

DIRECTED STUDY PROGRAM

C-47

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POWER PLANT AND PROPELLERS

GENERAL

The C-47 is powered by two 14 cylinder Pratt and Whitney engines, designated R-1830-92. Each engine is equipped with a 11 foot 7 inch diameter Hamilton Standard Hydromatic propeller geared down to a 16:9 ratio. The engines are equipped with PD-12H4 Stromberg pressure injection carburetors.

Starter

A Jack & Heinz, JH-3R combination electric inertia direct cranking starter is mounted on each engine, and is controlled by switches mounted on the overhead electric panel.

1. The engine is P & W _____.	
2. Each engine is equipped with a Hamilton Standard Hydromatic, _____ speed propeller of _____ diameter and geared to a ratio of _____.	R-1830-92
3. The carburetor is a model PD-12H4 _____ of the _____ type.	constant; 11 feet 7 in. 16:9
4. The starter is a Jack & Heinz, model JH-3R electric _____, _____ cranking type.	Stromberg; pressure injection
5. Each starter is controlled by two switches, one marked _____ and the other marked _____.	inertia continuous
6. The starter switches are located on the _____ panel.	energize engage
	overhead electric

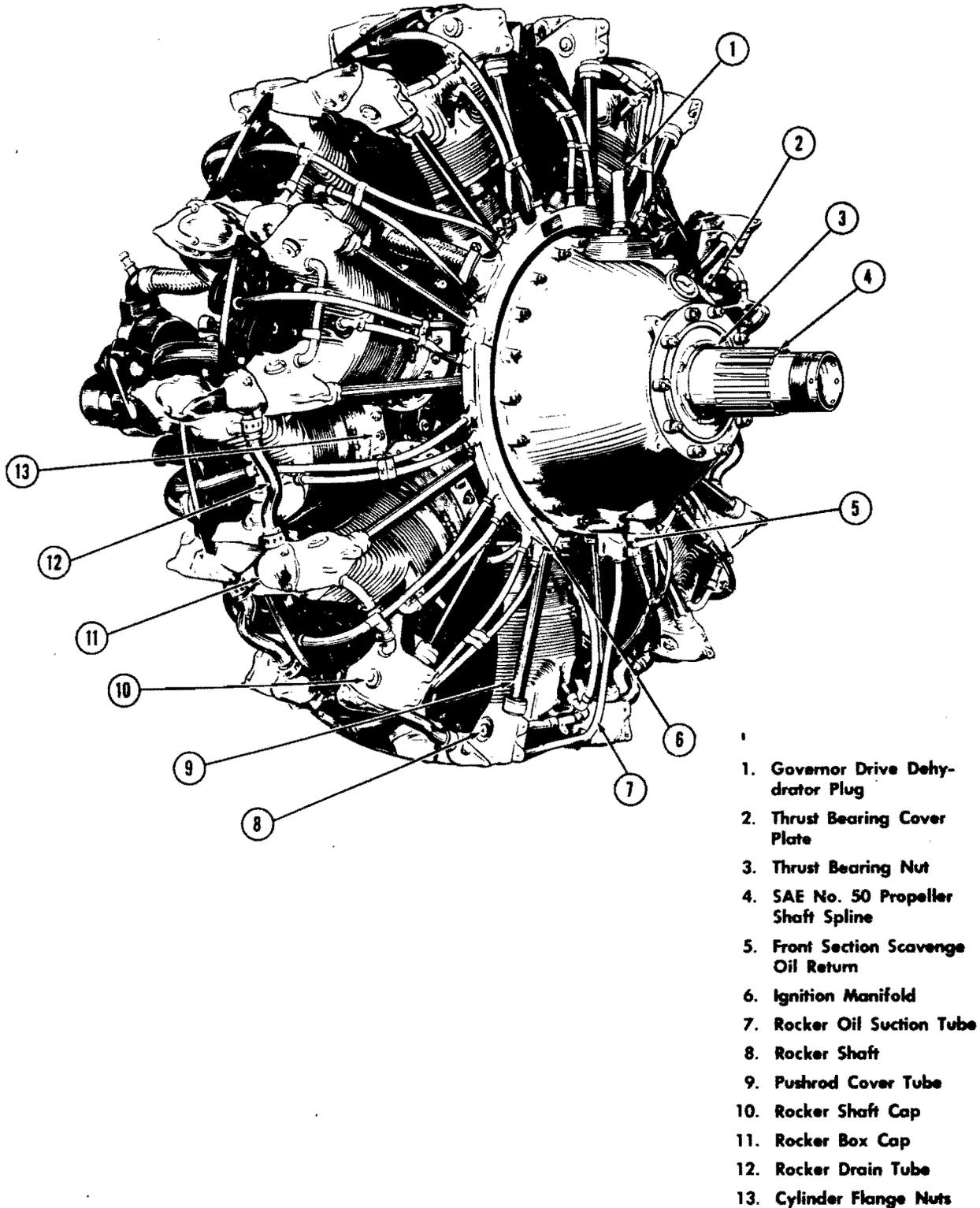
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RIGHT FRONT VIEW OF ENGINE

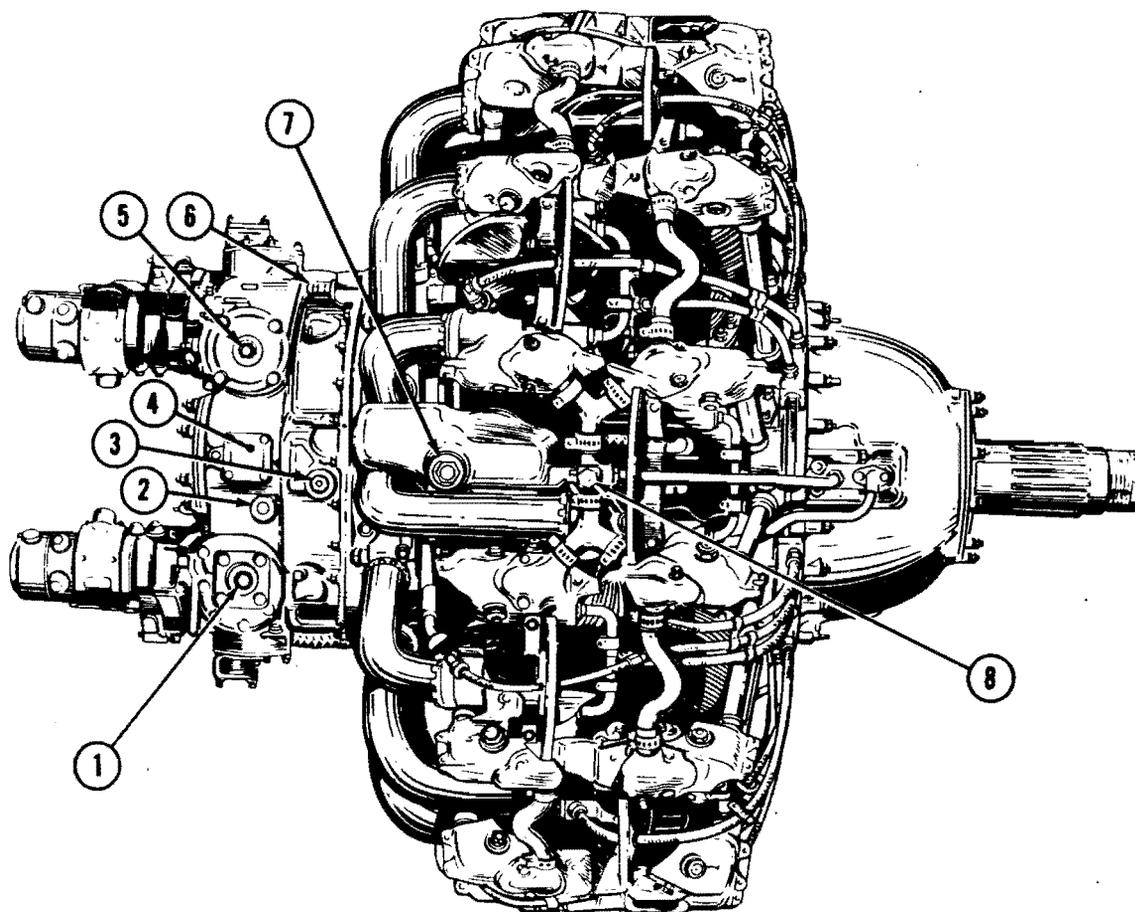
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1. Fuel Pump Drive
2. Rear Case Scavenge Oil Strainer
3. Fuel Drain Valve
4. Vacuum Pump Drive
5. Strainer Chamber Drain Plug
6. Oil Pressure Gage Connection
7. Oil Sump Drain Plug
8. Rocker Oil Drain Plug

BOTTOM VIEW OF ENGINE

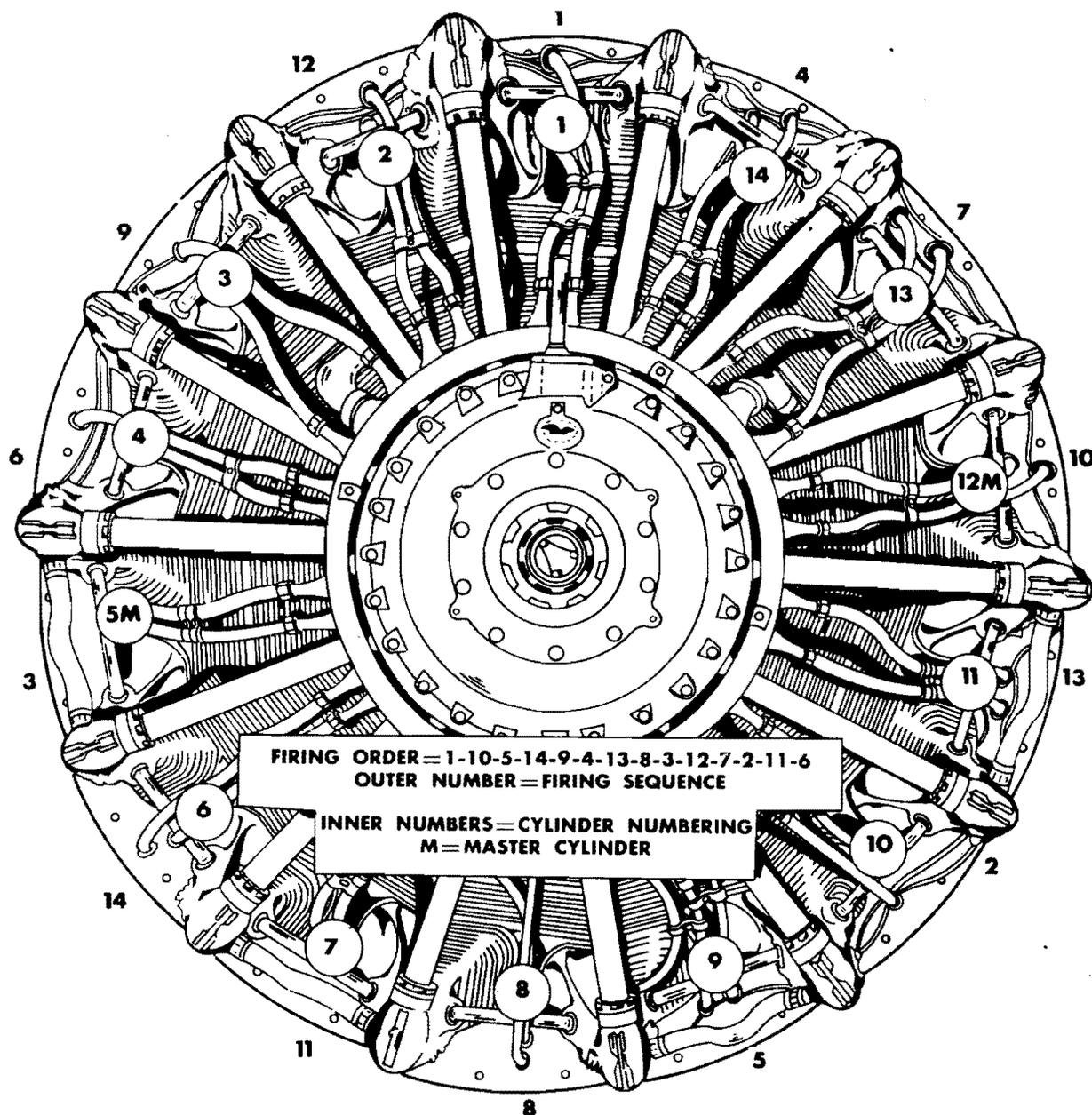
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Engine Cylinder Numbering and Firing Order

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IGNITION SYSTEM

Ignition system consists of a dual magneto, two distributors, a harness manifold, and twenty-eight spark plugs. For starting the engine an auxiliary source of electrical power for ignition is supplied by a vibrator ("boost" coil). The output of the "boost" coil flows through the system in the same manner as the magneto output during normal operation, and fires the front plugs of the front row of cylinders.

SUPERCHARGER

Supercharger is operable only in LOW blower position and the gear ratio is 7.15:1.

CARBURETION AND AIR INDUCTION

During normal operation, ram air is supplied through an air duct on the top cowl panel. When heater air is required for the carburetor, a carburetor heat door can be operated to close off the ram air duct and open a passage through which heated air from the engine section flows to the carburetor.

Metered fuel from the carburetor is discharged from a slinger ring directly into the blower chamber. Priming fuel is introduced into the air stream through discharge nozzles just before the blower throat.

FIREWALL SHUT OFF VALVES

Firewall shut off valves installed at the firewall, these solenoid operated valves are electrically operated from the cockpit and serve to shut off fuel and hydraulic fluid to the engine section. For details of operation, refer to the "Fire Protection" section of this manual.

NOTE: On Company modified C-47's the lubricating oil firewall shutoff valve has been deleted and there is no provision for shutting off engine oil.

1. Ignition is supplied by a _____ magneto, two _____, a harness manifold, and _____ spark plugs.

2. Each engine is supplied with a vibrator boost coil, which supplies a hot spark to the _____ magneto and through the distributor and harness to the _____ plugs of the _____ row of the cylinders, for starting the engine.

dual
distributors
28

3. The vibrator boost circuit is automatically closed when the _____ switch is depressed.

right
front; front

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4. The supercharger is operable only in the _____ blower position, and the gear ratio is _____.	starter engage
5. Ram air to the carburetor is taken from the air duct on the _____ cowl.	LOW 7.15:1
6. Heat is supplied to the carburetor by means of a heat door which shuts off the _____ and admits heated air from the _____ section.	top
7. Priming of the engine is effected through discharge nozzles at the _____.	ram air
8. Shut off valves are located on the _____ side of the each firewall to shut off the supply of _____ and _____ to the engine in case of emergency.	blower throat
9. In the standard C-47 supplied by the customer, there is also a firewall shut off valve to shut off the supply of _____ to the engine, which has been deleted on our company aircraft.	aft fuel hydraulic fluid
	oil

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STARTING ENGINES

Normal Starting - (See "Normal Operating Procedures" Section of this Manual.)

