UNIT III – ENGINE SYSTEM

GRAVITY FEED FUEL SYSTEM

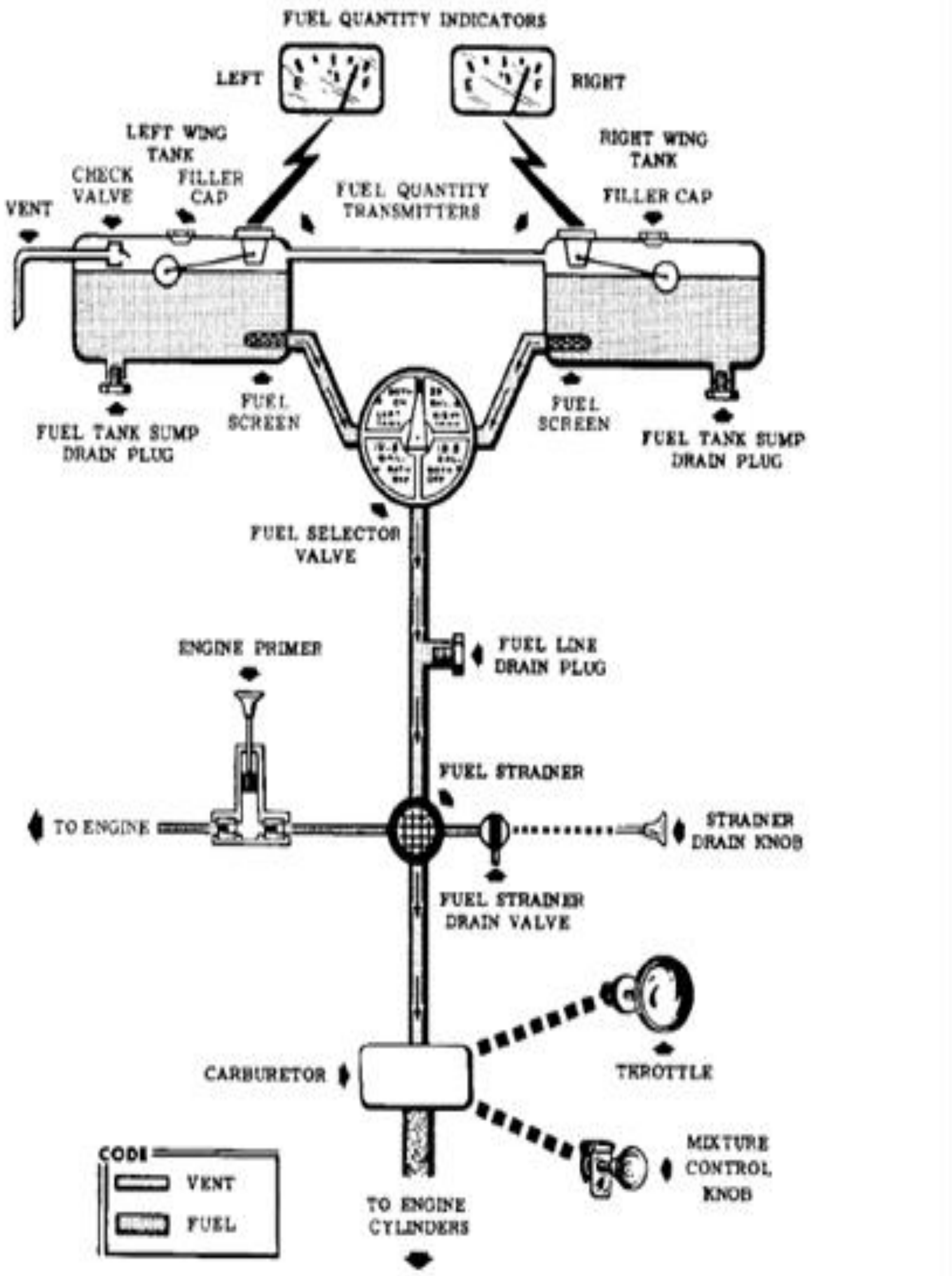


FIGURE 15-27 Gravity-feed fuel system. (Cessna Aircraft Co.)

A gravity-feed fuel system uses the force of gravity to cause fuel to theengine fuel-control mechanism.
For this to occur, the bottom of the fuel tank must be high enough toassure a proper fuel-pressure head at the inlet to the fuel-controlcomponent [carburetor] On the engine.
In high-wing aircraft this is accomplished by placing the fuel tanks inthe wings.
An example of this type of system is shown in figure.
In this example fuel flows by gravity from the wing tanks through thefeed lines to the fuel-selector valve.
After passing through the selector valve, the fuel flows through thefuel strainer and then continues on to the carburetor.
Fuel for the primer is taken from the main fuel strainer.
Since both tanks may feed fuel to the engine simultaneously, thespace above the fuel must be interconnected and vented outside of thewing, where the possibility of fuel siphoning is minimized.

PRESSURE FEED FUEL SYSTEM:

