

Boeing 707

Fuel

Training manual

For training purposes only
LEVEL 3

ATA 28

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1. FUEL SYSTEM INTRODUCTION.

The fuel system is an arrangement of fuel tank and component systems which insure that the engines are supplied with fuel in the proper amount at all times. Fuel is distributed in four main tank, two reserve tanks and a center wing tank. The amount of fuel carried by any airplane will be determined by the planned utilization of the airplane. Any acceptable fuel which conforms to manufacturer's specification can be used.

1.1. Fuel Tanks.

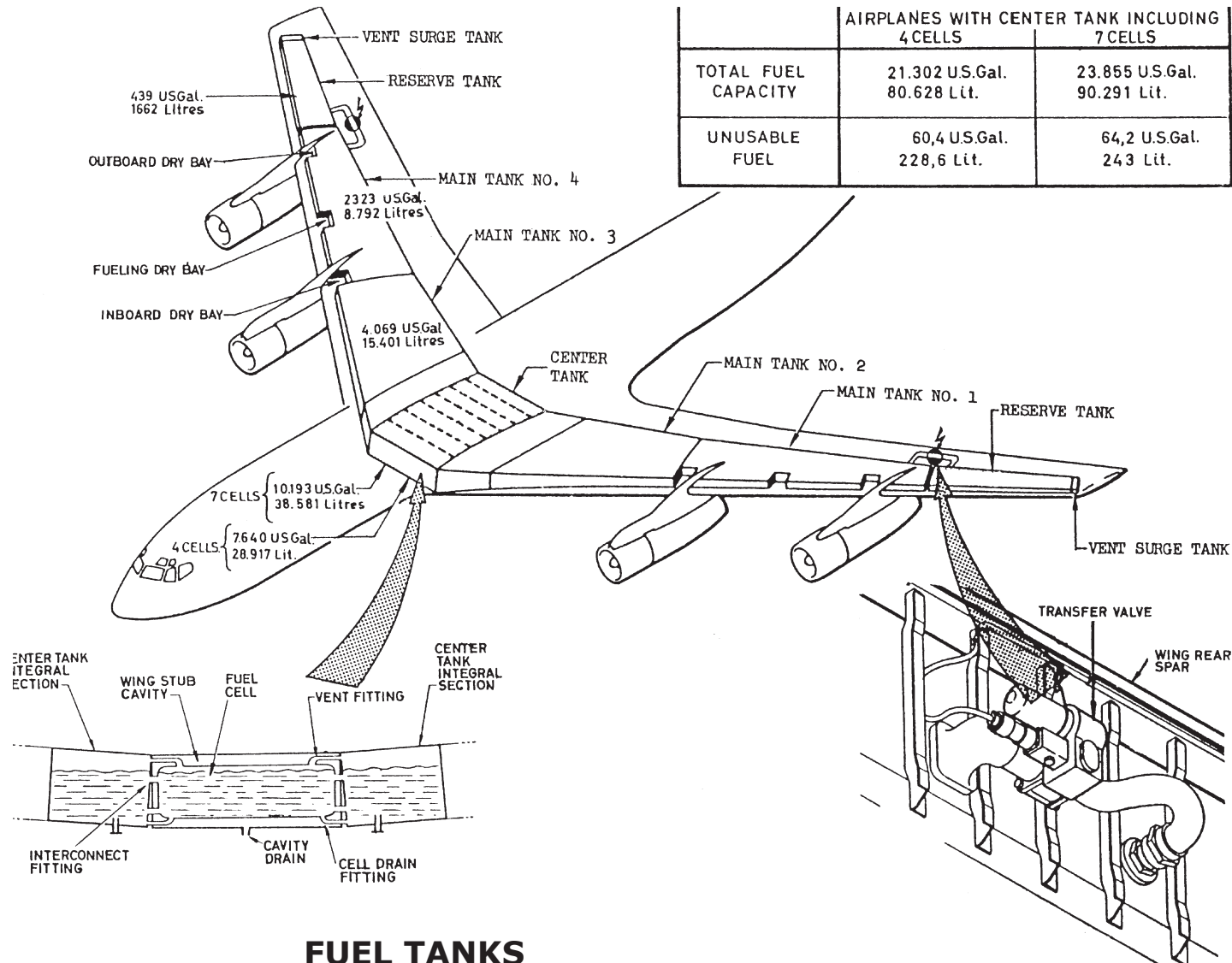
All fuel tanks (figure 2) are located in the interspar area of the wing structure between the front and rear spars. The wing skin and ribs form the walls of the tank and intermediate ribs serve as baffle plates. The four main tanks and two reserve tanks are completely integral with the wing structure. The center wing tank consists of two integral sections at the wing roots and a center section known as the center wing cavity. The center wing cavity is divided into seven compartments for the installation of bladder type fuel cells. Fuel flows in all three sections of the center wing tank through openings in the fuel cells and integral sections. All fuel tanks are structurally sealed fluid tight by the use of sealing compound and integrally sealed fasteners.

CAUTION : NO ADDITIVES, WHICH MIGHT AFFECT FUEL TANK SEALANT, SHOULD BE ADDED TO FUEL.

1.2. Vent Systems.

A fuel vent system provides positive venting to atmosphere of all fuel tanks, fuel cells and cavities thereby preventing excessive internal or external pressures across the fuel tank or cavity walls during all flight maneuvers. Venting of the four main tanks, two reserve tanks and integral sections of the center wing tank is accomplished with sealed spanwise upper wing skin stiffener ducts, interconnected with appropriate drains and vent tubing which connect the vent ports located in critical areas of the tanks.

This interconnected system is vented into a surge tank at the wing tip and overboard through a vent scoop. The center wing cavity is vented overboard through a separate vent and drain system beneath the cavity. The cavity vent system maintains atmospheric pressure on the outside of bladder type fuel cells. The fuel cells are vented into the integral sections of the center wing tank.



FUEL TANKS

1.3. Engine Fuel Feed System.

The engine fuel feed system consists of fuel lines, pumps and valves which distribute the fuel to the engines. It consists of four tank to engine fuel feed systems which are interconnected by a fuel manifold such that fuel may be delivered from any main tank or the center wing tank to any or all engines. The two reserve tanks store fuel and supply the fuel by gravity flow to main tanks N° 1 and 4 through electrically operated transfer valves. The fuel feed line from each main tank is pressurized by two boost pumps which are controlled by separate switches and independent circuits so that engine operation will not be affected by power failure to any single boost pump. The center wing tank boost pumps, known as the fuel boost override pumps, will override the main tank boost pumps to supply fuel through the fuel manifold to the engines. The distribution of fuel to the engines is controlled by electric motor driven sliding gate valves in the fuel lines. The valves are classified into three groups:

- the engine fuel shutoff valves, that shut off fuel to the engines;
- the fuel manifold valves, that control manifold distribution;
- and the reserve tank transfer valves, that transfer fuel from the reserve tanks to main tanks N° 1 and 4. They are controlled by manually operated switches located on the flight engineer's lower panel in the control cabin.

1.4. Pressure Fueling system.

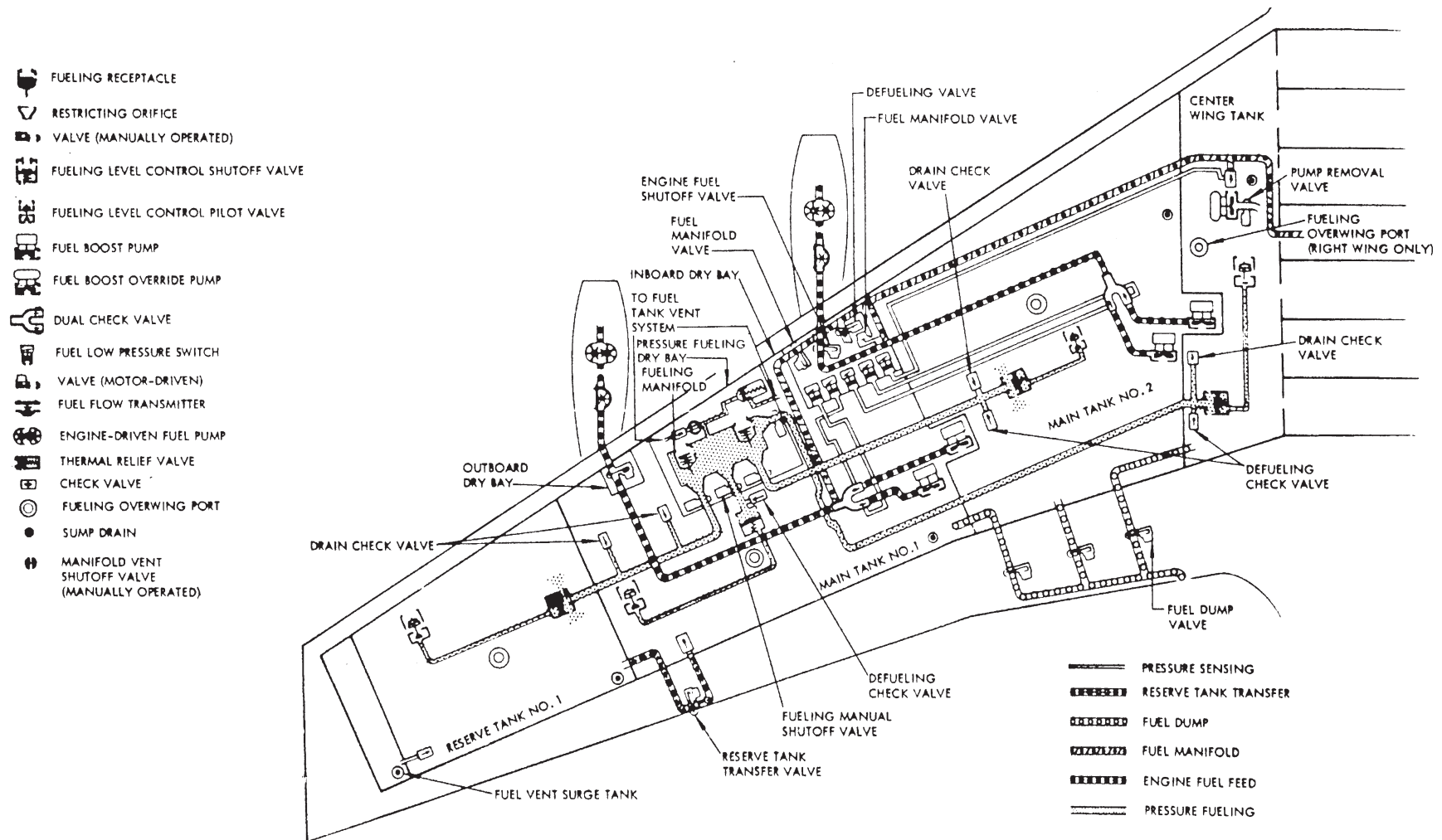
Pressure fueling is accomplished from a station located on the lower surface of each wing between the inboard and outboard engine nacelles.

Each pressure fueling station consists of two fueling nozzle ground connectors, two fueling receptacles, a fueling manifold and four fueling manual shutoff valves which permit the fuel tanks to be serviced individually. Each station services the main and reserve tanks on its respective side of the airplane. The center wing tank is serviced from either or both stations.

The maximum fuel delivery pressure is 50 psi. A restricting orifice plate at each fueling shutoff valve limits the flow rate to the respective tank.

The approximate flow rates in U.S. gallons from each fueling station are as follows : center wing tank 250 gallons per minute from each fueling station; main tanks N° 1 and 4, 234 gpm ; main tanks N° 2 and 3, 227 gpm and reserve tanks N° 1 and 4, 65 gpm.

Each reserve and main tank has a fueling level control pilot valve which actuates a fueling level control shutoff valve to automatically shut off the fuel flow when the maximum tank capacity has been reached. The center wing tank employs two pilot valves and two shutoff valves to permit it to be fueled from either or both fueling stations.



FUEL SYSTEM

1.5. Fuel Dump System.

The fuel dump system consisting of fuel lines, valves, dump chutes and chute operating mechanism provides the means by which fuel can be dumped in flight. Each wing contains an extendable dump chute which must be fully extended before fuel can be dumped. Each chute is fed fuel by dump lines from the main and center wing tanks on its respective side of the airplane. The reserve tank fuel is transferred to and dumped with the main outboard tank fuel. The controls are located on the flight engineer's auxiliary panel. When all dump valves are open, the system will dump all the fuel except a predetermined amount necessary for emergency operation.

1.6. Indicating Systems.

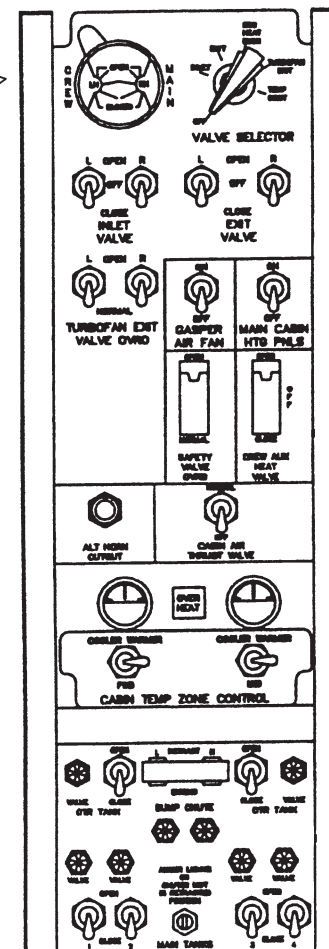
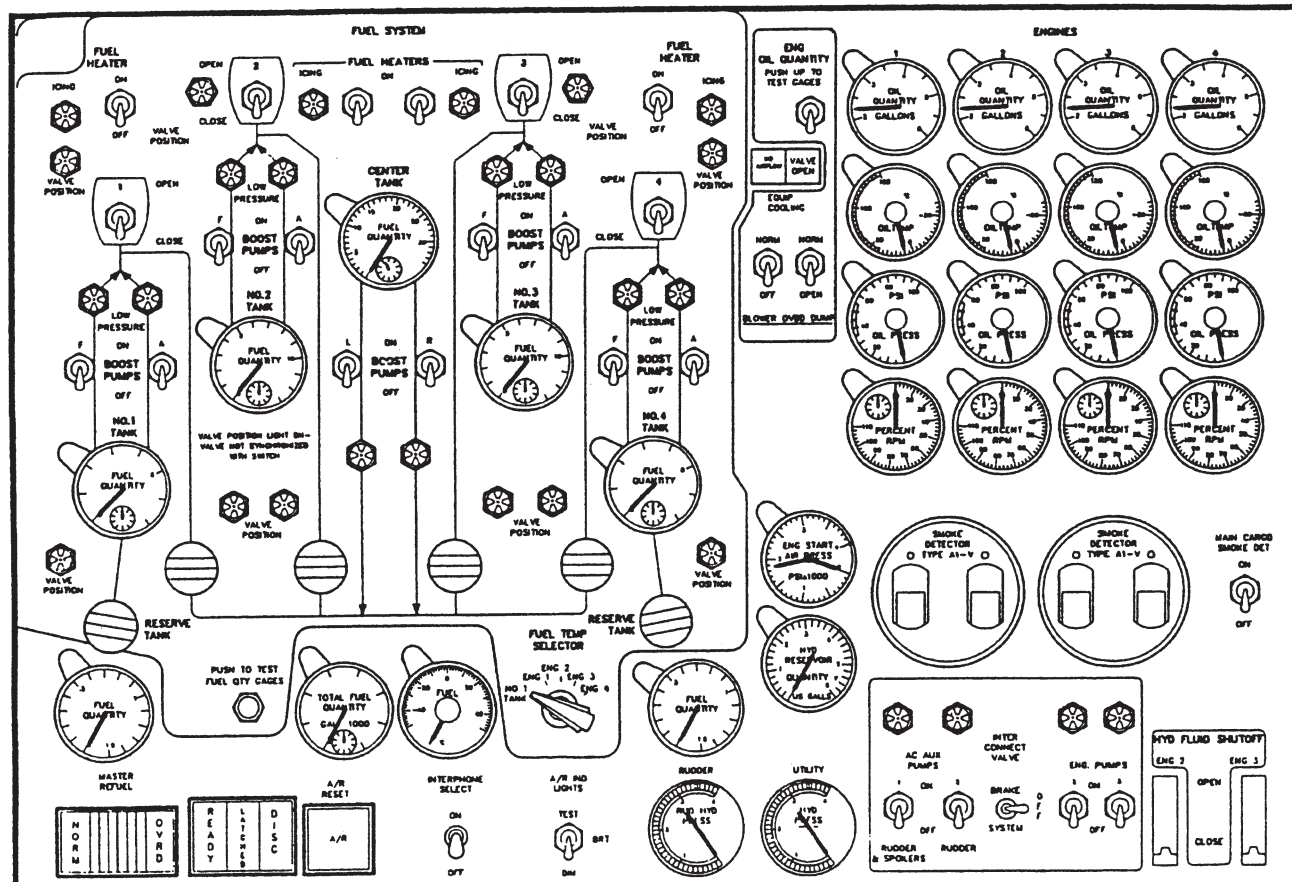
The fuel quantity indicating system provides a measure of the weight of fuel aboard the airplane. The system incorporates internally mounted electric capacitance type tank units in all fuel tanks, with elements which compensate for fuel density variations. The fuel quantity indicators on the flight engineer's lower panel are calibrated to read in kilogram of fuel remaining in each tank. One total fuel quantity indicator provides a continuous summation of the fuel quantities in all tanks.

The fuel flow indicating system provides a visual indication at the pilots' station of the fuel consumption rate in kilograms per hour for each engine. The fuel temperature indicating system provides a means for checking the temperature of fuel in the tanks and in the fuel lines at each engine. The system consists of an indicator and five position selector switch on the flight engineer's lower panel, and five fuel temperature bulbs (one in main tank N°1 and one at each engine on the outlet side of the fuel filter).

1.7. Engine Fuel Deicing System.

Each engine has a manually controlled engine fuel deicing system which conditions the fuel before it reaches the fuel control unit. The principal components of each deicing system are a fuel filter, an air control valve and an air/fuel heat exchanger. The four fuel heater switches and fuel icing indicator lights are located on the flight engineer's lower panel. Power to the system is 28 volts dc.

The fuel filter is fitted with a pressure warning switch which detects filter icing and then illuminates the icing indicator light. The air control valve controls the flow of high pressure discharge air to the heat exchanger thro which all of the engine fuel flow passes. A fuel temperature bulb is located on the outlet side of the fuel filter to monitor the fuel out temperature.



FLIGHT ENGINEER'S AUXILIARY PANEL

1.8. Miscellaneous Components.

Miscellaneous fuel system components include fuel filler cap assemblies, baffle check valves, defueling valve, fuel sump drain cocks, and drip sticks.

All fuel tanks have an exterior filler cap for individual tank servicing, or the tanks can be individually or simultaneously filled at the pressure fueling stations. The main tanks have baffle check valves installed in the bottom of the inboard ribs to allow fuel to flow inboard towards the boost pumps during normal flight attitude and to not allow fuel to flow away from the pump area during turbulence or airplane maneuvers.

Baffle check valves.

The baffle check valves are installed in the bottom of the ribs between lower wing stiffeners of the main fuel tanks to keep fuel from flowing away from the fuel boost rumps. Each baffle check valve is a swing type valve hinged at the top which opens only inboard. The valve is free acting and the valve flapper aligns itself automatically with the valve seat when it drops from the full open position.

