OPERATIONS OF SYSTEMS

XIV. Task A

Objective:

- To familiarize the student with the operation of systems of the Duchess BE-76

Content:

- Primary flight controls and trim
- Flaps, leading edge devices, and spoilers
- Rudders
- Powerplant and propellers
- Landing gear
- Fuel (proper operation of X-feed), oil, and hydraulic system
- Electrical (Essential Bus, Avionics & Bus Tie Breakers)
- Avionics (GPS, PFD, MFD)
- Pitot static/vacuum system and associated instruments
- Environmental.
- Deicing and anti-icing
- Equipment List / MEL

Schedule:

- 2 Hours

Equipment:

- Markers
- Systems Diagrams
- FAA-H-8083-3B AFH (Ch. 6) AC 20-29, AC 20-117, AC 91-43, AC 91-51, AC 91-74, AC 120-60, AC 135-17, 14 CFR part 61; POH; AFM.
- Notes

Instructor Actions:

- Discuss above elements and answer/ask questions

Student Actions:

- Take notes, and answer questions. Ask questions if any arise

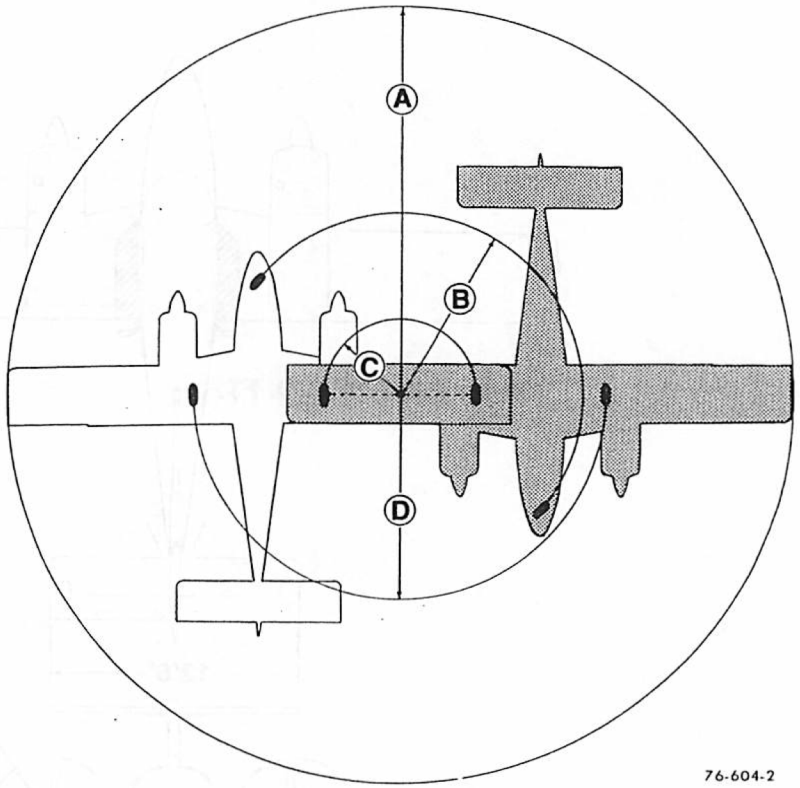
Completion Standards:

- The lesson is complete when the elements are discussed, and questions answered. Student should be able to answer questions related to elements in this lesson. Student should be able to explain & operate all aircraft systems, identify when a system malfunctions and proper emergency procedures / checklist usage to ensure safe flight according to PTS /ACS standards.

PRIMARY FLIGHT CONTROLS & TRIM

- The control surfaces are bearing supported and operated through the conventional cable assembly using push-rods and bell cranks.
- Aircraft trim is accomplished using either the manual or electric pitch trim system.
- An emergency disconnect button will disengage the trim motor when depressed allowing time to turn off the trim circuit breaker.
- The aileron trim is located in the lower center console; this is used to displace the ailerons for trimming through cable tension only.

- Ground steering is accomplished through rudder pedals and differential breaking and power from each engine.
- Spring Loaded linkages from the nose gear to the rudder pedals allow for nose wheel steering
- Toe brakes are located at the top of each rudder pedal to assist with differential steering
- Minimum turning radius is 27 feet 2 inch



GROUND TURNING CLEARANCE

Ⓐ Radius for Wing Tip .....27 feet 2 inches
Ⓑ Radius for Nose Wheel.....9 feet 10 inches
Ⓒ Radius for Inside Gear.....3 feet 1 inch
Ⓓ Radius for Outside Gear .....13 feet 8 inches

FLAPS

- Wing flaps are operated by an electric motor located under the right rear passenger seat and connected via torque tubes which operate worm gears to extend or retract the flaps.
- They are operated by a three position switch located to the right of the throttle quadrant with an UP, DOWN, and OFF position.
- The switch must be pulled out of the detent to raise or lower the flaps. There is an indicator gauge with UP, 10, 20, and DOWN (35). It takes 3 seconds to lower from UP to 10, 1 second from 10 to 20, and 1 second from 20 to DOWN (35).
- When flaps are positioned below 16 degrees the landing gear horn will sound if the gear is not down and locked (regardless of throttle position).

ENGINES

- Two Avco Lycoming, horizontally opposed, normally aspirated, direct drive 4 cylinder engines.
- The left engine is an O-360 (rotating clockwise). The right engine is an LO-360 (rotating counter-clockwise).
- Both engines are rated for 180 horsepower at 2700 RPM.
- Since the engines rotate in opposite directions, components are not interchangeable.
- Oil dip sticks are labeled left, right

ENGINE COMPONENTS

- **Wet Sump Oil |** The engines use a wet-sump pressure type oil system with an oil cooler. Maximum of 8 qts. and a minimum of 5 qts.
- **Carburetor |** The engine is normally aspirated with a carburetor & heat system which allows heated unfiltered air to enter the induction system to alleviate the possibility of induction ice.
- **Cowl flaps |** Controlled by levers inside the cockpit; they allow the amount of engine cooling air to be controlled to maintain a desired cylinder head temperature.
- **Dual Magnetos |** Engine ignition is provided through a dual engine driven magneto system which is independent of the electric system (if electrical power is lost, engine will continue to run).
- **Instruments |** Each engine is equipped with a fuel pressure gauge, oil pressure, oil temperature, cylinder head temperature, manifold pressure, rpm, and exhaust gas temperature.