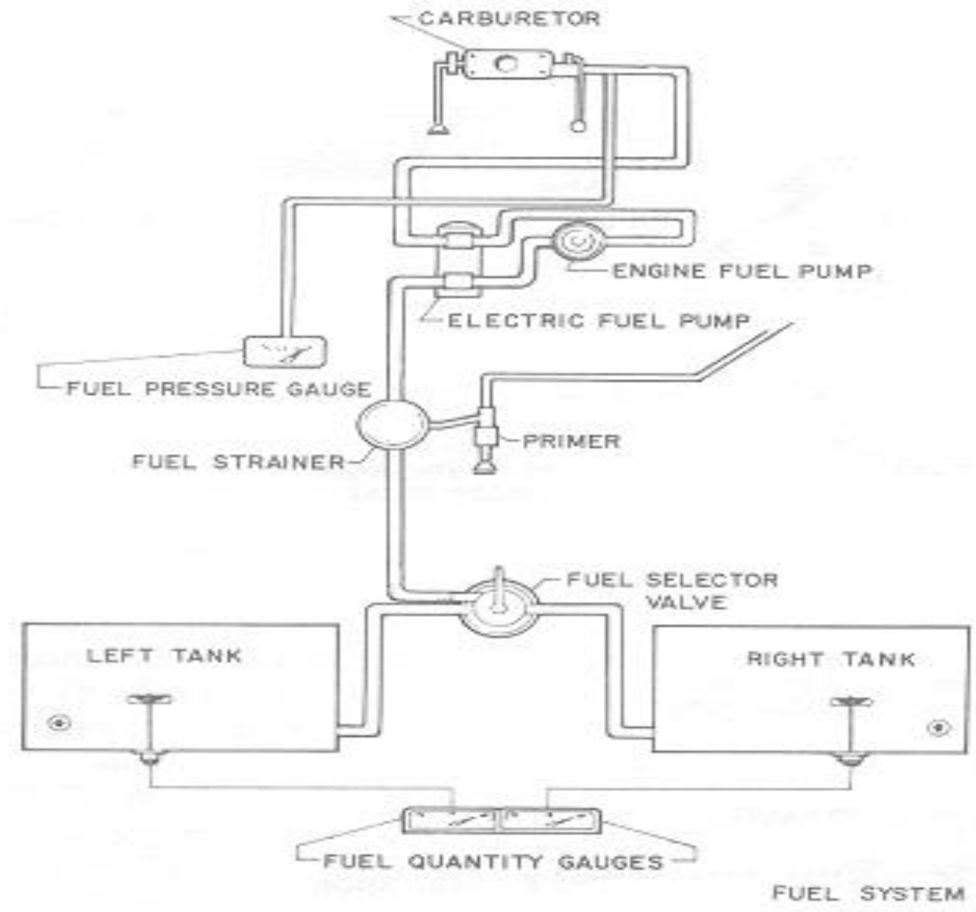
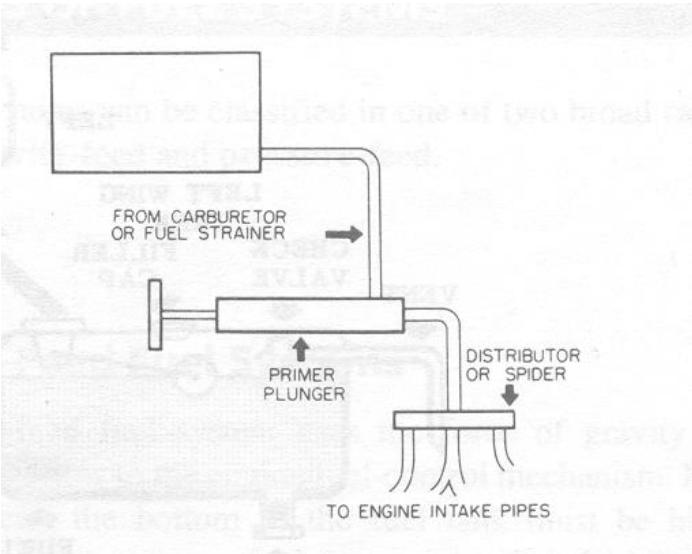


FIGURE 15–28 A light aircraft pressure-feed fuel system.

A pressure-feed fuel system, a simple version of which is shown infigure , uses a pump to move fuel from the tank to the enginefuel-control component.
This arrangement is required because the fuel tanks are located toolow for sufficient head pressure to be generated or because the tanksare some distance from the engine.
The system in figure is for a low wing aircraft, where the wing tanksare on the same approximate level as the carburetor.
The fuel flows from the tanks through separate fuel lines to the fuelselectorvalve.
After leaving the selector valve, the fuel flows through the fuel strainerand into the electric fuel pump.
Note that the engine-driven pump supplies the fuel pressurenecessary for normal operation.
During high-altitude operation, take-off, and landing, the boost pumpis operated to ensure adequate fuel pressure.
Most large aircraft and aircraft with medium-to-high powered enginesrequire a pressure-feed system, regardless of fuel-tank location,because of the large volume of fuel that must be delivered to theengines at a high pressure.
When reference is made to high pressure in the fuel-feed system, thevalue is on the order of 137.9, 206.9, 275.8 Kpa.

PRIMERS AND PRIMING SYSTEMS:

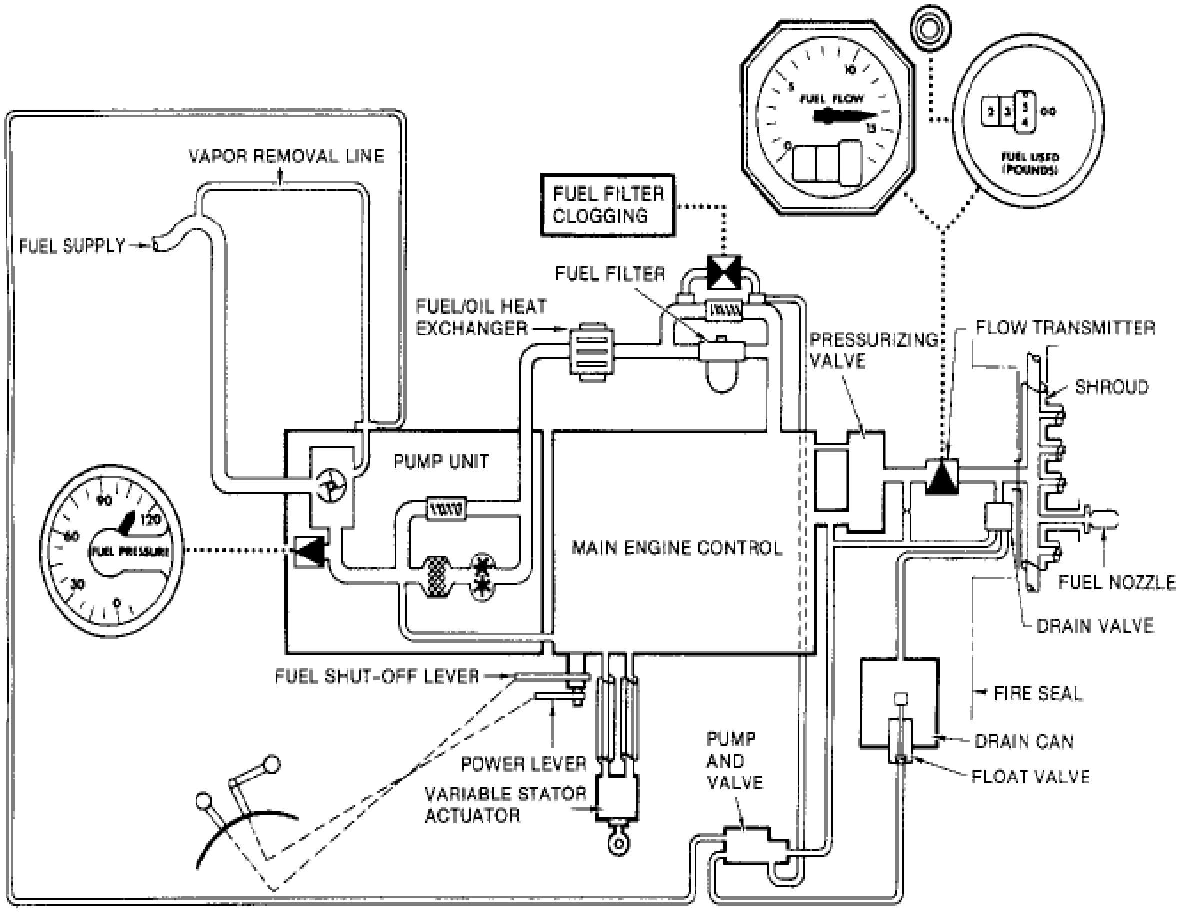


5–29 Priming system for a light aircraft engine.

Unlike an automobile engine, non-fuel-injected, reciprocating aircraftengines must often be primed before starting because the carburetordoes not function properly until the engine is running. For this reasonit is necessary to have a separate system to charge, or prime, thecylinders with raw fuel for starting. This is accomplished by thepriming system. The usual arrangement is to have the primer drawfuel from the carburetor inlet bowl or fuel strainer and direct it to adistributor valve, which, in turn, distributes the fuel to variouscylinders. Shown in figure.

FUEL SYSTEM FOR A GAS TURBINE ENGINE:

- The fuel system shown in figure is utilized in a small turbopropaircraft.
- The center tank is an integral fuel tank divided into threecompartments.
- Fuel in the two outboard main tanks flows by gravity through flappervalves into the center main tank.
- Fuel in the outer tanks must be transferred to the main tank before itcan be used by the engines.
- This transfer is achieved by a submerged centrifugal pump in eachouter tank.
- Fuel in the tip tanks is transferred to the main tank by pressurizingthe tip tank with engine bleed air.
- All tanks are vented through the valves to vent exists on the undersideof each wing.
- Two submerged centrifugal boost pumps are located in the maincenter fuel tank.
- Fuel from these pumps is fed to a fuel manifold, through a shutoffvalve for each engine, through fuel filters, and then to the enginepumps and the engine fuel-control units.
- Three fuel-quantity indicators are provided, one for the main tank, onedual-needle gauge for the outer tanks, and one dual-needle gauge forthe tip tanks.
- A fuel-flow indicator is provided for each engine.
- A valve in each tip tank prevents over-or under pressurization and isused to depressurize the tank before fuelling.

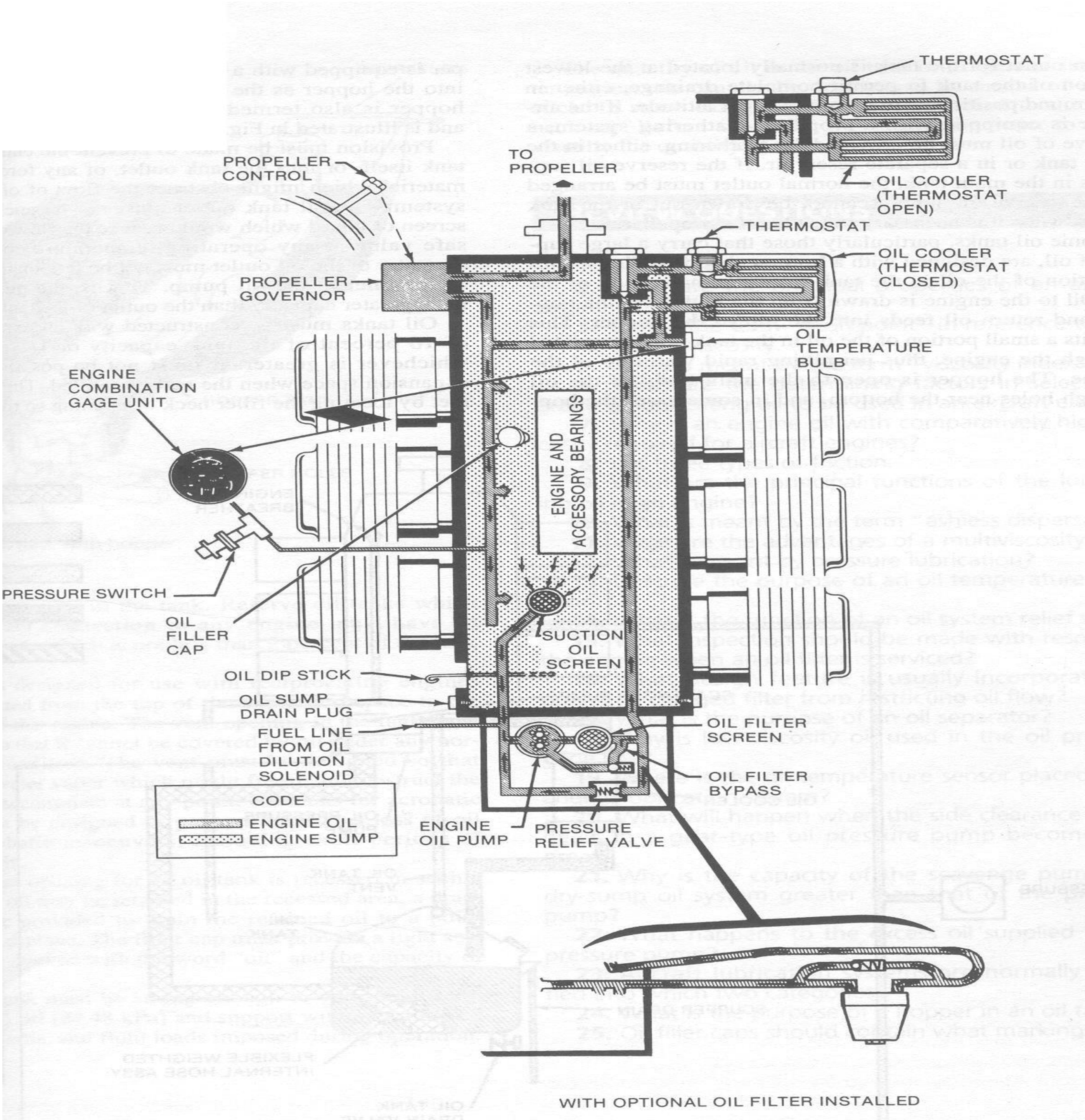


12-8 Turbine aircraft fuel system.