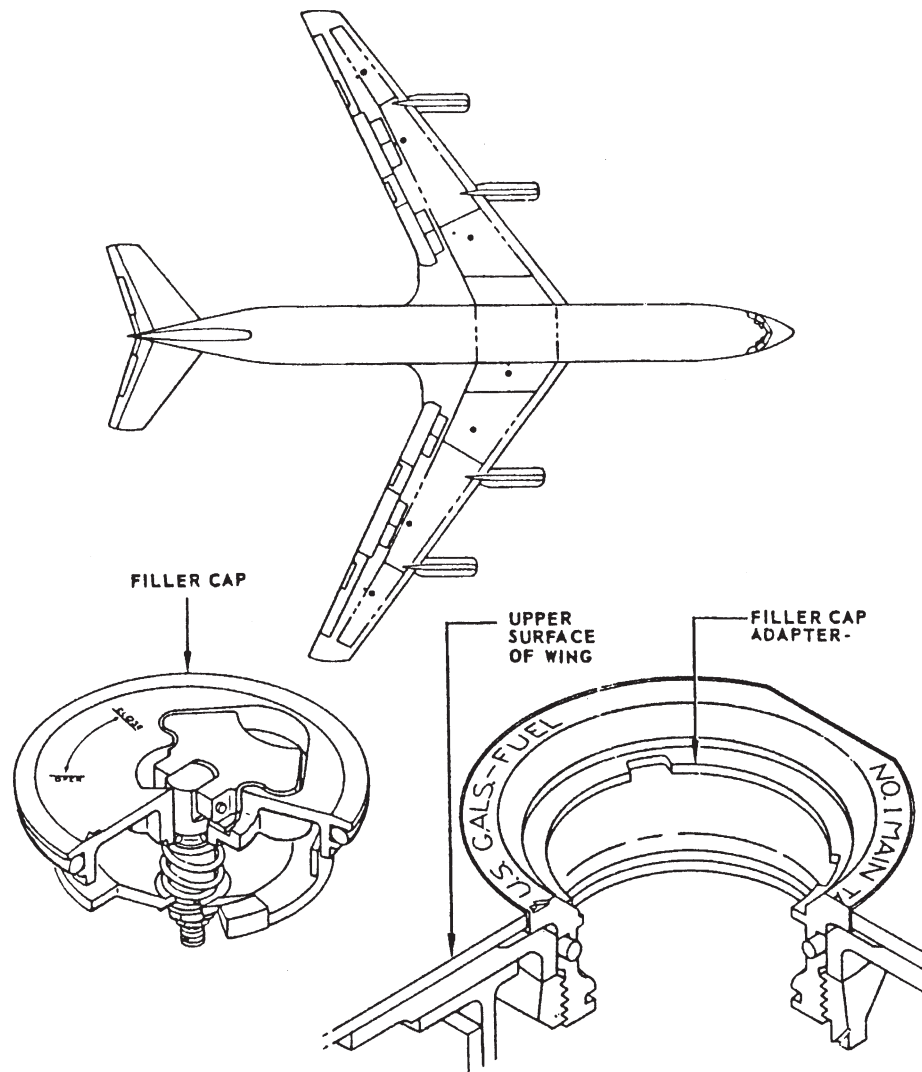
Access to the baffle check valves is gained through fuel tank access panels and rib access openings after the fuel tank is defueled. A baffle check valve can be replaced by removing the hinge pin on the valve. To function properly a baffle check valve must have no binding at the hinge points.

Fuel filler caps.

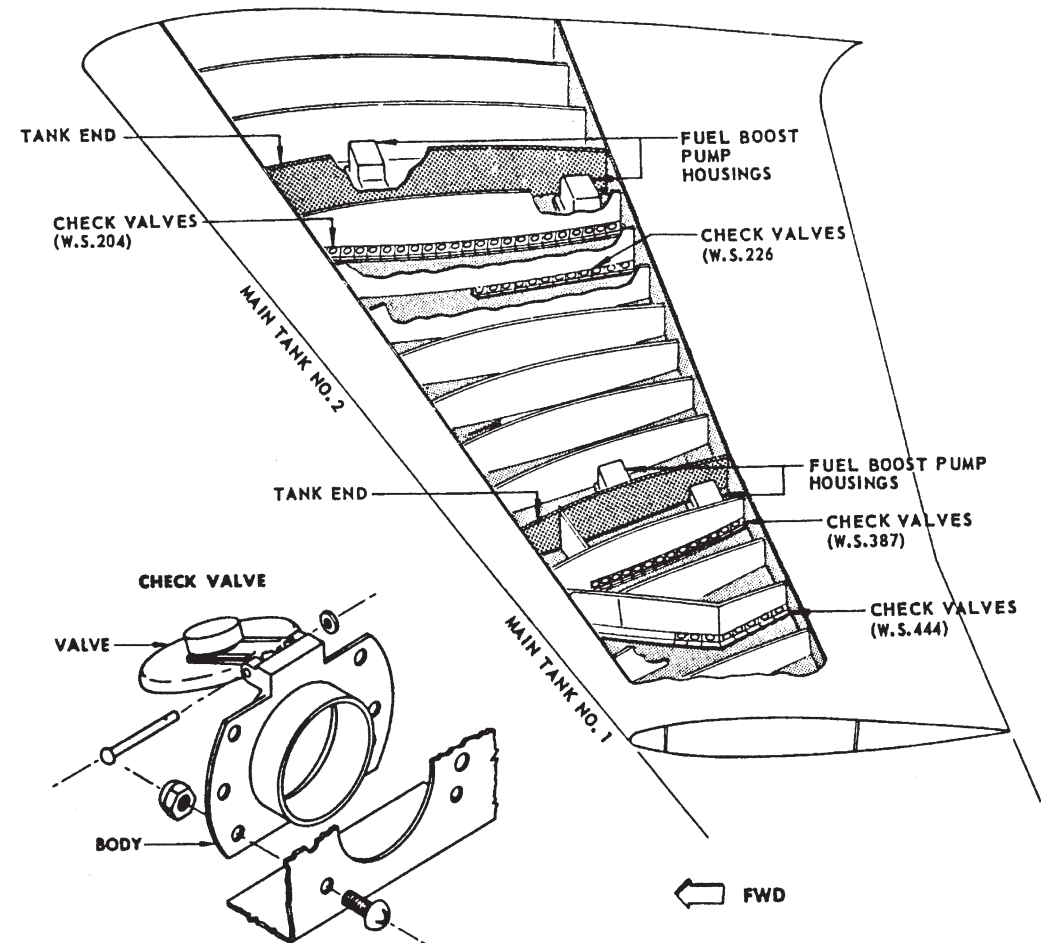
The filler caps are utilized during over wing tank truck fueling operations. Each cap assembly consists of a flush fitting cap with a locking device and adapter on each exterior filler port.

The filler cap assemblies are located on top of the wing. The filler cap is attached to the adapter on the exterior filler port by rotating the cap clockwise to a stop so that it is sealed by the locking device. The cap assembly is removed by disconnecting the retaining clip on the structure and unscrewing the filler adapter.

CAUTION: DO NOT OPEN FILLER CAPS BEFORE CHECKING FUEL LEVEL IN TANKS. IN CERTAIN AIRPLANE ATTITUDES, FUEL MAY BE OVER THE LEVEL OF A FILLER PORT.



FUEL TANK FILLER CAP ASSEMBLIES



BAFFLE CHECK VALVE

Fuel sump drain cocks.

Fuel sump drain cocks, installed at low points in each fuel tank, provide for draining the accumulation of moisture in each fuel tank and for draining the fuel trapped in the fuel sump when the tank is defueled. The drain cock is a flush mounted poppet type valve, spring loaded to the closed position. A screen covers the wet side of the drain cock and a screwdriver slot to open the drain cock is in the base. When the drain cock is pushed up with the screwdriver, it allows fuel to drain out of the tank. The sump drain cock is removed by using the F65834 wrench assembly. Sealing the drain cock to structure is accomplished with an O-ring.

Defueling valve.

Pressure defueling of the main tanks or center wing tank is accomplished through a defueling valve located in the inboard dry bay. The defueling valve allows the engine fuel feed manifold to be used for defueling. The valve is a sliding gate type shutoff valve installed in the inboard dry bay valve is operated manually by a handle which is normally in the closed position. The access door will not close unless the defueling valve is in closed position. The fuel boost pumps in the main tanks or the override pumps in the center wing tank deliver fuel to the defueling valve through their respective fuel manifold valves. Alternatively, fuel may be drawn from the tanks through the defueling valve by means of the fuel truck defueling pump. In addition, defueling check valves in the pressure fueling lines provide for rapid partial defue through the fueling receptacles. The reserve tanks are defueled through a reserve tank transfer valve to the adjacent main tanks. Residual fuel in each tank may be drained through fuel sump drain cocks located in the bottom of each tank.

Drip sticks.

In addition to the fuel quantity indicating system, the fuel quantity in each tank can be determined by calibrated drip sticks located in the wing lower surface. The drip stick is slowly lowered until fuel begins dripping from a drip hole near the base of the stick. At this moment the reading opposite the calibration plane is taken. The fuel quantity in the tank is obtained by comparing the drip stick reading with a special chart.

The Primary function of the drip stick is to measure the fuel level in the fuel tanks. The procedure assists the ground crew in its fueling operations by allowing a comparison on the fuel volume determined by the drip stick, with the fuel weight indicated by the fuel quantity indicators in the control cabin. The accuracy of measurement depends on level attitude of the airplane and changes in weight load.

The drip stick consists of a fiberglass tube, calibrated in inches, with a sealing cap at one end which locks into an adapter in the lower wing surface.

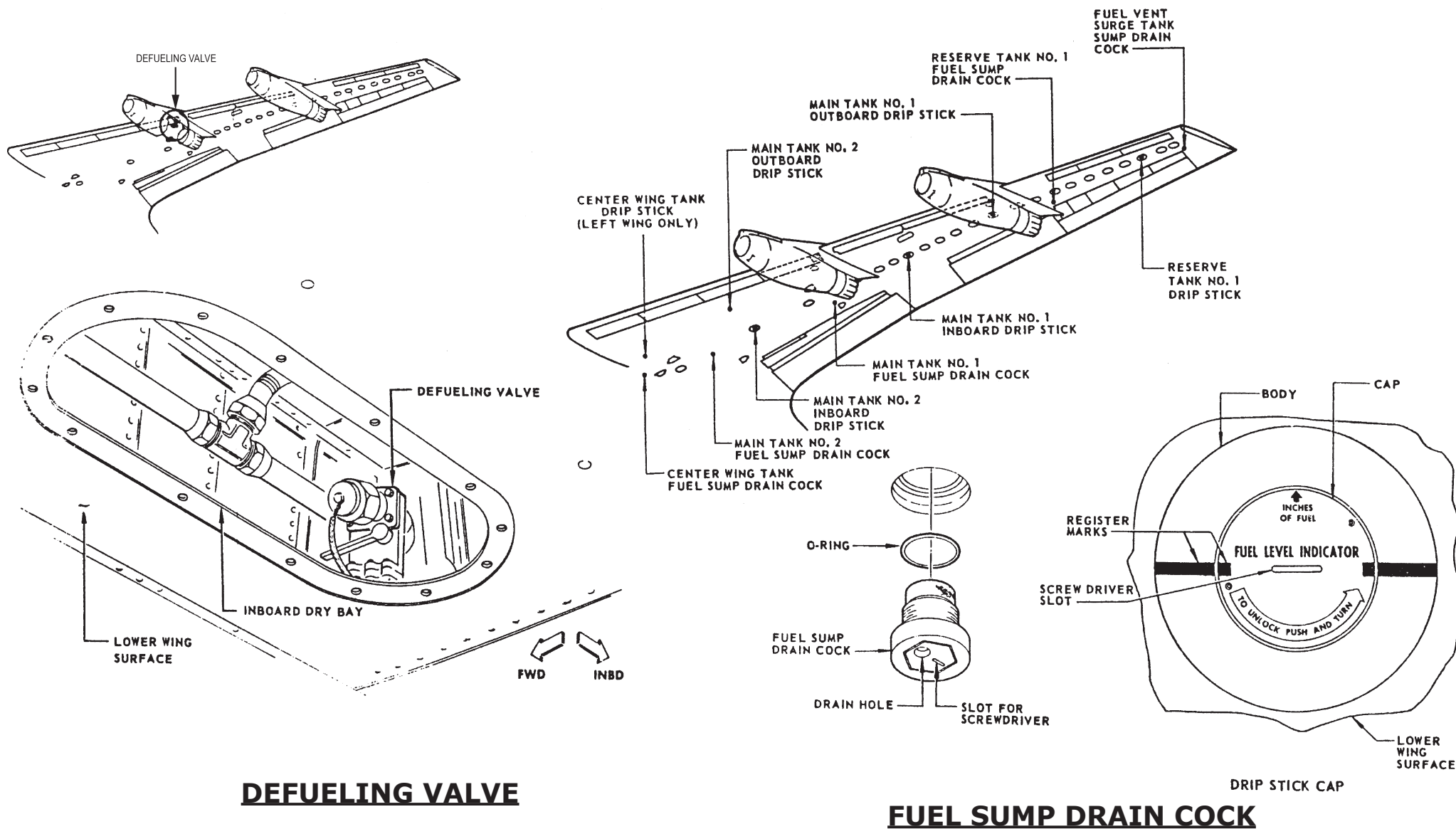
Drip sticks are of different lengths. This length is determined by the location at which they are used.

The entire fuel system has twelve drip sticks. One drip stick is installed in each reserve fuel tank. The main tanks and center wing tank have two drip sticks for better fuel level coverage.

When the seal cap is unlocked and the drip stick withdrawn slowly from the tank, fuel enters the top of the stick and runs down to a small drip hole near the base. At the moment the fuel appears, the reading opposite the calibration plane should be noted. This reading is the depth, in inches, of fuel in the tank. The drip stick reading shown indicates approximately 3.7 inches and not 4.3 inches of fuel depth. To find the gallons of fuel in a tank the drip stick reading is compared with a conversion chart which compensates for any deviation of the airplane from the level attitude, the deviation from level being determined by use of an attitude gage. When a reading has been completed, the drip stick cap is inserted into the adapter and locked by rotating clockwise to a stop. The drip sticks may only be used when fuel quantity is between the approximate limits noted in the chart below.

CAUTION: READ DRIP STICK CALIBRATION FROM TOP OF STICK DOWN.

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1.9. Fuel Lines.

All fuel lines are principally contained within the tank boundaries. They are fabricated mainly from standard aluminum alloy aircraft tubing and connected to the various fuel system components with standard NAS or MS union and couplings. Access to all tank equipment and fuel lines is provided externally by access panels in the lower wing surface and internally by openings in the tank ribs which are large enough to allow personnel to move through the ribs for inspection and maintenance.

1.10. Controls.

Fuel system controls, indicators and indicating lights, except those for the fuel dump and fuel flow system, are located on the lower instrument panel at the flight engineer's station. The fuel dump system controls are on the auxiliary panel adjacent to the lower panel. Fuel flow indicators are located on the engine instrument panel at the pilots' station.

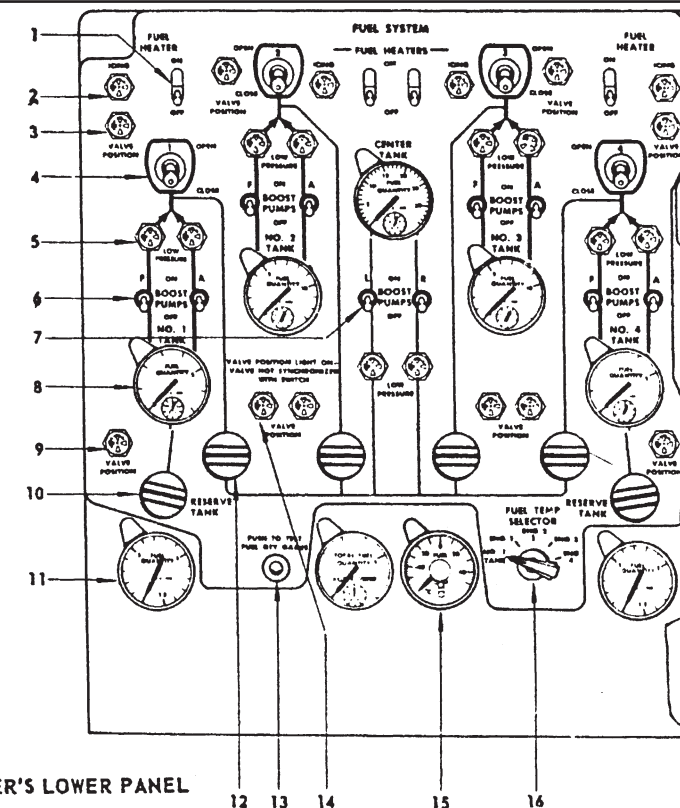
1.11. Fuel Tank Leak Detection.

Leakage from the tanks will be caused by a break in the seal plane, due to improper sealant application, improper mixing or storage of sealant, use of incompatible repair sealants, loose fasteners, damaged topcoating or improper installation of tank fittings. To be effective, fuel leak detection instructions, must be followed explicitly.

1.12. Fuel Tank Sealing.

The purpose of integral fuel tank seal is to provide an absolutely fuel tight barrier for the fuel in the tanks. To achieve this, various types of seals are used at different locations in the tanks to control the flow of fuel which otherwise would tend to leak from the tanks. Repairs to damaged fuel tank sealant must be made with approved materials, using approved methods and tools. The sealant materials used have synthetic rubber base and when properly cured are resistant to heat and extreme cold as well as fuel.

Drip Stick Location	Maximum Gallons	Minimum Gallons
Main Tanks No. 1 and 4 Outboard Drip Stick	2307	1654
Main Tanks No. 1 and 4 Inboard Drip Stick	1954	627
Main Tanks No. 2 and 3 Outboard Drip Stick	4065	2020
Main Tanks No. 2 and 3 Inboard Drip Stick	2598	308
Reserve Tank No. 1 and 4	439	264
Center Wing Tank (TURBOJET)	7640	108
Center Wing Tank (TURBOFAN)	10,193	192



FLIGHT ENGINEER'S LOWER PANEL

1. FUEL HEATER SWITCH
2. FUEL ICING INDICATOR LIGHT
3. ENGINE FUEL SHUTOFF VALVE POSITION LIGHT
4. ENGINE FUEL SHUTOFF VALVE SWITCH
5. FUEL LOW PRESSURE WARNING LIGHT
6. FUEL BOOST PUMP SWITCH
7. FUEL BOOST OVERRIDE PUMP SWITCH
8. FUEL QUANTITY INDICATOR
9. RESERVE TANK TRANSFER VALVE POSITION LIGHT
10. RESERVE TANK TRANSFER VALVE SWITCH
11. RESERVE TANK FUEL QUANTITY INDICATOR
12. FUEL MANIFOLD VALVE SWITCH
13. FUEL QUANTITY INDICATORS PUSH-TO-TEST SWITCH
14. FUEL MANIFOLD VALVE POSITION LIGHT
15. FUEL TEMPERATURE INDICATOR
16. FUEL TEMPERATURE SELECTOR SWITCH

2. INTEGRAL FUEL TANKS.

The integral fuel tanks provide the major portion of the fuel supply storage capacity. The tanks are located in the interspar area of each wing, and the ribs serve as baffle plates.

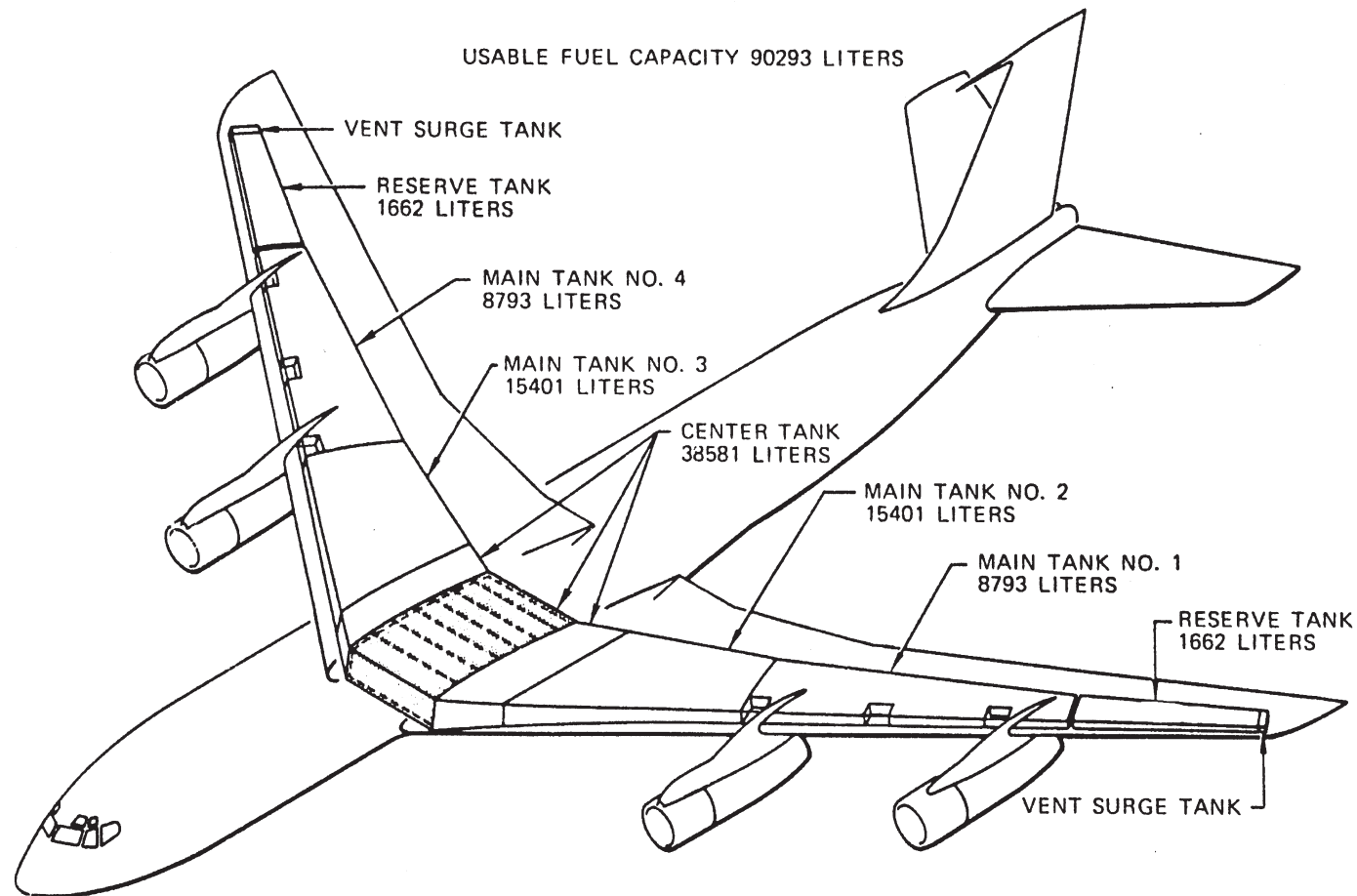
The integral fuel tanks are identified as main tanks N°1, 2, 3, and 4, reserve tanks N°1 and 4 and center wing tank. All main tanks and the two reserve tanks are integral with the wing structure. The center wing tank is comprised of two integral sections at the inboard wing roots and a center section which contains removable fuel cells. The center wing cavity is divided into compartments for the installation of bladder type removable fuel cells. Fuel flows in all three sections.

