is off center. When off center, these contacts energize the** winch brake control valve solenoid. **When energized, this solenoid directs pressurized hydraulic fluid to release the** winch brake **and to the P (pressure) port of the** winch control valve.
2. **Rotating the HOIST switch to OUT energizes the winch control shutoff valve solenoid. At the same time, current flows from the rotary switch to energize the winch control valve OUT solenoid thru the out-limit switch on the winch. Hydraulic fluid from the C 1 port of the winch control valve flows thru the pressure reducing valve. This reduces the pressure to 750 psi before it reaches the OUT port of the winch motor. This pressurized fluid operates the hydraulic motor to reel out the cable. The fluid returns to the system through the IN port of the winch motor to the winch control valve. A relief valve between the hoist in line and system return protects the winch motor case shaft seal from high pressure.**
3. **When the HOIST switch is released to OFF, the winch control shutoff valve and the winch control valve circuits open. The winch control valve and shutoff valve return to the deenergized position. This stops fluid flow to the winch motor, to the brake release line, and the winch control valve. The winch control shutoff valve then directs fluid from the brake release line to the utility hydraulic system return line and the spring-loaded brake is applied automatically.**
4. **Rotating the HOIST switch to IN closes the contacts that complete the winch control shutoff valve solenoid circuit. It also moves the wiper of the rotary switch into contact with the IN portion of the switch. Current flows through the wiper arm to the IN solenoid of the winch control valve, through the overload limit and in-limit switches on the winch, and the cable cutter plug. The IN solenoid positions the winch control valve to direct fluid through the C2 port of the valve, to the IN port of the winch motor. The pressurized fluid operates the hydraulic motor to reel in the cable. The fluid returns to the system through the OUT port of the winch motor, the pressure reducer, and the return port of the winch control valve.**
5. **When the CABLE CUTTER switch on either the hoist control panel or the operator's grip is ON, power from the 28-volt dc bus is connected to the cable cutter cartridge. In this condition, operation of the cable cutter from either the cockpit or cabin is independent of the HOIST MASTER switch.**
6. Limit switches **prevent winch overloading, stop winch OUT operation when the cable is extended 150 feet, and stop winch IN operation when the cable is extended 28-1/2 feet in the rescue mode or extended 3 feet in the cargo mode. An** overload limit switch **opens the circuit when the load on the cable exceeds 3,100 to 3,200 pounds when the winch is operated in the reel-in direction.**

7. A shifting lever **on the winch controls a two-speed gear train, labeled RESCUE (fast) and CARGO (slow). With the lever at RESCUE, the cable cutter must be plugged into the overhead CABLE CUTTER connector to complete the winch circuit. With the lever at CARGO, the cable cutter must be plugged into the stowage receptacle at sta 95 to complete the circuit. The shifting lever is mechanically linked to** three transfer switches. **These switches connect voltage to either the rescue or cargo in-limit switch. When the lever is at RESCUE, the rescue (fast) in-limit switch is connected in series with switch 1. With the lever at CARGO, the cargo (slow) in-limit switch is connected in series with switch 2. Switch 3 is a safety device which interrupts the hoist-out circuit when switches 1 and 2 are open. This arrangement prevents the winch from operating in either direction when the gears are not engaged.**

8. **In case of electrical failure, emergency hydraulic operation of the winch is possible by operating** manual override knobs **on the** winch control shutoff valve **and the** winch control valve. **The knob on the shutoff valve is an on-off valve that allows fluid to flow through the system when it is pushed in. It can be locked in by rotating it. Winch reeling direction (cable in or out) is controlled by rotating the knob on the control valve cw or** ccw, **When the manual override knobs are used, the cable limit switches are disabled, As a result, care is necessary to prevent reeling the cable too far in or out.**


TO RETURN CONTROL MODULE
CHECK VALVE
MANUAL CONTROL VALVE
FROM PRESSURE CONTROL MODULE
WINCH CONTROL SHUT-OFF VALVE
CABLE CUTTER
HOIST
HOIST OFF
OUT
IN
ON
HOIST MASTER REMOTE
OFF
PILOT
MANUAL CONTROL VALVE
R P
C1 C2
WINCH CONTROL VALVE
CABLE CUTTER SWITCH
WINCH IN
WINCH OUT
IN
OUT
R
RELIEF VALVE
RV
CHECK VALVE
CARGO HOOK RELEASE SWITCH
MICROPHONE SWITCH
WINCH CABLE SWITCH
CASE DRAIN
WINCH
BR
WINCH ARMING SWITCH
PRESSURE REDUCER AND RELIEF VALVE
WINCH BRAKE
CODE
PRESSURE
RETURN
TO RETURN CONTROL MODULE
CONTROL GRIP RECEPTACLE
3000 PSI INLET
830 PSI OUTLET
14361



NOTES

1 FOR RESCUE (FAST) OPERATION, CABLE CUTTER PLUG MUST BE PLUGGED INTO CABLE CUTTER RECEPTACLE AND GEAR SHIFT MUST BE IN RESCUE POSITION TO COMPLETE HOIST "IN" CONTROL CIRCUIT.

2 FOR CARGO (SLOW) OPERATION, CABLE CUTTER PLUG MUST BE PLUGGED INTO STOWAGE RECEPTACLE AND GEAR SHIFT MUST BE IN CARGO POSITION TO COMPLETE WINCH "IN" CONTROL CIRCUIT.

3 SWITCH NO. 3 IS OPEN WHEN SWITCH NO. 1 AND SWITCH NO. 2 ARE OPEN SWITCH NO. 3 IS CLOSED WHEN SWITCH NO. 1 OR SWITCH NO. 2 IS CLOSED. THIS ARRANGEMENT PREVENTS WINCH OPERATION WHEN THE GEARS ARE NOT ENGAGED.