Starting on ship's Batteries - this procedure is permissible only when an external power source is not available. Before starting, turn off all electrical equipment not absolutely required.

1. Normally the engine should be started on _____ power to conserve the _____.

2. When external power is not available and starting must be accomplished on plane's batteries, ensure that all electrical equipment is turned off except that which is absolutely _____.

external
plane's batteries

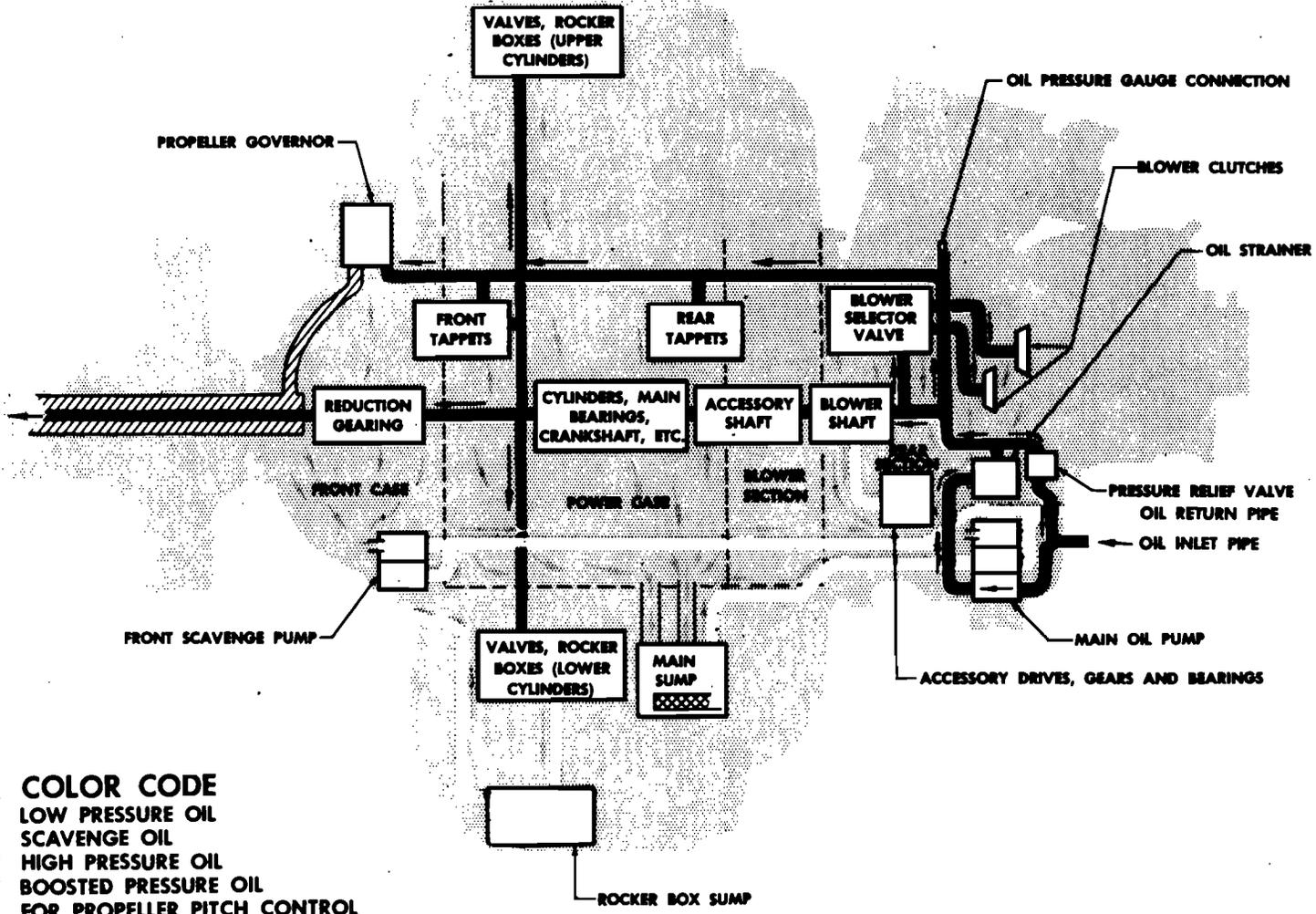
required

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Engine Oil System Flow Chart

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STARTING ENGINES

The First Officer will start the right engine and the Captain will start the left engine. It is recommended that the right engine be started first.

1. Propellers clear, fire guard posted.
2. Fuel booster pump switch - ON: (Check fuel pressure)
3. Starter switch - ENGAGE.

NOTE: To clear the engine and insure proper lubrication, pull the propellers through 15 blades with continuous starter operation. Fifteen blades are required for any start made after a 2-hour shutdown period. Eight blades will insure elimination or detection of hydraulic lock of engine starts made within 2 hours of last shutdown. If inertia starters are installed and the engine has been shut down 2 hours or more, the propeller will be turned through with the starter. The starter will be used as a direct cranking starter, using the energize and mesh switches simultaneously.

4. Ignition switch - BOTH.

5. Prime - AS REQUIRED.

Steady prime for cold start and intermittent prime for warm start. When engine starts to fire, hold steady prime and adjust throttle for 800-900 RPM, then, move mixture to Auto-Rich.

CAUTION

If the engine does not start, continuous use of the engine starter should be limited to 60 seconds. Allow 5 to 10 minute cooling periods between attempted starts.

6. Transition from prime to carburetor will noted by a 100-200 RPM drop. Release primer and re-adjust RPM to 1000-1200 for warm-up.

7. Oil pressure - WITHIN LIMITS.

CAUTION

If oil pressure is not indicated within 30 seconds, stop the engine and determine the reason.

8. Throttle - ADJUSTED.

Operate the engine at 1000 to 1200 RPM until oil temperature and oil pressure are within limits.

CAUTION

Prolonged idling below 800 RPM may damage the spark plug elbow insulation, as the cylinder head temperature will rise quickly and may exceed limits.

9. Fuel booster pump switch - OFF.

Turn the booster pump OFF after the engine is running smoothly.

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10. Fuel pressure - WITHIN LIMITS.
11. Vacuum pressure - CHECK.
12. Deicer pressure - Check.
13. Hydraulic system pressure - CHECK.
 - a. Test the right engine-driven pump with the landing gear lever in NEUTRAL and move the wing flap lever to DOWN.
NOTE: As the wing flaps are lowered, the hydraulic system pressure gage indication should decrease.
 - b. When the wing flaps have reached full down, the hydraulic system pressure should immediately increase to within limits.
14. Gear safety pins - REMOVED.
Captain will signal for ground crew to remove the safety pins.
15. Start the left engine repeating steps 1 through 10.
16. External power (if used) - DISCONNECTED.
Captain will signal for ground crew to disconnect the external power source.
17. Battery switch - ON.

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PROPELLERS

The Hamilton Standard propellers on our C-47s are three-bladed, hydromatic, full feathering, constant speed propellers. They have a diameter of 11 feet 7 inches and the blade settings are from 16 degrees (low pitch) to 88 degrees (high pitch), the constant speed range is from 16 - 45 degrees, blade angle. The propeller blade is known as the 6477A-0. This wide angle blade was developed by the manufacturer to assist in engine cooling for the C-47 engine installation when towing gliders. While the blade is more efficient for take-off performance than the needle blade propellers, it losses efficiency at altitude, and the airplane is not as fast.

In the constant speed range the position of the propeller blades is controlled by an engine operated governor which is adjustable from the cockpit to give any desired engine RPM from approximately 1200 RPM to 2700 RPM. The feathering and unfeathering of the propeller is accomplished by means of an auxiliary electric driven feathering motor operating an oil pump and controlled from the cockpit.

1. The propellers are Hamilton Standard, _____ - bladed, hydromatic, full _____, _____ speed type.	
2. Propeller diameter is _____.	three; feathering; constant
3. The high low pitch settings are _____ degrees and _____ degrees, the latter being the feathered position.	11 feet 7 inches
4. The constant speed range is from _____ to _____°.	16; 88
5. The propeller blade is model 6477A-0, known as a _____ blade.	16; 45
6. The paddle blade propeller was developed during the war for better engine _____ when towing gliders, and is more efficient for _____ performance although slower at _____.	paddle
7. The constant speed range is controlled by a governor from approximately _____ RPM to _____ RPM.	cooling; takeoff; altitude
8. Feathering and unfeathering are accomplished by an _____ pump located on the _____ of the firewall.	1200 2700
	electric aft side

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THE PROPELLER MECHANISM

The propeller blades are controlled by a hydraulically operated piston and cam assembly attached to the hub of the propeller with the cam geared to the base of the propeller blade. The piston carries rollers which fit into the same slots, and as the piston moves forward, the cam cylinder is rotated in a direction to increase the angle of the propeller blades. As the piston moves to the rear, the blades are rotated so as to decrease the blade angle. The dome in front of the propeller hub acts as the cylinder in which the piston acts.

There are two cam cylinders, inner cam, and an outer cam. The two cam cylinders are assembled concentrically, the outer cylinder being attached to the propeller hub, and the inner cylinder being geared to the propeller blades. The double cam arrangement reduces the length of piston travel necessary to produce a given blade movement; and the outer cylinder, being rigidly attached to the hub, prevents the piston from rotating instead of the propeller blades.

THE GOVERNOR

The governor is a small centrifugal governor driven by the front cam gear of the engine. The flyweights control a pilot valve which is held downward by a compression spring. The force of the spring and the centrifugal force of the flyweights balance each other when the engine is running at the proper speed. The speed of the engine may be changed by changing the compression force of the spring by means of the cockpit control. The governor contains an auxiliary oil pump which raises the pressure of the oil delivered by the governor to 200 psi.

With the compression of the governor spring set at a given value by the cockpit control, the engine must turn at a speed which will cause the flyweights to balance the spring force. If the throttle is opened and more power is applied, the engine speed tends to increase. The increase in speed causes the flyweights to overbalance the spring force and lift the pilot valve. Governor oil under 200 psi pressure is then directed to the space behind the piston in the propeller, and the angle of the blades is increased. The increase in blade angle increases load on the engine and reduces its speed.

When the speed is reduced to the proper value, the pilot valve returns to its proper position, and the oil behind the propeller piston is trapped and the blade cannot move.

If power is reduced by partially closing the throttle, the engine tends to slow down. The governor spring overcomes the force of the flyweights, and the pilot valve is pushed down. In this position the governor allows the oil in back of the piston to bleed back through the governor, and into the crank case of the engine. The centrifugal force of the propeller blades and the engine oil pressure in the forward part of the dome, force the piston to the rear, reducing the propeller blade angle. The reduction of the blade angle relieves the load on the engine and allows it to speed up until the force of the flyweights again just balance the compression of the governor spring.

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CHANGE IN ENGINE SPEED WITH COCKPIT CONTROL

When the propeller control in the cockpit is moved forward, the compression of the governor spring is increased. The additional force pushes the pilot valve down, and the blade angle will decrease until the engine speed increases to a value sufficient to bring the pilot-valve back to neutral.

When the propeller control is moved to the rear, the compression of the governor spring is reduced. This allows the flyweight to raise the pilot valve, and the blade angle will increase until the engine speed reduces sufficiently to bring the pilot valve back to neutral.

FORCES CONTROLLING PROPELLER BLADES

In the constant speed range the propeller blades are forced into high pitch (low engine speed) by the 200 psi governor oil pressure behind the piston in the dome. This pressure must overcome the centrifugal force on the propeller blades and the 85 psi in engine oil pressure which is always present in the forward part of the dome.

The propeller blades are forced into the low pitch position (high engine speed) by virtue of the governor oil pressure behind the piston being relieved, so that the centrifugal force on the propeller blades and the engine oil pressure in the forward part of the dome may force the blades into low pitch.

PROPELLER FEATHERING MECHANISM

The oil pressure necessary to force the cam rollers out along the steep part of the cam slot and to carry the propeller blades into the feathered position is furnished by an auxiliary electric-driven feathering pump. The pressure required for this operation is between 400 and 450 psi depending on the tightness of the blades and the temperature of the oil.

The feathering pump is operated from an electrical switch in the cockpit. The pump draws oil from the sump of the engine oil tank and delivers this oil to the bottom of the propeller governor. The feathering oil pressure operates a plunger valve which closes off the oil passage from the governor and allows the feathering oil to flow to the propeller through the same passage used for governor oil. The high pressure oil forces the cam rollers along the steep part of the cam slot until the end of the slot is reached. In this position the propeller blades are at an angle of 88 degrees and the propeller will not windmill. The propeller must be closely watched during feathering to see that the switch releases at the moment that the propeller stops turning. Ordinarily, the propeller feathering button will kick out when the propeller is fully feathered, but sometimes this switch is stuck and is not deliberately pulled, the propeller will immediately unfeather and continue to unfeather resulting in overspeeding the engine and possibly causing damage.

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In the event that the engine oil is lost due to a failure of an engine oil line, the propeller can always be feathered with the reserve oil which is below the outlet to the engine oil pump in the bottom of the oil tank. The quantity of reserve oil for feathering is enough to feather the propeller once.

1. The governor assembly includes a gear-driven _____ and regulating valve to supply _____ psi via the pilot valve to the propeller dome.

2. A piston and cam mechanism and the pump operate to set the blade angle as determined by the _____ valve.

boost pump
200

3. Oil pressure for feathering is supplied by the auxiliary feathering pump at between _____ and _____, and for unfeathering at _____ to _____ psi.

governor pilot

4. Operating the feathering switch causes the feathering pump to supply this pressure to the bottom of the propeller governor, operating a _____ valve which closes the _____ oil passage from the governor and supplies the high pressure oil to the propeller dome.