NECESSARY DESCRIPTIONS:
Aircraft fuel tanks in civil aircraft are normally located in the wings orfuselage.
Fuel tanks may of rigid, flexible, integrated construction.
Engine driven fuel pumps in the fuel system of piston engineaircraft are usually either:
1) Gear type,
2) Rotary vane type,
3) Diaphragm type.
Aviation gasoline, which is used for piston engines, low lea content,and octane rating of 100, relative density, is 0.72.
Aviation kerosene which is used for gas turbine engines and highflash point, relative density is -0.8

WET SUMP LUBRICATING SYSTEM

The figure shows a typical wet sump lubrication system
Lubricating oil for the engine is stored in the sump, which is attachedto the lower side of the engine.
Oil is drawn from the sump through the suction oil screen, which ispositioned in the bottom of the sump.
The oil passes through the gear type pump,to the oil cooler which is located at the front of the engine.
A bypass check valve is placed in the bypass line around the filterscreen to provide for oil flow in case the screen becomes clogged.
A non-adjustable pressure relief valve permits excess pressure toreturn to the inlet side of the pump.
Oil temperature is controlled by a thermally operated valve whicheither causes the oil to bypass the externally mounted cooler or routesit through the cooler passages.
Drilled and cored passages carry oil from the oil cooler to all parts ofthe engine requiring lubrication.
Oil from the system is also routed through the propeller for control ofpitch and engine rpm.
The oil temperature bulb is located at a point in the system where itsenses oil temperature after the oil has passed through the cooler.
Thus, the temperature gauge indicates the temperature of the oilbefore it passes through the hot sections of the engine.
The lubrication system may be equipped with provision for oil dilution.
A fuel line is connected from the main fuel strainer case to an oildilution solenoid valve mounted on the engine fire-wall


THERMOSTAT
TO PROPELLER
PROPELLER CONTROL
OIL COOLER (THERMOSTAT OPEN)
THERMOSTAT
OIL COOLER (THERMOSTAT CLOSED)
PROPELLER GOVERNOR
OIL TEMPERATURE BULB
ENGINE COMBINATION GAGE UNIT
ENGINE AND ACCESSORY BEARINGS
PRESSURE SWITCH
OIL FILLER CAP
SUCTION OIL SCREEN
OIL DIP STICK
OIL SUMP DRAIN PLUG
FUEL LINE FROM OIL DILUTION SOLENOID
OIL FILTER SCREEN
OIL FILTER BYPASS
CODE
ENGINE OIL
ENGINE SUMP
ENGINE OIL PUMP
PRESSURE RELIEF VALVE
WITH OPTIONAL OIL FILTER INSTALLED

OIL SYSTEM FOR DRY-SUMP ENGINE:

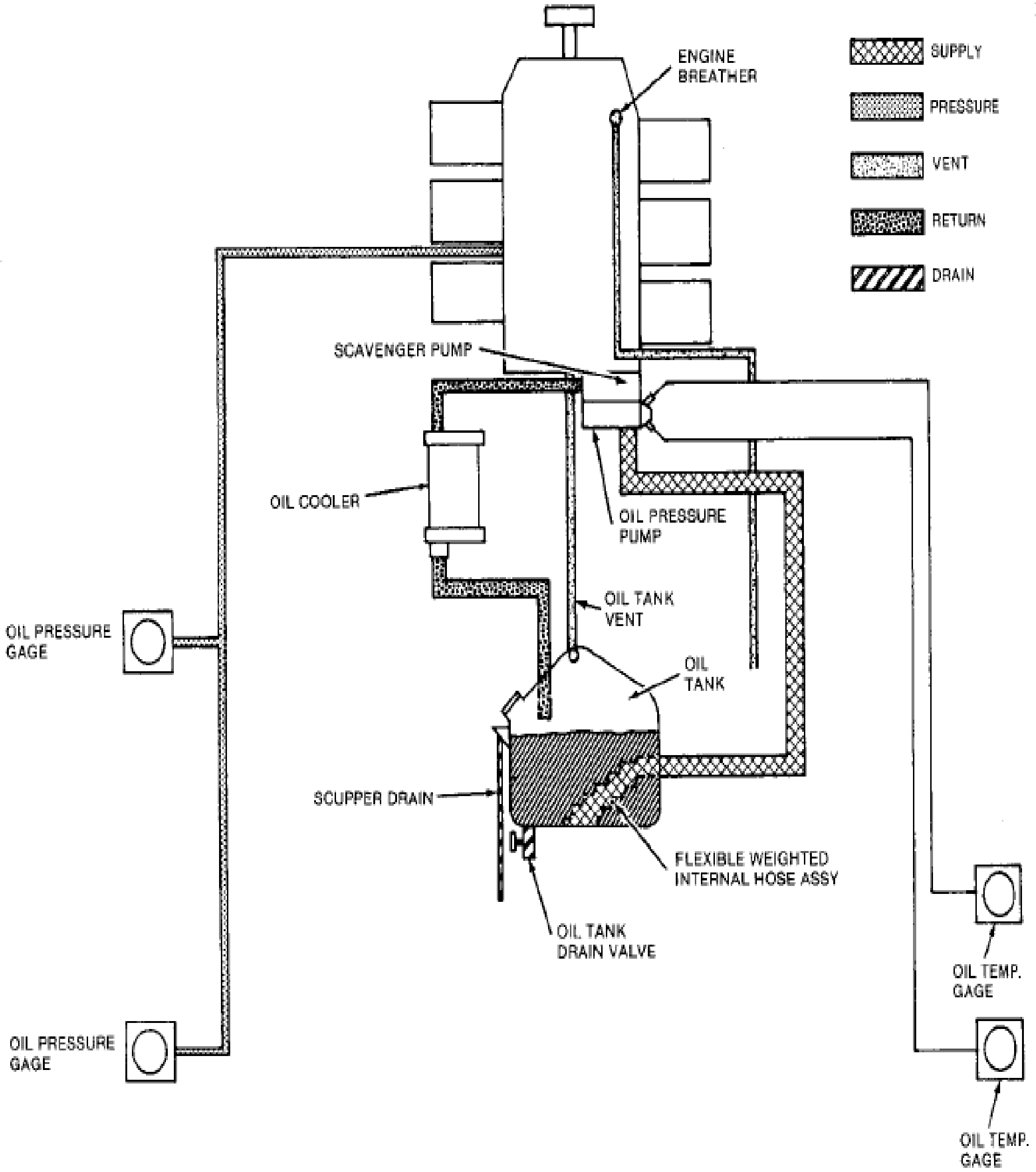


Figure shows the principal components of a dry sump lubrication systemfor an opposed reciprocating engine and the locations of thesecomponents

The system is called a dry-sump system because oil ispumped out of the engine into an external oil tank.