4 THESE SWITCHES ARE LOCATED ON THE WINCH.

14362

CHAPTER 15
AUXILIARY POWER UNIT

SECTION I
AUXILIARY POWER UNIT
DESCRIPTION
AND
SEQUENCE OF OPERATION

A. Auxiliary Power Unit Improvements

Description of Change, from that of the CH-47C configuration, is as follows:

1. Install the T-62T-2B (solar) auxiliary power unit in lieu of the T-62T-2A1 (solar) power unit.

2. The installation of this new auxiliary power unit is practically identical to that of the CH-47C aircraft.

3. The T-62T-2B APU includes the following features from that of the T-62T-2A1 APU:

   a. T-62T-2A1 power section (current CH-47 unit).

   b. Two pad gearbox (driving hydraulic motor/pump and 20 KVA alternator) similar to CH-46 T-62T-11 APU gear box.

   c. The speed switch and tach generator are removed and replaced with a magnetic pickup on the gearbox.

   d. The oil pressure switch will be rewired to eliminate low oil pressure from shutting down the APU. A new hermetically sealed switch replaces the existing switch.

   e. The fuel pressure switch is removed.

   f. The exhaust temperature switch is removed and replaced with an exhaust thermocouple.

   g. An electronic, solid state, speed sequencing and control unit (ESU) to regulate starting and protective functions is added.

   h. The apu hour-meter is removed.

   i. External plumbing and wiring harnesses were modified as necessary to support the foregoing changes.

B. Description

1. Function

   The gas turbine auxiliary power unit T62-T-2B (APU) is mounted in the aft cabin above the ramp. The basic components of the apu are the gas turbine engine hydraulic motor-pump, fuel control, accessory drive, and ac generator. An apu electronic sequence unit, which monitors apu operation is on the left side of the cabin above the ramp. The motor-pump on the apu pressurizes the utility and flight control hydraulic systems for main engine starting and ground checks. The apu also drives an ac generator which supplies power to No. 1 and No. 2 electrical systems.

The apu oil supply is integral and contained within the sump of the accessory drive assembly. The apu receives fuel from the left fuel system through a boost pump, a manual shutoff valve, and a solenoid valve.

2. Control Components

a. Electronic Sequence Unit (ESU)

The ESU is mounted on the left side of the cabin above the ramp. The unit monitors apu starting and operation. It monitors apu speed and exhaust gas temperature. It continuously compares these parameters with limits programmed into control box circuits. If a limit is exceeded, the control box will automatically shutdown the apu. Four magnetic built-in test equipment (bite) indicators are on the control box. These indicators are either black or white. A label on the control box explains the various bite indications and their meaning.

b. APU Control Switch

The apu control switch is on the electrical power panel on the overhead switch panel. It is a three-position switch marked APU OFF, START, and RUN. The switch is spring-loaded from START to RUN. To start the apu, the switch is moved from OFF to RUN for 3 to 5 seconds, then set to START for 2 seconds, then released to RUN. APU start is then automatic and controlled by the control box. The APU ON caution light will come on in about 10 to 12 seconds. To stop the apu, the switch is set to OFF. Normally, electrical power to control apu operation is from the 28-volt essential DC bus through the APU CONT NORM circuit breaker on No. 1 power distribution panel. Emergency power to control the apu is from the battery bus through the APU CONT EMERG circuit breaker on the No. 1 power distribution panel.

c. APU ON Caution Light

The APU ON caution light is on the master caution panel. Normally, the APU is intended for ground operation only. It is not intended for operation during flight. If the light remains illuminated following take-off, it alerts the pilot to shutdown the apu. When the light is on, it indicates the apu is up to speed, exhaust gas temperature, oil pressure, and oil temperature are normal. It does not necessarily indicate that apu hydraulic pump or generator output is normal. If the rotors are not turning, check the UTIL HYD SYS and RECT OFF caution lights to evaluate output of the apu hydraulic pump and generator. The APU ON caution light is controlled by the apu control box.

C. Limitations and Precautions

1. Automatic Shutdown

a. ESU Processor Board Failure

b. ESU Sensor/Data Board Failure

c. Over-temperature

d. Over-speed

e. Under-speed

f. Fail to Start

g. Loss of Speed Data

h. Shorted Thermocouple Probe

i. Open Thermocouple

j. Processor Sequence Fail

k. No Temperature Data

2. Max rear wind-speed for APU Start - 25 Kts

TEACHING PROCEDURE

D. Description

1. General

a. Helicopter contains APU system to provide hydraulic and electrical power for engine start and ground maintenance.

b. System contains an APU, an electronic sequence unit, a Start module, and a fuel system.

c. APU contains a motor-pump and an AC generator

d. Electronic sequence unit is a microprocessor with built-in test equipment.

e. ESU controls Start of APU and then monitors operation

f. System operates on 28 volts DC from essential bus for normal start and from the battery bus for emergency Start.

g. Fuel system contains pump, fuel solenoid valve and manual shutoff valve. (in-line filter, main filter, governor)

h. Hydraulic system contains accumulator, start module and motor-pump

E. Presentation

1. Components

a. Auxiliary power unit (P/N T-62T-2B)

(1) Location

   (a) Mounted in the extreme aft end of helicopter Station 600, waterline +60

   (b) Accessible from the ramp area

(2) Function

   (a) Provide electrical power for ground maintenance

   (b) Provide hydraulic power for engine start and ground maintenance

(3) Construction

   (a) Gas turbine engine with the following:

      1 Electrical harness

      2 Fuel control and associated equipment

      3 Mounting pads for generator and hydraulic motor-pump

(4) Operation

   (a) Electrical power to ESU starts operation sequence

   (b) Hydraulic sequence valve opens and pressure directed to motor-pump

   (c) Fuel and ignition are programmed to APU

   (d) At certain speeds, controlled by ESU, events occur until APU is to operating speed

   (e) Motor then becomes a pump and APU ON light on caution panel comes on

   (f) Generator is ready for use and hydraulic pressure available.