400
450
500
550

5. The high pressure forces the cam _____ along the steep part of the slot to the full extent of the cam _____.

plunger
normal

rollers

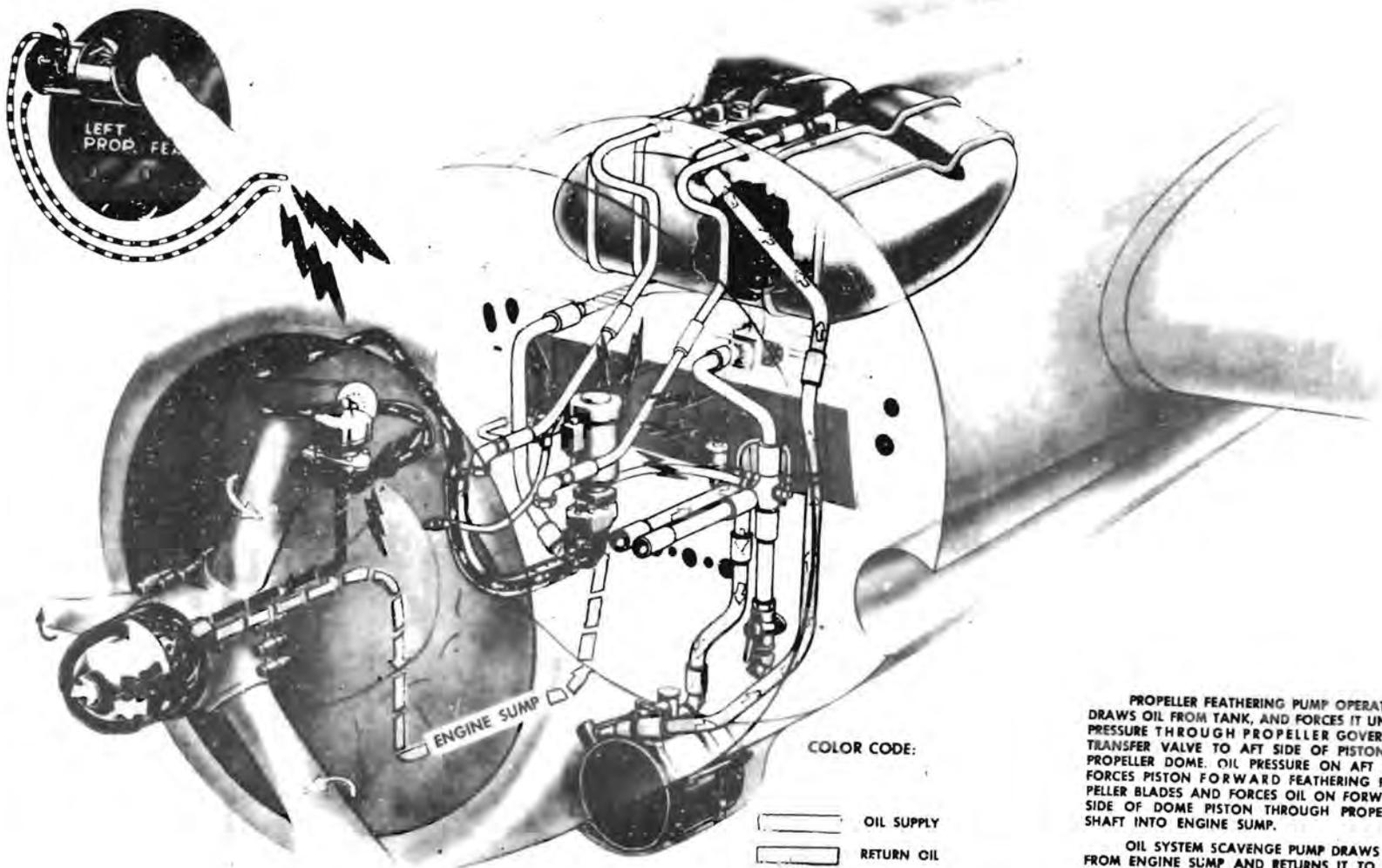
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Propeller Feathering Oil System

PROPELLER FEATHERING PUMP OPERATION
DRAWS OIL FROM TANK, AND FORCES IT UNDER
PRESSURE THROUGH PROPELLER GOVERNOR
TRANSFER VALVE TO AFT SIDE OF PISTON IN
PROPELLER DOME. OIL PRESSURE ON AFT SIDE
FORCES PISTON FORWARD FEATHERING PRO-
PELLER BLADES AND FORCES OIL ON FORWARD
SIDE OF DOME PISTON THROUGH PROPELLER
SHAFT INTO ENGINE SUMP.

OIL SYSTEM SCAVENGE PUMP DRAWS OIL
FROM ENGINE SUMP AND RETURNS IT TO THE
OIL STORAGE TANK HOPPER.

TO UNFEATHER PROPELLER OIL, PRESSURE
IS ROUTED TO FORWARD SIDE OF DOME PISTON
FORCING OIL ON AFT SIDE OF PISTON TO FLOW
THROUGH PROPELLER SHAFT INTO ENGINE SUMP.

COLOR CODE:

-  OIL SUPPLY
-  RETURN OIL
-  OIL PRESSURE
-  ELECTRIC CABLE
-  ELECTRIC OPERATION
-  FEATHERING PUMP VENT PIPE

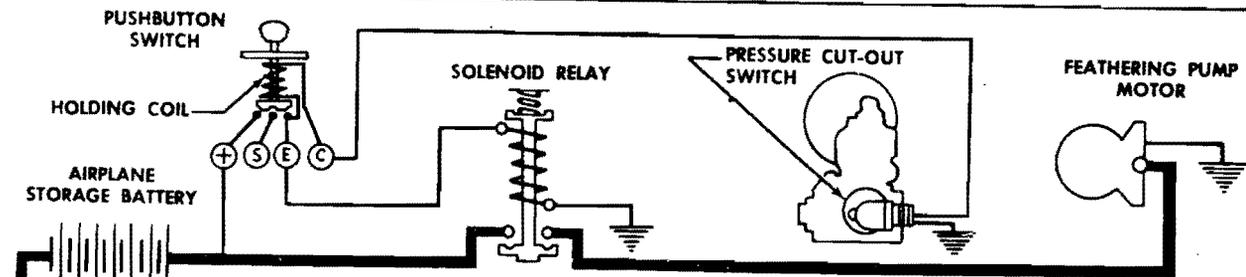
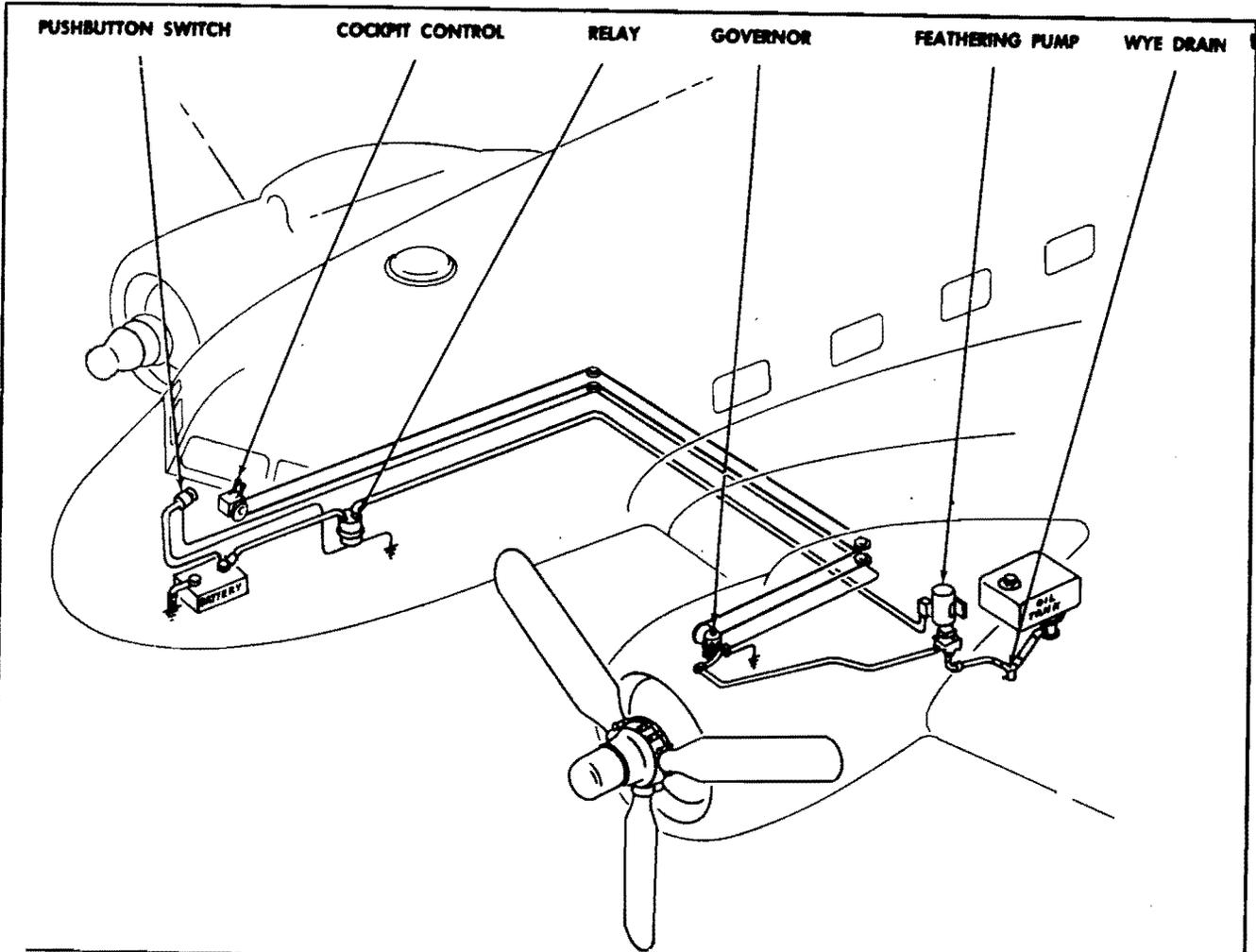
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WIRING DIAGRAM - IDENTICAL FOR ALL ENGINES

Typical Propeller Feathering Accessories Installation

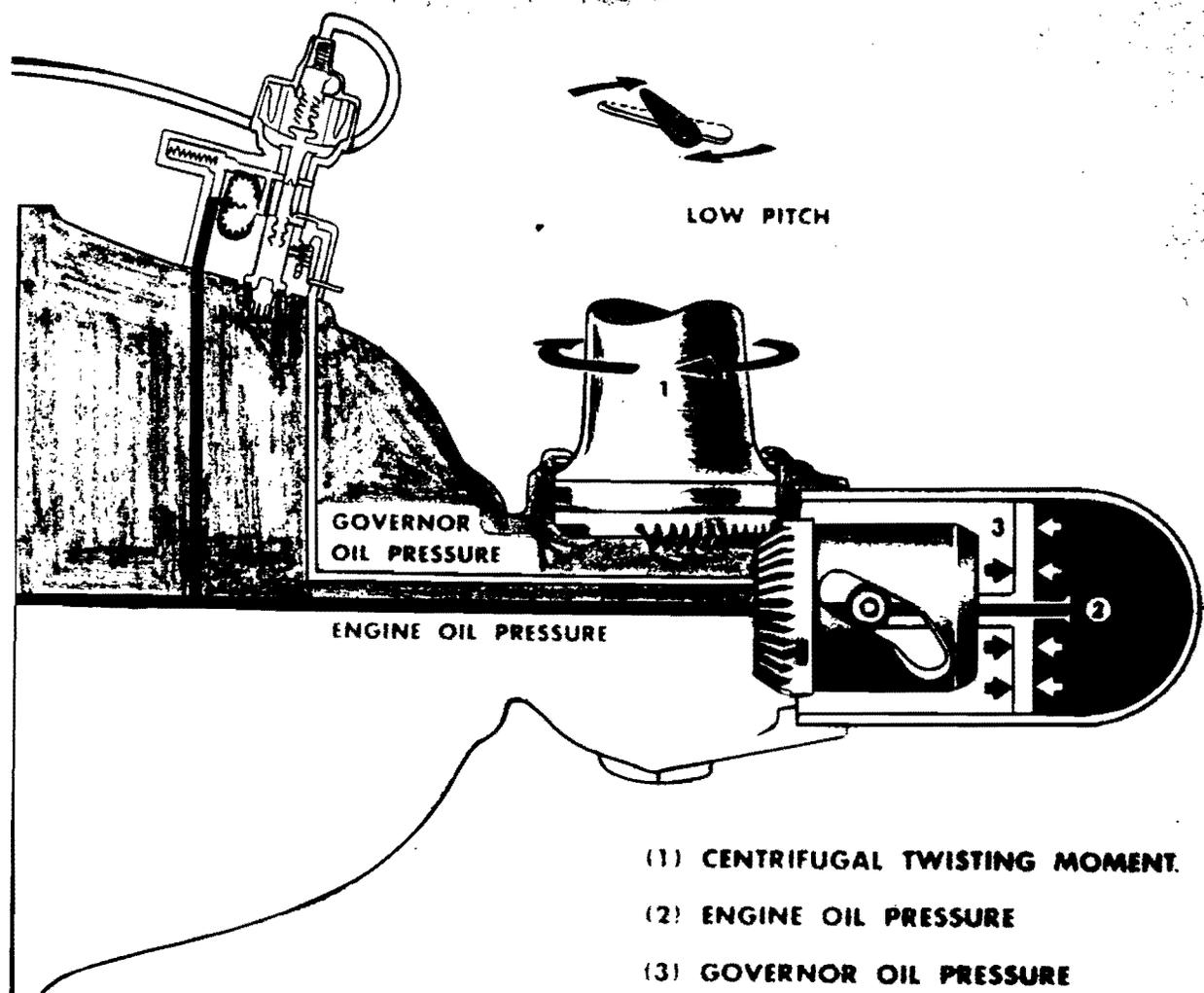
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-Propeller Control Forces

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FUEL SYSTEM

GENERAL

The C-47 is equipped with a four tank fuel system. The basic arrangement is considered to consist of two independent fuel systems, with a main or an alternate tank available to supply each engine.

A. Fuel Tanks

The two main tanks and the auxiliary tanks are mounted in the center wing of the aircraft. Each fuel tank is vented to the atmosphere.

B. Fuel Tank Selector Valves and Controls

A fuel selector valve for each engine, operated by dial and handle controls is in the cockpit. Under normal conditions, the left engine draws fuel from the left tanks, but by using the selector valves, fuel may be supplied from any tank to either engine.

NOTE: No provision is provided for fuel dumping, except on one special aircraft located at BKK.

C. Engine Driven Fuel Pumps

Are positive displacement vane type. A by-pass within the pump routes fuel from the electric fuel booster pump through the engine drive pump to the carburetor in the event of engine pump failure.

D. Electrical Fuel Booster Pumps

Are single speed, centrifugal type, installed in the tank-to-engine line. The control switches are located on the overhead switch panel. Power is supplied to both pumps through two circuit breakers, located on the main junction box. The booster pumps are used as outlined under "OPERATION" in this section.

E. Fuel Pressure Gauges

One dual direct reading, pressure operated type fuel pressure gauge, located on the engine instrument panel, indicates the pressure of the fuel at the carburetor inlet.

F. Fuel Priming

A solenoid valve, mounted on the inlet side of each carburetor, is operated by a single momentary switch in the engine starting switch cluster. To obtain fuel flow through the priming system for starting, the respective fuel booster pump must be on.

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G. Fuel Quantity

One liquidometer type, fuel quantity gauge is installed on the instrument panel. On the front of the indicator is a four-position selector switch which allows the selection of the dial for the tank desired. Each dial is calibrated from 0 gallon to the capacity of the particular tank. One liquidometer is installed in each of the four tanks.

NOTE: The fuel quantity gauges in Company C-47 are calibrated in a three point attitude, not in normal flight attitudes.

H. Carburetors

See "POWER PLANT" Section in this manual.

I. Fuel Measuring Stick

A "Dipstick", having a calibration in gallons for each tank is carried in the cockpit.

J. Fuel Tank Capacities

Left main.....	202 U.S. gallons.....	Right main
Left auxiliary.....	200 U.S. gallons.....	Right auxiliary

K. Fire Wall Shut Off Valve

Solenoid and manually operated (depending on type of Fire Extinguishing System) shut off valves are installed on the engine fire walls to shut off fuel to the engine section.