A reserve tank is located in the outboard section of each wing. Main tanks N°1 and 2 are located in the left inboard wing section and main tanks N°3 and 4 are located in the right inboard wing section. The integral sections of the center wing tank are located at the wing roots in the left and right inboard wing sections.

The main tanks, reserve tanks and integral sections of the center wing tank use the sealed structure of the wing to maintain a fluid tight boundary. This is accomplished primarily by close metal to metal fit of all parts, integrally sealed fasteners and by the application of sealing compound to the structure.

Located within each fuel tank are the fuel lines, pumps, valves, vents, drains, and electrical equipment for the operation of the fuel system. Fuel system equipment is described elsewhere in this chapter. Refer to the chapter table of contents.

Access to all equipment installed in the fuel tanks is provided for by access panels in the lower wing surface and by openings in the wing ribs which allow personnel to move through the ribs for inspection and maintenance.



FUEL TANK ARRANGEMENT

2.1. Main Fuel Tanks.

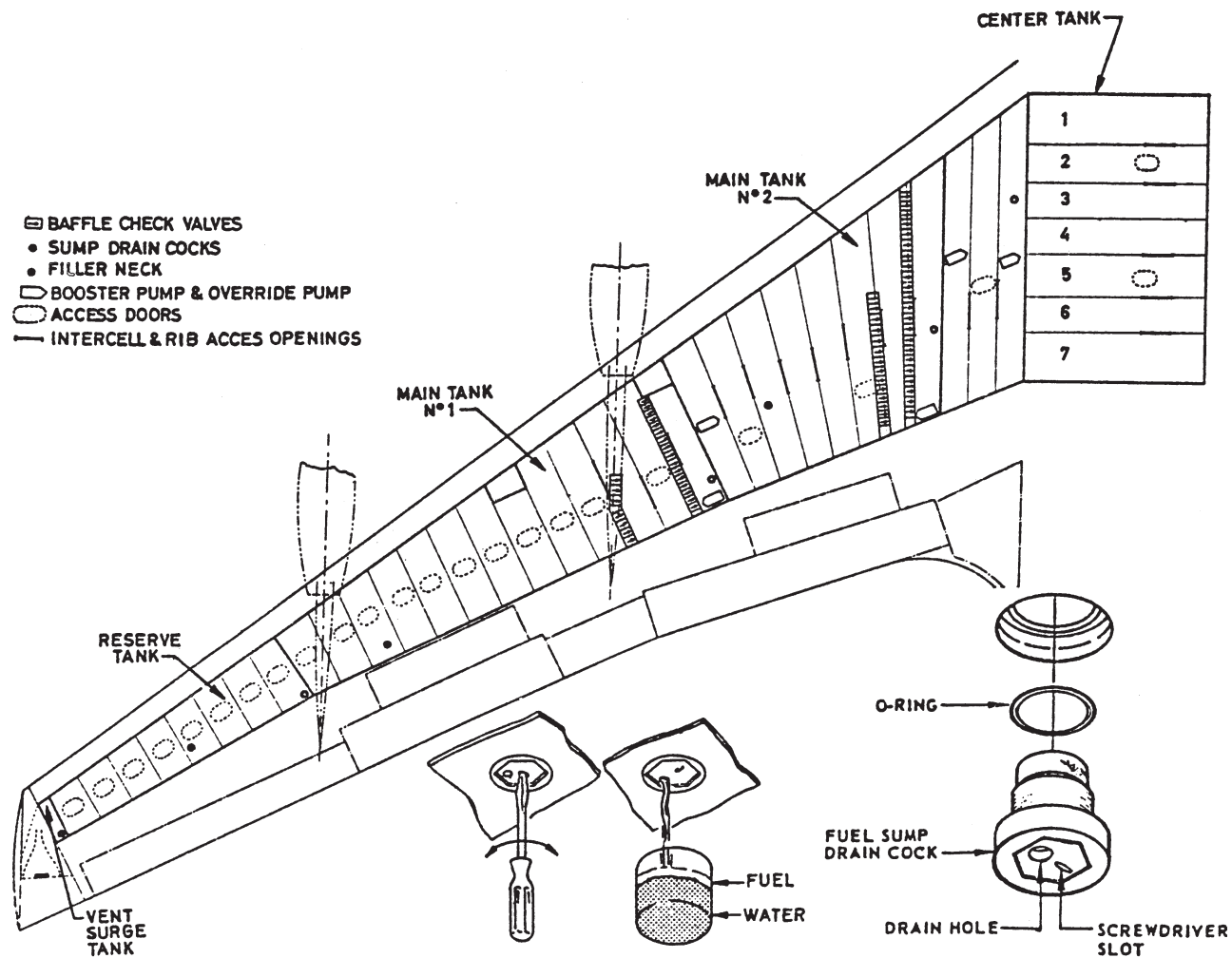
Main tanks N°1 and 2 are in the left inboard wing section; main tanks N°3 and 4 are in the right inboard wing sections. The tanks are separated from each other by end ribs, structurally sealed fluid tight by the use of sealing compound and sealed fasteners. Intermediate wing ribs serve as baffle plates. Some of the wing ribs have access openings in them to provide access to equipment and tubing located in the main tanks which is not directly accessible through access panels in the bottom of the tanks. These rib access openings are covered with structural members which must be removed before personnel can gain access to the equipment.

2.2. Reserve Fuel Tanks.

The two reserve fuel tanks N°1 and 4, store fuel and supply the fuel to main tanks N°1 and 4 respectively by gravity flow as required Both tanks are integral with the wing structure. The tanks are located interspar area of the left and right outboard wing sections. The tanks are separated from main tanks N°1 and 4 by wing ribs and each tank is sealed fluid tight by the use of sealed fasteners and sealing compound. Each tank is divided by wing ribs which serve as baffle plates. Access panels in the bottom of the tanks between the ribs provide access to fuel system equipment located within the tanks.

2.3. Center Wing Tank.

The center wing tank consists of three sections ; two integral sections located in the left and right inboard wing roots, and a center section which contains removable fuel cells. Fuel in the tank is supplied to any or all engines when the appropriate fuel manifold valves in the fuel lines are opened. The two integral sections of the tank are sealed fluid tight by the use of sealed fasteners and sealing compound. Each integral section is divided into three compartments by two wing ribs in which openings are provided for maintenance purposes. A tank access panel is located between the wing ribs in the bottom of the tank.



FUEL TANKS

2.4. Fuel Tank Access Panels.

Access to integral fuel tank equipment and tubing is provided by removable access panels in the lower wing panel. For ease in identifying the panels and referencing them throughout this chapter they are numbered 1 through 22 starting with 1 at the wing root, and going outboard to the wing tip. Reserve tank access panels (N°15 through 22) are installed in the bottom of the wing between every two ribs. Main tanks N°1 and 4 have Panels N°4 through 14. Main tanks N°2 and 3 have two panels (N°2 and 3) in the bottom of the wing. The center wing tank has four access panels, one in each integral section and two beneath fuel cells N°2 and 5.

There are two kinds of tank access panels, machined and cast aluminum.

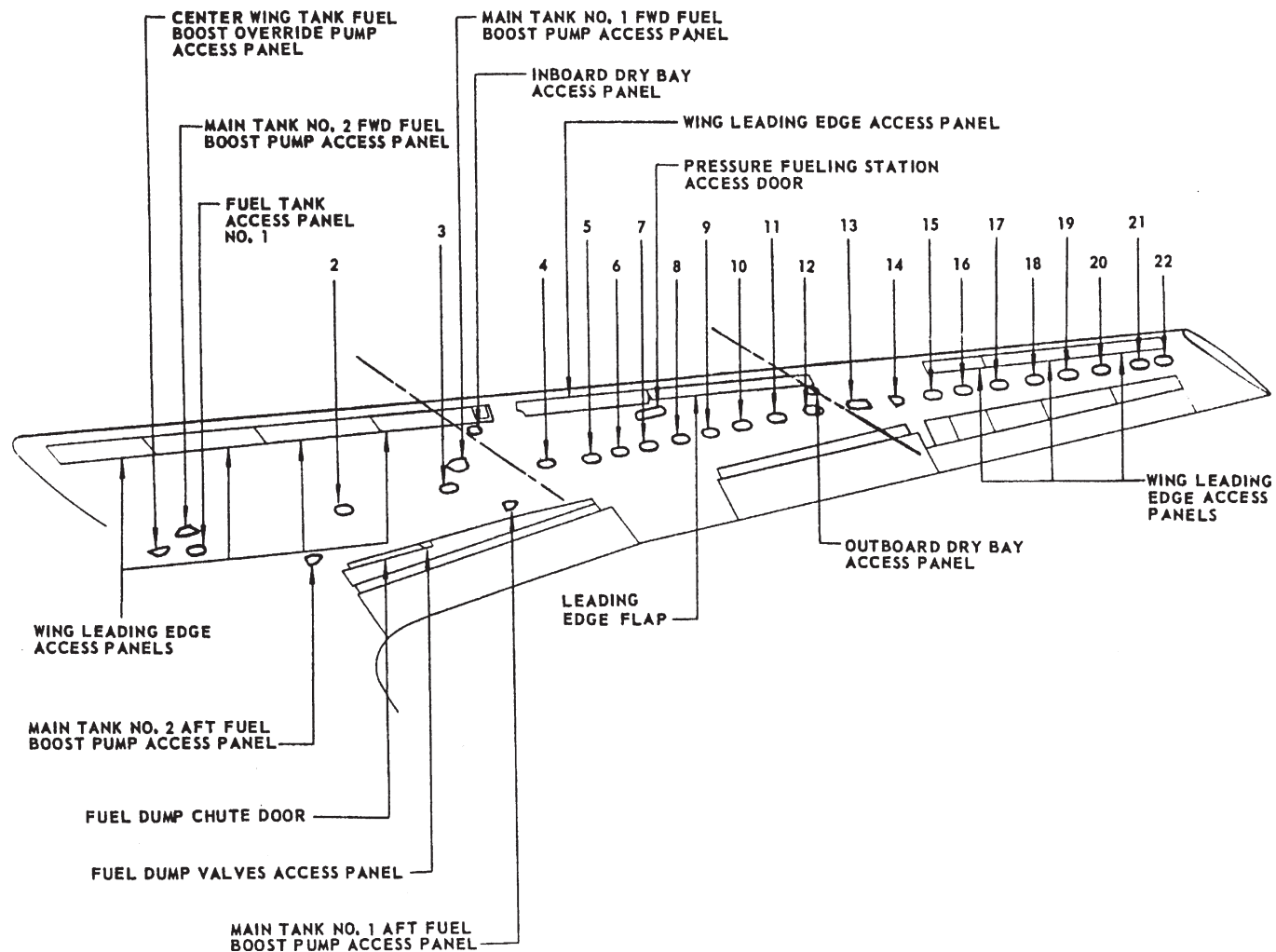
Machined panels are installed with seal rings which contain molded rubber seals fitted into grooves on both sides of the ring. All machined panels are clamped by screws installed in nutplates mounted on the upper surface of the panel.

Cast panels are mounted on the inside of the tanks and clamped by a clamp ring and screws to the lower wing Panels. A molded rubber seal fitted into a groove on the mating surface of each panel, acts as a static type fluid seal. Bonding jumpers are optional if knitted aluminum gaskets and/or clamp rings with bare surfaces are installed.

On some airplanes these panel installations are optional, while on others their use is restricted. Panels N°2, 7, 12, and 20 contain dripstick assemblies.

2.5. Rib Access Opening.

Rib access openings are provided in the ribs of the main tanks and integral sections of the center wing tank to provide access to equipment and tubing not directly accessible through the fuel tank access panels. They enable personnel to enter the tank at one of the fuel tank access panels and go through the rib opening to gain access to equipment located between ribs in areas that have no underwing access panels.



FUEL TANK ACCESS PANELS

3. REMOVABLE FUEL CELLS.

The removable fuel cells carry the fuel in the center section of the center wing tank. The cells are located in the center wing cavity which is divided by spanwise beams into seven separate cavities for the installation of up to seven fuel cells. The number of fuel cells installed can be varied and will depend on planned airplane utilization. Cut outs in the spanwise beam serve as intercell access openings and allow personnel to move from one cell to the other. Interconnect openings in the ends of the fuel cells open into the two integral sections of the center wing tank so that all together, the fuel cells and integral sections form one sectionalized center wing tank.

For ease in identifying the fuel cells and cavities in the text they are numbered 1 through 7, starting with 1 at the front spar and being consecutively numbered going aft to the rear spar.

The fuel cells are non self sealing and are of very light weight construction. Extreme care must be exercised in handling. Three primary layers of material, cemented together, make up a fuel cell. These are a nylon fabric inner liner, a nylon barrier, and a nylon fabric outer ply. The purpose of the inner liner is to contain the fuel and also act as a protective cover for the nylon film barrier.

The nylon film barrier prevents fuel from diffusing through the cell wall and the outer retainer ply gives strength to the cell and also gives protection to the nylon barrier. The inner liner and outer ply are made of rubber impregnated nylon fabric. This material is very strong but naturally not impervious to sharp objects, chafing or rubbing against metal or rough objects or any material that would tend to damage thin rubber sections.

In the airplane cavity, each fuel cell is laid on nylon back board and then attached to the cavity structure with nylon lacing cords. The cords run through ferrules attached to the outer periphery of the cell and through eye bolts and anchors attached to the cavity structure. Several chords of different lengths are required to secure each cell. The length of each cord depends on the size and shape of the individual cell, and the length between the anchor eye bolt and the tie off eye bolt.

The knots used to anchor the fuel cell lacing cord in the anchor and eye bolt fittings are tied in a specific manner to insure maximum protection from slipping or pulling off the fittings. Anchor knots are used for tying the cord to the first fitting and tie off knots are used at the last fitting. In some instances it is necessary to run two cords through an eye bolt or anchor the cord around the shank of the eye bolt and run another cord through.

In the latter cases the cord running through the eye bolt tends to hold the anchor cord in position.

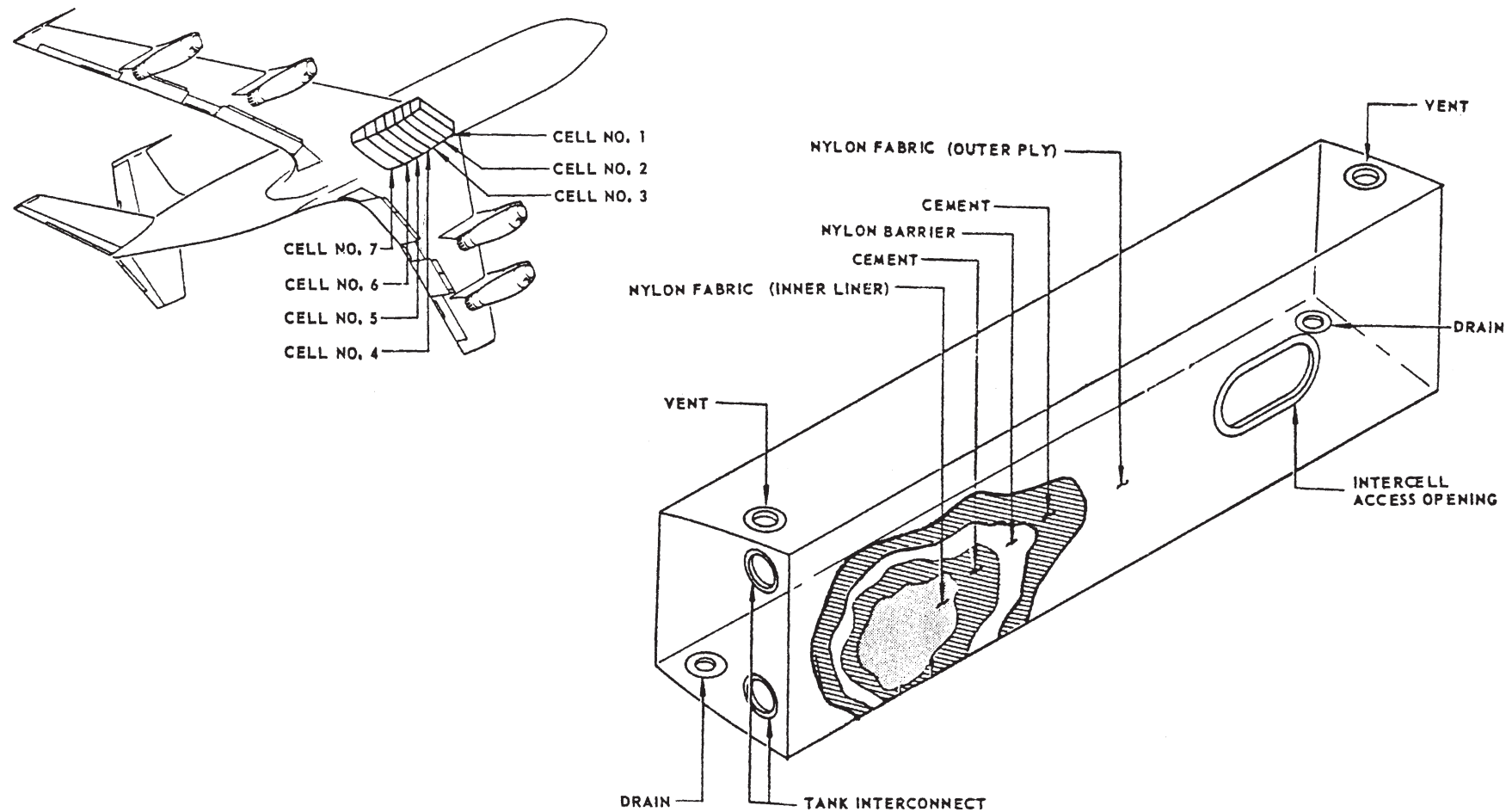
Each fuel cell is equipped with interconnect, vent and drain fittings which mate with fittings in the center wing tank integral sections and cavity structure. All fuel cell fittings are metal fittings molded to and forming the surface of cell opening. Each fitting or its mat surface has a groove for the installation of a rubber O ring which acts as a static gasket type of seal.

To function as a fuel tight seal, the O ring must be compressed between two metal surfaces having a high degree of smoothness. One of these surfaces is the bottom of the fitting O ring groove and the other is the sealing surface in the fitting mating part. Some of the fittings are attached to the mating part with bolts installed in nutplates, while others have steel thread inserts for the installation of attaching bolts.

Two fuel cell access openings are provided in the center wing section to enable maintenance personnel to enter the cavities and remove, install or inspect the fuel cell. One is located in the bottom of cavity N°2 and the other in the bottom of cavity N°5. The openings are covered by fuel cell access panels.

As there are only two fuel cell access openings, intercell access openings, are provided in the individual cell. The openings allow movement of personnel doing maintenance work inside the cells. The access openings between fuel cells N°4 and 5, N°5 and 6, and N°6 and 7 are covered with removable baffle plates.