(5) Specifications

   (a) Rated Speed - 58,355 rpm (100% rated speed)

   (b) Max Allowable - 6,794 rpm

   (c) Weight - 74.8 (including residual fluids)

   (d) Std Operating Conditions - Sea level to 15,000 ft. altitude

   (e) Rated Output Power - 95 SHP max

   (f) Rated Output Power - 66 SHP normal

(g) Max Rated Exhaust Gas Temp - 1130°F

(h) Fuel Consumption - 115 PPH at 95 SHP
- 89 PPH at 66 SHP

(i) Model No. - T-62T-2B

(6) Reduction Drive Assembly

(a) Location

1 On the fwd portion of the Power Plant Assembly and bolted to the Turbine Assembly

(b) Function

1 Reduces the output rotational speed (58,255 rpm) of the Rotor Assembly (Turbine Assembly) to speeds necessary to drive the engine accessories and engine-driven equipment.

(c) Specification

1 Input Speed (rated) - 38,225 rpm

2 Output Speed (at rated input)

a Axial Pad - 8216 rpm

b Right Angle Pad - 8000 rpm

c Accessory Pad - 4242 rpm

3 Magnesium Housing

(d) Construction

1 Axial Pad - Mounting position of APU motor pump

2 Accessory Pad - Mounting of fuel pump and Acceleration Control Assembly

3 Right Angle Pad - Mounting of 20 KVA generator

b. Electronic sequence unit (ESU) (P/N 160200-200)

(1) Location

(a) Located at Station 585, WL 50 left side

(b) Accessible from the ramp area

(2) Function

(a) Controls the Start sequence of the APU

(b) Monitors APU for faults and shuts down APU if fault occurs

(3) Construction

(a) Contains microprocessor and program in read only memory (ROM)

(b) Has built in fault display

1 Four magnetically latched indicators

(c) Two electrical connectors for interface to aircraft wiring

(d) Microprocessor runs check on itself every 40 milliseconds during Start sequence

(e) Checks APU operating parameters at least once every 40 milliseconds during operation

(4) Operation

(a) Operates on 28 volts DC

(b) When switch on overhead panel is set to run, voltage is supplied to

1 Airframe fuel pump

2 Fuel solenoid valve

3 ESU

(c) ESU bite indicators are reset

(d) Placing switch to start opens hydraulic valve

(e) Start sequence is started and continues as programmed

(f) ESU compares APU speed and initiates the next sequence

(g) After start is complete, ESU monitors APU and itself

c. Fuel System

(1) Location

(a) Fuel pump and solenoid valve in aft left inter-tank area

(b) Manual shutoff valve located at Station 540, left side

(2) Function

(a) Supply fuel to APU

(b) Provide means to shutoff fuel to APU in emergencies

(3) Operation

(a) Pump and solenoid valve operate on 28 volts DC

(b) When APU start switch placed to run, 28 volts directed to pump and valve through fault relay

(c) When ESU detects a fault, fault relay is energized and interrupts voltage to pump and valve

(d) Manual valve can be operated to shutoff fuel flow to APU. Access from outside or inside

d. APU start module

(1) Location

(a) Right side of ramp area, Station 585, WL 60

(b) On outboard side of aft transmission enclosure

(2) Function

(a) Controls application of hydraulic pressure to APU motor-pump and spins APU until it starts

(3) Operation

(a) Operates on 28 volts DC

(b) When start switch placed to Start, ESU signals pilot solenoid valve to open

(b) This operates pressure operated valve and directs pressure to APU motor-pump

(d) When APU reaches 90% of speed, start solenoid is closed

(e) Motor-pump becomes pump and supplies pressure to utility system

2. System Operation

a. Electrical power to operate the APU system is obtained from -

28 VDC - essential bus - normal operational through APU cont nor CB

28 VDC - battery bus - emergency operation through APU cont emer CB

b. APU accumulator must have a 3000 psi charge

c. Placing APU Start switch to run closes contacts 4-5. The 28 volts DC from terminal 4 of the APU switch is applied to three circuits. This voltage is applied to the ESU for power and to reset the bite indicators. Also applied through fault relay contacts to open the fuel solenoid valve and run the fuel pump.

d. When terminals 1-2 are closed with switch in start, voltage from terminal 1 goes to ESU and provides a start signal. This operates the hydraulic valve. Pressurized fluid from the accumulator flows through the valve and motors the motor-pump and the APU.

e. As the APU starts to rotate, a magnetic pickup generates a signal proportional to APU speed. The APU processes this speed signal which schedules events at 5, 14, 70, and 90% of rated speed. The ESU also monitors exhaust gas temperature. A thermocouple in the combustor assembly generates a signal which is proportional to EGT. When the APU reaches 5% of rated speed a 40 second timer starts. If the APU does not complete a Start in 40 seconds, the fault relay operates and stops fuel flow to the APU.

f. At 5% rated speed, the ESU applies a start fuel signal (28 volts) to the APU. This signal opens the start-fuel valve and power the exciter. The exciter provides a high-energy pulse to the spark plug. Fuel is directed through the start fuel nozzle and vaporized in the combustor where it is ignited by the spark plug. This action increases APU speed.

g. At 14% rated speed, the ESU applies the main fuel signal to the APU. This signal opens the main fuel valve. From this valve, fuel flows through the fuel manifold assembly and six vaporizer tubes to the combustor. This additional fuel accelerates the APU.

h. At about 20% of rated speed, the APU start accumulator depletes its charge. This causes the motor-pump to shift to neutral.

i. At 70% rated speed, the start-fuel signal stops. The exciter and Start fuel are turned off. Combustion is self-sustaining.

j. At 90% rated speed, ESU closes the start valve, and generates a 90% rpm switch on signal. The motor-pump shifts to a pump and recharges the accumulator. The 90% rpm switch on signal starts a 1.5 second timer. After 1.5 seconds, the ESU applies 28 volts to the APU ON capsule on the master caution panel.

k. The ESU then monitors the APU for faults and shuts the APU down when a fault occurs.

l. Over temp during start is a temperature 1250°F, over temp during operation is a temperature 1150°F, over speed is a speed 110% of rated speed. Under speed is a speed (90% after 90% plus 1.5 seconds).