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OPERATIONS

A. Minimum Fuel On Board - For any take-off, shall not be less than specified by Flight Dispatch Form. The minimum stick measureable fuel in each of the two main tanks will be not less than 50 gallons in each tank.

B. Fuel Usage Procedure - (Normal)

1. Take-off and landing shall be made with each main tank supplying fuel to its respective engine.
2. Start warm up and taxi on auxiliary tanks.
3. Switch to main tanks prior to run-up.
4. 20 gallons per side (minimum), then change to the main tanks and continue, or cruise on the auxiliary tanks until approaching your destination, then at some convenient time in or near the traffic pattern, change to the main tanks, continue and land.

NOTE: Normally do not intentionally run a tank completely dry. If flight conditions necessitate completely draining tanks, the last 20 gallons (approximately) in each tank should be run out with the booster pump off, carefully monitoring the fuel pressure for indication that tank is running dry. Turn on booster pump before switching tanks.

C. Fuel Loading Procedures

1. The main tanks will be loaded to capacity prior to filling auxiliary tanks.

D. Use Of Fuel Booster Pumps

1. Booster Pump ON
 - a. For starting engines
 - b. For take-off
 - c. In climb when required to maintain a minimum of 16 psi
 - d. In cruise above 10,000 feet of altitude or at any time required to maintain fuel pressure at a minimum of 16 psi

E. When selecting a new fuel source, turn on booster pump before selecting new tank.

F. Anytime fuel pressure drops below 16 psi.

G. For all landings.

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CAUTION: Booster pumps should not be operated in any system where it is known or suspected that a leaking or broken fuel line exists. When booster pumps are used, the fuel system from the booster pump to the carburetor is under pressure, whereas operation on engine pumps only places the same fuel line areas under suction.

A leak in the line with booster pumps "OFF" will be indicated by fluctuating fuel pressure resulting from the introduction of air into the system. With booster pumps "ON" there will be no cockpit indication of a minor leak; also, fuel will be pumped into the area of the leak, creating a fire hazard.

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1. There are _____ fuel tanks, consisting of a _____ and _____ on each side of the center section.	
2. Each main tank holds _____ and each auxiliary tank holds _____ gallons.	four; main; auxiliary
3. Each fuel tank is vented to the _____.	202; 200
4. There are _____ fuel selector valves located at the top of the center _____ on each side.	atmosphere
5. The left fuel selector belongs to the _____ and the right fuel selector belongs to the _____.	two control pedestal
6. Each fuel selector can direct fuel from _____ of the _____ tanks to its engine.	left engine right engine
7. For example, the left engine may be operated on the _____ auxiliary tank and right engine operate from the _____ tank simultaneously.	any one four
8. There is _____ for fuel dumping.	right; left main
9. There are two engine driven fuel pumps of the _____ displacement type which supply fuel to their respective engines at _____ psi on Company aircraft, _____ psi on USAF aircraft.	no provision
10. The fuel pump contains a _____ to allow fuel from the boost pump through the carburetor, for _____ in case of _____ failure.	positive 16 to 18 16 to 18
11. There are two electric fuel _____ pumps located downstream from the fuel _____ valve in each side.	by-pass; starting engine pump
12. They are _____ speed, _____ type.	boost; selector
13. They are controlled by switches on the _____ switch panel.	single centrifugal
14. 28 V dc is supplied to the pump through circuit breakers on the _____ junction box.	overhead
15. There is one direct reading fuel pressure gauge on the _____ instrument panel, which indicates fuel pressure at the _____.	main
16. It is called direct reading because fuel under pressure is piped to the _____ from the _____ line.	engine carburetor inlet

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17. A _____ switch located on the engine starter switch panel actuates a _____ valve on the inlet side of the carburetor.	instrument carburetor
18. The primer switch will not prime the engine unless the _____ is turned on.	momentary primer
19. Fuel quantity is measured by a _____ located in each of the _____ fuel tanks.	boost pump
20. A liquidometer consists of a _____ at the end of a moveable arm which in turn is geared to actuate a _____ across a semicircular _____.	liquidometer four
21. The 28 V dc supplied through this contact arm and resistance strip is circuited to indicate fuel quantity in _____ on a _____ position electric gage.	float contact arm resistance strip
22. The gage may be selected to any one of the four tanks by a _____ selector switch.	gallons four
23. In the Company aircraft the quantity gages are calibrated with the A/C in a _____ attitude, and not in a _____ attitude.	rotary
24. A dip stick is provided for measuring the fuel by insertion through the fuel tank _____ and is calibrated to indicate fuel quantity in either the _____ or _____ tanks.	three point normal flight
25. The minimum stick measureable fuel in each of the two main tanks must not be less than _____ for any take-off.	filler neck main auxiliary
26. Minimum fuel for any take-off shall not be less than _____ specified in the _____ form.	50 gallons
27. All takeoffs and landings shall be made with the _____ tanks to their respective engines.	flight dispatch
28. It is recommended to start, warm up and taxi on the _____ tanks.	main
29. You should switch to _____ tanks prior to run up.	auxiliary
30. From the start of take-off, the procedure is to burn at least _____ gals from each main tank and then switch to _____ tanks until approaching destination, or until the _____ tanks have been burn off.	main

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31. Under normal conditions _____ run a tank dry, but if conditions necessitate, the last _____ gals should be run out with booster pump _____.	20 auxiliary auxiliary
32. Always turn _____ on before switching tanks.	do not; 20; OFF
33. In fueling the A/C _____ tanks must be filled prior to filling _____ tanks.	booster pump
34. The fuel boost pumps are used for _____ engines, for _____, in _____, in _____ above 10,000 ft., or at any time when they are required to maintain fuel pressure at minimum of _____ psi (Company A/C) or _____ psi (USAF).	main auxiliary
35. When changing tanks, turn _____ before selecting new tanks.	starting; takeoff; climb; cruise; 16; 14
36. Boost pump ON whenever the fuel pressure drops below _____ psi.	booster pumps ON
37. The normal fuel pressure range is _____ psi for Company A/C, and _____ for the USAF.	16 (Co. A/C) or 14 (USAF)
38. When using boost pumps, the fuel lines from the tanks to the engine fuel pumps are under _____, whereas under normal operation with boost OFF the same fuel lines are under _____ pressure.	16 to 18 14 to 16
39. For this reason, never use _____ when a leaking fuel line is known or suspected to exist.	positive pressure; negative pressure (suction)
40. A leaking fuel line with boost OFF will be indicated by _____ resulting from _____ leaking into the line.	boost pumps
41. With boost ON there will be _____ in the cockpit of a minor leak, since fuel under pressure will be leaking into _____ of the aircraft.	pressure fluctuation air
	no indications other areas

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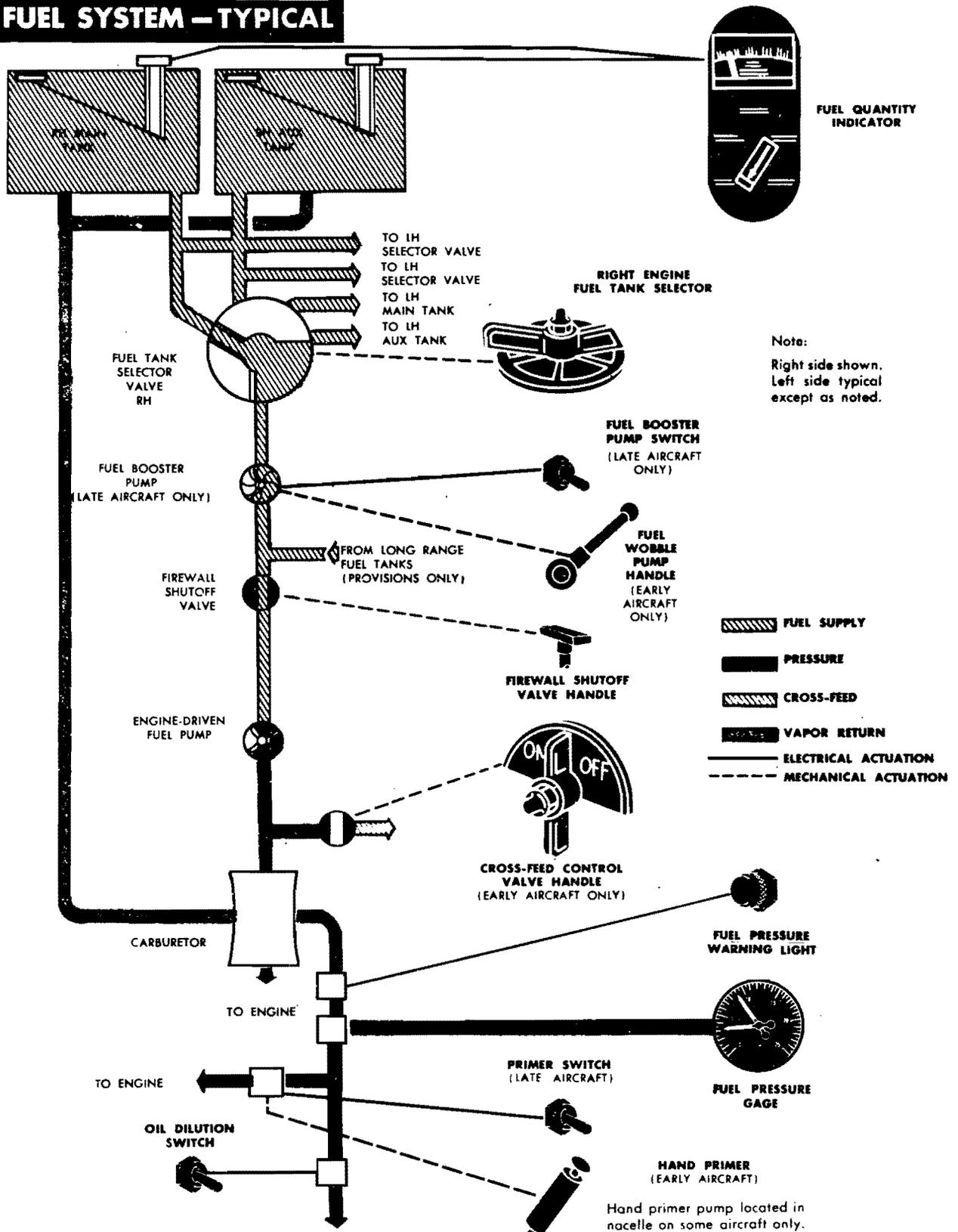
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FUEL SYSTEM - TYPICAL



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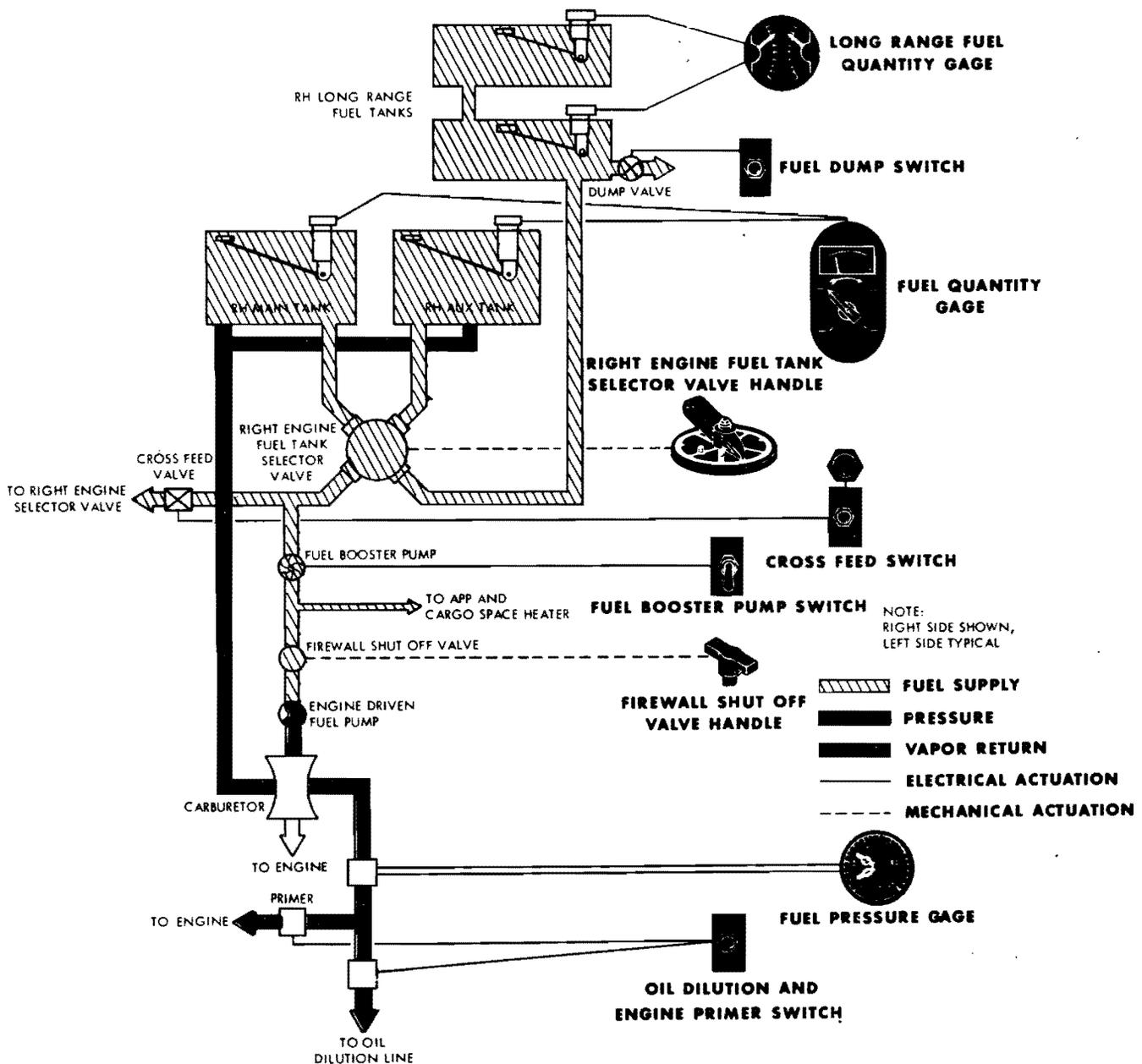
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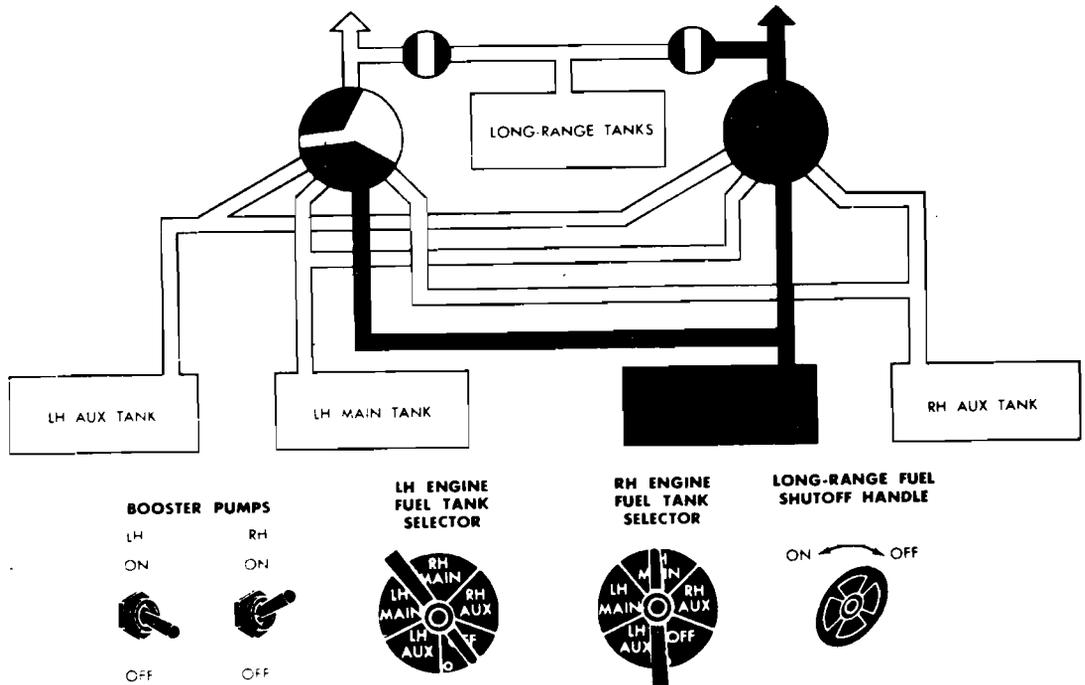
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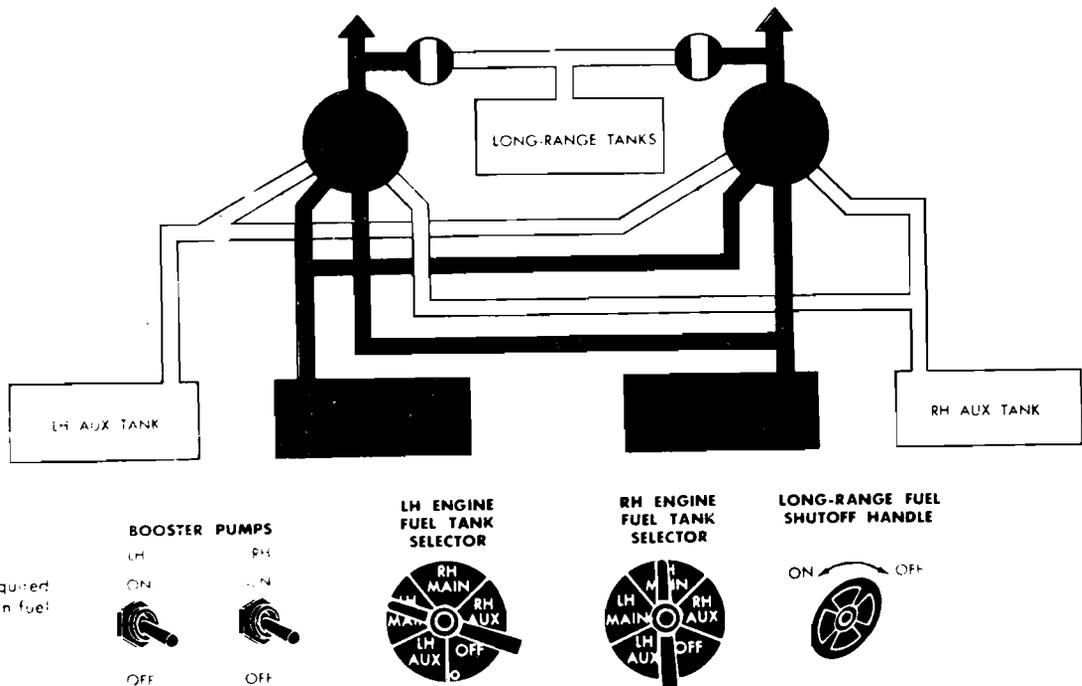
FUEL SYSTEM (SOME SC-47 AIRCRAFT)