- Manifold Pressure
  Normal Operating Range (Green Arc) – 15 to 29.6 in HG
- Tachometer
  Normal Operating Range (Green Arc) – 2000-2700 RPM Maximum (Red Radial Line) – 2700 RPM
- Cylinder Head Temperature
  Normal Operating Range (Green Arc) – 200 to 500 OF Maximum (Red Radial) – 500 OF

PROPS

- The airplane is equipped with two Hartzel 76 in, constant-speed, full feathering, two-blade propellers.
- Propeller rpm is controlled by the engine-driven propeller governor which regulates oil pressure in the hub.
- The propeller controls (Blue) , on the control console, allow the pilot to select the governor's rpm range.
- Springs and dome air pressure, aided by counterweights, move the blades to high pitch low rpm position.
- Engine oil under governor-boosted pressure moves the blades to a low pitch high rpm position.
- Low Pitch +/- 12.1 +/-1, High Pitch 17-20 +/- 1, Feathered 81

CONSTANT SPEED

- Is the ability to vary propeller pitch to maintain a constant engine rpm.
- When the propeller control is moved forward, positive oil pressure, regulated by a propeller governor, drives a piston, which rotates the blades to a low pitch high RPM position.
- When the propeller control is moved aft, oil pressure is reduced by the propeller governor.
- After an rpm is selected, the prop governor will automatically adjust oil pressure inside the propeller hub. This results in a constant propeller rpm regardless of flight attitude or manifold pressure setting.

UNDER-SPEED (CLIMB)

- Less centripetal force - Flyweights come in
- Pilot valve opens
- Increased Oil pressure into hub driving the prop pison
- Prop moves to low pitch, higher rpm

OVER-SPEED (DESCENT)

- More Centripetal Force, Flyweights move out
- Pilot valve closes
- Oil pressure returns to reservoir
- Nitrogen, spring, counterweights pushes back prop piston
- Props move to higher pitch, lower RPM

FEATHERING

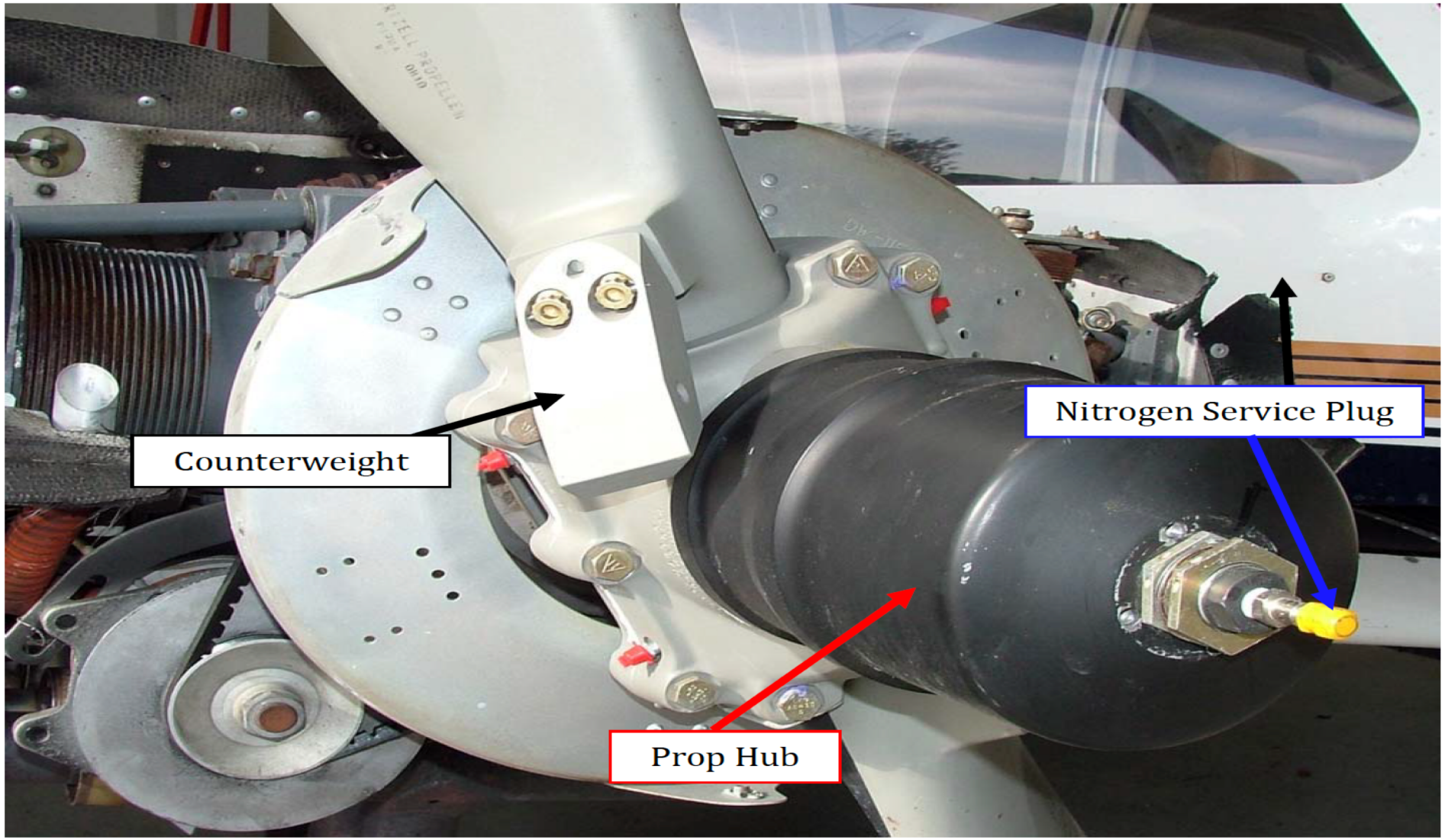
- Fathering allows the propeller blades to be angled in alignment with relative wind.
- Feathering reduces the amount of drag produced by the propeller wind-milling caused by an engine failure.
- By reducing its exposed area to the relative wind. This is accomplished by moving the propeller control to the low rpm (feather) detent position.
- The propellers should be cycled occasionally during cold weather operations, run up. This will maintain warm oil inside the propeller hubs.
- In the case of an engine failure or loss of oil pressure the prop will feather to a high pitch low RPM setting. Opposite of a single engine constant speed prop.