CHAPTER 16
MISSION EQUIPMENT

SECTION I

CARGO CARRYING HOOK SYSTEM
DESCRIPTION
AND
THEORY OF OPERATION

EXTERNAL CARGO HOOK SYSTEM

DESCRIPTION

The external cargo hook system consists of three separate cargo hooks mounted on the underside of the helicopter. The system allows a single load to be carried suspended at up to three points or three separate loads to be carried at the same time.

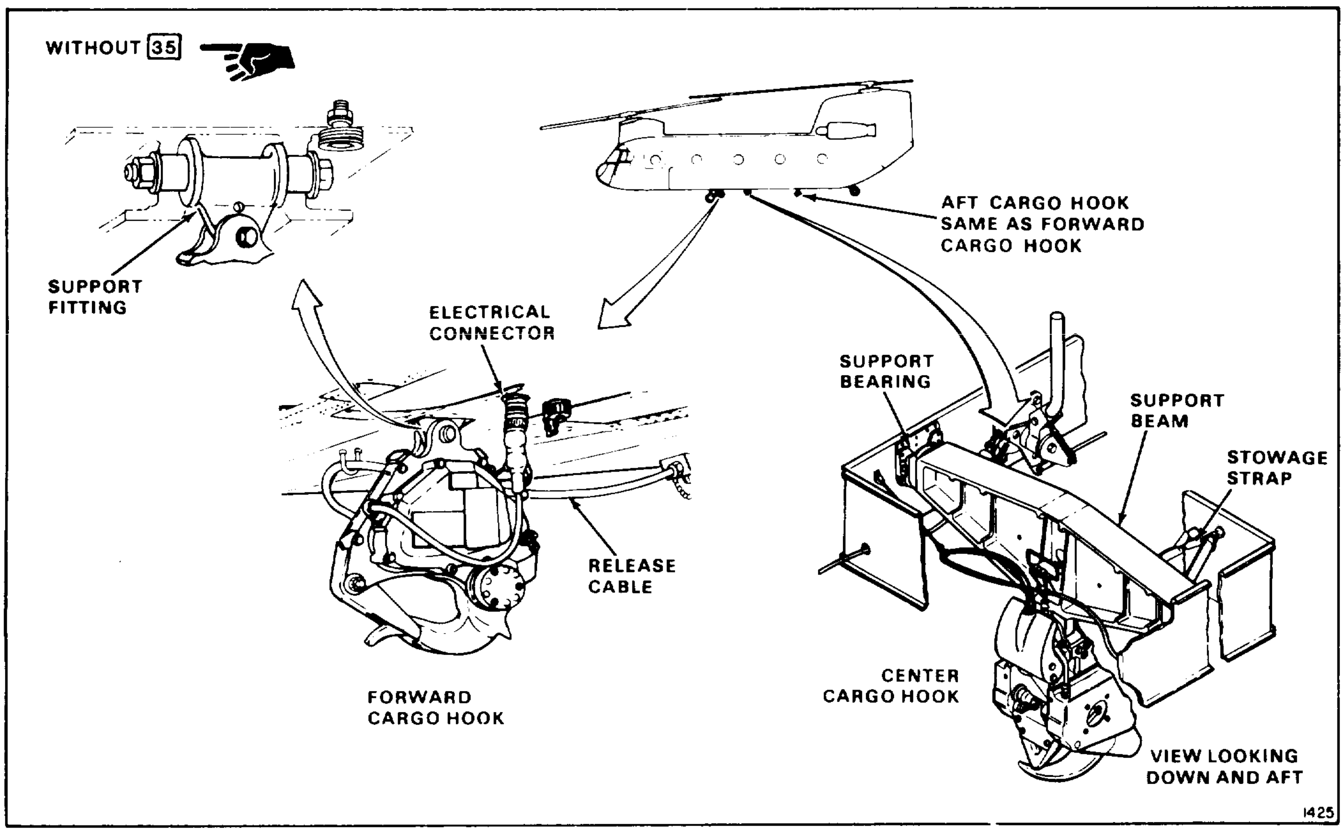
The center cargo hook is suspended from a beam under the cabin floor at station 331. The hook is attached to the beam with a bolt that lets the hook swing to each side. The beam is carried in bearings attached to structure at the sides of the rescue hatch in the floor. It can pivot forward and aft from the attaching points,