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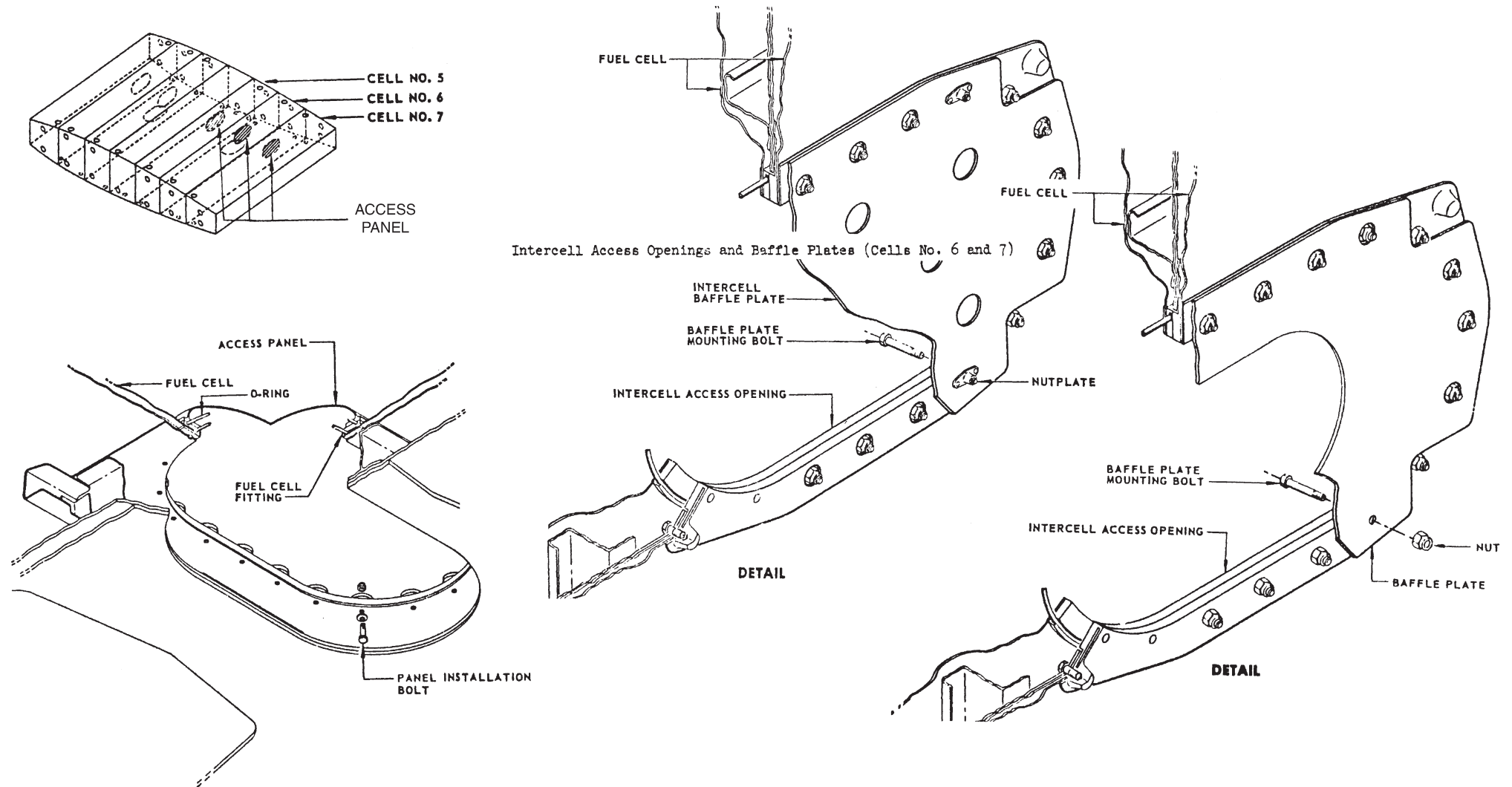
REMOVABLE FUEL CELLS LOCATION

3.1. Fuel Cell Access Panels.

The fuel cell access panels are installed on the bottom of fuel cell cavities N°2 and 5. Access to the panels is on the right hand side of the fuselage in the air conditioning equipment compartment. The panels are O ring sealed and bolted to the inner surface of the fuel cell access opening fitting and to the center wing cavity structure. Removal of the access panels permits removal or installation of the fuel cells and also allows personnel to enter the cells for inspection and maintenance.

3.2. Intercell Baffle Plates.

The intercell baffle plates, are installed at the intercell access openings between fuel cell N°4 and 5, N°5 and 6, and N°6 and 7. The purpose of the baffle plates is to act as a barrier to fuel surges which would otherwise exert excessive pressure on the spanwise beam between cells N°3 and 4 in which there is no access opening. The baffle plates are installed with the same bolts which bolt the intercell access opening fittings together. The baffle plate between cells N°4 and 5, is attached by bolts and nuts. The baffle plates between cells N°5 and 6, and N°6 and 7, are attached by bolts into nutplates.



FUEL CELL ACCESS PANELS

4. CENTER WING CAVITIES.

The center wing cavities accommodate the bladder type removable fuel cells. Seven individual cavities are provided for the installation of up to seven fuel cells. The cavities are all located between left and right body buttock lines 70.5 and body stations 600K and 820. Spanwise beam separate one cavity from another. For ease in identifying the location of the cavities in the text, they are numbered 1 through 7 starting with 1 at station 600K and being consecutively numbered going aft.

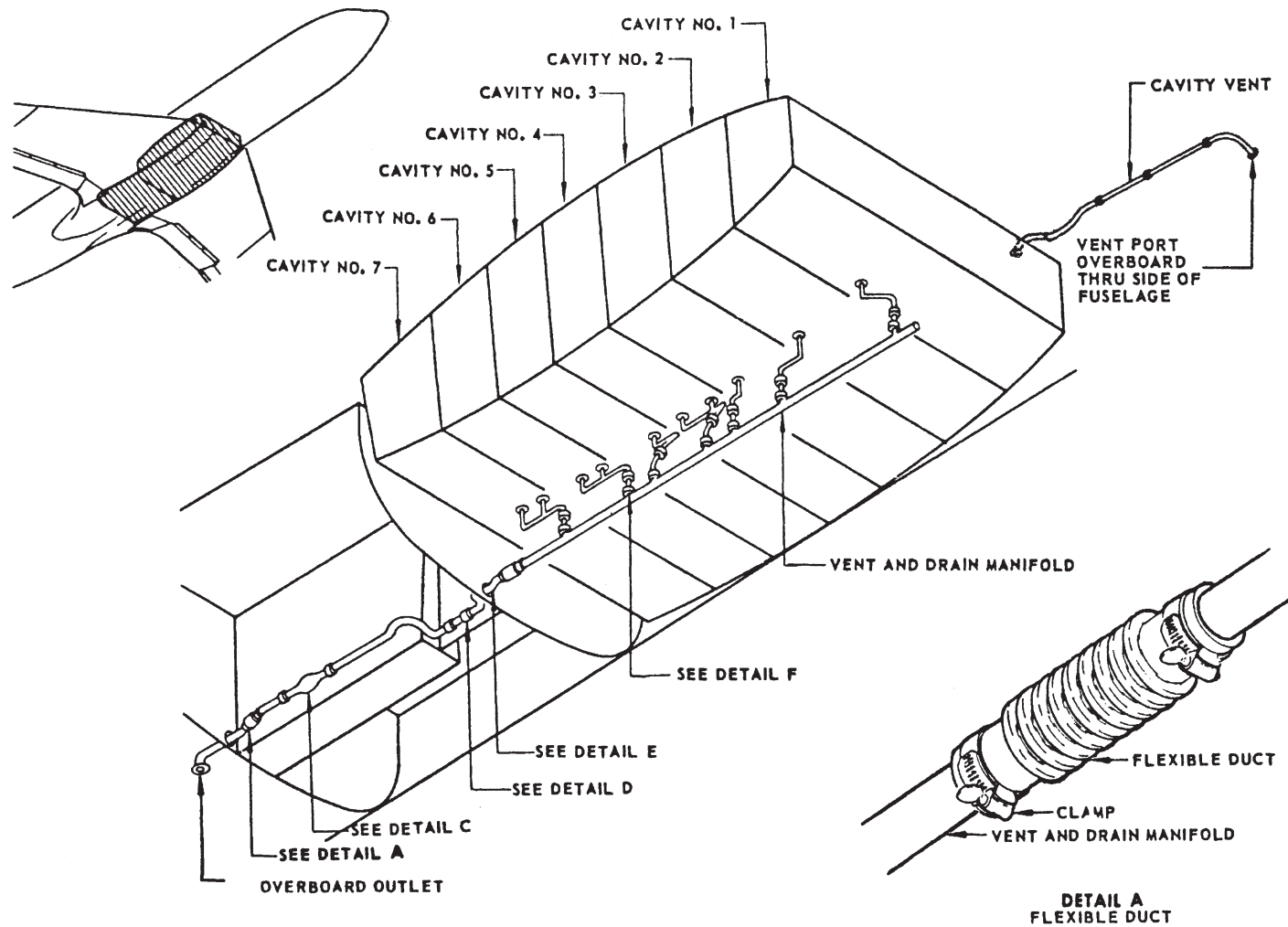
Center wing tank lower and upper stiffeners run spanwise through each cavity. To protect the removable fuel cell from damage, the lower stiffeners are completely covered by backing boards, the upper stiffeners are covered only at the extreme left and right ends of the cavity.

Each cavity incorporates the necessary fittings and openings for the fuel cells. Cut outs in the spanwise beams serve as intercell access openings and also allow maintenance personnel to move from one cavity to another.

In addition, cavities N°2 and 5 have cut outs in the bottom which serve as center wing tank access openings.

A vent and drain system is provided for each center wing cavity to prevent accumulation of moisture either from condensation or from fuel cell leakage. The drain fittings are located between the stiffeners in the cavity lower floor panel. Beneath the lower panel, the drains are connected by tubing and flexible hose to a manifold which is routed overboard aft of the left main landing gear wheel well. Additional venting is provided by a vent at the top front of N°1 cavity with an outlet in the side of the fuselage forward of the left wing root.

The center wing cavities are isolated from each other by sealing the structure in the bottoms and a portion of the wall. The reason for this is to confine fuel which leaks from any fuel cell to its respective cavity. This facilitates locating the leaking cell.



CENTER WING CAVITY VENTS AND DRAINS

4.1. Center Wing Cavity Fuel Cell Fittings.

Each fuel cell cavity incorporates the necessary interconnect, vent and drain openings and fittings for the fuel cells. The interconnect fittings are attached to the cavity end ribs by lockbolts. The vent fittings are located in the left and right top corners of the cavity. They form an interconnect between the cavity (or the fuel cell when these are installed) and the integral sections of the tank. The vent fitting is bolted to structure in the integral section. The drain fittings are located in the bottom of the cavities at the left and right aft corners. These fittings are also bolted to structure in the integral section.

4.2. Center Wing Vents and Drains.

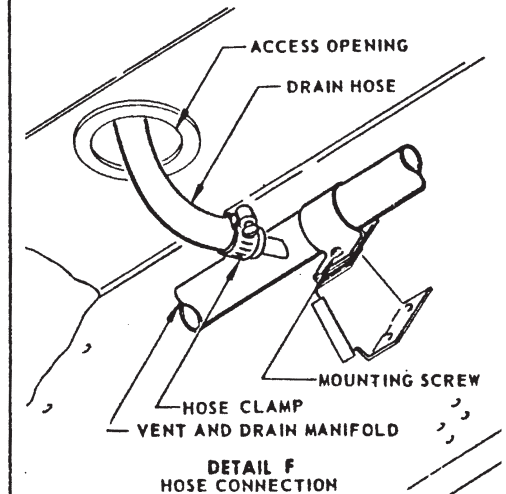
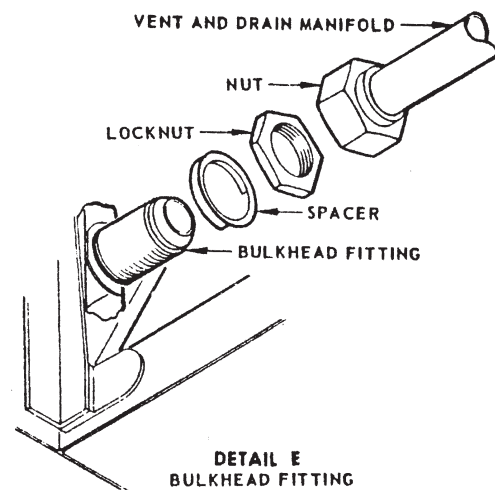
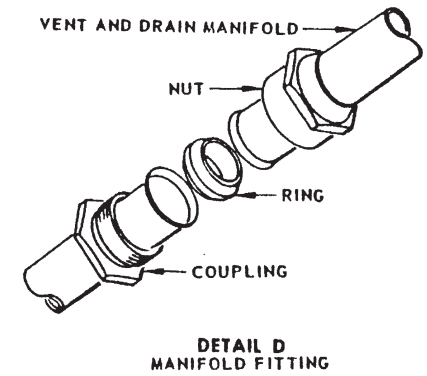
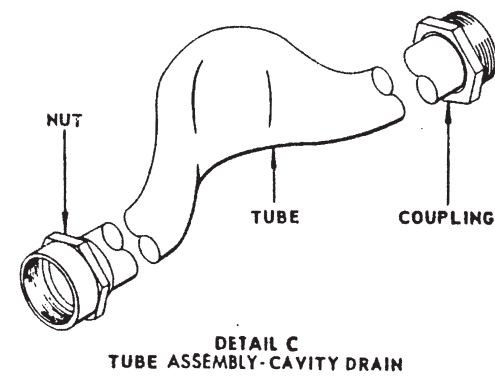
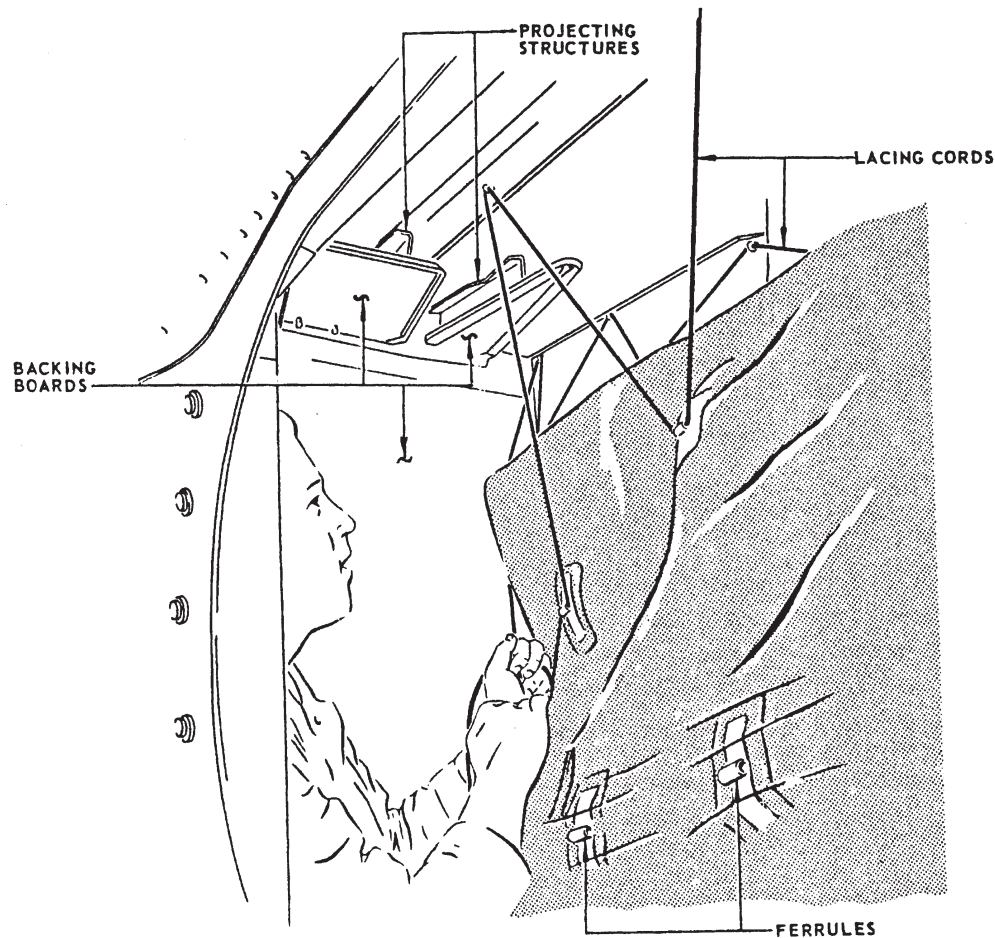
The center wing cavity vent and drain system prevents accumulation of moisture either from condensation or from fuel cell leakage. The cavities are isolated by sealing the structure in the bottom and a portion of the wall to keep leaking fuel in the cavity and routed to cavity drains. The cavity drains between the stiffeners in the lower panel are connected to a drain manifold by flexible tubing. The drain manifold is routed along the right side of the keel beam in the main landing gear wheel well to an overboard drain fitting aft of the wheel well. This drain line also supplies ventilation to center wing section cavities. All tubing connections are standard union couplings or bulkhead elbows. An additional vent line is installed at the front of cavity N°1. This vent line has an outlet in the lower surface of the fuselage forward of cavity N°1.

4.3. Center Wing Cavity Sealing.

An absolute fuel seal is required for the entire bottom surface and for 1.5 inches up on the front spar, rear spar, and all spanwise beams. Sealant is applied to isolate the cavities so that leaking fuel is routed to individual cavity drains and into the cavity drain manifold. Elsewhere in the cavities, an intermediate fuel seal is required.

4.4. Center Wing Cavity Backing Board.

The purpose of backing board is to prevent the fuel cell from chafing against bare stiffeners. Backing board consists of nylon resin impregnated material which softens and expands when soaked in water at room temperature. The board contracts and hardens after drying.



CENTER WING CAVITY VENTS AND DRAINS

5. VENT SYSTEM.

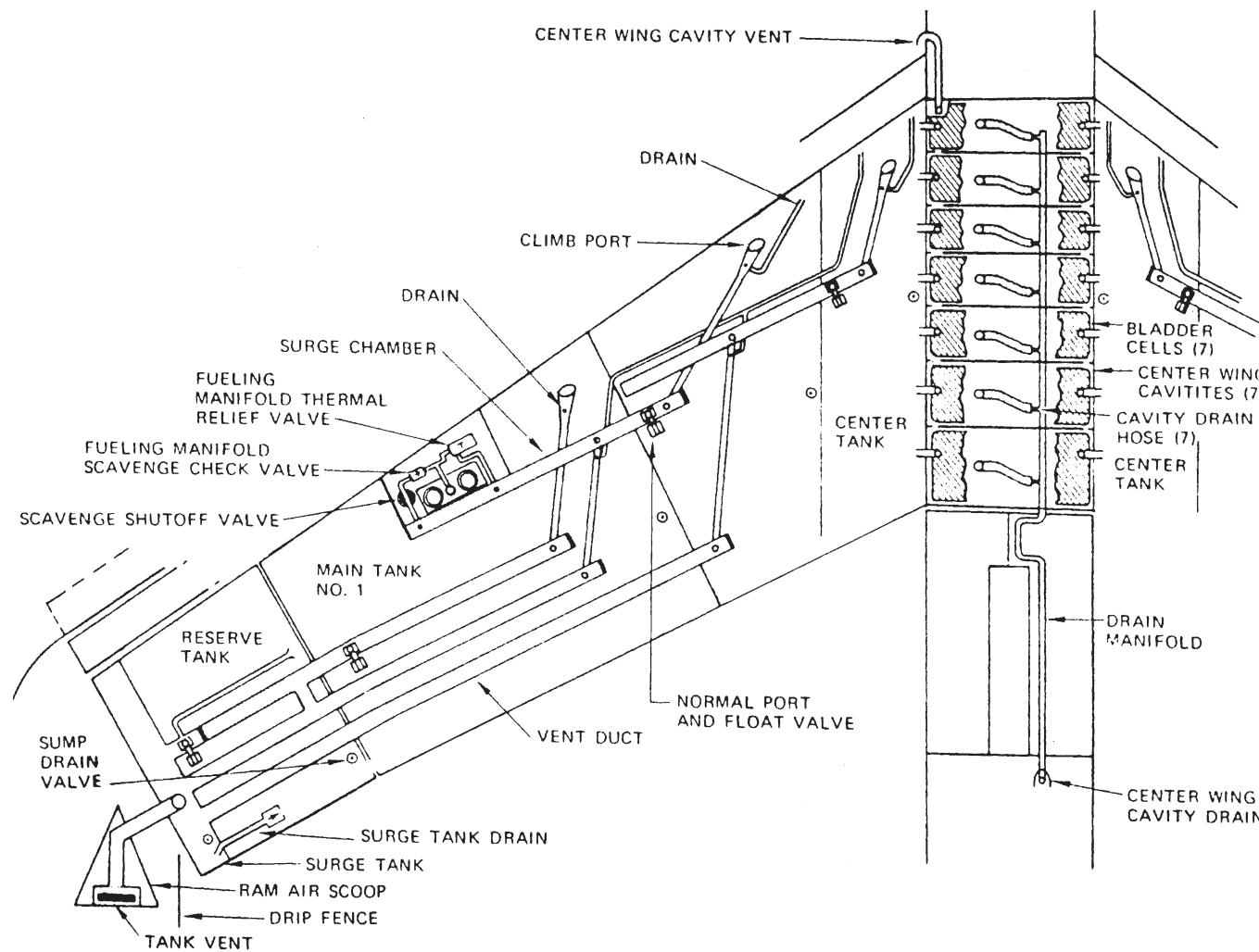
The fuel vent system provides positive venting of the integral fuel tanks and removable fuel cells to atmosphere during the various attitudes of the airplane. Venting of the fuel tanks is accomplished with sealed hat shaped upper wing skin stiffener ducts, interconnected with appropriate drain and vent tubing. This spanwise interconnected system is vented into a vent surge tank and overboard through a vent scoop at the wing tip.