Oil flows from the oil tank tothe engine-driven pressure pump.The oil temperature is sensed before the oil enters the engine; that is, the temperature of the oil in the oil-in line is sensed, and theinformation is displayed by the engine oil temperature gauge.

The pressure pump has greater capacity than is required by theengine; therefore, a pressure relief valve is incorporated to bypassexcess oil back to the inlet side of the pump.

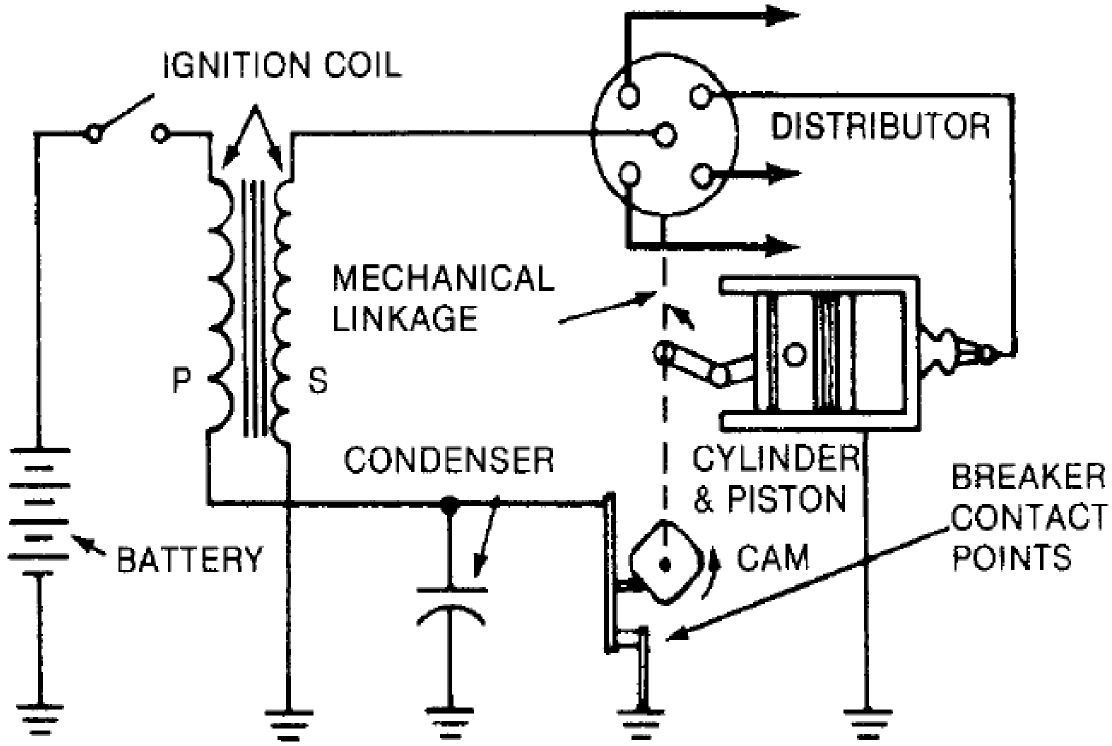
A pressure gauge connection, or sensor, is located on the pressureside of the pressure pump to actuate the oil pressure gauge.

The oil screen is usually located between the pressure pump and theengine system.
Oil screens are provided with bypass features to permit unfiltered oilto flow to the engine in case the screen becomes clogged, sinceunfiltered oil is better than no oil.
After the oil has flowed through the engine system, it is picked up bythe scavenge pump and returned through the oil cooler to the oil tank.
The scavenge pump has a capacity much greater than that of thepressure pump, because the oil volume it must handle is increased asa result of the air bubbles and foam entrained during engineoperation.
The oil cooler usually fitted with a thermostatic control valve tobypass the oil around the cooler until the oil temperature reaches aproper value.
To prevent pressure buildup in the oil tank, a vent line is connectedfrom the tank to the engine crankcase.
This permits the oil tank to vent through the engine venting system.Check valves are employed in some systems to prevent oil from flowingby gravity to the engine when the engine is inoperative.

IGNITION SYSTEM

The function of the ignition system is to supply a spark to ignite thefuel/air mixture in the cylinders.

BATTERY IGNITION SYSTEM:

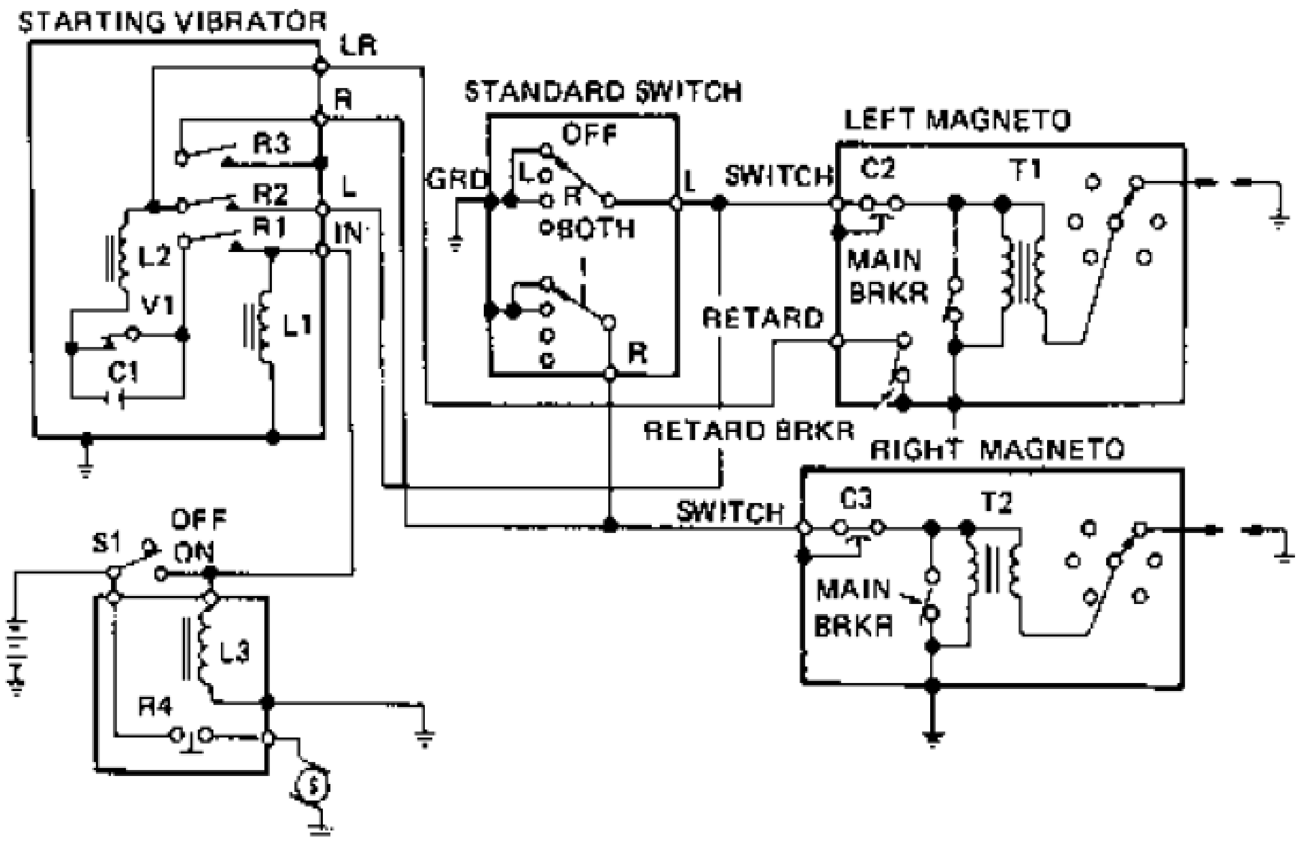


Few aircraft and most automobiles use a battery ignition systemwhich has a battery or generator rather than a magneto as its sourceof energy.

In the battery ignition system, a cam which is driven by the engineopens a set of points to interrupt the flow of current in a primarycircuit.

The resulting collapsing magnetic field induces a high voltage in thesecondary of the ignition coil, which is directed by a distributor to theproper cylinder.

MAGNETO IGNITION SYSTEM:



It is superior to battery ignition because it produces a hotter spark athigh engine speeds and it is self-contained unit, not dependent on anyexternal source of electrical energy.
The magneto, a special type of engine driven aircraft. generator uses apermanent magnet as a source of energy.
It develops a high voltage that forces a spark to jump across the sparkplug gap in each cylinder.
Magneto operation is timed to engine so that spark occurs only whenthe piston is on the proper stroke at specified no. of crank shaftdegrees before the TDC piston position.
It is classified into two:

1) Low tension magneto system,
2) High-tension magneto system.
Low-tension magneto system generates low voltage and high-tensionmagneto system generates high voltage.
High-tension magneto system is older of the two systems. Lowtensionmagneto system eliminates some problems inherent in thehigh-tension magneto system during high altitudes, all weathercondition operation and more no. of cylinders per engine, flashoverand radio radar communication interference.

LOW TENSION MAGNETO SYSTEM:
The figure represents a simplified schematic of a typical low-tensionsystem.
Electronically, Low-tension system is different from high-tensionsystem.
In low-tension system, low voltage is generated in the magneto andflows to the primary winding of transformer coil through thedistributor.
In transformer, the voltage is increased to a high voltage bytransformer action and conducted to the spark plug by very shorthigh-tension leads.
Low tension system normally eliminates flashover in both thedistributor and ignition harness because the “Air caps” within thedistributor have been eliminated by use of brushed type distributorand high voltage is present only in short leads between thetransformer and spark plug.
Electrical leakage is considerably reduced because the currentthroughout the most of the low-tension system is transmitted at a lowvoltage potential.
The various components of the ignition systems are
1) Ignition switch,
2) Magneto
3) Distributor
4) Transformer
5) Spark plug.

AUXILARY IGNITION UNITS:
During engine starting output of magneto is low because of thecranking speed of the engine is low; here lesser the amount of inducedvoltage produced by the magneto.
AIO is employed in order to provide a high ignition voltage there byfacilitate engine starting.
The various auxiliary ignition limits are
1) Booster coil,
2) Induction vibrator,
3) Impulse coupling.

SPARK PLUG:
The purpose is to conduct a short impulse of high voltage currentthrough the wall of the combustion chamber.
The main components are

1) Outer shell,
2) Insulator,
3) Electrode.

JET ENGINE IGNITION SYSTEM:
It is required only for starting the engine.
Once combustion has begun, the flame is continuous; it is moretrouble free than piston engine ignition system.
Most turbojet engines are equipped with a high-energy capacitor type(or) electronic type ignition system.

ELECTRONIC IGNITON SYSTEM:

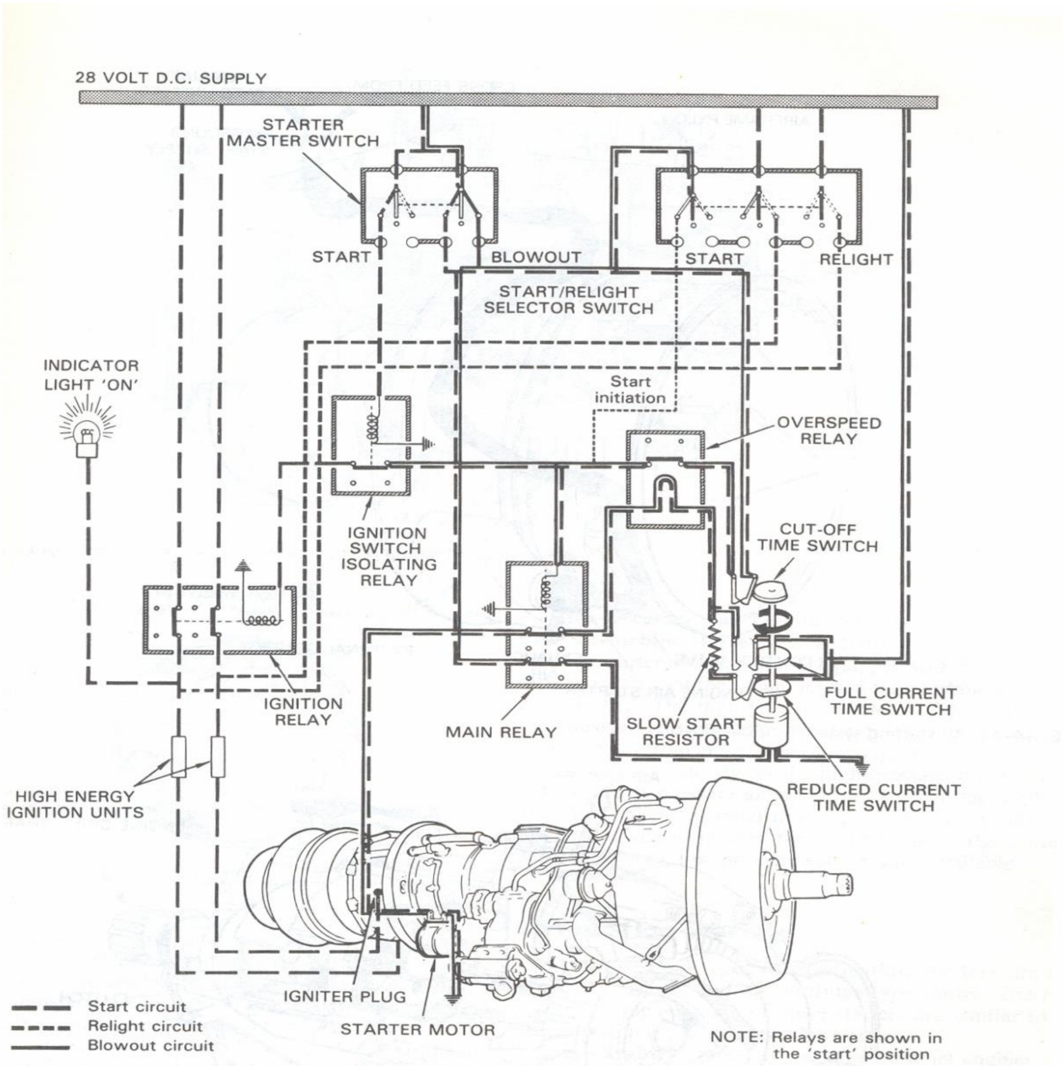
This system consists of a dynamotor (or) regulator filter assembly, anexciter unit; two high-tension transformer units tow high-tensionbeds, tow igniter plugs and necessary control switches and equipmentfor operation in an aircraft.
The dynamotor is used to step up the direct current f aircraft battery(or) the external owner supply to the operation voltage of the exciterunit.
The voltage is used to charge two storage capacitor
which store the energy to be used for ignition purposes.
The voltage across these capacitors is stepped up by the transformerunit.
At the instant of ignition plug firing. To resistance of gap is loweredsufficiently to permit the larger capacitor to across the gap.
The discharge of second capacitor is used of low voltage but of veryhigh energy.
The result is a spark of great heat intensity; capable not only ofigniting abnormal mixtures but also of burning away any foreigndeposits on the plug electrodes.
The exciter is dual unit and it produces spark at each of the twoigniterplugs. A continuous series of spark is produced until theengine stars.
The battery current is then cut-off, and the plug does not fire whilethe engine is operating.

GAS TURBINE STARTING SYSTEM
Two separate systems are required to ensure that a G.T.E. will startsatisfactorily.
Provision must be made for the compressor and Gas Turbine torotate up to a speed at which adequate air passes into o thecombustion system to mix with fuels.
1) Provision must be made for ignition of the air/fuel mixture inthe combustion system.
2) During engine starting the two systems must operate simultaneously.
3) Sequence of events during the start of a turbo jet engine:
The starting procedure for all jet engines is basically the same, butcan be achieved by various methods.
The type and power source for the starter varies in accordance withengine and aircraft requirements.
Commercial aircraft requires the engine to be startedwith theminimum disturbance to the passengers by the economicalmeans.
Whichever system is used reliability is prime importance.
The starter motor produces a high torque and transmitsto theengine.

TYPES OF STARTERS:
- Electrical starter,
- Cartridge starter,
- Isopropyl Nitrate starter,
- Air starter,
- Gas Turbine starter.

ELECTRICAL STARTER:

The electric starter is usually a D.C. electric motor coupled to theengine through a reduction gear and clutch, which automaticallydisengages after the engine, has reached a self-sustaining speed.The electric supply may be of low or high voltage and is passedthrough a system of relays and resistance to allow the full voltage tobe progressively built up as the starter gains seed.
The electrical supply is automatically cancelled when the started loadis reduced after the engine has satisfactorily started.

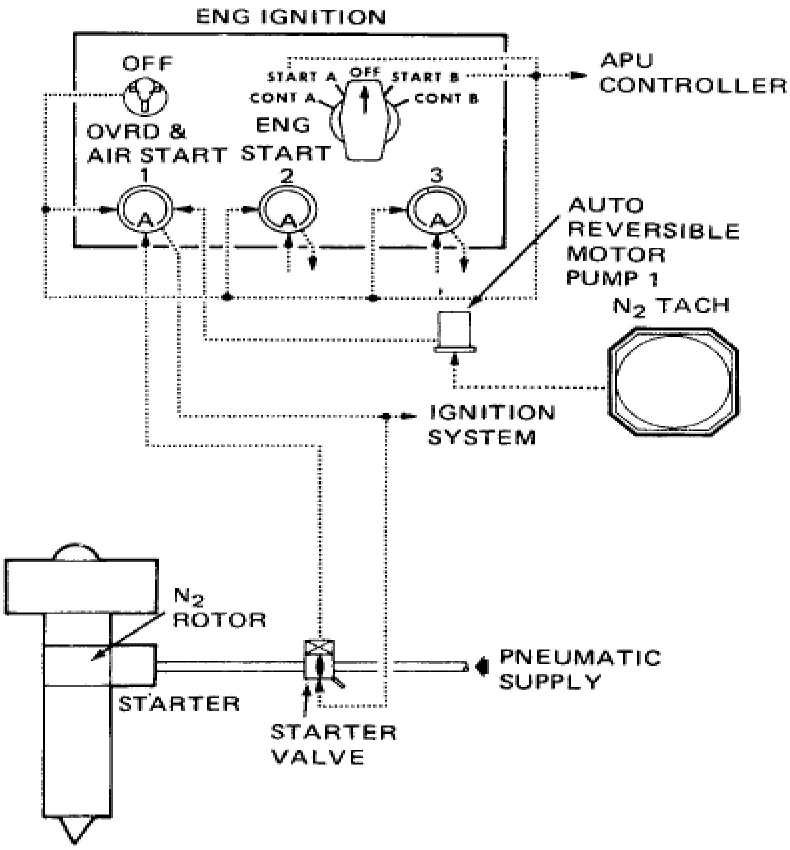


.ow-voltage electric starting system. *(Rolls-Royce)*

CARTRIDGE STARTER:
Sometimes used on military engine and provide a quick methods ofstaring.
The starter motor is basically a small impulse type turbine that isdriven by high velocity gases from a burning cartridge.
The power output of the turbine is passed through a reduction gearand automatic disconnect mechanism to rotate the engine.