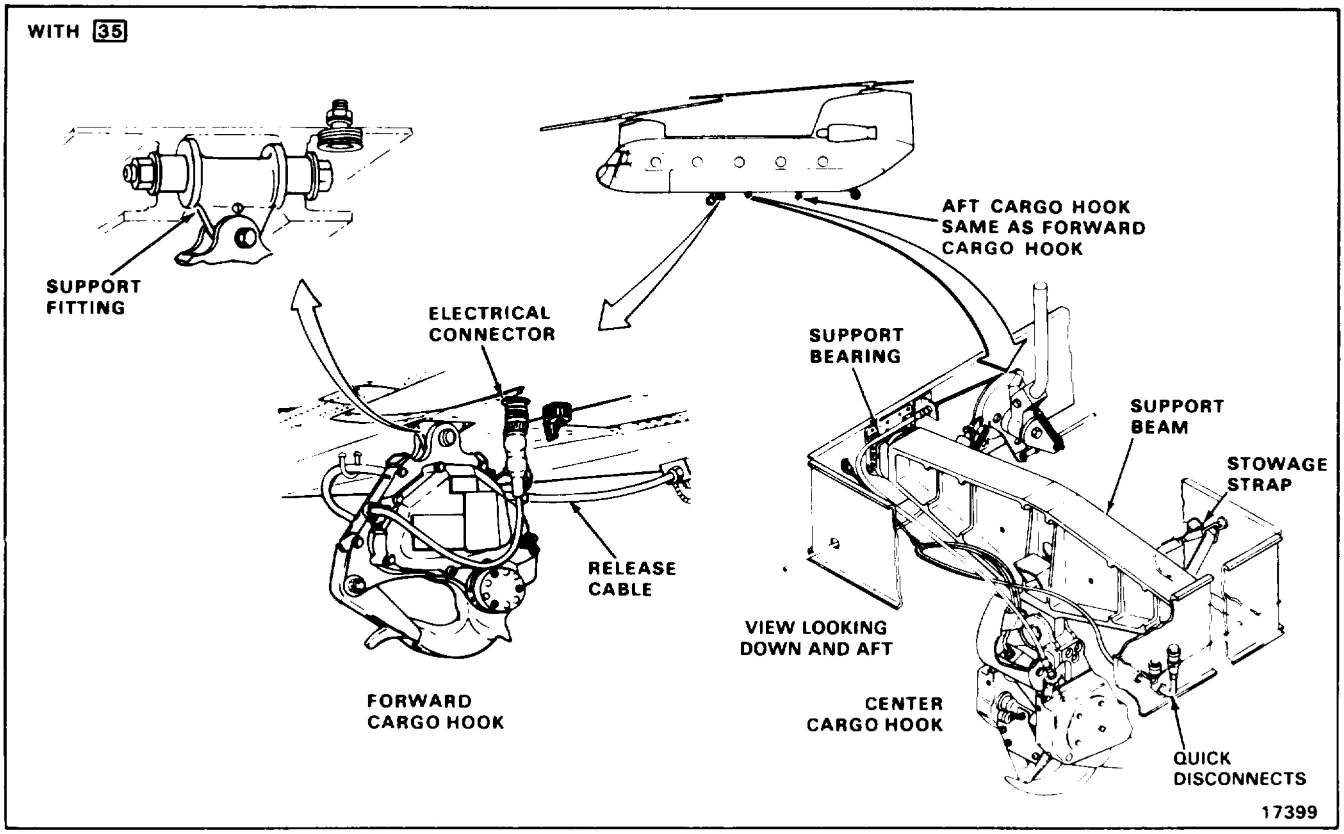
When not in use, the hook is stowed between cabin floor and rescue hatch door. In use, the hatch door is opened and the hook is unstrapped to hang down through the open hatch. The hook lifting capacity is 26,000 pounds.

The forward and aft hooks hang from fittings attached to the floor beams at stations 249 and 409. Each fitting is a universal type that allows the hook to swing forward and aft and from side to side. Normally the hook is electrically actuated through a connector on the fuselage skin. It can also be released manually through a cable that connects to a release mechanism. The lifting capacity of each hook is 17,000 pounds. When used together, the two hooks can lift a load of 25,000 pounds.

All three hooks can be released in any one of three modes — normal, emergency, or manual. See Task 16-2 for a description of hook operation in each of these modes.

Power to operate the cargo hook system in normal operation comes from the No. 228 volt dc bus. Two circuits are provided, each controlled by a separate circuit breaker. One circuit provides power to the system. The other contains the control switches and relays. Two separate power and control circuits are provided for emergency release of the hooks. Again, each has its own circuit breaker.



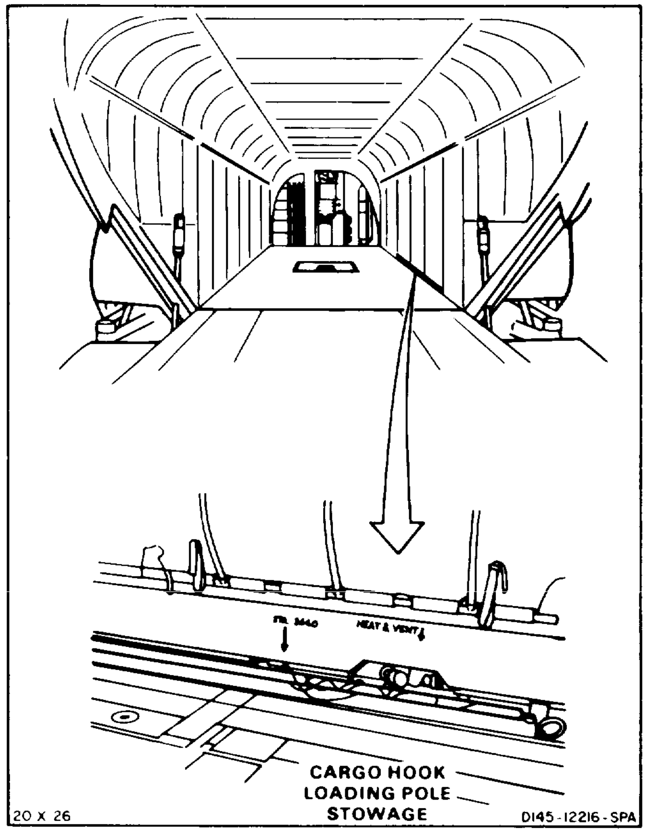

WITH 35
SUPPORT FITTING
ELECTRICAL CONNECTOR
AFT CARGO HOOK SAME AS FORWARD CARGO HOOK
SUPPORT BEARING
SUPPORT BEAM
STOWAGE STRAP
RELEASE CABLE
VIEW LOOKING DOWN AND AFT
FORWARD CARGO HOOK
CENTER CARGO HOOK
QUICK DISCONNECTS
17399

EXTERNAL CARGO HOOK SYSTEM (Continued)

CENTER CARGO HOOK LOADING POLE

The cargo hook loading pole is used to pick up the sling loop of external cargo loads from inside the helicopter. The loop is then placed on the cargo hook by hand. The pole has a hook at one end and a cable at the other end. The cable is attached to the fuselage to prevent accidental loss of the pole when in use and to provide a discharge path for static electricity.

When not in use the pole is stowed on the lower right side of the cabin at about sta 360, just below the heater duct.



WARNING

Make sure the ground cable is connected when using the loading pole. With the rotors turning, static potential between the helicopter and a load on the ground can be as high as <u>40,000 volts.</u>

THEORY OF OPERATION

Normal Release

NOTE

The relays referred to in this section are in the Normal Release Relay Box at the right side of the cabin near sta 280.