- Feathering is accomplished by moving the propeller control full aft into the detent position.
- Feathering takes approximately 10-17 seconds.
- Unfeathering accumulators store oil from the engine and a nitrogen charge to for force the propellers out of the feather position.
- The important thing to remember is that these are a one-shot deal. They build pressure by means of the engine oil pumps. If they are used and the blades don't come out of feather, they can't be used again until the engine has been restarted. You will have to use the starter to try to restart the engine in the air.
- Unfeathering takes 8-12 seconds, depending on oil temperature.
- Speed must be above 100kts before attempting to bring props out of the feathered position

PROP PINS

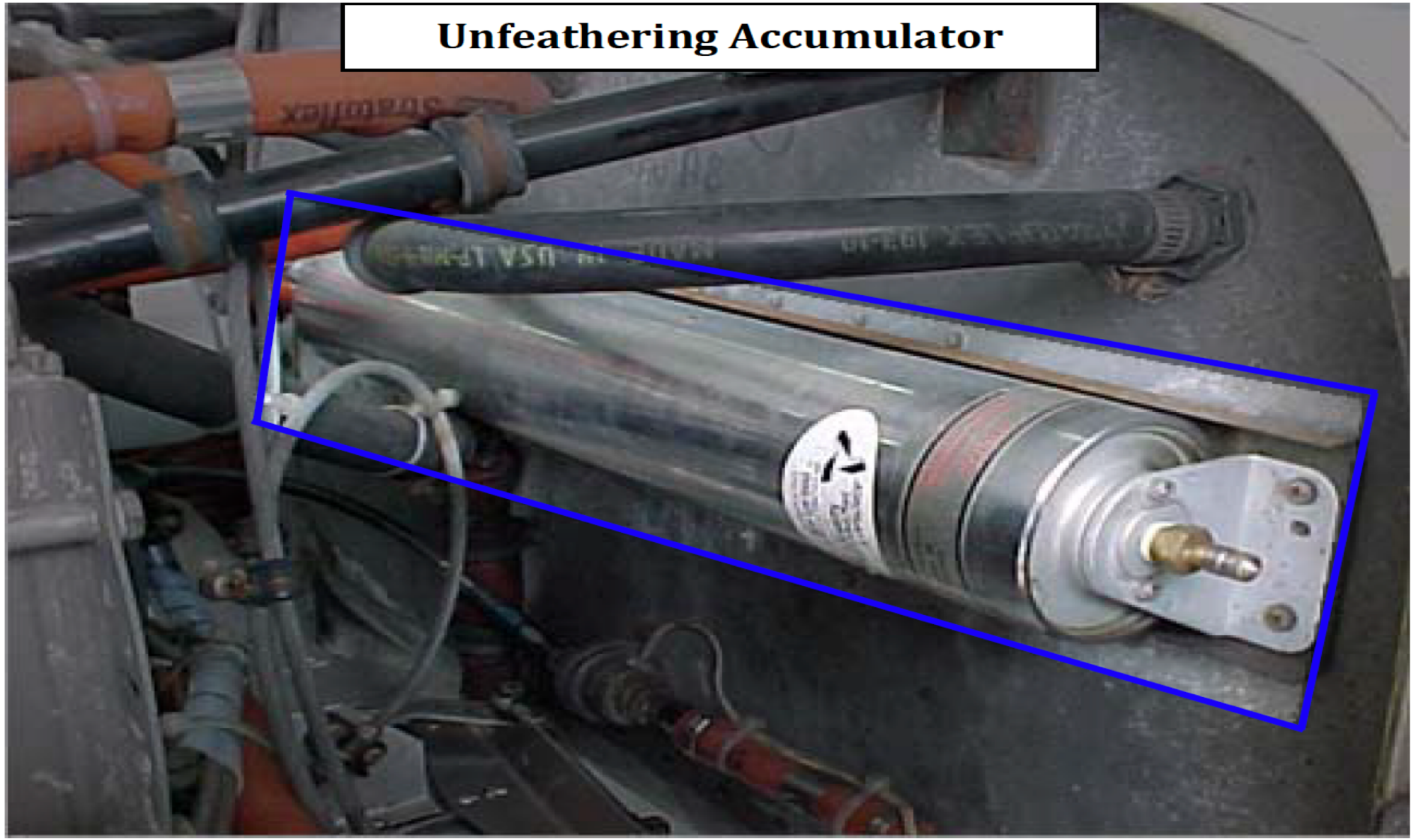
- The blades have centrifugal lock pins that retract into the blade bases.
- When the propeller is rotating faster than 700-800 RPM, these pins will remain in the blade bases and allow the propeller to move into the feather position.
- Below 700-800 RPM, the pins will spring out preventing the blades from feathering.
- This is why the blades don't feather on engine shutdown on the ground.
- The danger of unfeathering below 100 knots, prop comes put of feather but is to slow and the pins come out. But does not start we have a prop that can not be feathered