FUEL SYSTEM MANAGEMENT



**NORMAL ENGINE STARTING OPERATION.
 BOOSTER PUMP ON TO ENGINE BEING STARTED.**



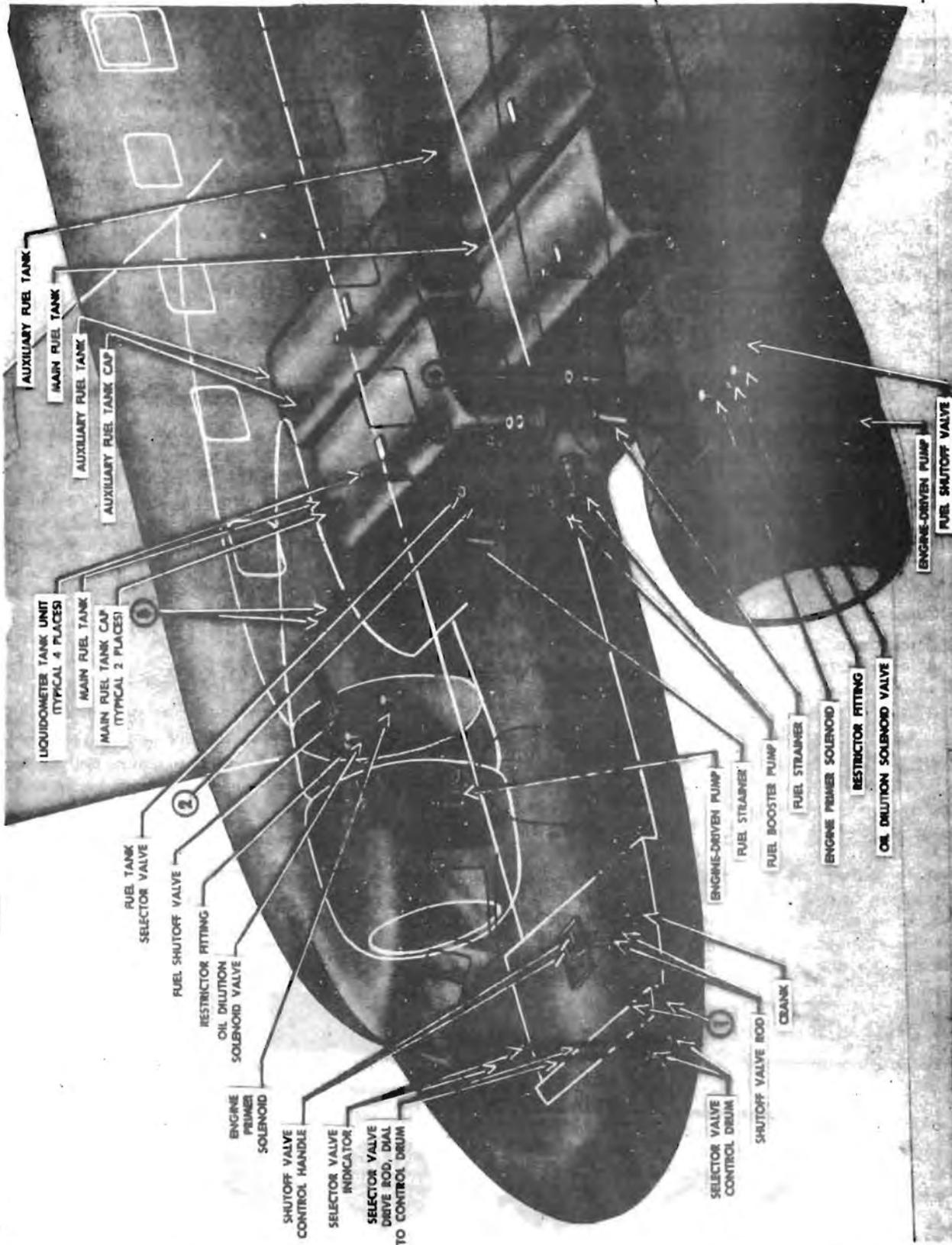
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Fuel System Components and Controls

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OIL SYSTEM

GENERAL

Engine lubricating oil is supplied by two independent oil systems, one for each engine. Each system contains a tank, a cooling radiator, engine driven pressure and scavenging pumps, and pressure and temperature indicators.

A. Oil Tanks

Are located aft of the respective engine firewall. Each tank has a capacity of 29 gallons with space provided for 10% expansion and foam. A stand-pipe is incorporated providing a 2½ gallon reserve of oil which is available only to the propeller feathering pump.

B. Oil Cooler and Controls

Oil is cooled by a radiator installed in the oil return line between the engine and the tank. Oil temperature is controlled by positioning of the oil cooler air exit shutters, which can be operated by a manual control.

C. Oil Emergency Shut-Off Valves

Have been deleted from Company aircraft. There is no provision for shutting off oil to the engine in the event of engine fire.

D. Oil Pressure - Temperature - Quantity

Oil Pressure - Is measured by two direct reading, pressure operated gauges.

Oil Temperature - Is measured by two D.C. powered units which extend into the nacelle oil tank outlet. A dual oil temperature indicator is mounted on the engine instrument panel.

Oil Quantity - Is measured by dip stick attached to oil filler cap under access doors on the top of each nacelle.

E. Oil Dilution Switches

Consist of a spring loaded single-pole, double throw switch, placarded OIL DILUTION LEFT, RIGHT mounted on the electrical panel to energize one solenoid valve mounted on the forward face of each firewall. The circuit receives 24 volt DC power through a 10 Ampere circuit breaker located in the main junction box.

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OPERATION

A. Oil Cooler Controls

Are normally left forward unless oil temperature falls below 60°C when the controls are moved aft in order to maintain desired oil temperature.

B. Oil Dilution Procedure

1. Maximum engine oil temperature when starting or during dilution 50°C (shut down engine if necessary).
2. Engine : 1000-1200 RPM
3. Hold dilution switch ON for a length of time as indicated in the following chart :

Anticipated O.A.T.	Oil Dilution Period
4° to -12°C	2 minutes
-12° to -29°C	3 minutes
-29° to -46°C	7 minutes

NOTE:

1. Engine must not be run at oil temperatures above 50°C in order to avoid vaporizing the gasoline already mixed with the oil. If necessary stop engine and wait for oil to cool before continuing dilution. After oil has become cooler, restart and continue dilution. At no time shall oil pressure be less than 15 psi.
2. Run engines briefly at 1500 RPM and operate propeller governor from low to high, 3 cycles while diluting.
3. Push feathering button and pull out after a 400 RPM drop is noted.
4. After dilution period has been completed, stop engine in normal manner, holding dilution switch ON until engine stop turning.
5. Enter length of time oil was diluted in the log book.

C. Restarting With Diluted Oil

1. Start engine and operate at 1000 RPM (auto rich) until oil temperature reaches 40°C.

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OPERATION (Con't)

2. Increase engine RPM to 1500 and check oil pressure (diluted oil will result in lower pressure). Hold 1500 RPM until oil temperature rises to 60°C and oil pressure is normal.
3. Operate the propellers from full low pitch several times.
4. Check oil quantity prior to take-off.

CAUTION:

Do not attempt take-off until all oil pressures are normal and engine oil temperature is 40°C or higher.

NOTE:

During the first hour of flight, initial oil consumption may be higher than normal until all traces of fuel disappear.

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LIMITATIONS

A. Oil Quantity

1. Tank Capacity ... $26\frac{1}{2}$ gallons/eng (usable by the engine plus 2.5 gallons reserved for propeller feathering.
2. Normal Minimum for take-off Dependent on fuel load but not less than 15 gallons per nacelle tank.

B. Maximum Oil Consumption Limits

<u>Location of Aircraft</u>	<u>Maximum Limit</u>	<u>Remarks</u>
1. Main Base	1.5 GPH	Engine must be changed.
2. At Airline Stations Condition "A"	1.5 GPH	Aircraft temporarily grounded. Engine disposition pending instructions from MMB.
3. At Airline Stations Condition "B"	1.8 GPH	Aircraft grounded for engine change or for ferry for engine change.

C. Oil Pressures & Temperatures

See "Power Plant" section of this manual.

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OIL SYSTEM

- | | |
|--|-----------------------------------|
| 1. There are _____ lubricating oil systems, one for _____ | |
| 2. Each system includes a tank, a cooling _____, engine driven pressure and _____ pumps, and pressure and temperature indicators. | two, each engine |
| 3. The oil tanks are located on the _____ side of each firewall. | radiator, scavenging |
| 4. Each tank has a capacity of _____ gals, of which _____ gals is useable oil and _____ gals is foaming space. | aft |
| 5. Standpipe in the tank provides _____ gals of oil available to the engine, and _____ gals available only to the _____ pump. | 29, 25, 4 |
| 6. This reserve available _____ to the feathering pump is sufficient for _____ complete feathering cycles. | 22½, 2½, prop feathering |
| 7. Oil is cooled by a radiator in the _____ line between the engine and the tank. | only, two |
| 8. Oil temperature is regulated by positioning the oil cooler _____ which is operated by a _____ control in the _____. | return |
| 9. In the USAF A/C there is a _____ between the tank _____ and the engine. | air exit shutter, manual, cockpit |
| 10. In the Company owned A/C this firewall shutoff valve has been _____. | firewall shutoff valve |
| 11. Oil pressure is measured by two _____ gages in the cockpit. There is a pressure line from the engine to the cockpit instrument. | deleted |
| 12. Oil temperature is measured by two 28 V dc powered _____ in each oil tank outlet which actuate instruments in the cockpit. | direct reading |
| 13. Oil quantity is measured by _____ attached to each oil _____ under an access door in each _____. | thermometer bulbs |
| 14. The oil cooler controls are normally in the _____ position unless oil temperature falls below 60°C, when the controls are moved _____ appropriately to maintain desired oil temperature. | dipstick, filler cap, nacelle |
| | forward, aft |

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15. In normal operation, minimum oil for any takeoff is _____ gals per tank.

16. The max allowable oil consumption is _____ gals per engine per hour.

15

17. With oil consumption in excess of _____ gals per hour per engine at a main base, a mandatory _____ is indicated.

1.5

18. At airline stations in excess of _____ gals per hour per engine, the A/C is temporarily _____, pending instructions from _____.

1.5, engine change

19. At airline stations with oil consumption at _____ gals per hour per engine or more, the A/C is _____ for engine change, or _____ for engine change.