ISOPROPYL NITRATE:
It has a turbine that transmits power through a reduction gear to theengine.
The turbine is rotated by high-pressure gases resulting from thecombustion of isopropyl nitrate.

AIR STARTERS:



Air starting is used on most commercial aircraft,advantages are
Light weight and simple and most economical to operate.
Air starter motor transmits power through a reduction gear and clutchto the starter output shaft, which is connected to the engine.
The starter turbine is rotated by air taken from an external groundsupply auxiliary power unit (or) cross feed from a running engine.

GAS TURBINE STARTER:

G.T.Starter is used for some jet engines and is completely self-contained. It has its own fuel, ignition, starting and oil system.
This type of starter is economical to operate and provides a high poweroutput for a low weight.

TWO MARKS

1. What are the basic components of an aircraft fuel system?

1) Fuel tank in which the fuel is stored for flight,
2) Fuel pump to supply the engine or engines when it is required.
3) Filters to ensure the fuel is clean for use.
4) On/Off cocks to isolate the fuel system or sections of it, when itis not in use.

2. Explain the purpose and requirements of fuel tanks

Fuel tanks are used to store the fuel for the aircraft until the enginesuse it.
Fuel tanks for aircraft may be constructed of aluminum alloy, fuelresistant synthetic rubber, composite rubber or stainless steel.The material selected for the construction of a particular fuel tankdepends upon the type of aircraft.
Fuel tanks and the fuel system, in general, must be made of materialsthat will not react chemically with any fuels stored in it.

3. What are the different types of fuel tanks?
There are various basic types of fuel tanks designed for use in aircraft.The specific type chosen when designing the aircraft is a result of aircraft design, sizeandshape of the tank area, and the types of operations for which theaircraft is designed.
The fuel tank construction can be divided into three basic types;
1. Integral type.
2. Rigid removal type.
3. Bladder type.

4. What is the purpose of fuel pumps?
Fuel pumps are used to move fuel through the fuel system whengravity flow is insufficient.These pumps are used to move fuel from the tanks to the engines,from tanks to other tanks, and from the engine back to the tanks.

5. Explain the requirements of fuel pumps:
Fuel systems for reciprocating engines and turbine-engines requiremain pumps and emergency pumps. Reciprocating engine systemsthat are not gravity-fed require at least one main pump for eachengine, and the pump must be driven by the engine.
The pump capacity must be such that it supplies the required fuelflow for all operations.

6. List out the different types of fuel pumps

The types of fuel pump are;
1. Vane-type fuel pump.

2. Variable-volume pumps.

3. Centrifugal pump.
4. Ejector pump.

7. What is the purpose of surge tank?
The surge tank is located in the wing tip. It prevents spillage of fuel due to excess pressure during fuelling. It also is part of the fuel jettisoning system

8. Name the different types of ignition systems

1) Battery Ignition System
2) Magneto ignition system
3) Electronic Ignition

9. What is the purpose of fuel primer in a piston engine?

Priming injects raw fuel into the engine cylinder. Aircraftengines must often be primed before starting because the carburetordoes not function properly until the engine is running. Also in cold climates it becomes easier to start the engine after priming

10. What is vapor lock and what are the causes?
Vapor lock is a condition in which AVGAS vaporizes in the fuel line and blocks the flow between the fuel tank and the carburetor. This normally occurs on warm days on aircraft with

engine-driven fuel pumps that suck fuel from the tank(s). Vapor lock can also be caused by excessively hot fuel, low pressure, or excessive turbulence of the fuel traveling through the fuel system.

11. What are the requirements and the purpose of engine lubricating system?

The Primary purpose of the lubrication system of the engine is to Reduce Friction and component 'Wear" The secondary functionsare:

1. Cooling of internal components
2. Cleaning the engine by carrying away combustion sludge and metal particles
3. Protects against corrosion
4. Failure Indication of mechanical parts or loss of power

12 Define detonations

Detonation is the rapid, uncontrolled explosion of fuel due to high pressure and temperature in the combustion chamber. The fuel-air charge ignites and explodes before the ignition system spark lights it. Detonation can alsooccur when the fuel is ignited via the spark plug but explodes before it is finished burning. The engine is not designed to withstand the forces

13 What are the grade of fuels used for Piston and Jet engines ?

For Piston engine
AVGAS 82UL -Purple
AVGAS 100 - Green
AVGAS 100LL - Blue
For Jet engines: ATF JETA, JETA-1, JET B

14. What is the purpose of fuel system in aircraft?

An aircraft fuel system must provide a safe and uninterrupted flow of contaminant free fuel to the aircraft engine(s) regardless of the aircraft's attitude. It should also be structurally strong to withstand different pressures and loading

15. What is fuel Jettisoning?

If an aircraft's design landing weight is less than that of the maximum takeoff weight, a situation could occur in which a landing is desired before sufficient fuel has burned off to lighten the aircraft. Fuel jettisoning systems are required on these aircraft so that fuel can be jettisoned in flight.

16. What are the purpose of fuel strainers and filters? (4)

Because of the ever-present possibility of fuel contamination byvarious types of foreign matter, aircraft fuel systems are required toinclude fuel strainers and filters. The fuel is

usually strained at threepoints in the system, first through a finger strainer; second through amaster strainer, which is usually located at the lowest point in thefuel system; and third, through a strainer in the carburetor or nearthe fuel control unit.
A fuel strainer or filter is required between the fuel-tank outlet and theinlet of either the fuel-metering device or an engine-driven positivedisplacement, whichever is nearer the fuel-tank outlet.