Propeller Hub with Spinner Removed

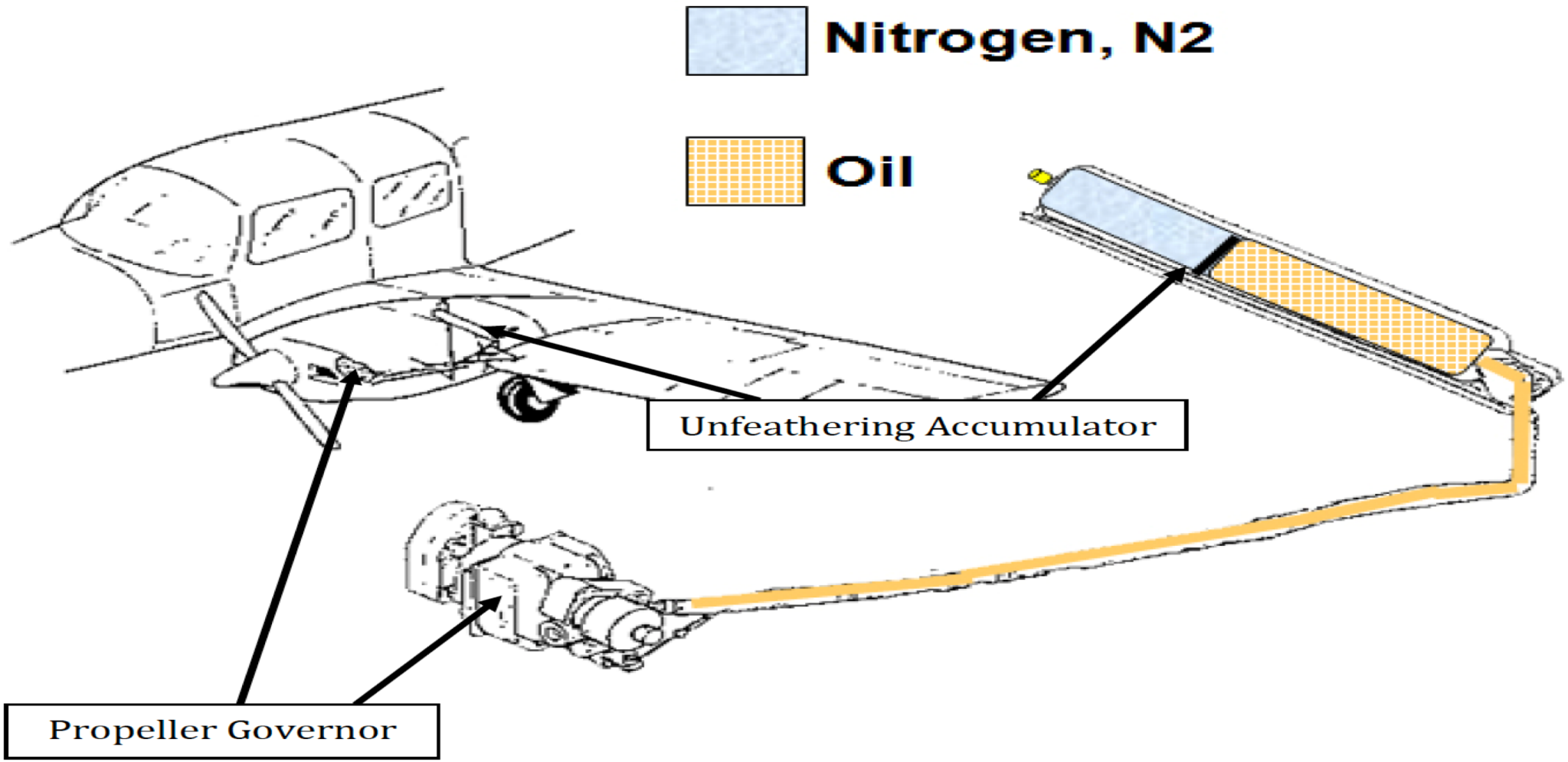


Propeller Governor

Unfeathering Accumulator



Propeller Governor and Unfeathering Accumulator Locations



LANDING GEAR

- The Duchess is equipped with a tricycle retractable landing gear that is hydraulically actuated.
- Hydraulic pressure is provided by an electrically-driven, reversible hydraulic pump.
- Electric Hydraulic Power Pack located in aft fuselage
- There are two circuit breakers: one for the pump and one for the control circuit.
- The gear is held in the up position by a hydraulic pressure of 1250-1550 psi.
- Main Gear remains in the down and locked position using an over-center brace and springs.
- Nose Gear remains in the down and locked position using a j hook locking mechanism

LANDING GEAR CONTROL SWITCH

- Landing gear is controlled by a two position control switch. It must be pulled out of detent before it can be moved in the opposite direction
- Landing gear position light indicators are located above the control switch.
- 3 Green = Gear down
- Red = Gear in transit
- No lights = Gear up
- Lights are push to test , can be replaced by another.

GEAR DOWN CYCLE

- Landing Control Lever Down
- Electrical Current sent to hydraulic power pack
- Hydraulic fluid fills actuators
- Gear moves down
- Pressure switch on gear illuminate light, red – in transit, green down and locked
- When gear is down pressure switch is activate
- Pump turns off
- Gear is held in place with over center lock and springs

GEAR UP CYCLE

- Gear level up
- Electrical current sent to hydraulic power pack
- Pump sends hydraulic fluid to actuators
- Gear comes up
- Gear is held up with a constant pressure of 1250-1550 psi.
- If pressure falls below 1250 due to leak pump will reactivate
- Pressure switch at 1550 psi will turn pump off.
- Pressure Switch on the gear will compress turning gear light off. No illimitation = gear up.
- * Gear Relay*

GEAR TIME DELAY RELAY (ME-183 LATER)

- Landing gear retraction operation is protected by a time-delay relay switch witch will disengage electrical power to the hydraulic pump motor after 30 seconds of continuous pump operation
- In the case of a hydraulic leak, the gear pump will continuously turn on and off, draining electricity. Gear relay will turn pump off after 30 seconds.
- If the landing gear transit light remains illuminated , it indicated improper response of the landing gear.
- The time delay relay can be reset by by moving the landing gear switch handle to the down position.
- In this case the landing gear and retraction system should be checked prior to the next flight

SAFETY RETRACTION SWITCH

- To prevent gear retraction on the ground, a safety pressure switch is installed on the pitot system to deactivate the electric hydraulic pressure pump circuit when impact air pressure is below 59 to 63 knots.
- WARNING | Never rely on the safety switch to keep the gear down during taxi, takeoff roll, and landing roll. Always verify the landing gear switch is in the down position, prior to turning on electrical power.

GEAR WARNING HORN

- The aircraft is equipped with a gear warning horn that will activate under the following conditions:

1. Gear is not in the down and locked position when throttles are reduced below a setting to sustain flight. 12 in.
2. Gear is not in the down and locked position with flaps extended below 16°.
3. Gear handle is in the up position on the ground.

- (Gear warning systems are no replacement for proper checklist usage and should not be relied upon to prevent an inadvertent gear up.)

WARNING HORN Q SWITCH

- AN Optional Q "Quite" Switch is available to quite the gear warning horn.
- Airspeed must be above 99-106 with flaps above 16
- When a single throttle is reduced to activate the warning horn, the manual push button can be used to silence the gear horn.
- A Red light in the button illuminates when activated.
- If the other throttle is reduced it will alarm again, and can not be silenced.
- Re-advanced the throttle after silence with reset the warning horn silence switch.
- Warning horn is also reset when gear is extended
- When flaps are below 16 degrees the warning horn can not be silenced

EMERGENCY GEAR EXTENSION

- EMERGENCY GEAR EXTENSION | The gear system is equipped with a hydraulic bypass valve located beneath the floor panel in front of the pilot. By turning the valve counter-clockwise 90°, hydraulic pressure will release and allow the gear to free fall to the down and locked position.
- **This can only be done with an airspeed below 100 KIAS and the emergency checklist should be used**.
- In the event that hydraulic pressure is lost, the gear will free fall to the down and locked position.
- **See emergency gear extension procedure in the POH**

FUEL

- The Duchess is approved to use 100 (green) and 100LL (blue) aviation gasoline only.
- Total capacity 103 gallons
- Total useable 100 gallons
- The fuel system uses an "ON-CROSSFEED-OFF" selector arrangement located on the lower center floor panel.
- Total fuel capacity is 51.5 gallons per wing tank with 50 gallons useable per side. Each tank has a visual measuring tab with markings for 30 (28.5 useable) and 40 (38.5 useable) and full at tank top.
- Combustion Heater when in operation uses 2/3 gallon per hour from right tank.