1.5 grounded, MMB

1.8, grounded, ferry

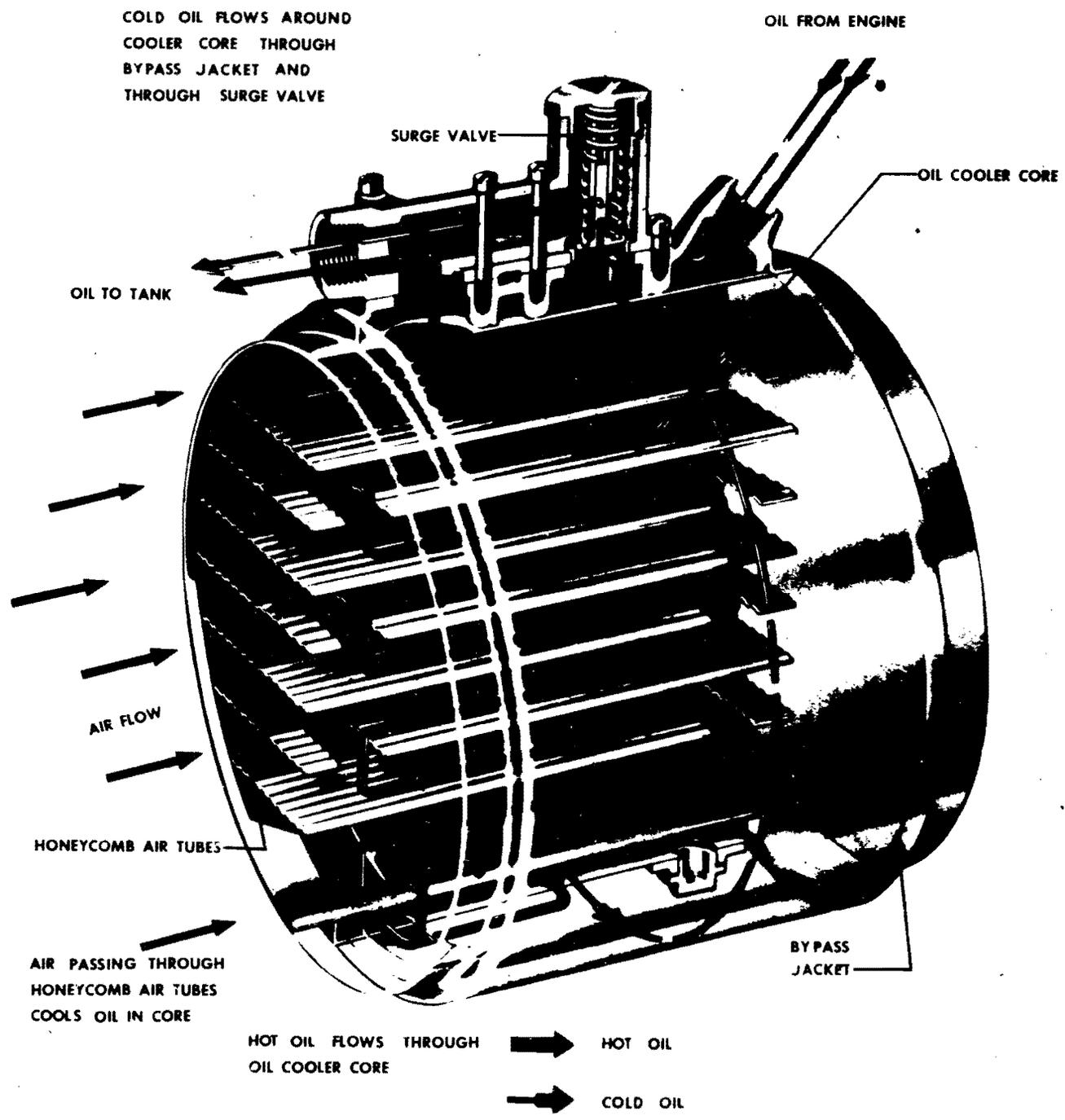
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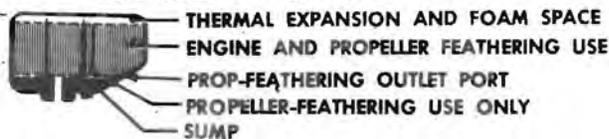
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Oil Flow through Cooler

OIL QUANTITY LEVELS



PURPOSE OF OIL TANK: To store and introduce lubricating oil into the oil system. The oil tank provides a temperature accelerating well (hopper), a propeller feathering oil supply sump, a quantity measuring rod, and connectors for vent pipes to the engine. It also provides a space, above the 29-gallon capacity level, which allows for foam and 10% oil thermal expansion.

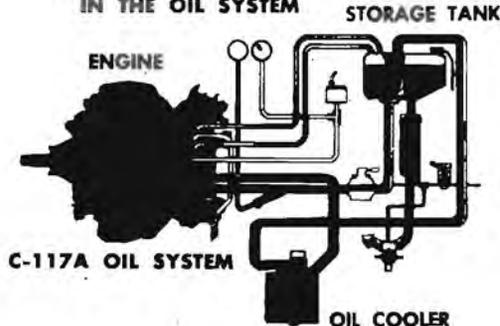
PURPOSE OF TEMPERATURE ACCELERATING WELL (HOPPER): To accelerate the temperature rise of the circulating oil, by partially separating the oil supply to the tank from the warm used oil returning to the hopper enabling the returned oil to recirculate directly to the engine. The hopper also acts as a means of removing foam and air from the oil going to the engine.

HEATING UNIT PORT (PLUGGED)
HAND HOLES

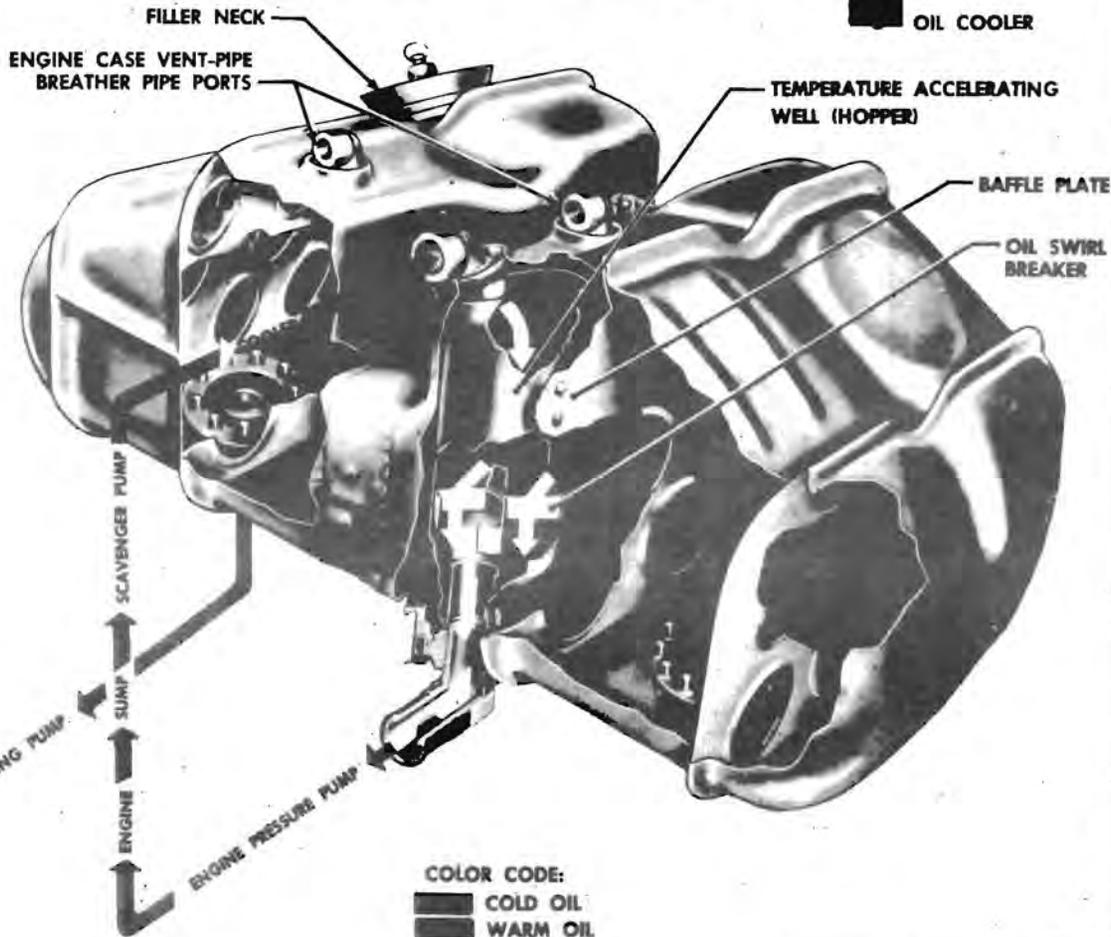


BOTTOM VIEW OF TANK

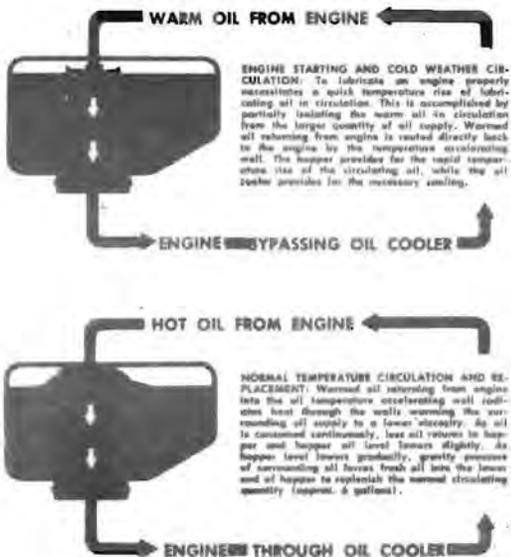
USE OF STORAGE TANK IN THE OIL SYSTEM



C-117A OIL SYSTEM



COLOR CODE:
 COLD OIL
 WARM OIL



Oil Tank Diagram

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HYDRAULIC SYSTEM

The landing gear, wing flaps, windshield wipers, auto-pilot and wheel brakes are operated hydraulically. Hydraulic pressure is normally supplied to all units by two engine-driven pumps, one mounted on each engine. A manually operated hand pump provides an emergency source of pressure in the event of total failure of the normal pressure supply. Approximately 6 gallons of hydraulic fluid, are required to fill the system.

1. The units operated by the main hydraulic system are: gear, brakes, wing flaps, windshield wipers, and _____ on Company A/C.

2. There are two _____ hydraulic pumps, one on each _____.

auto-pilot

3. _____ gallons of hydraulic are required to fill the system.

engine-driven,
engine accessory section

6

The hydraulic hand pump, located at the base of the hydraulic control panel, is provided to operate the hydraulic system units when there is insufficient pressure in the hydraulic system, or when the engine pumps fail in flight. The hand pump is accessible to both pilots and can also be operated to increase the pressure in the hydraulic pressure accumulator for ground operation of the hydraulic system when the engines are not running.

1. There is a manually operated auxiliary hydraulic pump located at the _____ of the hydraulic panel and accessible to _____ in flight.

base, both pilots

The reservoir is installed to the right of the hydraulic control panel and is equipped with a filler neck for servicing the reservoir from the walkway area. A sight gage is installed on the upper portion of the hydraulic control panel to indicate the fluid level in the reservoir at all configurations. The outlet to the engine-driven hydraulic pumps is located above the bottom level of the reservoir so that an emergency supply of fluid, available only to the hydraulic pump, always remains in the bottom of the reservoir and cannot be drawn out by the engine pumps. The outlet for the hydraulic hand pump is located at the bottom of the reservoir sump. The capacity of the hydraulic reservoir is 10 quarts of oil when filled to the top arrow of the sight gage. Seven quarts of oil are available for supplying the engine-driven pumps and remaining 3 quarts in the reservoir sump are available only to the hydraulic hand pump. Sufficient space is provided at the top of the reservoir to allow for thermal expansion of the oil.

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1. The hydraulic panel located aft the copilot and facing the captain contains at its top a filler neck for the _____, which is located _____.

2. Beside the filler neck is a reservoir quantity _____, placarded to proper levels with the A/C in _____ configurations.

reservoir,
back of the panel

3. Capacity of the hydraulic reservoir is _____ quarts.

sight gage, various

4. There is a standpipe in the reservoir extending _____ quarts above the bottom the reservoir.

10

5. Thus, _____ quarts are available to the engine pumps through the opening at the top of this standpipe.

3

6. The _____ quarts remaining below the standpipe are available only to the _____ for emergency operation.

7

3, aux hand pump

Hydraulic Fluid Shut-Off Valves - are located on the respective engine firewall. Both valves, normally open, may be closed to shut off fluid supply to the respective hydraulic pump by actuating the corresponding engine firewall selector switch located in the floor hatch between the two pilots.

1. There is a hydraulic _____ valve on the aft side of each engine firewall.

2. These emergency firewall shut-off valves are operated by controls under the _____ between the _____.

firewall shut-off

floor hatch, two pilots

Engine-Driven Pump - delivers fluid under pressure to a common pressure feed line through an isolation check valve. The pump driven shaft is designed to shear, in the event that all hydraulic fluid available to the pumps is lost, as a safety feature to prevent fire from an over-heated pump.

1. Each eng hydraulic pump is driven by a _____, designed to shear in case of loss of hydraulic fluid to the pump, to prevent fire due to an _____ pump.

shear shaft, overheated

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System Pressure Regulator - automatically maintains normal pressure between 800 and 1000 PSI on Co. A/C and 600-875 PSI on USAF A/C.

System Accumulator - provides a reserve supply of fluid under pressure and dampens the high impact loads on lines and units. The initial air charge of the accumulator is 300 PSI. (250 on USAF A/C)

System Relief Valve - automatically prevents excessive system pressure if the pressure regulator fails. This valve starts to relieve at 1100 ± 50 PSI on Co. A/C and 1000 ± 50 PSI on USAF A/C.

1. Downstream from each pump is a system _____ to regulate pressure in Company A/C to _____ PSI, and in USAF A/C to _____ PSI.	
2. There is a system _____ in the main system to provide a _____ supply of fluid under pressure and to _____ high impact loads on lines and units.	pressure regulator, 800-1000, 600-875
3. The air precharge in the accumulator is _____ PSI in Co. A/C, and _____ PSI in USAF.	accumulator, reserve, dampen
4. There is a system relief or safety valve which is set in Co. A/C to relieve pressures in excess of _____ PSI, and in USAF A/C at _____ PSI.	300, 250
	1100 ± 50 , 1000 ± 50

System Pressure Gauge - is a direct system, indicating accumulator or emergency hand pump pressure depending on operating conditions.

Landing Gear Pressure Gauge - is a direct operating pressure instrument and indicates the hydraulic pressure in the landing gear down line.

1. There are two hydraulic pressure gages in front of the copilot, of the _____ type.	
2. The forward gage is teed off from the landing gear down line, and indicates _____ pressure, except when the gear selector lever is in the down position, when the gage indicates _____ since the valve is open to the system.	Bourdon Tube
3. The aft gage indicates _____ at all times.	gear down line, system pressure
	system pressure

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Windshield Wiper System - the wipers operate from hydraulic fluid pressure routed from a cross fitting in the brake system pressure line through a needle-type control valve to a hydraulically actuated motor assembly. From the motor unit, two flexible driven shafts connect to the windshield wiper unit on each forward windshield to drive the wiper blades. The needle valve controls the operating speed of the wiper blades by regulating fluid flow to the motor. Return fluid flows through a cross fitting in the brake system return line back to the reservoir.