The expansion space above the fuel in the tank shifts according to the different attitudes of the airplane. During normal take-off, high angle climb or acceleration, expansion space shifts to the forward inboard corner of the tanks. During normal climb, level flight or descent the expansion space is in the outboard center portion of the tanks. To provide adequate venting to atmosphere under any operating condition, inboard and outboard vent ports are provided in these areas in each tank and are so located that at least one port is open to the expansion area at all times. The inboard port is open at all times, and the outboard port is protected by a float valve since fuel could enter the vent system through the outboard port, at body centerline pitch attitude above $12^{\circ}30'$, and flow overboard. Each inboard vent port is connected by 2.5 inch tubing to an elbow flange which is bolted over an aperture in the bottom of the spanwise vent ducts.

The sealed spanwise vent ducting forms an integral part of the wing tanks vent system. Portions of these sealed ducts are used to connect vent ports in the tanks to atmosphere through the surge tank and the vent scoop. Other portions of the sealed ducts act as surge chambers to trap fuel surging into the vent system during rapid attitude changes or rolling of the airplane. Fuel trapped in the surge chambers drains back into the tank when normal flying attitude is established. Fuel surges too large to be trapped in the surge chambers are directed by the vent system to surge tanks located near the wing tips. Fuel in the surge tanks will drain back into the reserve tanks through the check valves located near the rear spar in the reserve tanks.

The removable fuel cells which comprise the center portion of the center wing tank are vented into the integral sections of the center wing tank through openings at the top of the cells. The center wing tank cavities, in which the fuel cells are installed, are vented through a system of vent and drain lines to an overboard outlet located beneath the fuselage.

The ram air vent scoop applies impact pressure to the vent system during flight. This pressure insures against negative pressure conditions in the tanks during attitude changes and decrease fuel vaporization.



TANK VENT SYSTEM

5.1. Fuel Vent Float Valves.

The fuel vent float valves prevent fuel from entering the vent ports located in the outboard center area of each wing tank. The valve consists of a float mounted on an axle hinged to a mounting base. The mounting base is installed over the vent port on the lower surface of the sealed vent duct.

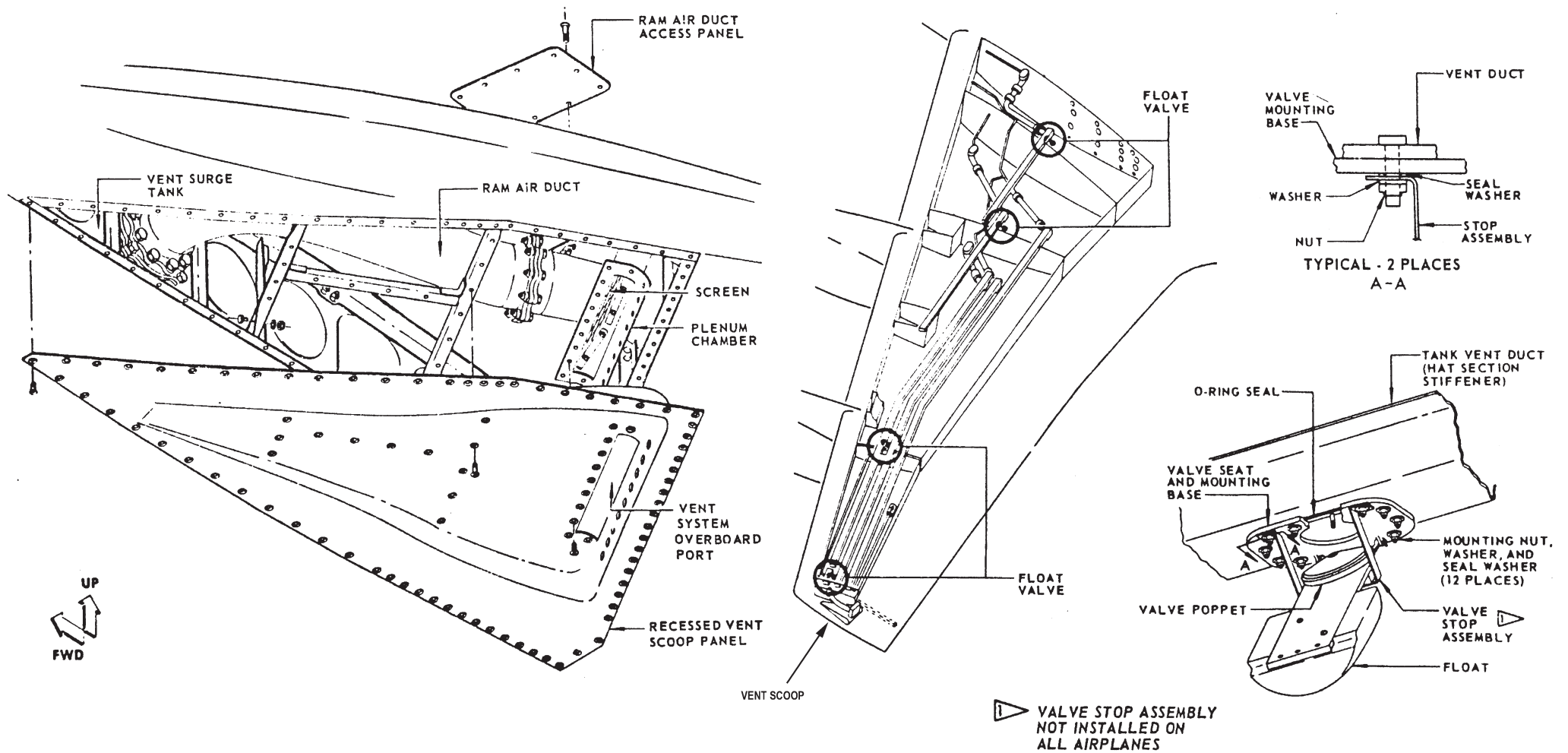
A valve stopper attached to the float arm incorporates a seal which contacts and seals the vent port when the valve is closed. The valve, when installed, is held in the normally open position by the weight of the float and float arm. On airplanes where fitted, a nylon stop, cradled in a U shaped bracket attached to the valve mounting base, limits the downward travel of the float. As fuel rises in the tank, the float rises closing the valve aperture. When the fuel level recedes the valve reopens.

5.2. Fuel Vent Scoop.

The fuel vent scoops located outboard of N°1 and 4 reserve tanks, are the overboard vents for the vent system. Each scoop consists of a recessed vent scoop panel mounted in the lower surface of the wing, and a plenum chamber with screened air inlet connected by a ram air duct to the vent surge tank. The diverging sidewalls of the slotted plenum chamber insure that ram air will be applied to the vent system during all flight attitudes of the airplane. The design of the scoop is such that icing conditions have minimum effect on ram air pressure.

5.3. Vent Surge Tank.

A five gallon surge tank outboard of each wing reserve tank provides fuel surge capacity for the vent system. The purpose of the surge tank is to accommodate fuel surges too large to be trapped in the surge chambers during rapid attitude changes of the airplane. This integral tank incorporates a connection to atmosphere through the vent scoop and a drain connection to the reserve tanks. A check valve in this drain line prevents reverse flow from the reserve tanks back into the surge tanks.



FUEL VENT SCOOP

5.4. Vent Tubing, Couplings and Bulkhead Fittings.

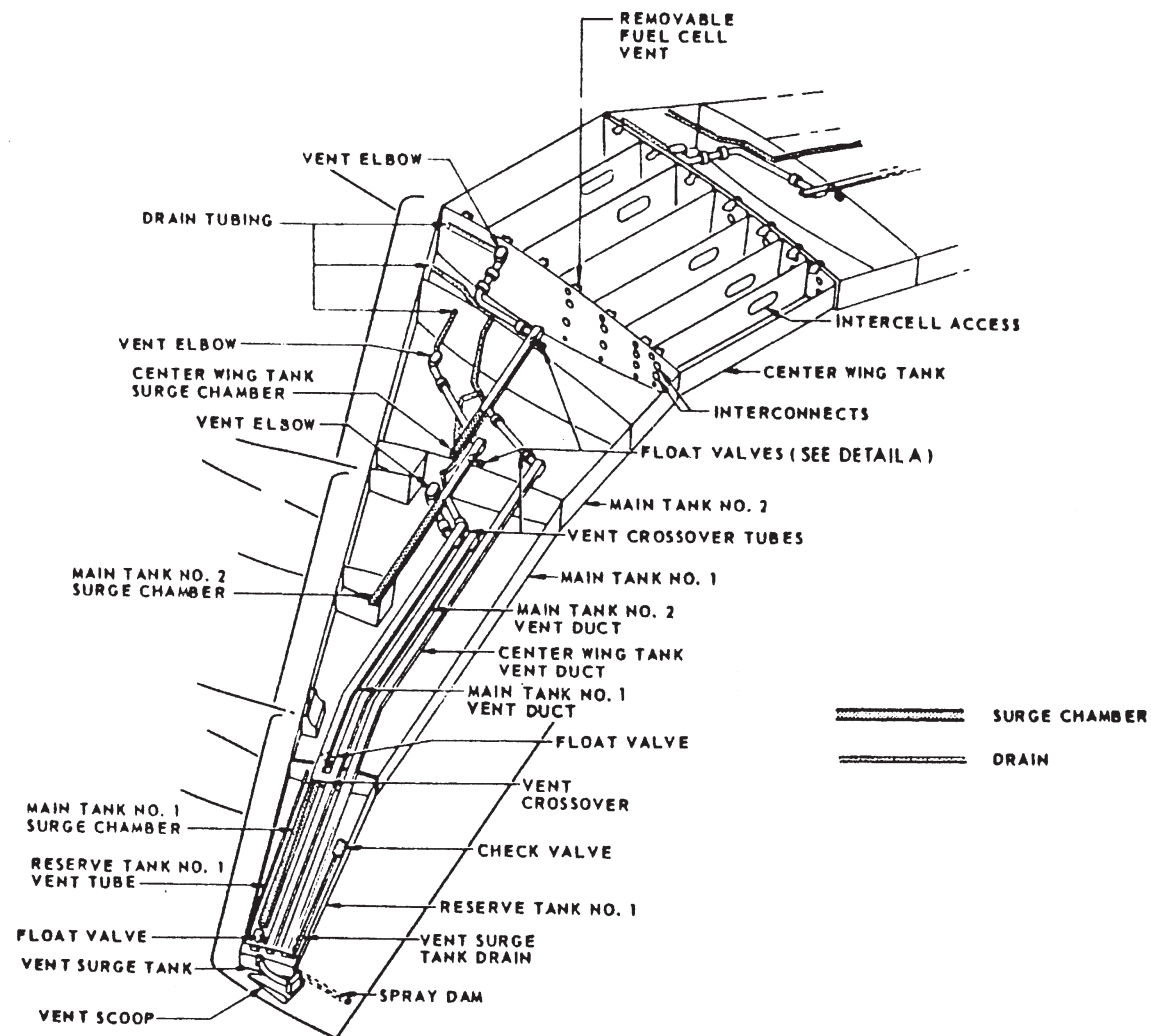
Wing tank vent system tubing connections are of two types : couplings employing standard NAS and MS tube fittings, and unions and couplings using seal type bulkhead unions and retainers. The bulkhead fittings are used in the vent drain line at the inboard end of each main tank. Standard tube end fittings connect to the bulkhead union which is held in place by a retainer bolted to the bulkhead. O ring seals are provided at, the bulkhead union and at the retainer bolts.

Vent crossover tubes at the inboard end of main tanks N°1 and 4 connect the inboard and outboard hat shaped upper wing skin vent ducts. Each crossover tube consists of 2.5 inch tubing connected at each end to an elbow flange. The elbow flanges are bolted and sealed to the vent ducts. The tube connections and equipment in the vent system must be lockwired to prevent loosening and subsequent fuel leakage.

All vent system tubing and equipment is electrically bonded to the airframe with bonding jumpers or by faying surface bonding, where equipment is mounted on airframe structure. Individual tubing is bonded to structure with bonding clamps and jumpers. Where tubing is connected both tubes are bonded to the same point on the airframe.

5.5. Vent System Sealing.

The wing tank vent system is sealed in all areas where fuel leakage might occur. Seal applications are designed to prevent external leakage and also to prevent leakage between tank and vent areas. Sealing is accomplished by the use of a sealant compound which is applied around structural fasteners, between faying surfaces, and along the edges of structural members and equipment.



FUEL VENT SYSTEM

6. ENGINE FUEL FEED SYSTEM.

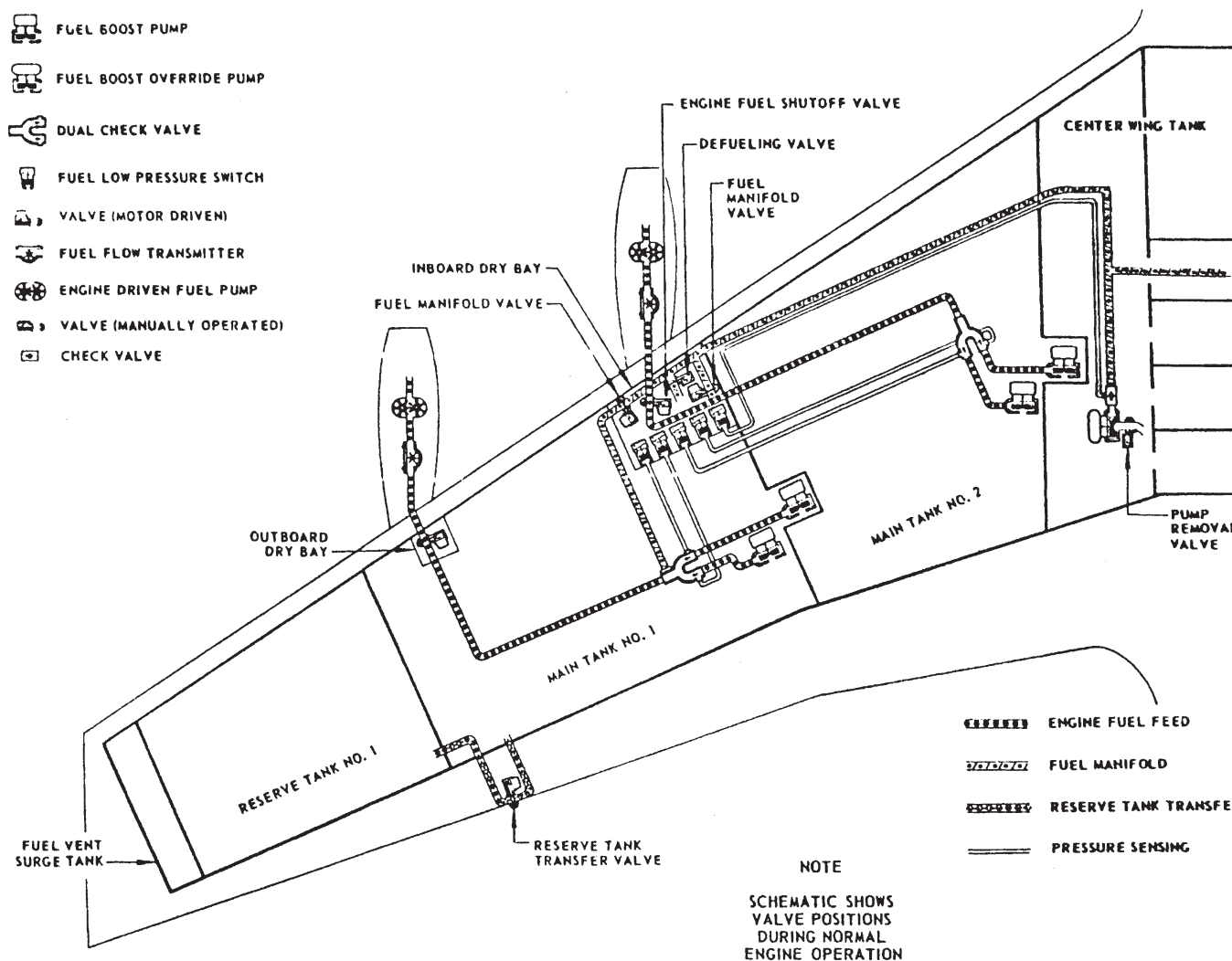
The engine fuel feed system is a system of fuel lines, pumps and valves which distributes fuel to the engines. It consists of four main tank to engine fuel feed subsystems which are interconnected by a fuel manifold, such, that fuel may be delivered from any main tank or center wing tank to any or all engines. The reserve tanks are not connected to the fuel manifold. Fuel from reserve tanks is gravity fed to main tanks N°1 and 4.

Each fuel tank except the reserve tanks, is equipped with two ac powered fuel boost pumps. The pumps are controlled by separate switches and independant circuits, so that engine operation will not be affected by the failure of a single electrical power source. The center wing tank boost pumps, known as the fuel boost override pump, will override the main tank boost pumps to supply fuel to the engines.

Electric motor driven shutoff valves control fuel flow to the engines.

The valves are classified into three groups : the valves that shut off fuel to the engines, the valves that control manifold distribution, and the valves that transfer fuel from the reserve tanks to main tanks N°1 and 4. The names of these valves are respectively : the engine fuel shutoff valves, the fuel manifold valves, and the reserve tank transfer valves.

The engine fuel feed system delivers fuel from the tanks through the fuel feed lines to the engines. The controls are centralized on the flight engineer's lower panel and are laid out in the form of a flow diagram. Electrical power is used to position the valves and to drive the pumps.