FUEL GAUGES

- 2 Float type electric fuel gauges monitor amount of fuel.
  - Only accurate when empty! Visual check
  - Max – 50 gal per side

- 2 Fuel Pressure
  - Minimum (Red Radial) – 0.5 psi
  - Normal Operating Range (Green Arc) – 0.5-8.0 psi
  - Maximum (Red Radial) – 8.0 psi


OFF
CARB
HEAT
ON
CLOSE
HALF
OPEN
COWL
FLAP
MIC
PHONE
ON
CROSS
FEED
LEVEL
FLIGHT
ONLY
CROSS
FEED
LEVEL
FLIGHT
ONLY
OFF
LEFT
ENGINE
RIGHT
ENGINE
50 GAL USA
FUEL SELECTOR

- 5 Pumps, There are two engine-driven and two electrically-driven auxiliary fuel pumps, 1 Heater pump.
- The electric pumps are used for engine start, takeoff, landing, and fuel selector changes. Each tank feeds its respective engine.
- Engine priming is accomplished by using the "PUSH TO PRIME" switch in accordance to normal procedures. #1, #2, #4 Cylinders
- Fuel Vents each cap, overflow vents outboard the ailerons.
- Fuel cannot be transferred from tank to tank; however, either tank may feed both engines in crossfeed mode. The fuel crossfeed system is to be used during emergency conditions in level flight only.
- A minimum of 9 gallons of fuel must be in each tank prior to flight. This is noted by the yellow arc on the fuel gauges.
- There are a total of 8 fuel sumps: 4 per side. 1 sump for each tank, 1 sump for each engine strainer, 2 for each crossfeed line.

CROSS-FEED OPERATION EMERGENCY ONLY

- Under Normal operations each engine uses its own fuel pumps to draw fuel from its respective wing fuel system.
- Emergency Crossfeed operations allow, either engine to consume all the available fuel from the opposite side.
- Fuel crossfeed operations only in straight and level flight, under emergency conditions only.
- The crossfeed system can not transfer fuel from one wing system to the other.

CROSSFEED POH EMERGENCY OPERATIONS

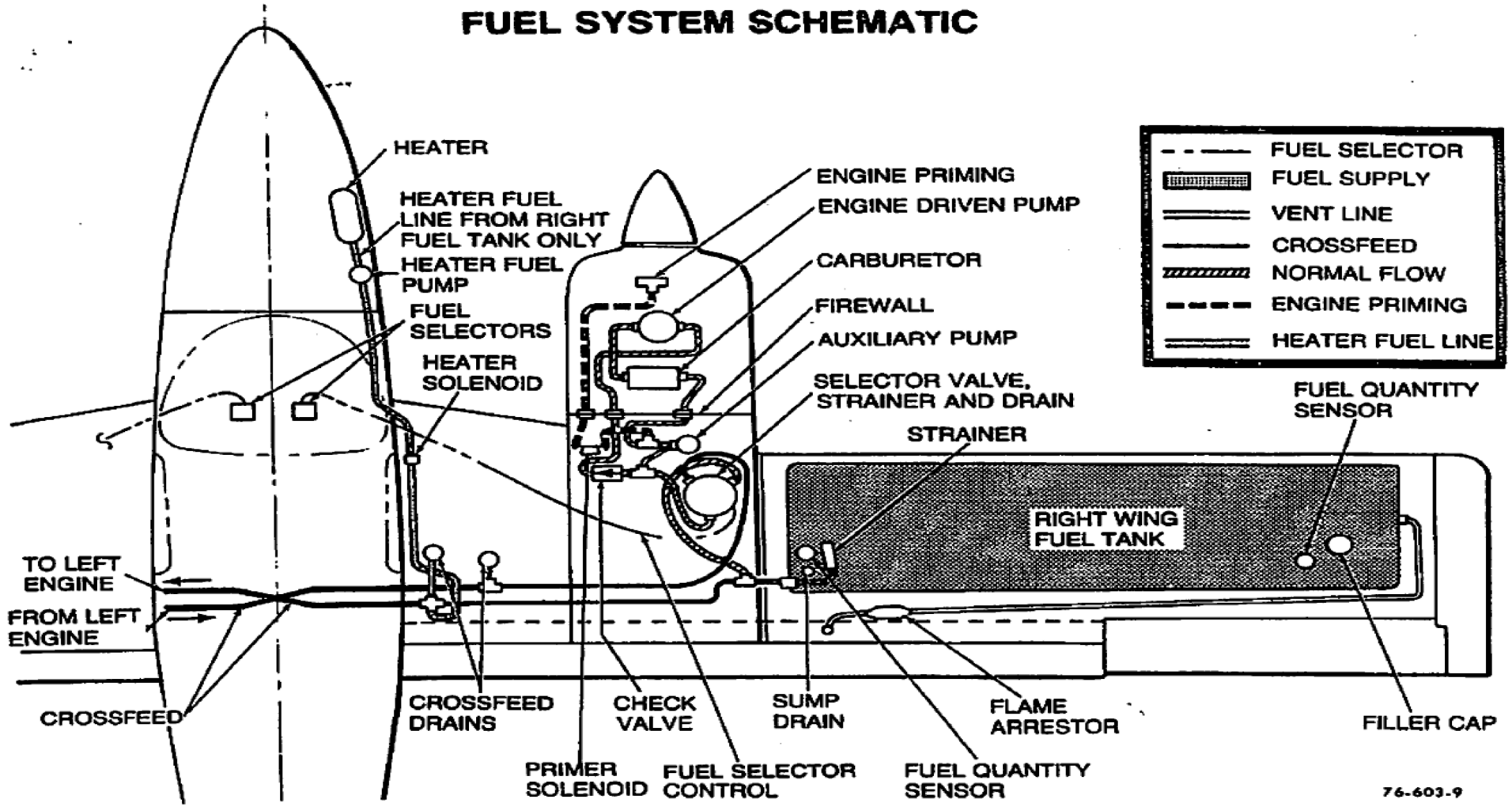
Left Engine Inoperative

- Right Aux Fuel pump – ON
- Left Fuel Selector – OFF
- Right Fuel Selector – CROSSFEED
- Right Aux Fuel pump - ON/OFF as req.