Setting the **MASTER switch** on the **CARGO HOOK control panel** to ARM energizes **power control relay K1** through the control circuit breaker, The energized relay lights the ARMED SW FAIL light on the cabin relay box and arms the following:

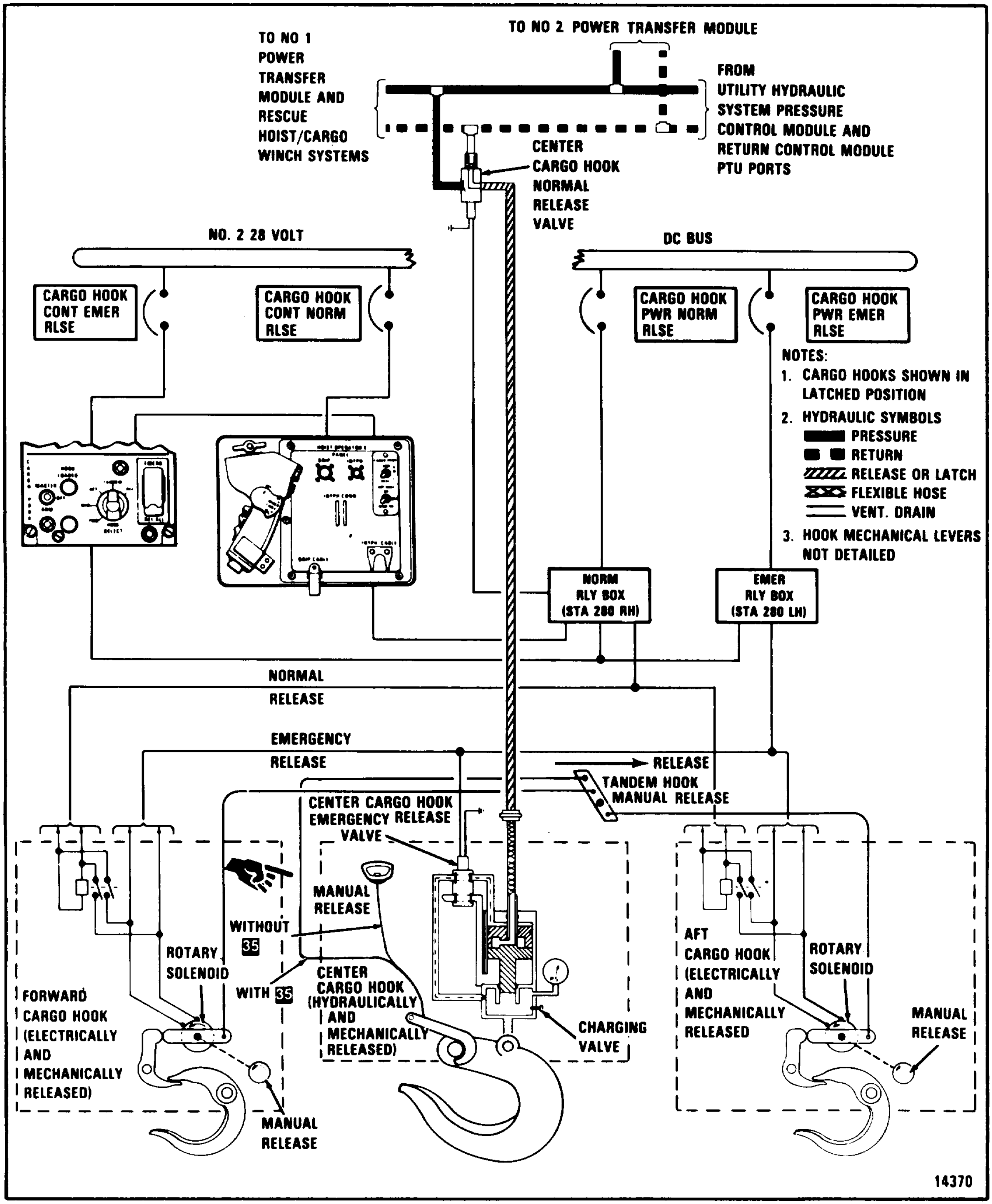
- System power circuit, through the power circuit breaker
- **CARGO REL buttons** on the pilot's and copilot's control stick grips
- **CARGO HOOK switch** on the HOIST OPERATOR PANEL in the cabin
- **Ground relay K4** contacts
- **Center hook release relay K3** contacts
- **Forward hook release relay K8** contacts
- **Aft hook release relay K9** contacts

Setting the CARGO HOOK switch on the HOIST OPERATOR PANEL to ARM arms the CARGO HOOK RELEASE switch on the control grip in the cabin.

Operating the hook release button on either of the control stick grips or the hook release switch in the cabin energizes **ground relay K4,** which is then latched energized through its own contacts. The RELEASE SW FAIL and GROUND RELAY ACTIVATE lights on the relay box come on. The FAIL light stays lit as long as the release switch (or button) is held. The ACTIVATE light will stay lit as long as relay K4 stays energized.

The closed contacts of relay K4 also provide a ground for the center hook **hydraulic solenoid valve** and for the normal release relay circuits of the forward and aft hook.

Finally, the release switch (or button) energizes one or more of **release relays K3** (center), **K8** (forward), and **K9** (aft), depending on the position of the HOOK SELECT switch on the cockpit overhead panel. Current from the power circuit flows through the closed release relay contacts to energize the **release solenoid** of the selected hook.