ENGINE FUEL FEED SYSTEM

6.1. Engine Fuel Shutoff Valves.

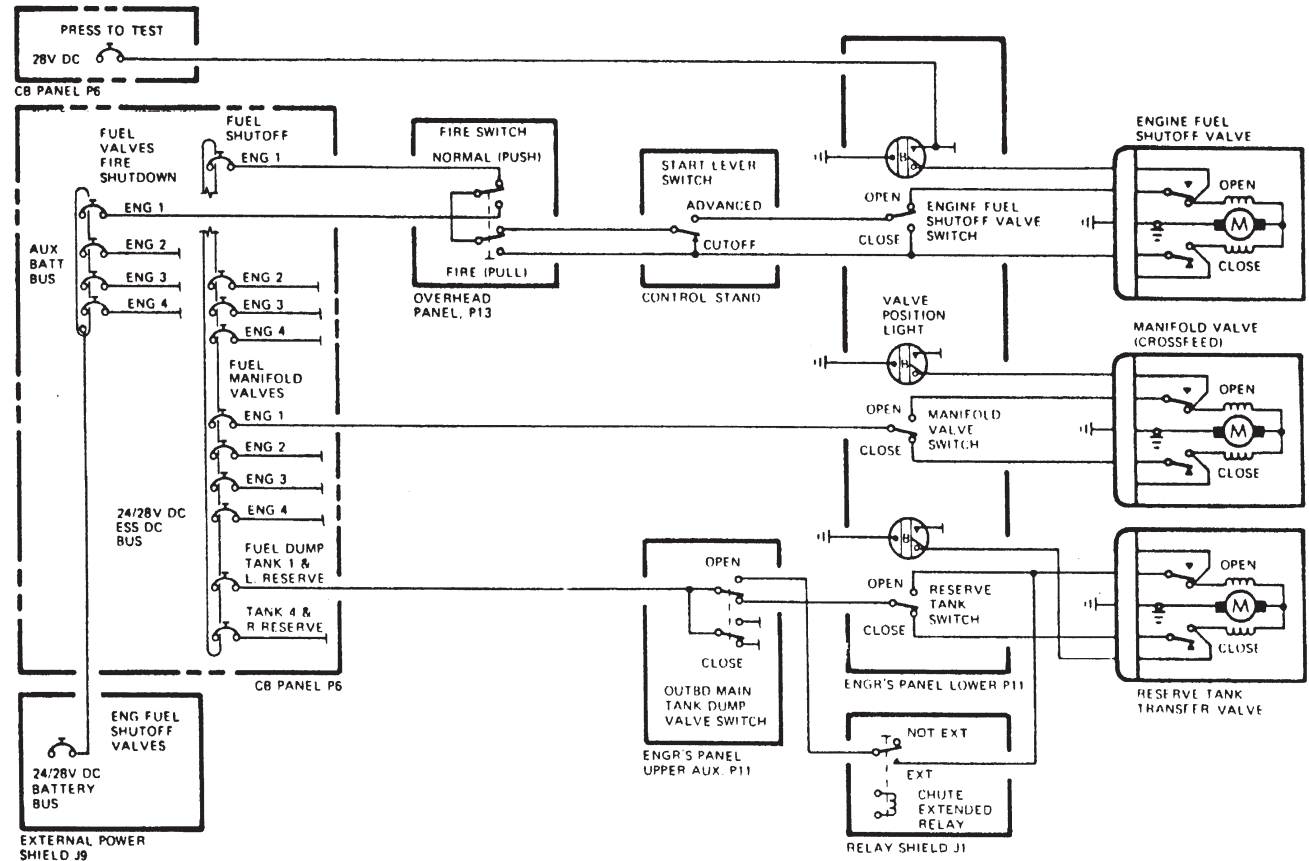
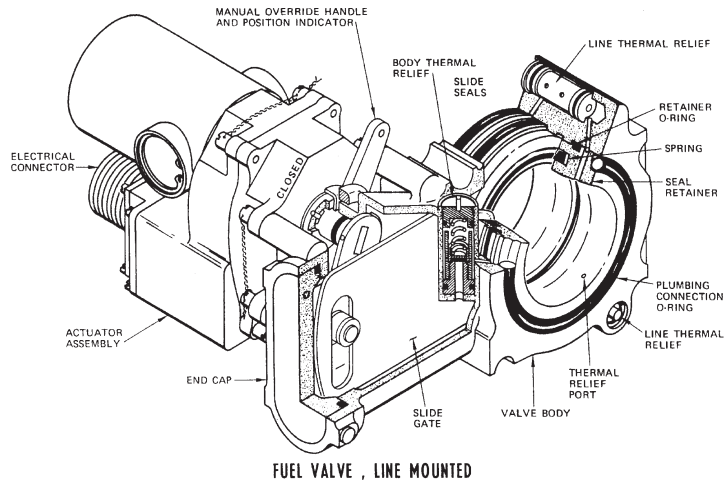
Four engine fuel shutoff valves provide a means of shutting off the supply of fuel to the engines. Each valve is an electric motor driven slide shutoff valve consisting of a valve housing, sliding gate, electric motor and a manual override handle. One valve is located in the inboard and outboard dry bays of each wing. The manual override handle provides a visual means of checking the valve position and a manual means of opening or closing the valve when the motor is not energized. The valve housing incorporates a thermal relief provision to limit the pressure buildup in the fuel manifold. The valves are individually controlled by engine fuel shutoff valve switches on the flight engineer's lower panel and by engine fire switches on the overhead panel and for A/C LX-N19997 and LX-N20000, by the start lever on the pedestal.

6.2. Fuel Manifold Valves.

Four fuel manifold valves provide a means of directing fuel to more than one engine from any one tank except the reserve tanks. These valves are the same type as the engine fuel shutoff valves. There is one manifold valve for each engine and the valves are located in the inboard dry bays. The manifold valves are controlled by individual fuel manifold valve switches on the flight engineer's lower panel.

6.3. Reserve Tank Transfer Valve.

The reserve tank transfer valves control the transfer of fuel from the reserve tanks to the outboard main tanks. These valves are the same type as the engine fuel shutoff valves. There is one transfer valve located in the fuel transfer line between the reserve tank and the outboard main tank of each wing. The valve is in that portion of the line that projects outside of the rear spar. The transfer valves are controlled primarily by the reserve tank transfer valve switches on the flight engineer's lower panel. A secondary control of the transfer valves comes through the fuel dump switches.

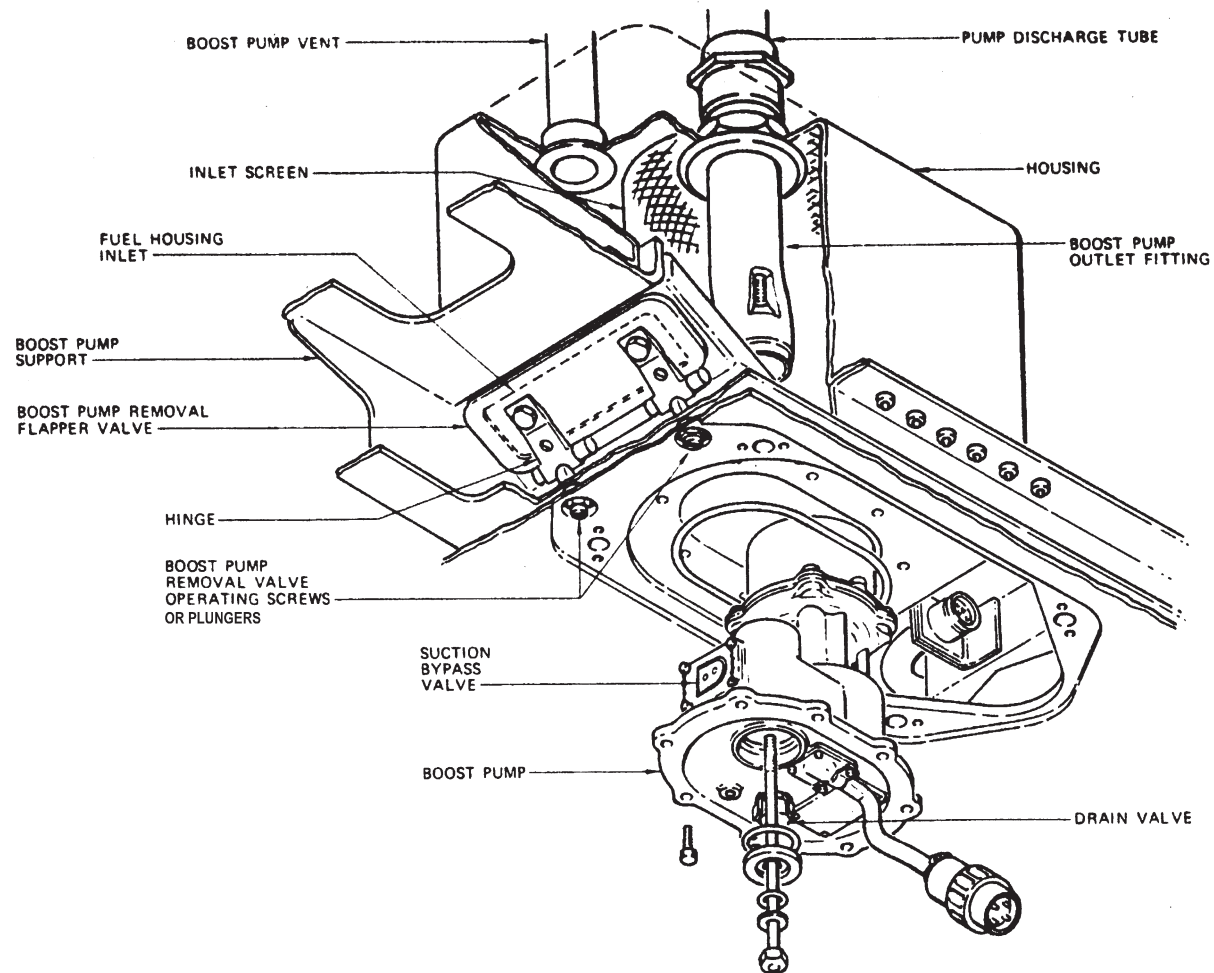


FUEL VALVE, LINE MOUNTED

6.4. Fuel Boost Pumps.

The fuel boost pumps remove fuel from the main tanks and deliver it under pressure via fuel feed lines to its respective engine or by fuel manifold lines to other engines. Each pump is a centrifugal type driven by an electric motor which uses 115/200 volt 3 phase ac power. The pumps are explosion proof and are located in dog house type covers at the lowest points in the main tanks. The pumps are bolted to the lower wing surface and project up into the pump housings.

Fuel enters each pump through a flapper type pump removal valve and a wire mesh screen at the inlet port. The pump removal valve allows removal of the boost pump without defueling the tank. The screen protects the pump and lines from foreign material. Part of the fuel being pumped is recirculated through the pump to cool the motor and to lubricate the bearings. This fuel discharges through holes in the top of the motor case and mixes with incoming fuel in the pump housing. A vapor discharge line vents the pump housing to the tank. Each pump is operated independently through a fuel boost pump switch on the flight engineer's lower panel.

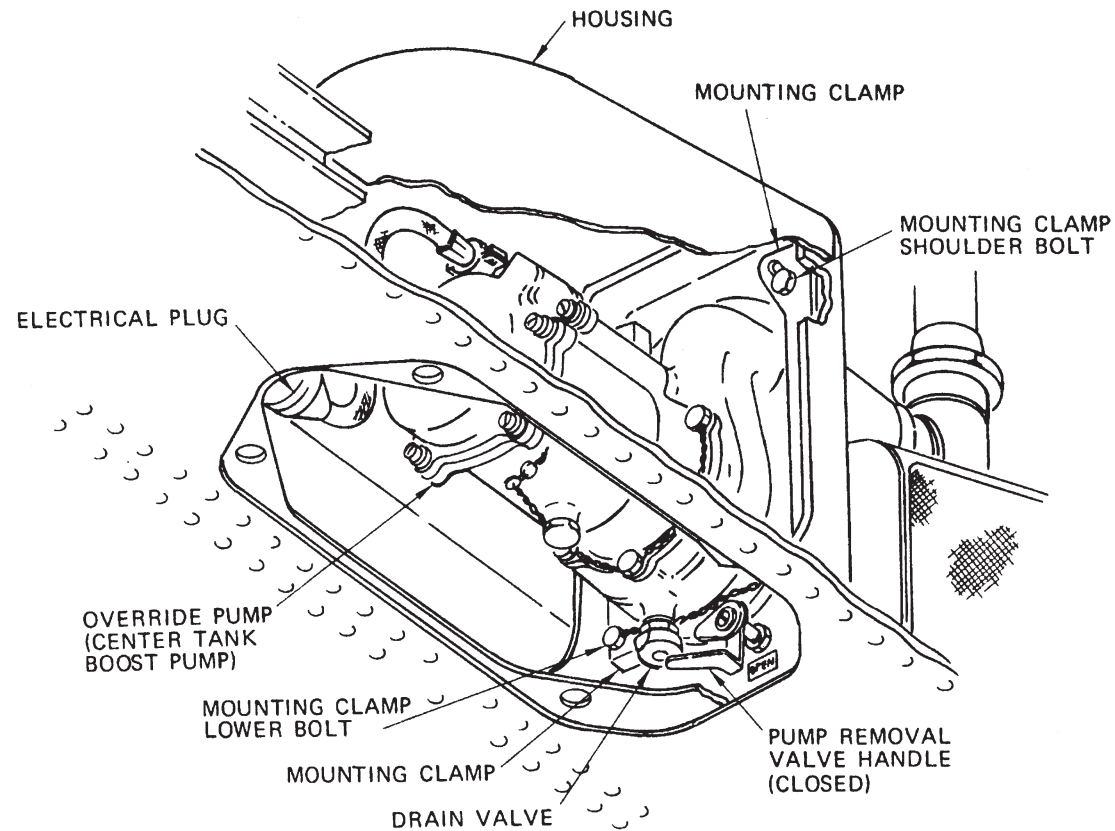


MAIN TANK BOOST PUMP INSTALLATION

6.5. Fuel Boost Override Pumps.

Two fuel boost override pumps remove fuel from the center wing tank and deliver it under pressure to the fuel manifold. The pumps are electric motor driven centrifugal type pumps using 115/200 volt 3 phase ac power. These pumps are located in the integral sections of the center wing tank, one pump to each integral section. The pumps are clamped to the inboard wall of the override pump dry bay.

Fuel enters the pump through a manually operated pump removal valve and wire mesh screen at the inlet port. The pump removal valve allows removal of the override pump without draining the center wing tank. The screen protects the pump and lines from foreign material part of the fuel being pumped is circulated through the pump to cool the motor and to lubricate the bearings. This fuel discharges through holes in the top of the motor case and mixes with incoming fuel in the pump housing. A vapor discharge line vents the pump housing to the tank. Each pump is operated independently through a fuel boost override pump switch on the flight engineer's lower panel.



VERRIDE PUMP INSTALLATION

6.6. Pump Removal Valves.

Fuel Boost Pump Removal Valve (Automatically operated).

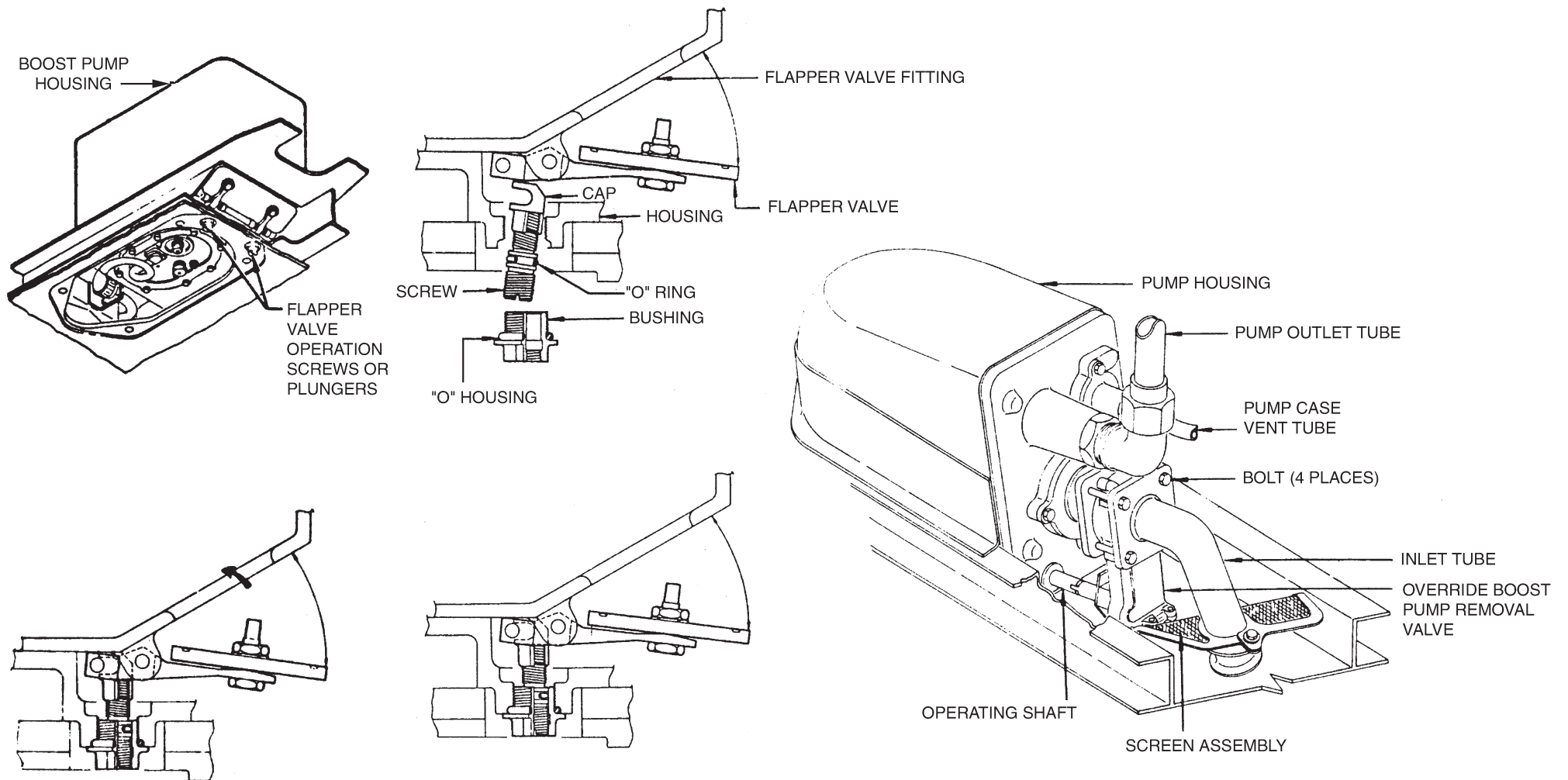
The flapper type pump removal valve permits removal of the fuel boost pumps without draining the main fuel tanks. These valves are of the hinged flapper type and are located in the inlet to the dog house type boost pump cover. They are spring loaded closed, and are open whenever the boost pump access panels are in place.

Fuel Boost Pump Removal Valve (Screw operated).

The flapper type pump removal valve permits removal of the fuel boost pumps without draining the main fuel tank. These valves are of the hinged flapper type and are located in the inlet to the dog house type boost pump cover. They are operated through two screw mechanisms, in the full closed position the screws protrude to prevent installation of the boost pump access panels.

Fuel Boost Override Pump Removal Valve.

The manually operated pump removal valve permits removal of the fuel boost override pump without draining the center wing tank. These valves are slide shutoff type valves and are located in the inlet lines of the override pumps. The valve handle projects through the wall of the fuel boost override pump dry bay, so that the valve can be manually shutoff from outside the tank.



BOOST PUMP REMOVAL VALVE SCREW OPERATING MECHANISM

6.7. Dual Check Valves.

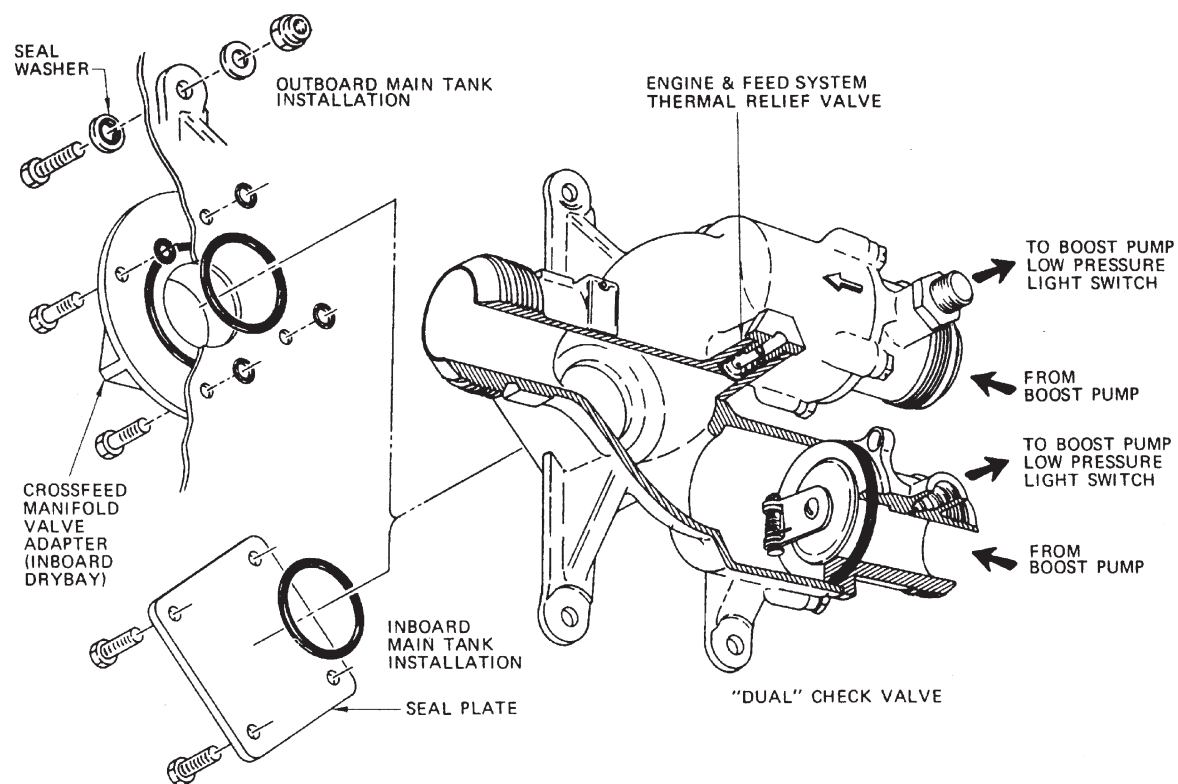
Four dual check valves, one in each main tank, prevent reverse flow into the tank. Each valve consists of a Y shaped casting having two inlet, one outlet and one manifold port. A flapper valve is fitted in each of the inlet ports which also have connections for the lines to the fuel low pressure switches.