Right Engine Inoperative

- Left Aux Fuel pump – ON
- Right Fuel Selector – OFF
- Left Fuel Selector – CROSSFEED
- Left Aux Feul pump - ON/OFF as req.

FUEL SYSTEM SCHEMATIC



OIL

- **Wet Sump Oil |** The engines use a wet-sump pressure type oil system with an oil cooler.
- Each oil sump has a Maximum capacity of 8 qts. and a minimum of 5 qts.
- Oil is checked through an oil access door on the engine cowling.
- Each oil dipstick is calibrated for that specific engine, can not be switched.
- Oil operating temps are controlled via a thermostat bypass control
- The bypass control will limit the amount of oil flowing through the oil cooler when temps are below normal, and will bypass the cooler if the it it becomes blocked.

OIL GAUGES

Oil Temperature

- Caution Range (Yellow Arc) – 60O – 120OF
- Normal Operating Range (Green Arc) – 120O-245OF
- Maximum – (Red Radial) – 245OF

Oil Pressure

- Minimum Idle (Red Radial) – 25 PSI
- Caution Range (Yellow Arc) – 25-60 PSI
- Normal Operating Range (Green Arc) -60-100 PSI
- Maximum (Red Radial Line) 100psi

BRAKES

- There are hydraulically actuated disc brakes on the main landing gear.
- The top of each rudder pedal operates the brakes through a master cylinder.
- The brake hydraulic system is separate from the landing gear hydraulic system. The brake reservoir is located on the left side of the nose compartment.
- MIL-H-5606

ELECTRICAL

- The Duchess is equipped with a 28 volt DC electrical system.

Components

- **Batteries |** Two 12 volt, 25 amp lead acid batteries
- **Alternators** | Two 28 volt, 55 amp, self exciting, belt driven alternators
- **Voltage Regulators**
- **Loadmeters Over voltage /under voltage ligts**
- **Starters |** W/ Starter engaged warning light
- **5 Electrical Buses (L,R Main Bus,L,R Avionics Bus, Batt Bus**
- **Circuit Breakers**

BATTERIES

- The aircraft is equipped with two 12 volt, 25 amp lead acid batteries, connected in series to create 24 volts.
- Batteries are used to supply power to the starters for initial start,or to provide emergency power in the case of alternator failures.
- The batteries, are installed directly aft of the baggage compartment and may be reached through the rear panel.
- Battery fumes and gases are vented through two vents located on the underside of the fuselage

ALTERNATORS

- Two 28 volt, 55 amp, belt driven alternators are installed on the aircraft.
- The output of each alternator is controlled by a separate ACU voltage regulator.
- The alternator systems are completely separate, except for the bus tie fuse, the mutual tie to the battery bus through two bus isolation breakers.
- The aircraft uses a split bus system with each alternator powering its respective bus. The battery is used for engine start and emergency power.
- Each alternator as a self-excitation feature. Alternator self-excitation can not be activated until above 1200-1400rpm.
- Initiation of a flight using self-excitation is prohibited

VOLTAGE REGULATOR

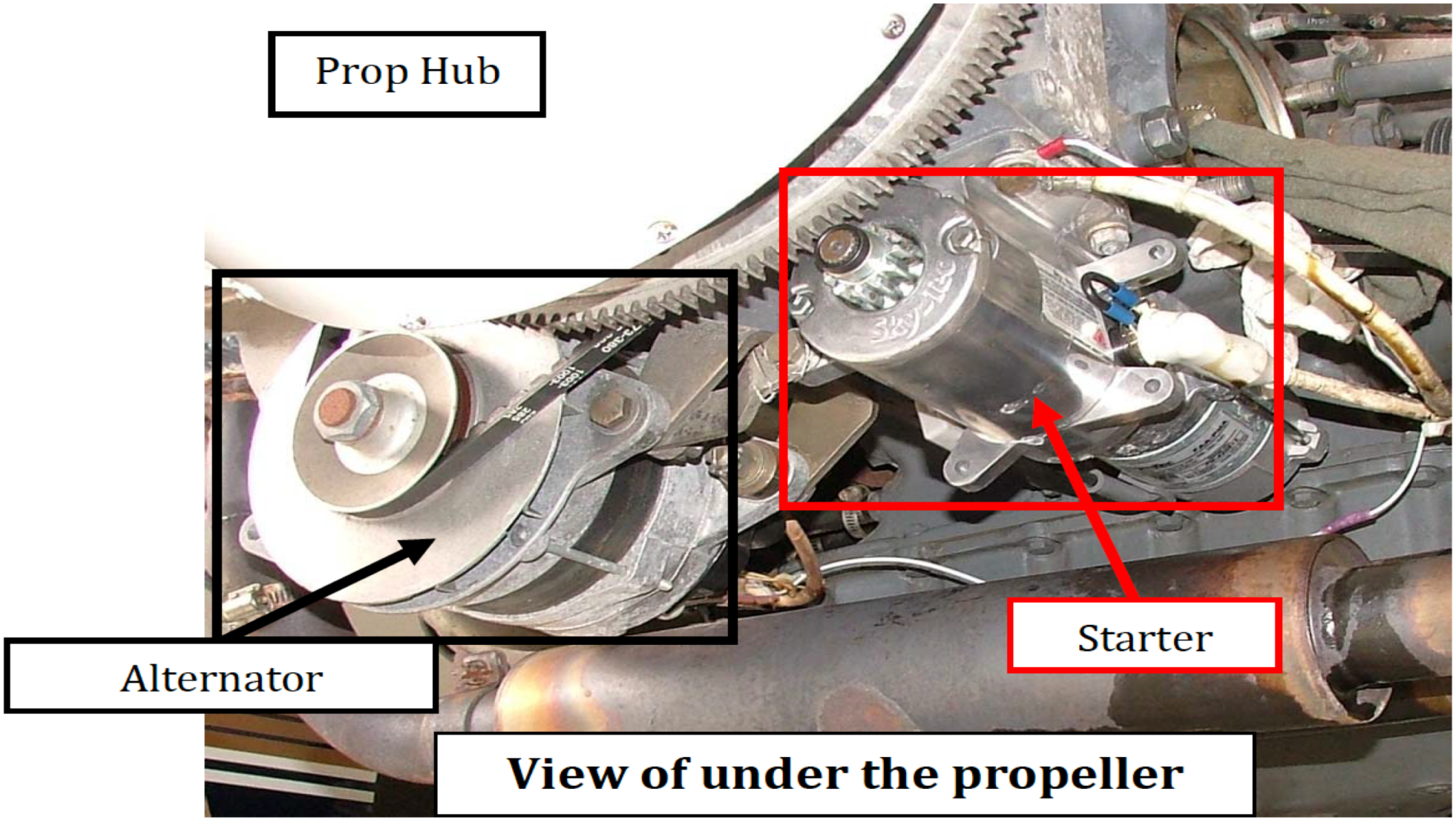
- The output of each alternator is controlled by a separate voltage regulator
- The voltage regulators automatically maintain the bus voltage at a set value for all loads up to the alternator rating
- The voltage regulators also maintain approximately equal load sharing between the two alternators , 40%