TO NO 1 POWER TRANSFER MODULE AND RESCUE HOIST/CARGO WINCH SYSTEMS
TO NO 2 POWER TRANSFER MODULE
FROM UTILITY HYDRAULIC SYSTEM PRESSURE CONTROL MODULE AND RETURN CONTROL MODULE PTU PORTS
CENTER CARGO HOOK NORMAL RELEASE VALVE
NO. 2 28 VOLT
DC BUS
CARGO HOOK CONT EMER RLSE
CARGO HOOK CONT NORM RLSE
CARGO HOOK PWR NORM RLSE
CARGO HOOK PWR EMER RLSE
NOTES:
1. CARGO HOOKS SHOWN IN LATCHED POSITION
2. HYDRAULIC SYMBOLS
PRESSURE
RETURN
RELEASE OR LATCH
FLEXIBLE HOSE
VENT. DRAIN
3. HOOK MECHANICAL LEVERS NOT DETAILED
NORM RLY BOX (STA 280 RH)
EMER RLY BOX (STA 280 LH)
NORMAL RELEASE
EMERGENCY RELEASE
RELEASE
TANDEM HOOK MANUAL RELEASE
CENTER CARGO HOOK EMERGENCY RELEASE VALVE
MANUAL RELEASE
WITHOUT 35
WITH 35
ROTARY SOLENOID
FORWARD CARGO HOOK (ELECTRICALLY AND MECHANICALLY RELEASED)
CENTER CARGO HOOK (HYDRAULICALLY AND MECHANICALLY RELEASED)
CHARGING VALVE
MANUAL RELEASE
AFT CARGO HOOK (ELECTRICALLY AND MECHANICALLY RELEASED)
ROTARY SOLENOID
MANUAL RELEASE
14370

If the **center cargo hook** has been selected, the following sequence takes place:

- With **hydraulic solenoid valve 134L1** energized to open, pressurized fluid from the utility hydraulic system flows to the hook **actuating cylinder.** The cylinder is forced upward and the hook opens.
- As the hook opens, it closes normally-open **switch S3.** At the same time, the moving cylinder closes normally-open **switch S2.** These switches complete the circuit to light the MID HOOK OPEN light on the master caution panel.
- The hook will remain open until the **MASTER switch** on the cockpit overhead panel or the **CARGO HOOK switch** on the cabin panel is momentarily set to RESET. When this is done, latched relays K3 and K4 are deenergized, closing the hydraulic solenoid valve. The flow of hydraulic fluid to the cylinder is stopped and the fluid return line is opened, allowing pneumatic pressure stored in the cylinder to close the hook.

If the **forward or aft cargo hook** has been selected, the following sequence takes place:

- When the release solenoid is energized, it moves the hook's **release arm** up, unlatching the release lever that holds the load beam closed. Assuming that the load is heavy enough to overcome the spring-loading of the beam, the beam pivots open, releasing the load. With the load released, the spring-loading closes the hook.
- Almost immediately after the release solenoid is energized, a **solenoid protection switch** on the hook opens to reenergize the **normal release relay.** This deenergizes the solenoid, causing the protection switch to open again. The release solenoid is re-energized and the entire sequence repeats, continuing until the hook release button or switch is released.
- When a hook is open, hook-open and linkage-open **limit switches** on the hook close. This energizes relay K5 (aft) or K6 (forward) to close. Contacts on these relays close to light the FWD or AFT HOOK OPEN lights on the master caution panel. When the cockpit **MASTER switch** or the cabin **CARGO HOOK switch** is set to **RESET,** the relays are deenergized and the lights go out.
- A hook-loaded switch on each hook closes when a load of about 150 pounds is applied. The closed switch completes a circuit to light the forward or aft HOOK LOADED light in the cockpit.

Emergency Release

NOTE

> The relays referred to in this section are in the Emergency Hook Release Relay Box at left side of the cabin near sta 280.

In the emergency release mode, all three hooks are opened at the same time by operating the **EMER REL ALL guarded switch** on the cockpit overhead panel. The sequence of operation is as follows:

- When the emergency switch is operated, current from the flight essential bus flows through the CARGO HOOK CONT EMER RLSE circuit breaker and the switch to engage **relay K1** and **time delay relay K2.**
- Closed contacts in energized relay K 1 allow current to flow through the CARGO HOOK CONT EMER RLSE circuit breaker to close contacts in the time delay relay. This activates the relay, holding the contacts closed for 10 seconds after the cockpit switch is released. These closed contacts hold the contacts in relay K1 closed for the same 10-second period. The closed K 1 contacts keep a release solenoid on each of the three hooks energized.
- The energized release solenoid on the center hook allows pneumatic pressure from a chamber in the hook actuating cylinder to flow to an auxiliary piston in the cylinder. Motion of this piston raises the cylinder to open the hook. When the solenoid is deenergized (after 10 seconds), the directed pressure is

vented to atmosphere. The remaining pressure in the pressurized chamber moves the cylinder to close the hook.

- The release solenoids at the forward and aft hooks unlatch the hooks, allowing the load to pull them open. With the load released, the spring-loaded hooks close, latching when the release solenoids are deenergized (10 seconds after being deenergized).

Manual Release Without 35

Manual release of the center cargo hook is done by pulling a D-shaped ring at the top front of the hook. Pulling the D-ring releases a cam lock mechanism, allowing the hook to pivot open. **Switch S2** closes to light the MID HOOK OPEN capsule on the master caution panel. The hook is reset manually by pushing up on the tip to lock the cams into position. When the hook is reset, switch S2 opens and the HOOK OPEN light goes out.

Manual release of the forward and aft hooks is done by the handle in the rescue hatch. Pulling the handle aft rotates a lever arm in each hook. This frees a latch to pivot away from the load beam (hook). The weight of the load is then free to pull the load beam open and the load drops. At the same time, an actuator in the hook linkage lights the FWD and AFT HOOK OPEN lights on the master caution panel. The hooks then return to the closed and latched position and the lights go out

Manual Release With 35

Manual release of the center, forward, and aft cargo hooks is accomplished by using the handle in the rescue hatch.

Pulling the handle aft releases a cam lock mechanism, allowing the center hook to pivot open. **Switch S2** closes to light the MID HOOK OPEN capsule on the master caution panel. The hook is reset manually by pushing up on the tip to lock the cams into position. When the hook is reset, switch S2 opens and the HOOK OPEN light goes out.

Pulling the handle aft also rotates a lever in the forward and aft hooks, This frees a latch to pivot away from the load beam (hook). The weight of the load is then free to pull the load beam open and the load drops. At the same time, an actuator in the hook linkage lights the FWD and AFT HOOK OPEN lights on the master caution panel. The hooks then return to the closed and latched position and the lights go out.