A thermal relief valve is mounted in the wall of the outlet port. On the outboard valves the manifold port is connected to the fuel manifold, on the Imboard valves this port is not used and is fitted with a seal plate.

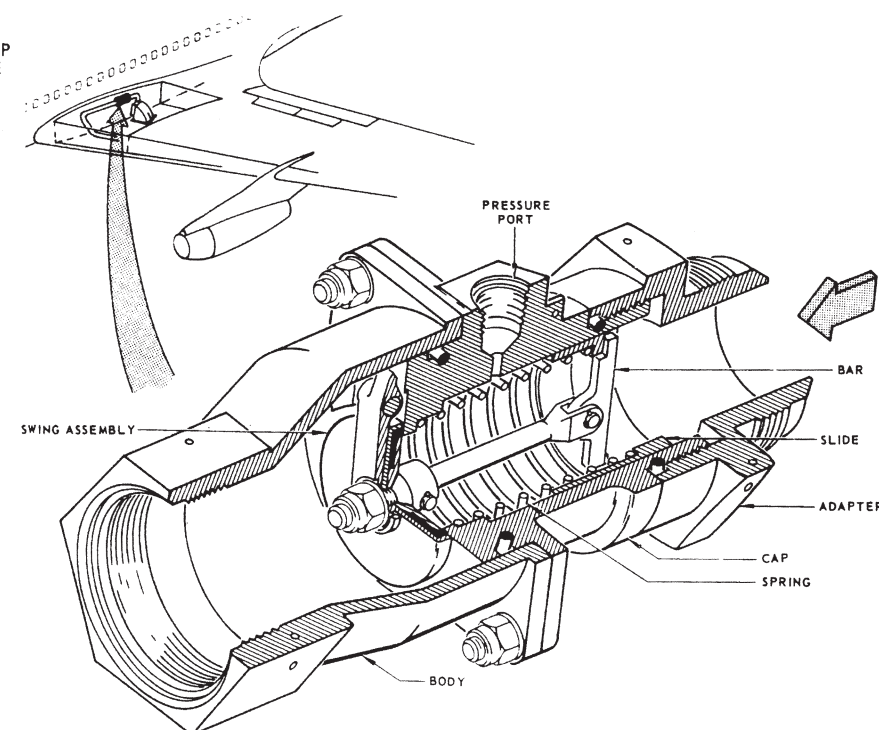
The complete dual check valve assembly is bolted to the structure in the tank. Access to the valves is through the fuel access panels in the lower wing surface. The valves permit the fuel boost pumps to supply fuel to the manifold when the boost pump discharge pressure is greater than the fuel manifold pressure. In addition the valves will prevent reverse flow to the tank at any time.

6.8. Override Pump Check Valve.

An override pump check valve prevents reverse flow into the center wing tank when its respective fuel boost override pump is inoperative, or when the center wing tank is empty. The valve assembly consists of a spring loaded closed flapper valve mounted inside a cylindrical housing. The housing has three ports : fuel in, fuel out and a pressure sensing port, which is located upstream of the flapper valve and is connected to a line leading to its respective fuel low pressure warning switch. The valves are located in the override pump discharge lines, where the fuel manifold crosses over to the other wing. When the override pump pressure exceeds the fuel manifold pressure by three psi the flapper will, open and allow the override pump to supply fuel to the manifold.

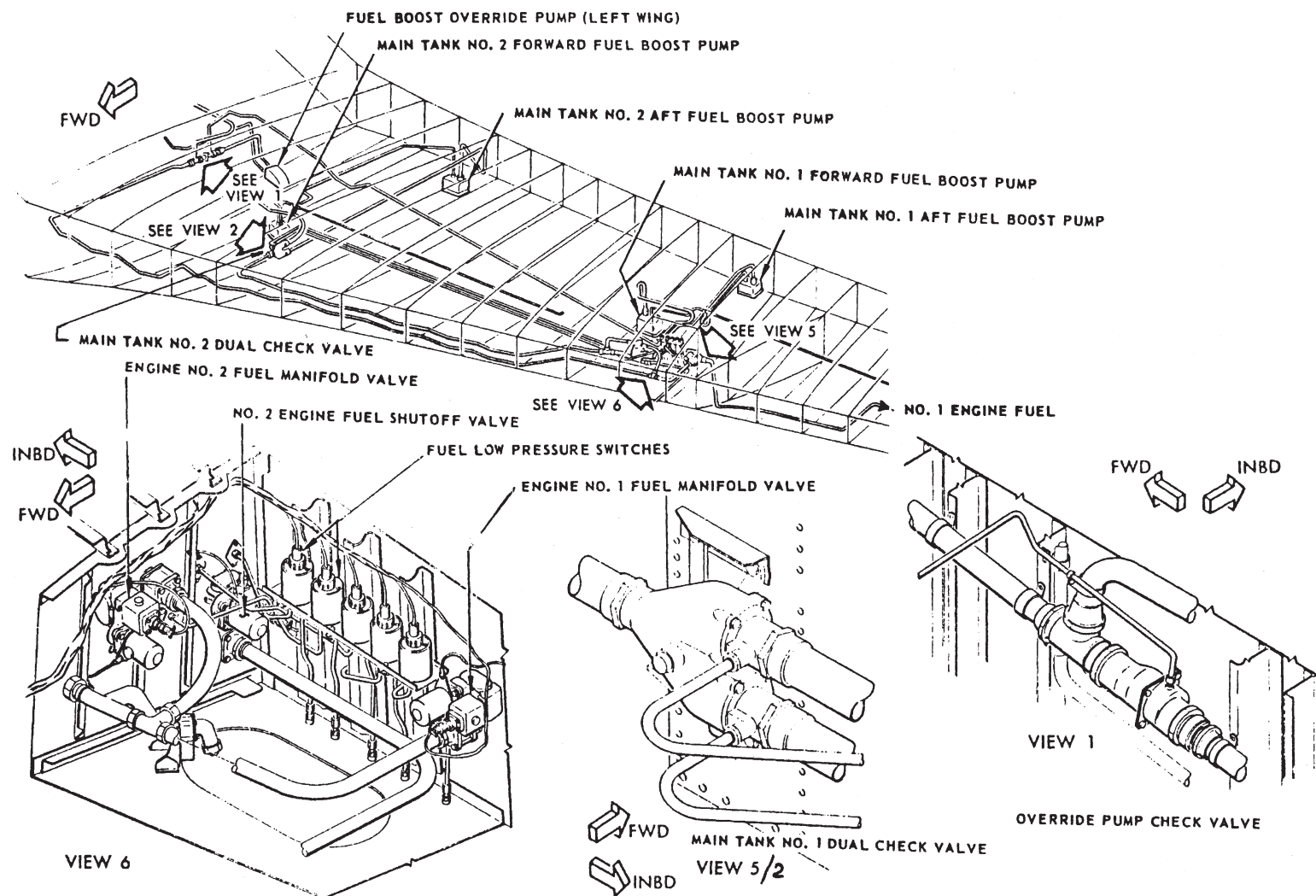


MAIN TANK BOOST PUMP CHECK VALVE



6.9. Fuel Low Pressure Switches.

Fuel low pressure warning switches control the fuel low pressure warning lights on the flight engineer's lower panel. Each switch assembly consists of a cylindrical housing containing a diaphragm and a switch. The housing has two ports, one for inlet pressure and one for venting. The pressure inlet port is connected to a sense line coming from either a dual check valve or an override pump check valve. The venting port is connected to a line leading overboard. These switches are located five in a row on a bracket in each inboard dry bay. When the pump output pressure drops below 5.5 to 6.5 Psi, the switch senses this drop in pressure and closes to complete the circuit to energize the warning light.



ENGINE FUEL FEED SYSTEM EQUIPMENT LOCATION

6.10. Operation.

The engine fuel feed system controls are located on the flight engineer's lower panel which is laid out in the form of a flow diagram. The controls consist of four lock toggle switches for the engine fuel shutoff valves, ten "ON-OFF" toggle switches for the fuel pumps and six rotary type switches for the fuel manifold and reserve tank transfer valves.

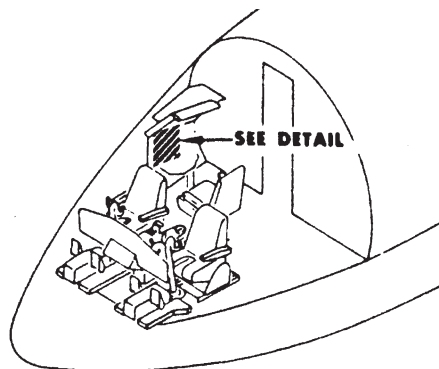
All of the valves are operated by 28 volt dc motors which receive their power through circuit breakers on the essential 28 volt circuit breaker panel (P6). All the pumps are driven by 115/200 volt three phase 400 cycle power which is supplied through circuit breakers on panels P1, P2, P3 and P4. Pumps in the same tank do not receive power from the same bus. The pump power supply has been arranged so that loss of power to one bus will affect a maximum of three pumps, two boost and one override. The two boost pumps lost will be on opposite sides of the airplane.

Operation of the system is accomplished by opening the desired manifold valves, opening the engine fuel shutoff valves and starting the pumps.

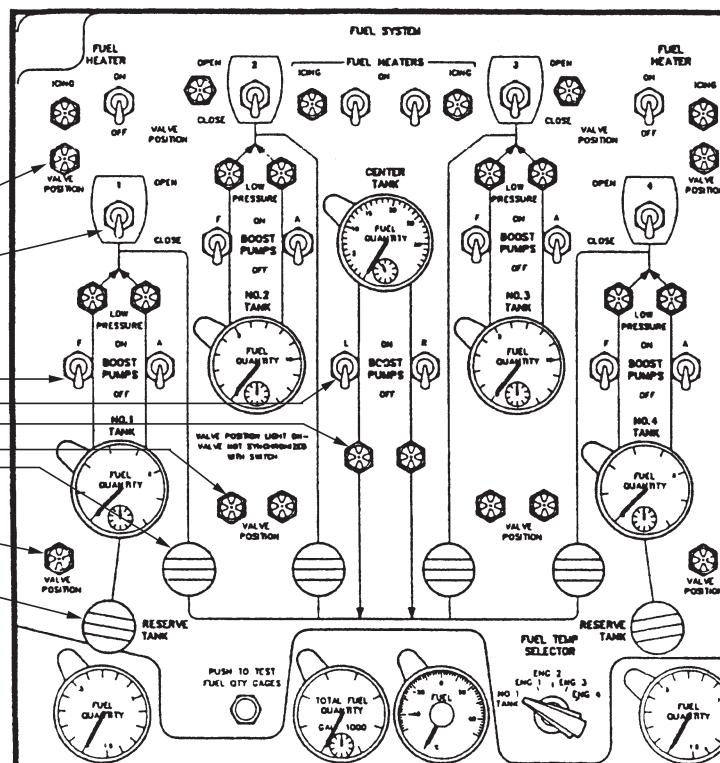
Each pump has a fuel low pressure warning light which is on when the pump is off or below normal pressure and goes off when the pump is delivering normal pressure. Each valve has a light which comes on while the valve slide is being repositioned.

When the boost pumps are operating, fuel is pumped from the tanks via the fuel feed lines where it is distributed through fuel manifold valves and engine fuel shutoff valves to the engines. The reserve tank transfer valves are kept closed until the fuel quantity in the adjoining main tank is less than 12,000 pounds (5443 kilograms). When this value is reached the fuel transfer valves may be opened.

Control of the engine fuel shutoff valves is assumed by fire switches on the pilots' light shield panel. When the switches are pulled to the "FIRE" position, the engine fuel shutoff valve switches are overridden and the valves close.



- ENGINE FUEL SHUTOFF VALVE POSITION LIGHT
- ENGINE FUEL SHUTOFF VALVE SWITCH
- BOOST PUMP LOW PRESSURE WARNING LIGHT
- BOOST PUMP SWITCH
- BOOST OVERRIDE PUMP SWITCH
- BOOST OVERRIDE PUMP LOW PRESSURE WARNING LIGHT
- FUEL MANIFOLD VALVE POSITION LIGHT
- FUEL MANIFOLD VALVE SWITCH
- RESERVE TANK TRANSFER VALVE POSITION LIGHT
- RESERVE TANK TRANSFER VALVE SWITCH



FLIGHT ENGINEER'S LOWER PANEL

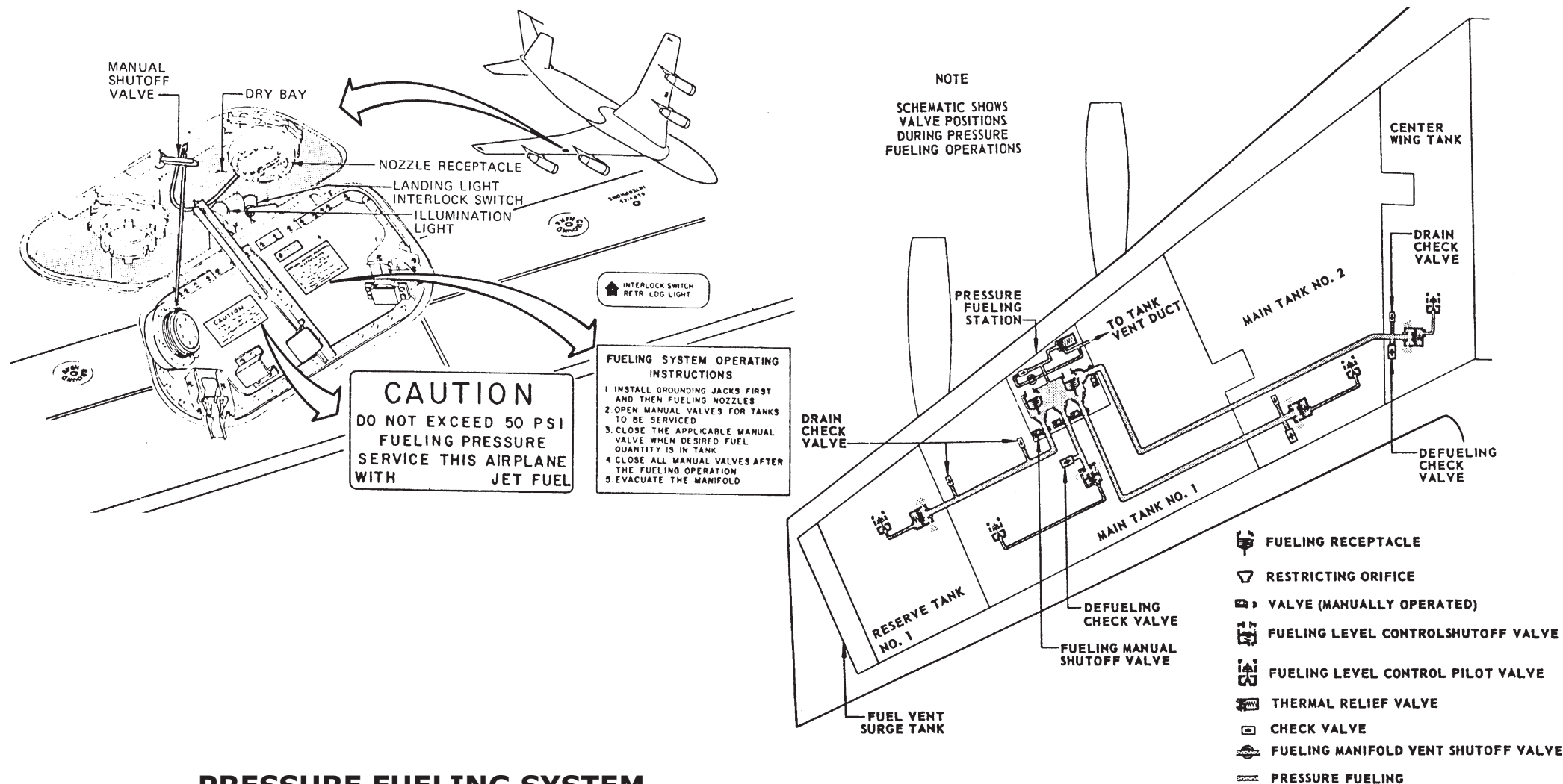
7. PRESSURE FUELING SYSTEM.

The pressure fueling system is a manually controlled system of fueling and valves which distributes fuel under pressure from two fueling lines stations to the fuel tanks at a high rate flow. Rapid partial defueling may also be accomplished through the pressure fueling system.

Each fueling station is equipped with a fueling manifold, two fueling receptacles, four fueling manual shutoff valves and two fueling hose nozzle grounding jacks. Each fuel tank is provided with a fueling level control shutoff valve and a fueling level control pilot valve. All major components are interconnected by fuel delivery lines to form the complete distribution system.

CAUTION: TO PREVENT POSSIBILITY OF PRESSURE FILLING STATION ACCESS DOORS INTERFERING WITH THE WING LEADING EDGE FLAP, THE DOORS MUST NOT BE OPENED BEYOND THEIR NORMAL DETENT POSITION.

The fueling operation consists essentially of coupling the fuel hose nozzles to the receptacles, opening the fueling manual shutoff valves and pumping fuel to the tanks. An automatic shutoff feature limits the fuel that may be pumped aboard and therefore prevents overfilling the tanks.



PRESSURE FUELING SYSTEM

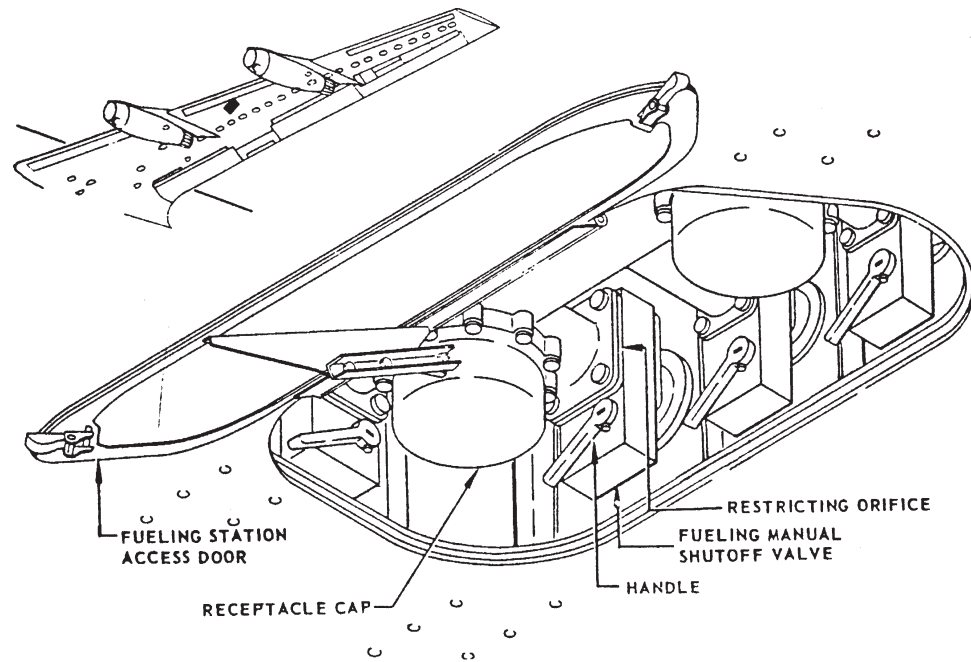
7.1. Fueling Manifold.

The fueling manifold is the distribution center of the pressure fueling system. The manifold consists of an aluminum tubing assembly with two inlet ports, four outlet ports, a vent port and two support brackets. Hangers attach to the support brackets to secure the manifold to the wing structure at the pressure fueling station. Chains that retain the receptacle cams are attached to the bottom of the manifold. A fueling receptacle is attached at each inlet port, and a fueling manual shutoff valve is attached at each outlet port. Fuel delivery to the manifold is controlled at the feed source and fuel distribution from the manifold is controlled by the fueling manual shutoff valves.