LOADMETERS

- The airplane is equipped with 2 loadmeters instead of ammeters.
- Loadmeters show the percentage of the electrical load that is being carried by the respective alternator.
- It is important to make sure that each alternator isn't carrying more than 40% of the load at low RPM and not carrying more than 80% of the load at full power.
- If a loadmeter is registering a zero indication and under-voltage annunciator light is on, that is an indication that the respective alternator has failed.
- If one alternator fails, the remaining alternator should be able to provide adequate electrical power.
- Undervoltage / Overvoltage warning lights

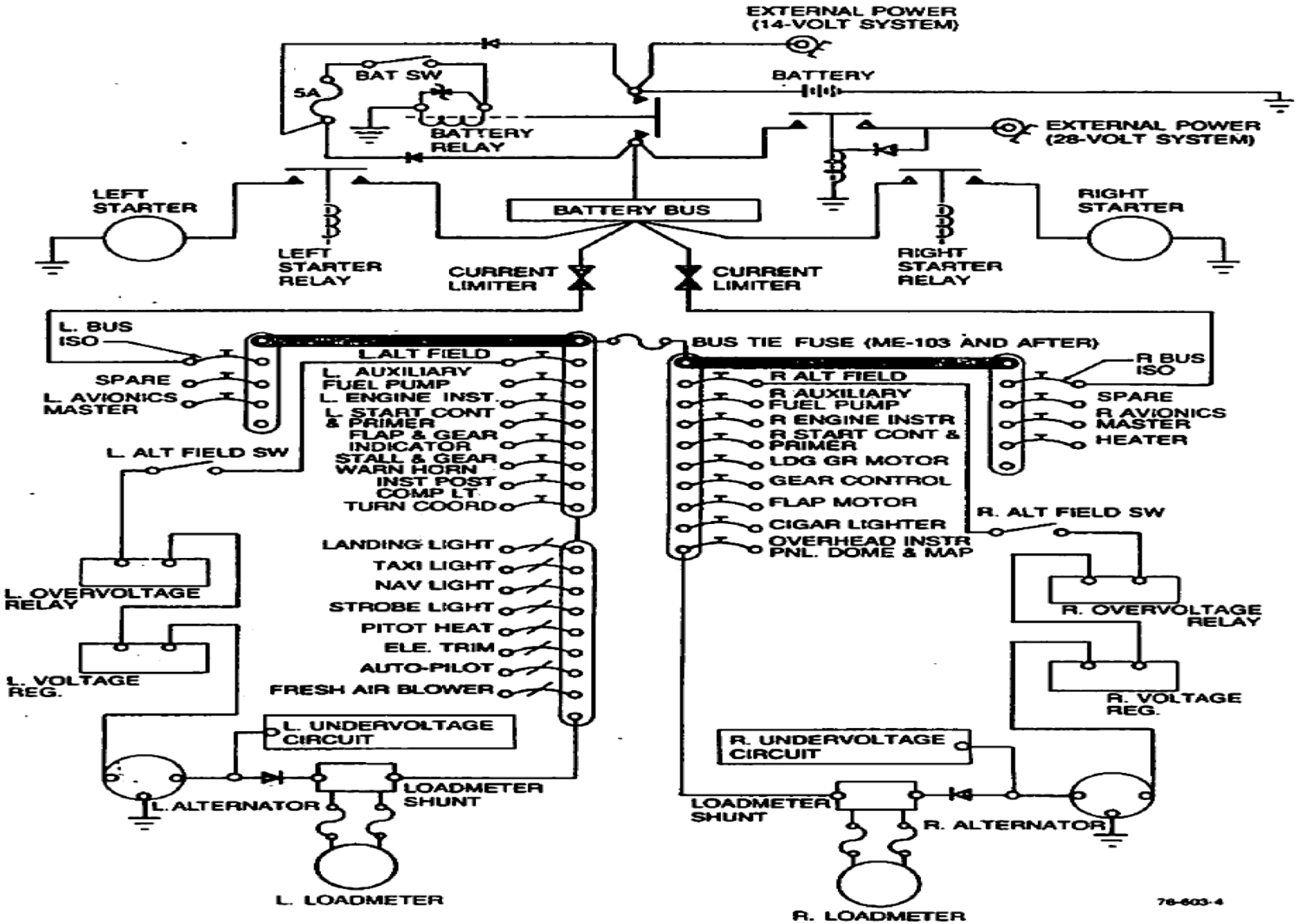
STARTER

- Each engine is equipped with an electrically actuated starter.
- The starters are relay controlled and actuated by a push to prime rotary type, momentary on ignition switch.
- To energizer the starter circuit hold the ignition switch in the start position
- A Starter Engaged Warning light will illuminate whenever electrical power is being supplied to the starter.
- If the light remains on after start, the starter relay is still engaged and loss of electric power may result.
- The battery and alternator switch should be turned off if warning light remains illuminated.
- If warning light never illuminates, the indicator system is inoperative. The loadmeter should be monitored to ensure the starter does not remain engaged after start.
- Starter is limited to 30 seconds on, followed by 2 minutes off


Prop Hub
Alternator
Starter
View of under the propeller

ELECTRICAL BUSES & CIRCUIT BREAKERS

- Electrical power engines off, is provided by the batteries through the battery contactor to the buses via circuit breakers to the respective electrical components
- Electrical power engines on, is provided by the alternators through the voltage regulator to the buses via circuit breakers to the respective electrical components
- The aircraft uses a split bus system with each alternator powering its respective bus. A mutual bus tie in case of alternator failure.
- 5 Electrical Buses
  - Battery Bus
  - Left Avionics Bus
  - Right Avionics Bus
  - Left Primary Bus
  - Right Primary Bus
- Bus isolation circuits are used to separate bus 1 and bus 2 from the battery bus circuit.