NORMAL RELEASE

The hook release system is normally operated from either cockpit or cabin. Selection of the hook or hooks to be released is made at a five position rotary HOOK SELECT switch on the overhead panel in the cockpit. Switch positions are FWD, MID, AFT, TANDEM, and ALL. The position of this switch determines which hook opens when the CARGO HOOK RELEASE switch on either control stick or the hoist operators grip is pressed. The switch operates through a dual hook relay box containing relays and three maintenance indicator lights.

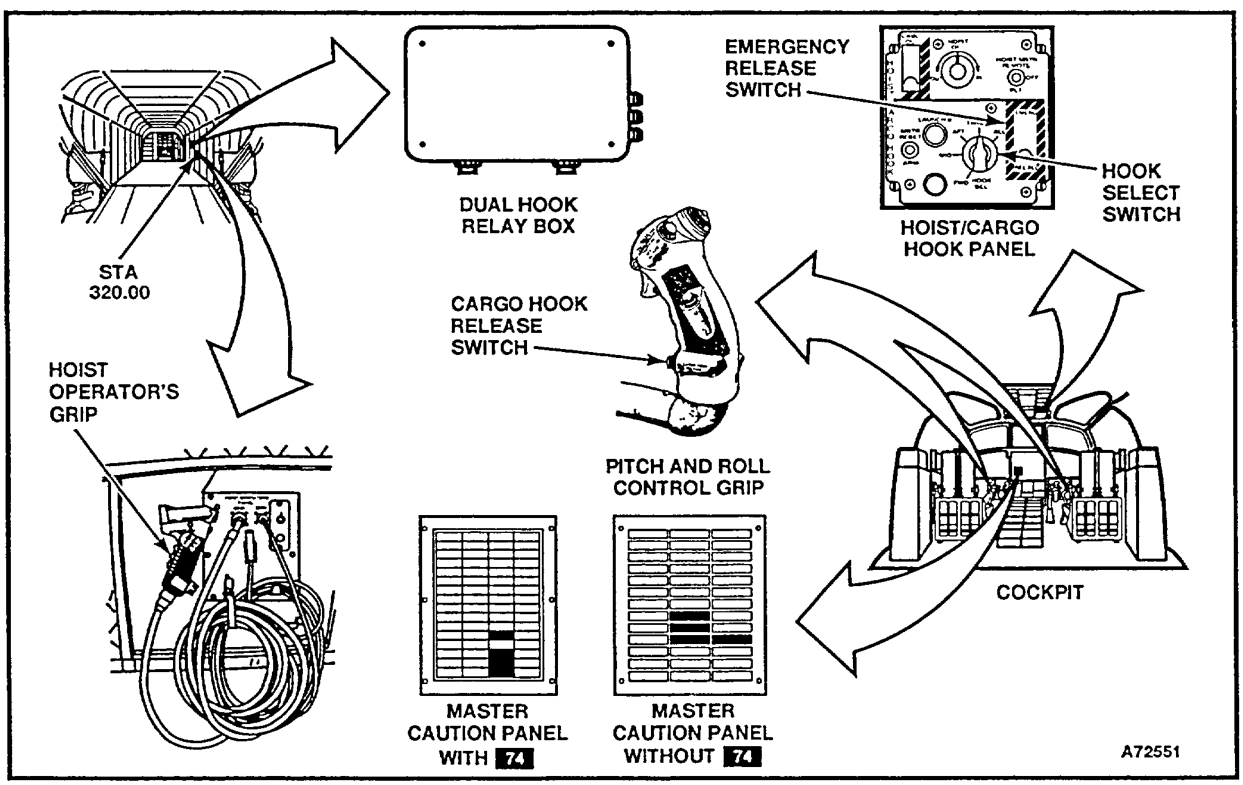
Actual release of the hook or hooks is done from the cockpit or cabin. Cockpit release is made by the CARGO HOOK MASTER switch on the CARGO HOOK panel. The switch has three positions ARM, RESET and OFF. When the switch is set to ARM, power is applied to the CARGO HOOK RELEASE switches on the cyclic sticks and also to the CARGO HOOK ARMING switch at the hoist operators station. OFF position is used to close the mid cargo hook. RESET position is used to turn off the HOOK OPEN caution lights. Cabin operation is by a switch on the hoist operators grip.

The forward and aft hooks are electrically released. The center hook is hydraulically released through a solenoid valve in the tunnel area.

Three indicator lights on the master caution panel show if any of the three hooks are open. A fourth light indicates a fault in dual hook operation. It comes on to show if one of the hooks is not prepared to open.

EMERGENCY RELEASE

In an emergency, all three hooks can be released at the same time from a switch on the overhead panel in the cockpit. It is a guarded switch marked EMERG REL ALL. The switch releases all three hooks regardless of the position of the HOOK SELECT switch. Setting the switch to REL ALL, energizes an emergency hook release relay. The relay then energizes electrical release solenoids in the forward and aft hooks and a solenoid valve in the center hook. The solenoid valve in the center hook releases an air-charge stored in the lower half of the hydraulic actuator, transferring the charge to the upper release half of the actuator to open the hook.



After emergency release, the forward and aft hook will relatch, automatically. The center hook must be manually reset and recharged with air to 2,000 to 2,200 psi.

MANUAL RELEASE WITHOUT 35

If needed, all three hooks can be released by manual controls in the cabin rescue hatch area. The center hook has a manual release handle (D-ring). Pulling the ring unlocks the hook and lets it drop open. The forward and aft hooks are released at the same time by pulling a lever at the right side of the hatch. The center hook must be closed by hand after manual release. The forward and aft hooks automatically reset closed after release. Manual release of all hooks is independent of the electrical, hydraulic, and pneumatic release systems.

MANUAL RELEASE WITH 35

All three hooks can be released at the same time by pulling a lever located at the right side of the hatch.