1. The windshield wipers operate hydraulically from _____ pressure, through a _____ type control valve below the _____.

2. A _____ w/w motor is connected by linkage to _____ wiper blades.

system, needle,
glare shield

single, both

Hand Pump-To-Accumulator Shutoff Star Valve - provides a bypass around the check valve in the pressure manifold when it is necessary to increase the pressure in the accumulator by operating the hand pump.

NOTE: For all normal hand pump operation, this shut off valve is safetied with easy-break safety wire to the CLOSED position, so that direct actuation of any functional system may be obtained immediately without having to charge the accumulator first. If system pressure is zero, then the star valve can be positioned to OPEN and parking brake pressure can be pumped directly to the accumulator by use of the emergency hydraulic hand pump.

1. Normally the star valve is _____ and _____.

2. When the star valve is closed, all pressure from the aux pump is direct to the hydraulic _____, bypassing the _____; therefore _____ hydraulic unit may be actuated directly from the aux hand pump.

closed,
safetied

3. When the star valve is open, pressure from the aux hand pump is directed to the _____.

manifold, accumulator,
any

4. This configuration is used only when it is desired to set the _____ before starting the engines when the system pressure is zero.

system accumulator

parking brakes

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Wing Flaps - Lowering and raising of the flaps are accomplished by the actuation of a flap handle on the 4-way wing flap control valve, which positions the valve ports for the required direction of fluid flow. Partial raising or lowering of the flaps is made by returning the handle to neutral position after the flaps have reached the desired position as shown on the wing flap indicator along the bottom edge of the main instrument panel.

1. The wing flap selector valve may be positioned to flaps _____, flaps _____ or _____.

2. The flap position indicator is located along the bottom edge of the _____.

up, down, neutral

main, instrument,
panel

The wing flap relief valve is set at 375 PSI to prevent lowering of more than 3/4 wing flaps at an indicated airspeed greater than 97 knots. When during lowering of the flaps, strong wind resistance is encountered on the wing flaps, fluid back pressure in the DOWN line forces down the relief valve, blocking entire system flow and halting downward movement of the flaps. Should excessive wind resistance be encountered after the flaps have been lowered to an intermediate position and the handle returned to neutral position, excessive back pressure in the DOWN line will cause the relief valve to relieve fluid back to the reservoir until normal value. However, when the wing flaps are entirely down, mechanical leverage will prevent the wind load from forcing the flaps up.

1. In the wing flap down line is a _____ set at _____ PSI, whose purpose is to prevent lowering the flap to 3/4 or full an A/S greater than _____ knots.

2. Although the relief valve will prevent lowering the flaps at excessive speeds, once extended the flaps _____ blow up automatically with subsequent excessive speed, due to _____.

relief valve, 375, 97

will not, mechanical
linkage

An orifice check valve is installed in the wing flap up line after the relief valve with direction of free flow towards the actuating cylinder. The orifice check valve restricts the return flow of fluid from the actuating cylinder when the flaps are raised, introducing a time lag which prevents rapid raising of the wing flaps and consequent sudden loss of lift in flight.

When the airplane is on the ground the flap control handle should be left in the UI position at all times, so that excessive pressures will not be built up in the flap lines by thermal expansion.

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There are no thermal relief valves in the flap system.

CAUTION: The flaps will be damaged when the airplane is flown in excess of the placarded flap airspeeds.

1. In the wing flaps up line there is an _____ valve to prevent sudden flap retraction when the selector valve is placed in the up position.

2. When the A/C is parked, the wings flaps selector should be left in the up position to relieve _____ pressures in the hydraulic lines.

3. There are no _____ valves in the flap system.

oriface restrictor

thermal

thermal relief

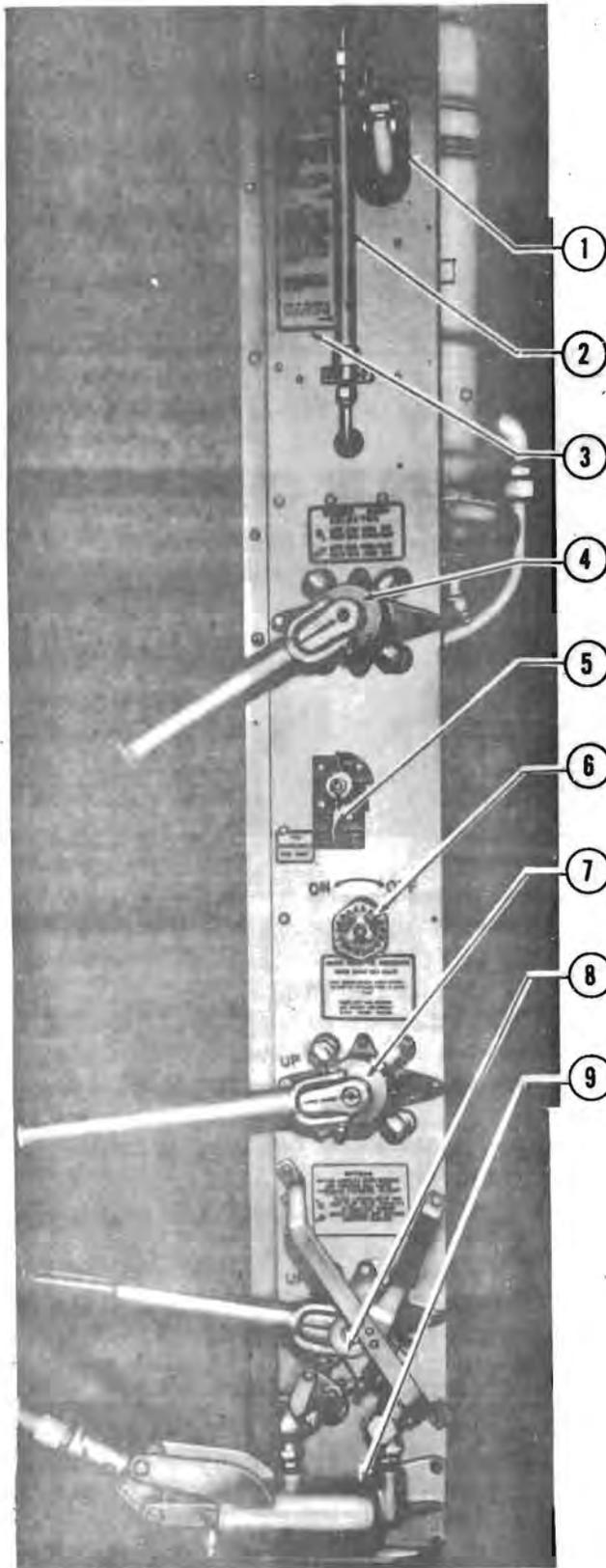
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**Hydraulic Control Panel —
Front View**

1. Hydraulic Fluid Reservoir Filler Neck
2. Hydraulic Fluid Reservoir Fluid Level Sight Gage
3. Hydraulic Fluid Reservoir Filling Instructions
4. Engine Pump Selector Valve
5. Autopilot Emergency Shutoff Valve
6. Hand Pump-to-Pressure Accumulator Shutoff Valve
7. Wing Flap Control Valve
8. Landing Gear Control Valve
9. Hydraulic Hand Pump

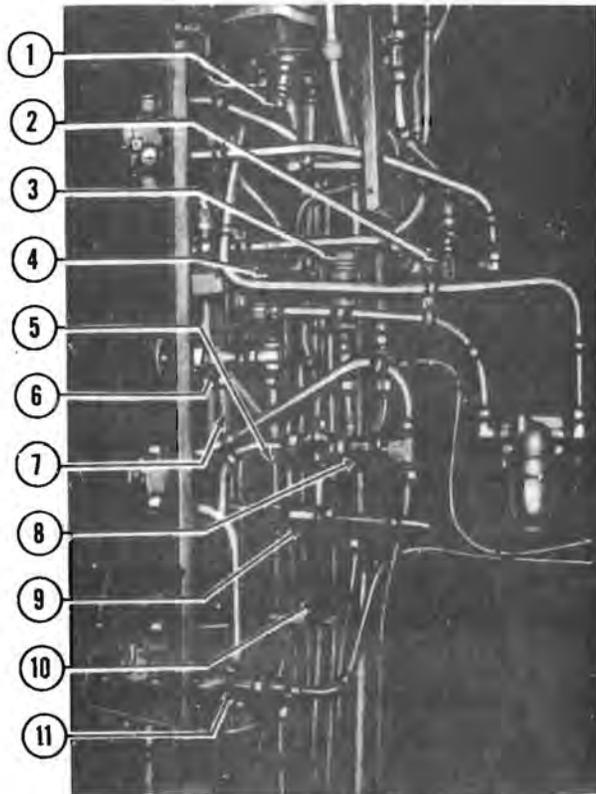
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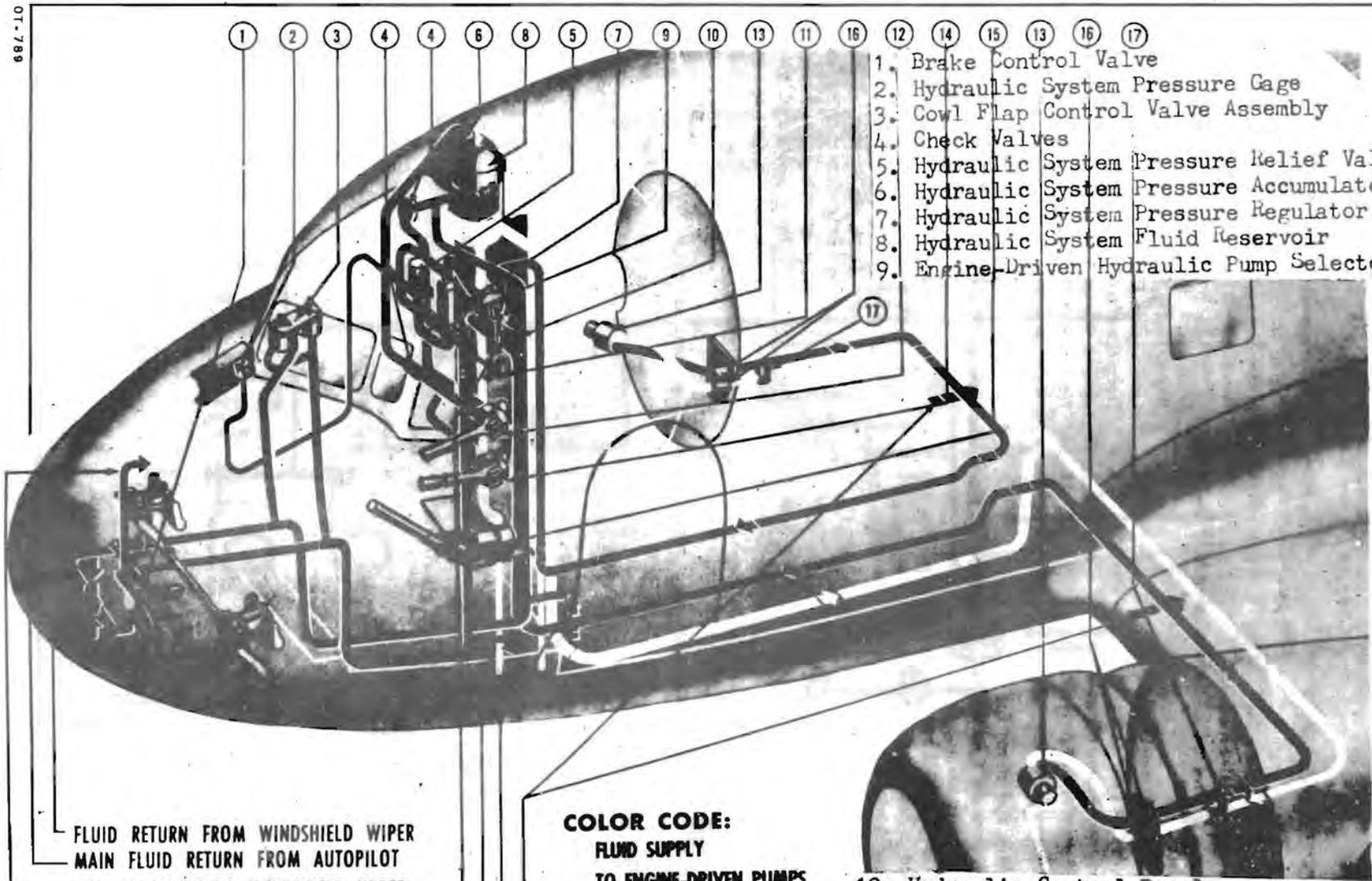
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*Hydraulic Control Panel –
Rear View*

1. Hydraulic Fluid Reservoir Drain Plug
2. Autopilot Pressure Regulator
3. Hydraulic System Pressure Relief Valve
4. Hydraulic System Pressure Regulator
5. Check Valve
6. Hand Pump-to-Pressure Accumulator Shutoff Valve
7. Pressure Manifold
8. Check Valve
9. Check Valve
10. Wing Flap Relief Valve Assembly
11. Return Manifold



- 1. Brake Control Valve
- 2. Hydraulic System Pressure Gage
- 3. Cowl Flap Control Valve Assembly
- 4. Check Valves
- 5. Hydraulic System Pressure Relief Valve
- 6. Hydraulic System Pressure Accumulator
- 7. Hydraulic System Pressure Regulator
- 8. Hydraulic System Fluid Reservoir
- 9. Engine-Driven Hydraulic Pump Selector

- 10. Hydraulic Control Panel
- 11. Hand Pump-to-Pressure Accumulator Shutoff
- 12. Wing Flap Control Valve
- 13. Engine-Driven Hydraulic Pump
- 14. Landing Gear Control Valve
- 15. Hydraulic Hand Pump
- 16. Firewall
- 17. Firewall Shutoff Valve

FLUID RETURN FROM WINDSHIELD WIPER
 MAIN FLUID RETURN FROM AUTOPILOT
 FLUID PRESSURE TO WINDSHIELD WIPER
 FLUID PRESSURE TO AUTOPILOT SYSTEM
 FLUID PRESSURE TO NONRAM AIRSCOOP
 FLUID RETURN FROM NONRAM AIRSCOOP
 FLUID RETURN FROM AUTOPILOT DRAIN TRAP

COLOR CODE:
 FLUID SUPPLY
 TO ENGINE-DRIVEN PUMPS
 ● FLUID PRESSURE
 ◆ FROM ENGINE-DRIVEN PUMPS
 ▼ FLUID RETURN
 SYSTEM DRAIN