POWER DISTRIBUTION SCHEMATIC

AVIONICS

- Garmin GTN-650 Touch Screen
- King Avionics
  - COM/NAV
  - ILS
  - DME

PITOT/ STATIC SYSTEM

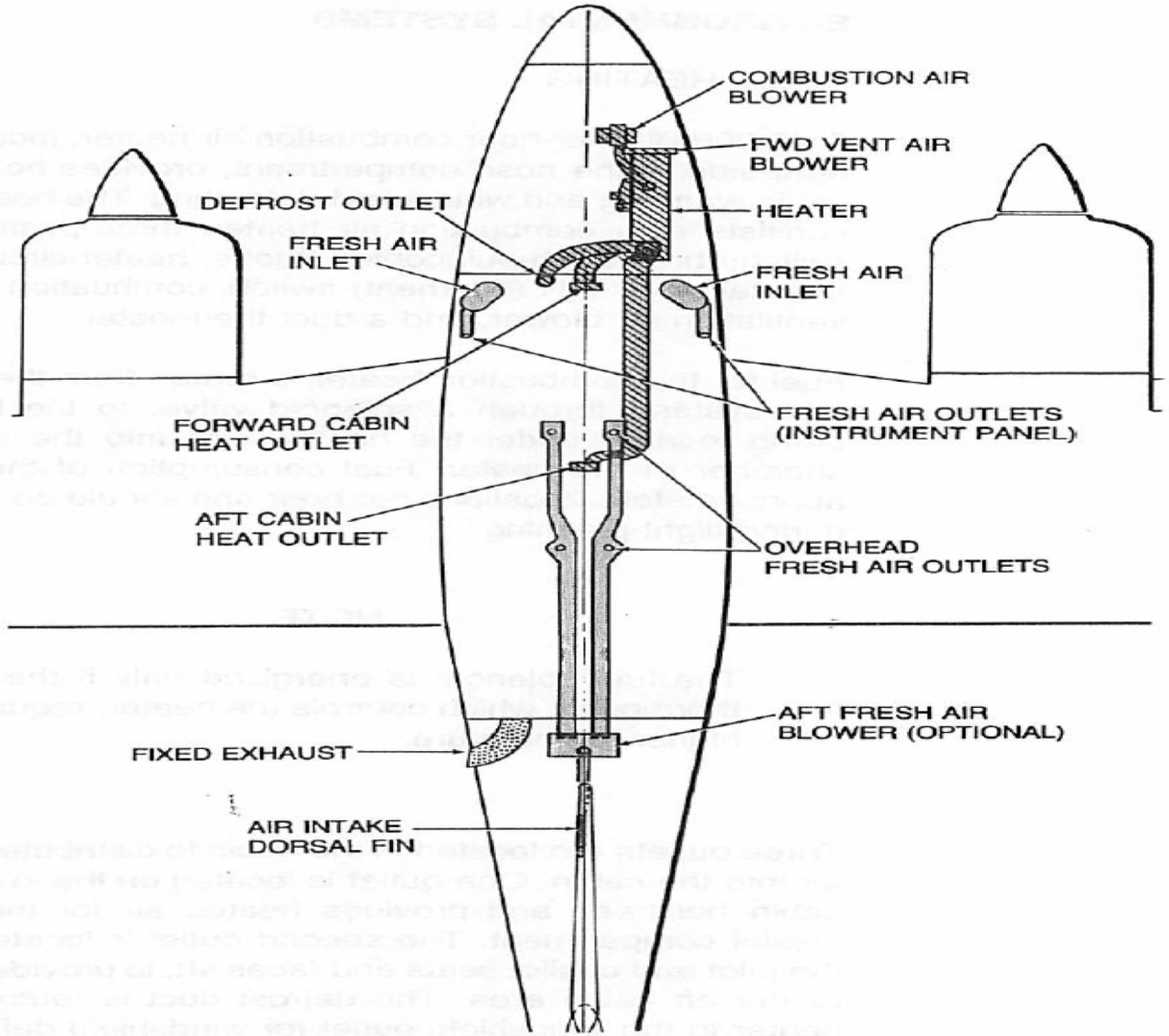
- The pitot tube is located on the left wing.
- The pitot tube is also equipped with a pitot heat system.
- There are two static ports - one on each side of the aft fuselage.
- There is an alternate static located on the left lower side of the cabin.
- See Alternate Static Emergency Procedures
- Static Air plumbing can be drained by turned alternate static on momentarily, then off.

PRESSURE SYSTEM

- Two engine-driven, dry pressure pressure pumps supply air pressure to drive the attitude and directional gyro instruments, and autopilot (if installed).
- The pumps are interconnected to form a single system.
- Check valves will automatically close if either pump fails to ensure continued operation.
- Pressure Gauge provides indication of pressure in the system.
- Normal operation is (4.3 -5.9 psi)
- Two red lights on either side of the pressure gauge will illuminate if the corresponding pressure pump has failed.
- A Central Filter located in the nose compartment protects the instrumentation, and must be changed according to service reccomendations.

ENVIRONMENTAL

- The Duchess is equipped with a 45,000 BTU Janitrol gas heater located on the right side in the nose compartment.
- This provides heated air for cabin warming and windshield defrosting.
- Fuel consumption for the heater is approximately 2/3 of a gallon per hour taken from the right fuel tank. This fuel must be taken into consideration during flight planning.
- The heater has an over-temp switch that automatically deactivates the heater upon reaching an internal temperature of 300°F.
- The over-temp switch cannot be reset in flight and must be reset after examination by a certified mechanic on the ground.
- See POH for operation



ENVIRONMENTAL SCHEMATIC

DE-ICING / ICING

- Pitot Heat
- Cabin Heat / Janitol Gas heater
- Carb Heat per Engine