Hydraulic System - Supply, Pressure, and Return

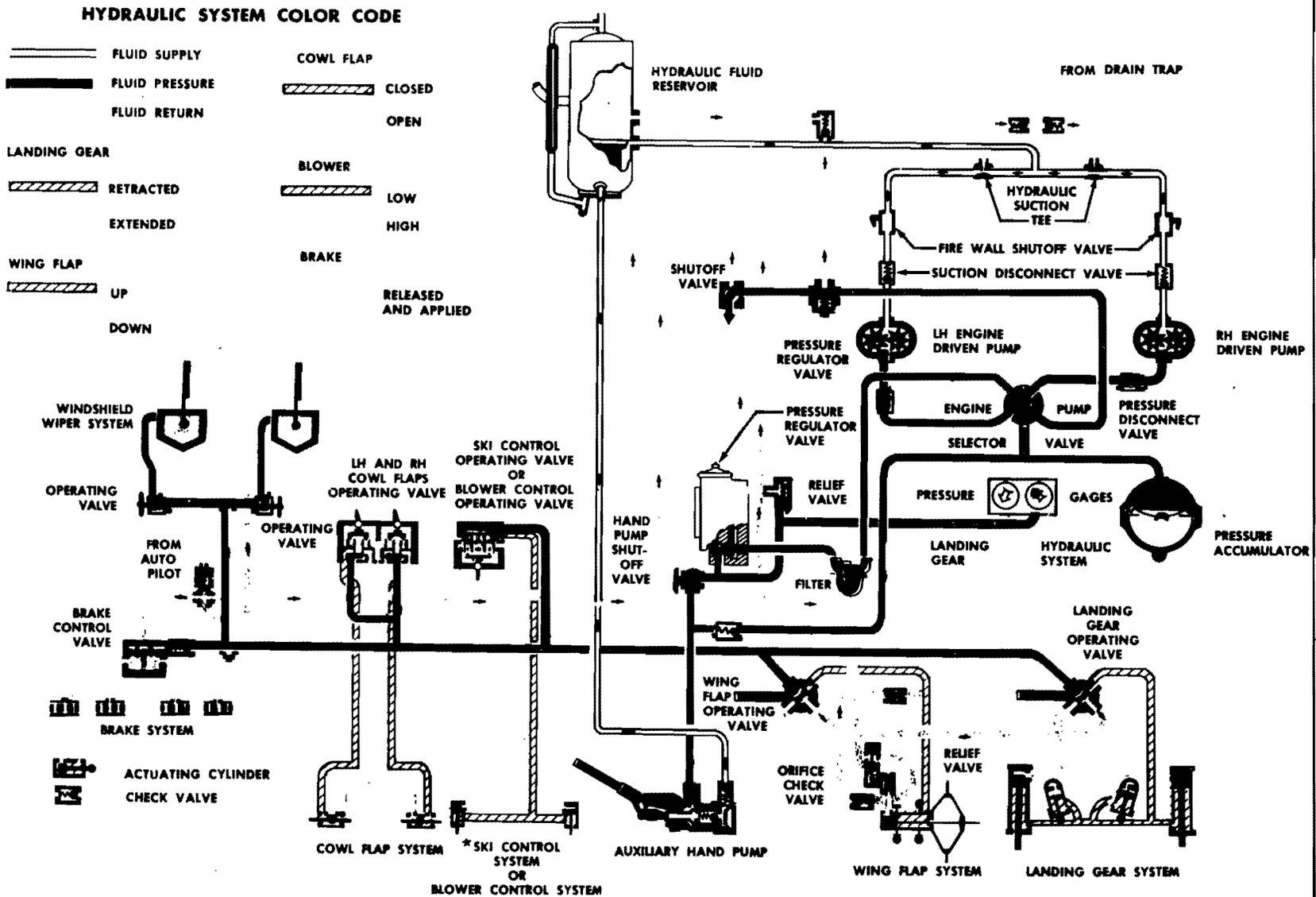
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Hydraulic System (Late C-47 and C-117 Airplanes) * WHEN INSTALLED ON C-47 AIRPLANES

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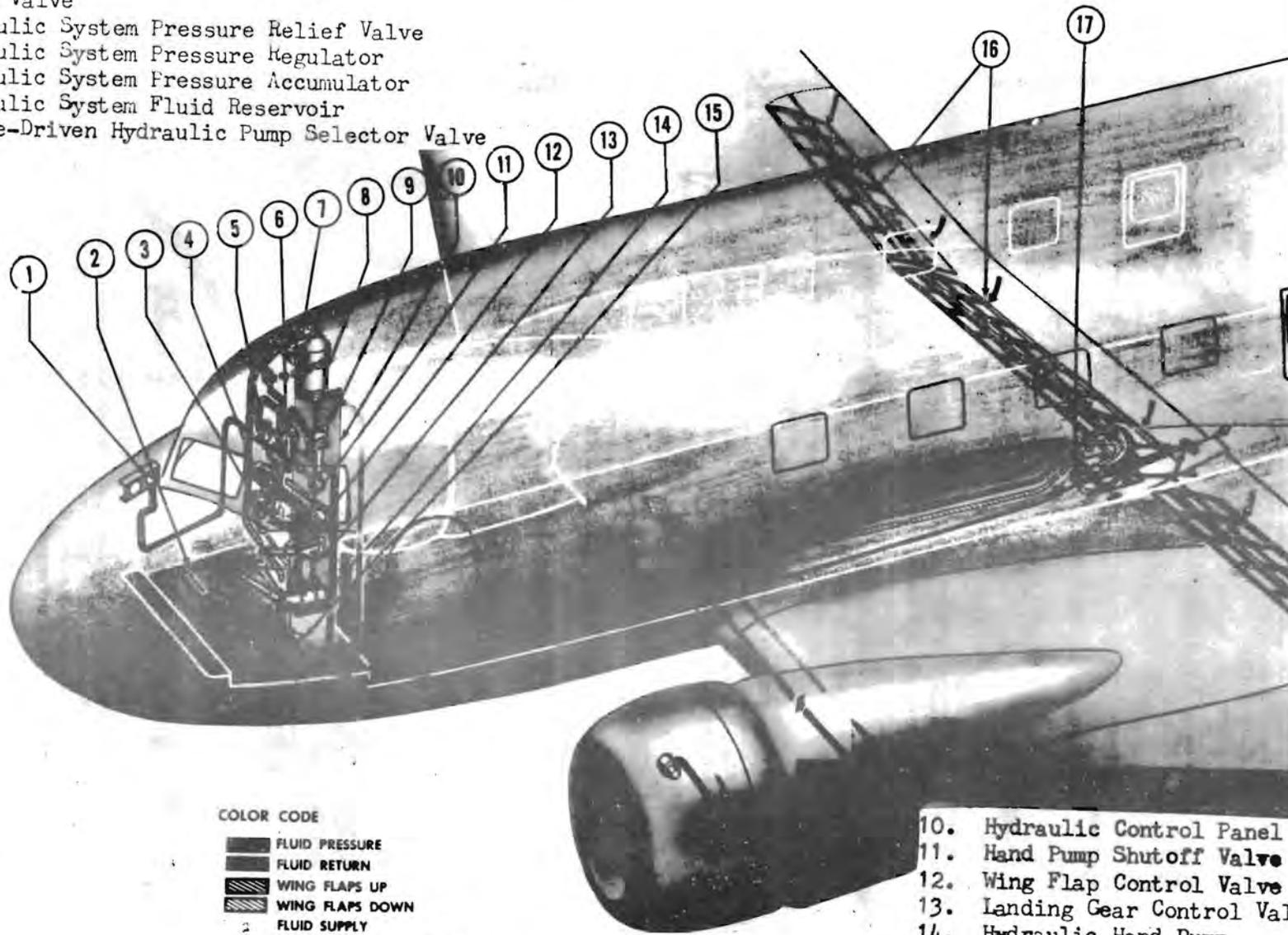
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1. Hydraulic System Pressure Gage
2. Wing Flap Indicator
3. Wing Flap Relief Valve Assembly
4. Check Valve
5. Hydraulic System Pressure Relief Valve
6. Hydraulic System Pressure Regulator
7. Hydraulic System Pressure Accumulator
8. Hydraulic System Fluid Reservoir
9. Engine-Driven Hydraulic Pump Selector Valve



COLOR CODE

- FLUID PRESSURE
- FLUID RETURN
- WING FLAPS UP
- WING FLAPS DOWN
- FLUID SUPPLY TO ENGINE DRIVEN PUMPS

10. Hydraulic Control Panel
11. Hand Pump Shutoff Valve
12. Wing Flap Control Valve
13. Landing Gear Control Valves
14. Hydraulic Hand Pump
15. Orifice Check Valve
16. Wing Flaps
17. Wing Flap Actuating Cylinder

Wing Flap Hydraulic System

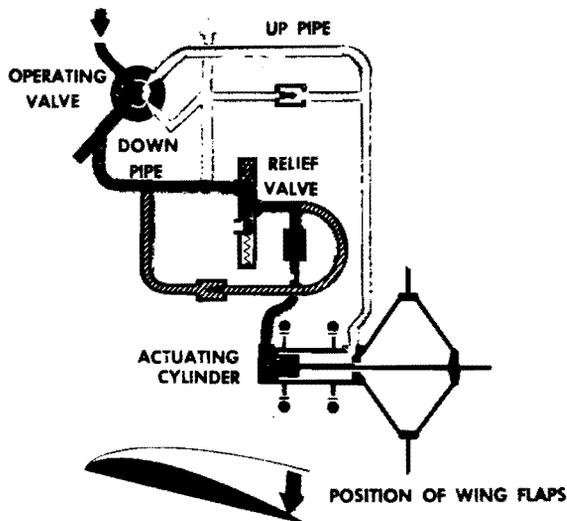
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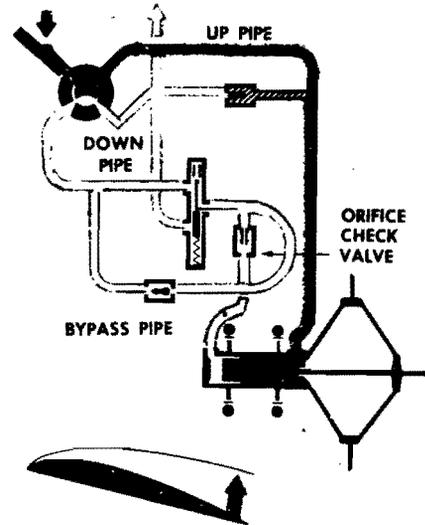
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NORMAL DOWN FLOW:

The DOWN position of the operating valve handle directs the fluid pressure in the down pipe. Valve piston remains in normal position allowing down flow unless down pipe pressure exceeds approximately 485 pounds per square inch. Wing flaps move down.

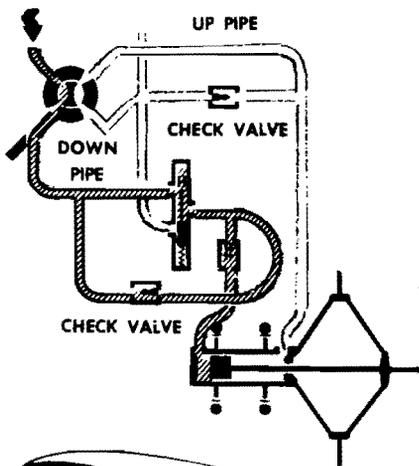


NORMAL RETURN FLOW:

The bypass pipe is an emergency measure for almost instantaneous return of relief valve to its normal position. When by-pass pipe flows (as in the previous diagram) the pressure drop in the down pipe allows the spring to raise relief valve piston. Normal return flow of fluid results.

COLOR CODE:

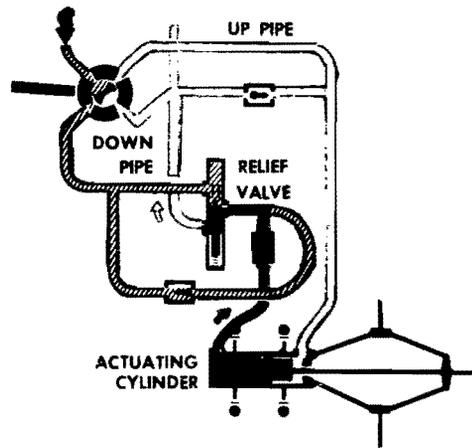
- PRESSURE
- PRESSURE FLOW
- RETURN
- RETURN FLOW



WIND

SYSTEM FLOW BLOCKED:

The DOWN position of the operating valve handle directs fluid pressure into the down pipe. Wing flaps move down. Back pressure in down pipe caused by strong wind resistance on wing flaps forces down the relief valve piston blocking entire system flow. Downward movement of wing flaps is halted.



WIND

RELIEF FLOW:

The NEUTRAL position of the operating valve handle blocks flow in wing flap system. Strong wind resistance on wing flaps causes fluid back pressure to flow through relief port. Wind raises wing flaps until back pressure is relieved. Note: When wing flaps are entirely down, mechanical leverage prevents wind load from forcing them up.

Wing Flap Hydraulic System - Normal Flow

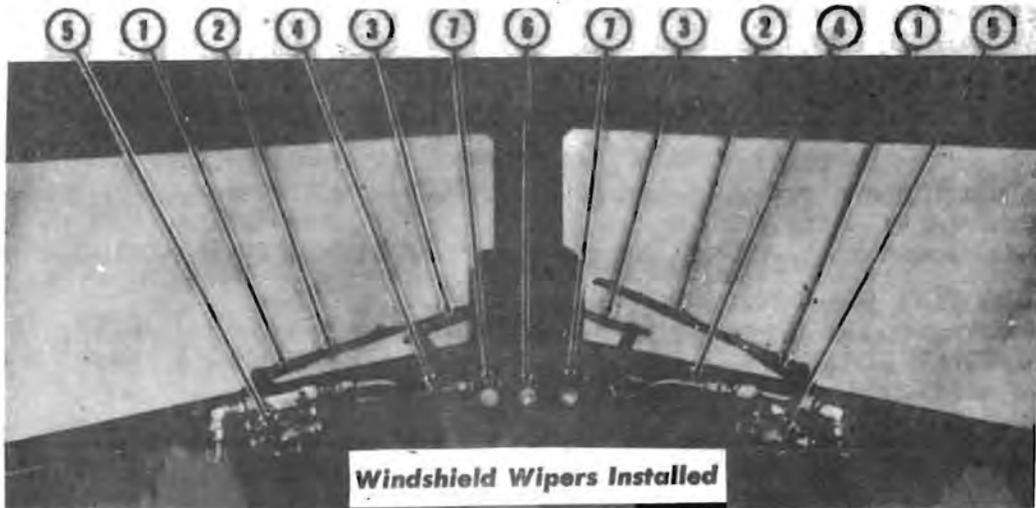
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1. Wiper Operating Arms
2. Wiper Blades
3. Anti-icing Tubes
4. Flexible Shaft Housings

5. Wiper Motor
6. Windshield Anti-icing Control Valve
7. Windshield Wiper Control Valve

Wing Flap Indicator

1. Main Instrument Panel
2. Pilot's Aileron Control Wheel
3. Wing Flap Indicator
4. Lubrication Fitting
5. Rudder-Brake Pedals