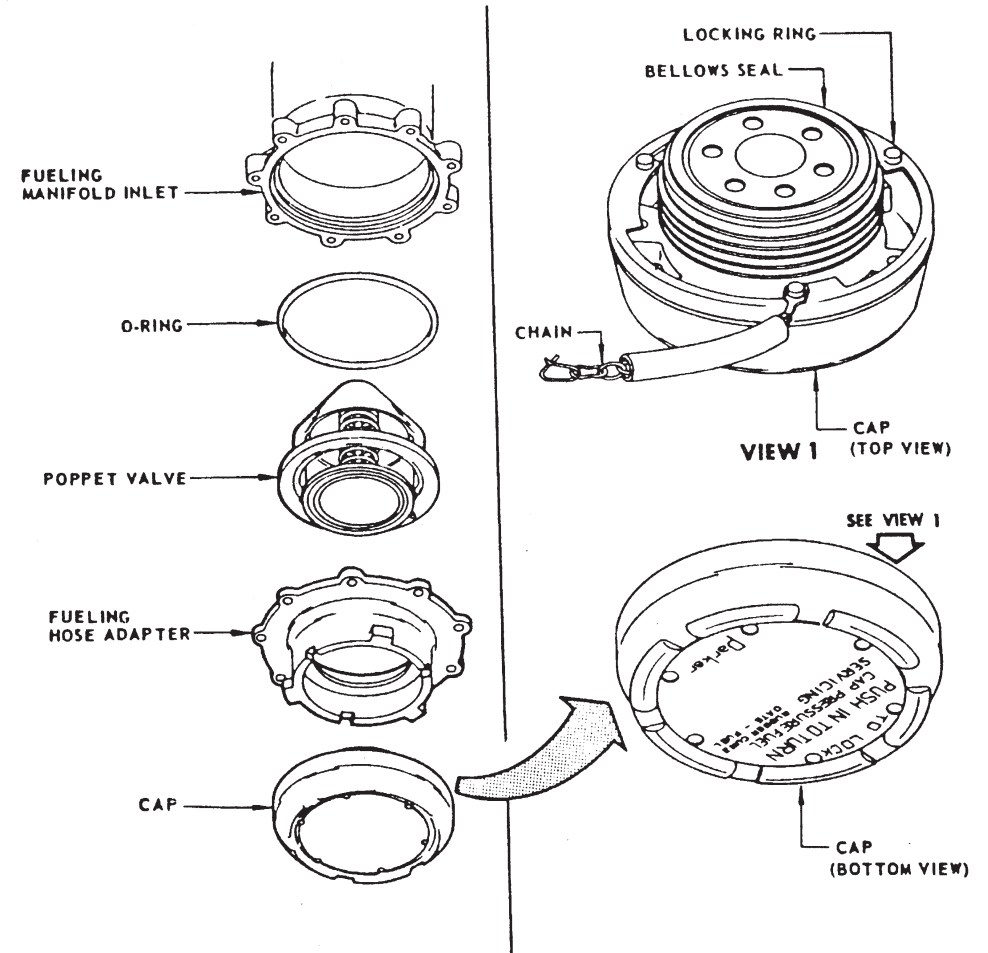
7.2. Fueling Receptacle.

Two fueling receptacles adapt each fueling manifold to receive the hose nozzles. Each receptacle contains a valve which seals the manifold inlet when the fuel hose is disconnected. The receptacle consists of a fueling hose adapter and a spring loaded poppet valve. The poppet valve is clamped between the manifold inlet and the fueling hose adapter flange. Each adapter has mating lugs which couple and secure the fuel hose. A plunger in the fueling hose nozzle opens the poppet valve to allow fuel to flow through the nozzle into the manifold.

Two fueling receptacle caps cover and seal the fueling receptacles when fueling operations are completed. Each cap consists of a housing, a locking ring and a bellows seal. The locking ring couples with the lugs on the receptacle to secure the cap. A short piece of chain attaches the cap to the manifold to prevent the cap from getting lost or damaged. The cap is manually forced up and twisted into the locked position to create a compression seal on the fueling hose adapter.



PRESSURE FUELING STATION



FUELING RECEPTACLE AND CAP

7.3. Fueling Manual Shutoff Valves.

Eight fueling manual shutoff valves perform the function of controlling fuel distribution to all of the fuel tanks. Four of these valves are located at each fueling station between the manifold outlet ports and the fueling line bulkhead fittings. These valves consist of a ported housing, a sliding gate and a manually operated handle. All valves are secured by attachment bolts which clamp them between the flanges of the manifold and the bulkhead fittings. The valve handles are manually positioned to either "OPEN" or "CLOSED" to control fueling distribution.

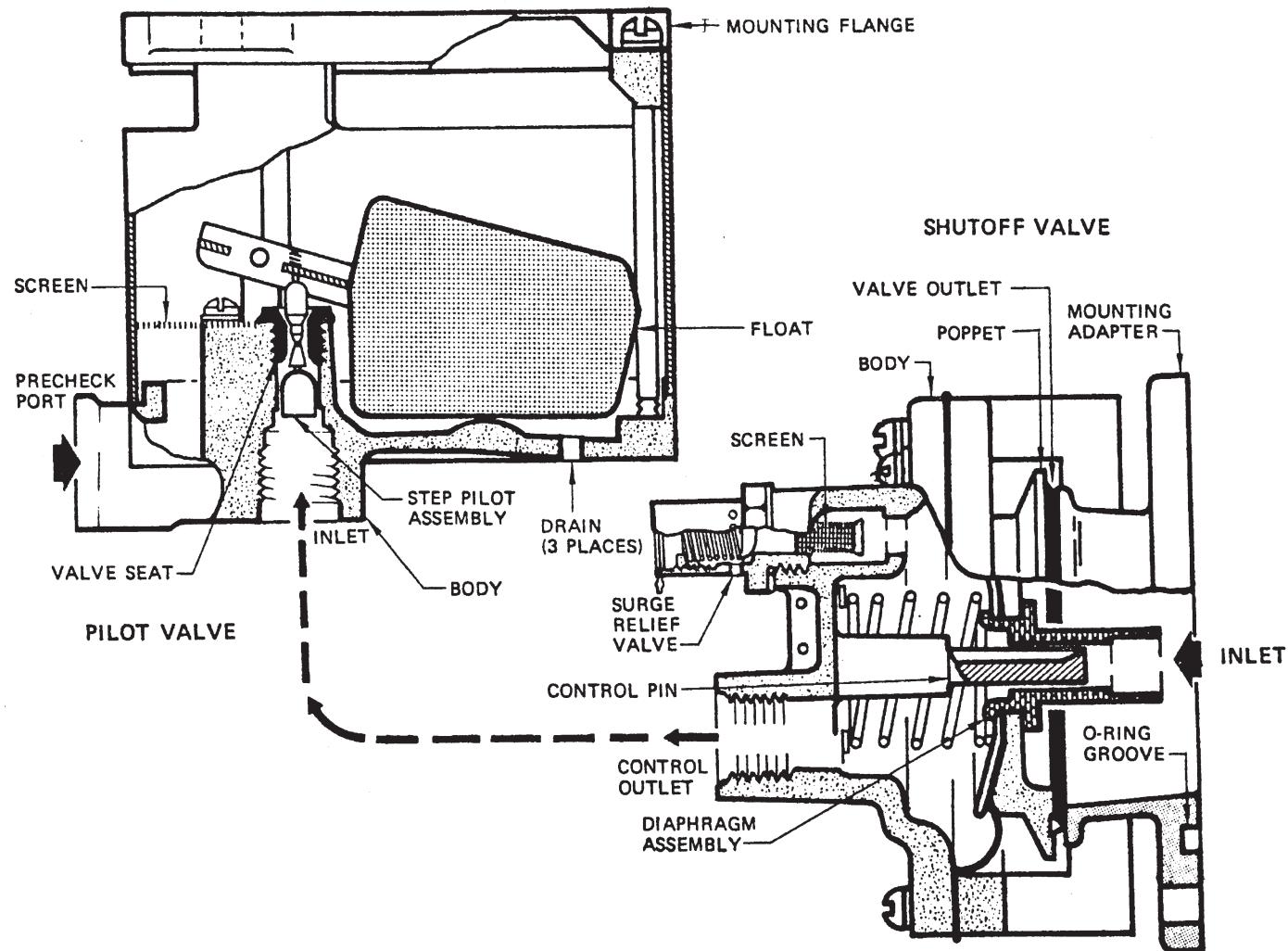
7.4. Fueling Level Control Pilot Valve.

The fueling level control pilot valve limits the quantity of fuel that can be pumped into a tank, by automatically controlling the closing of the fueling level control shutoff valve. Each valve assembly consists of a cylindrical valve housing, a float and a poppet. The valve is bolted to a bracket at the top of the tank and is connected to the fueling level control shutoff valve through a pilot line. The float actuates the poppet to close a pilot port in the base of the housing. This builds up pressure in the pilot line and closes the fueling level control shutoff valve.

7.5. Fueling Level Control Shutoff Valve.

The fueling level control shutoff valve in each tank automatically stops fuel flow into a tank when its respective fueling level control pilot valve senses a full tank condition. The valve housing is separated into two chambers by a diaphragm. The forward chamber contains the fueling line inlet port and the fueling outlet ports. The aft chamber contains a sensing port and a spring. The two chambers are connected by a small bleed hole through a poppet in the center of the diaphragm.

The valve attaches to a bulkhead fitting where the fueling line enters the inside of a tank. A pilot line connects the sensing port of the aft chamber to the fueling level control pilot valve. Closing of the fueling level control pilot valve builds up pressure in the pilot line and aft chamber equal to the fueling pressure in the forward chamber. This enables the spring to close the poppet, which stops the flow of fuel into the tank. After fueling pressure is removed from the line, the spring keeps the poppet closed to prevent the fuel in the tank from re-entering the lines ahead of the shutoff valve.



AUTOMATIC FUELING LEVEL VALVES

7.6. Miscellaneous Components.

Restricting Orifice Plates.

A restricting orifice plate in each pressure fueling line limits the maximum fueling rate for that tank. The orifices are holes of a specific diameter bored through flat plates which are clamped between the fueling manifold outlet flanges and the fueling manual shutoff valves.

Fueling Manifold Vent Check Valve.

The fueling manifold vent check valve vents the manifold to the fuel tank vent system to facilitate evacuation. The valve is located in a vent line leading from the manifold. The valve is spring loaded closed, but is set to open and vent the manifold when a negative pressure of approximately 0.5 psi exists in the manifold.

Drain Check Valve.

Drain check valves on some pressure fuelling lines permit fuel to drain from the line into the tank when fueling pressure is released. Each valve is a spring loaded poppet valve which is kept closed by the fueling pressure in the line. The valve returns to its normally open position when the pressure in the line drops below 2.5 psi. Main tanks N°2, 3 and center wing tanks each have one valve fitted in a downward position. The reserve tanks each have two valves : the inboard ones being fitted in a downward position and the outboard ones in an upward position. Main tanks N°1 and 4 pressure fueling lines are not fitted with drain check valves.

Thermal Relief Valve.

The thermal relief valve relieves the manifold from excessive pressure buildup due to thermal expansion of the fuel. The valve is a spring loaded poppet valve fitted into a vent line from the manifold. The valve is set to start opening at approximately 70 psi and reseal at approximately 60 psi.

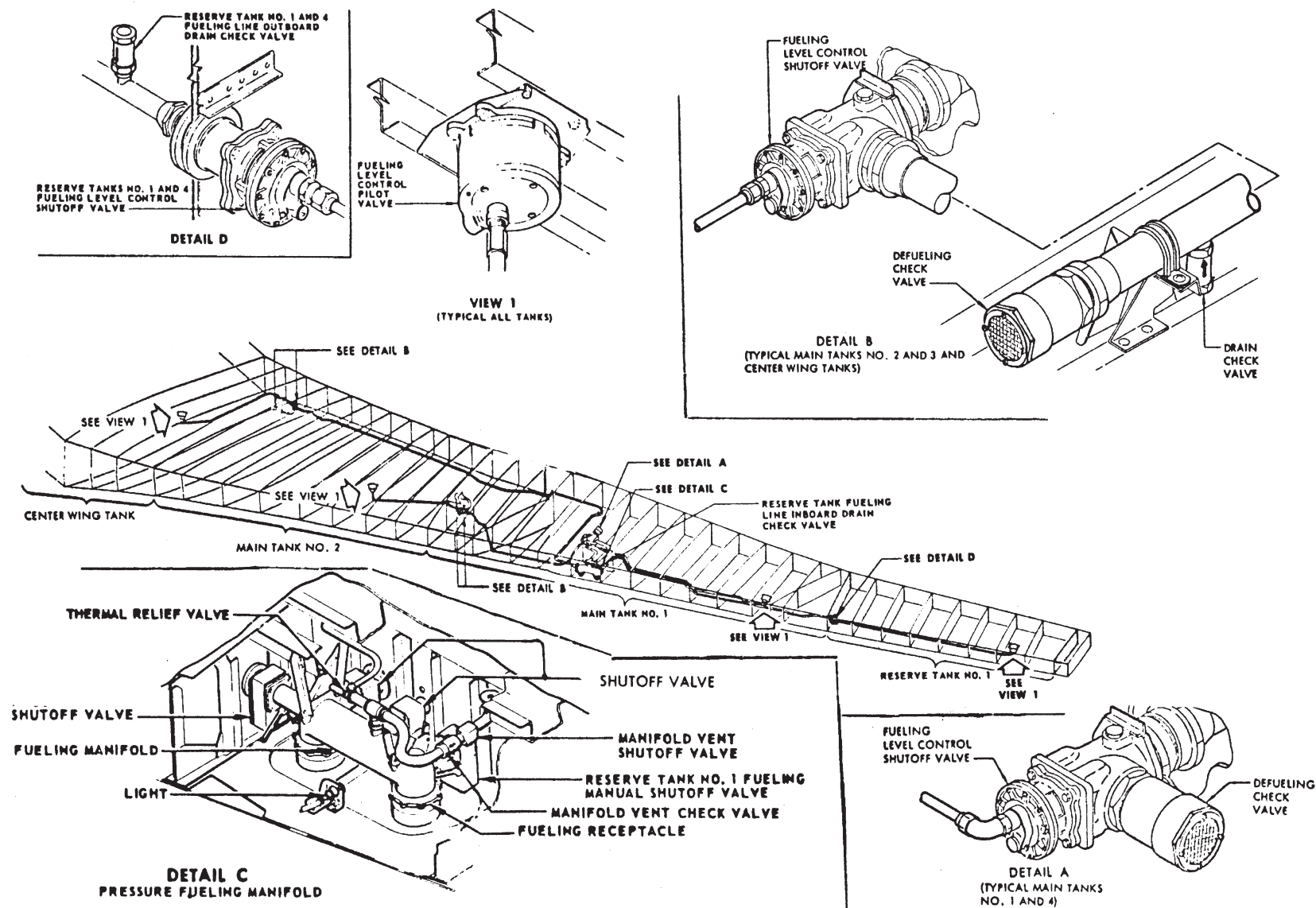
Defueling Check Valve.

Defueling check valves adapt the pressure fueling system for defueling.

The valves are connected to the end of the branches of the fueling lines in each of the main and center wing tanks. Each valve is of the hinged flapper type, and is spring loaded closed. When fuel is being delivered into the tanks, the fuel pressure in the fueling line keeps the flapper closed. When suction is applied to the fueling lines, the flapper opens and fuel flows from the tank into the pressure fueling line. In this manner by applying pump suction to the fueling manifold, fuel is drawn from the fuel tanks. The tanks cannot be completely defueled by this method. Defueling has to be completed through the defueling valve.

Fueling Manifold Vent Shutoff Valve.

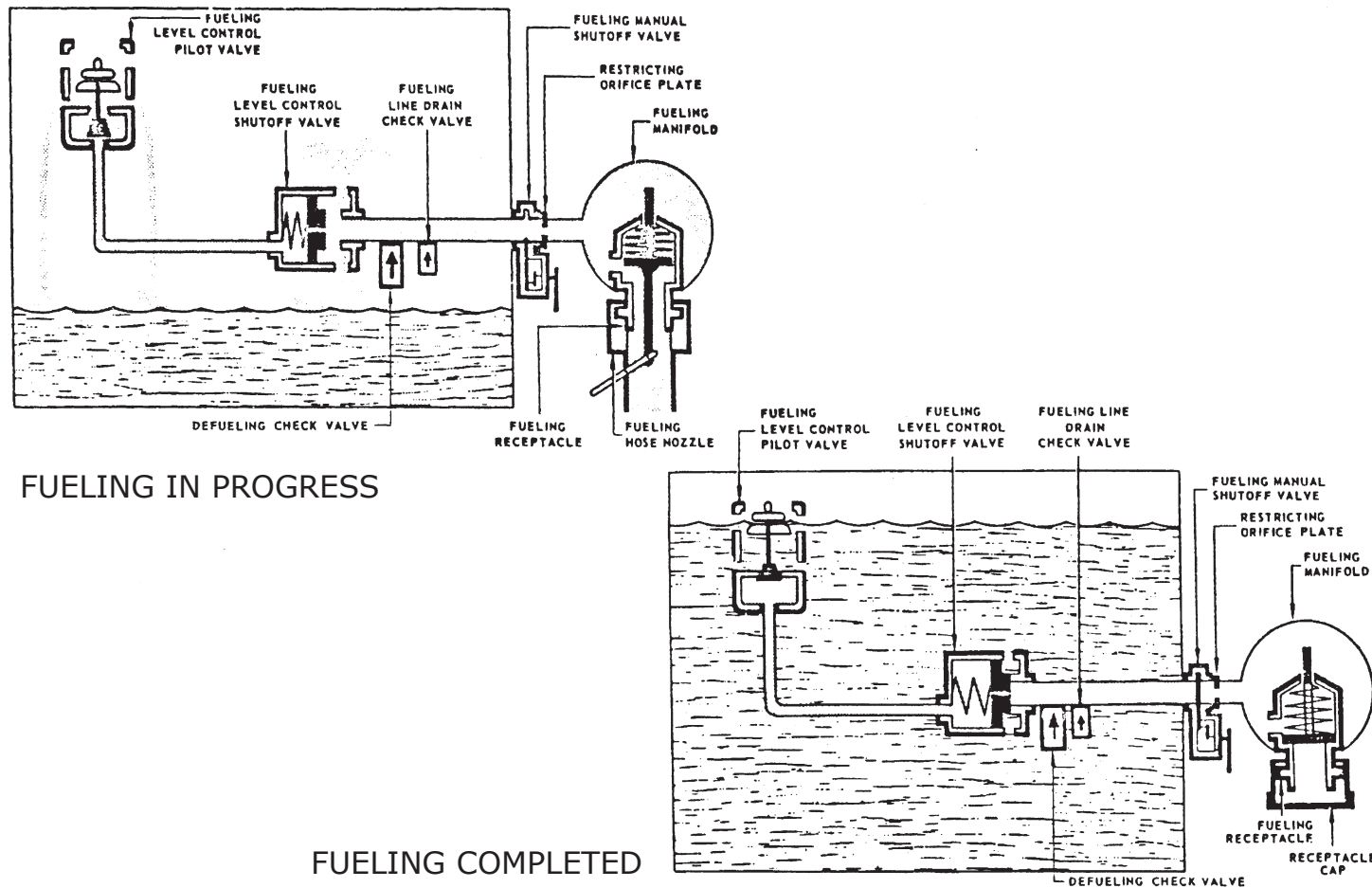
The fueling manifold vent shutoff valve located in the vent line of each fueling manifold allows the vent line to be closed. The valve is a manually operated drain cock type and is normally in the open position. When the valve is in the closed position, the pressure fueling system can be used to partially defuel the tanks.



7.7. Operation.

When fueling the airplane, fuel will flow into the tanks until a full fuel load is aboard, therefore if partial fueling is desired, the fuel quantity gages, on the flight engineer's panel, or the dripsticks must be monitored till the required amount of fuel is indicated ; at this time the manual fueling shutoff valves should be closed. If the fuel quantity gages are being monitored, external power must be connected to the airplane and the fueling switch, adjacent to the external power receptacle, must be in the "ON" position.

With the fueling hoses connected to the receptacles and the manual fueling shutoff valves open, the airplane is ready to receive fuel. Starting the pump operation pressurizes the fueling manifold and lines. This fueling pressure forces open the fueling level control shutoff valves and fuel flows into the tanks. If the manual shutoff valve is not closed fuel continues to flow until the fuel level is sufficient to actuate the fueling level control pilot valve, which in turn closes the fueling level control shutoff valve.



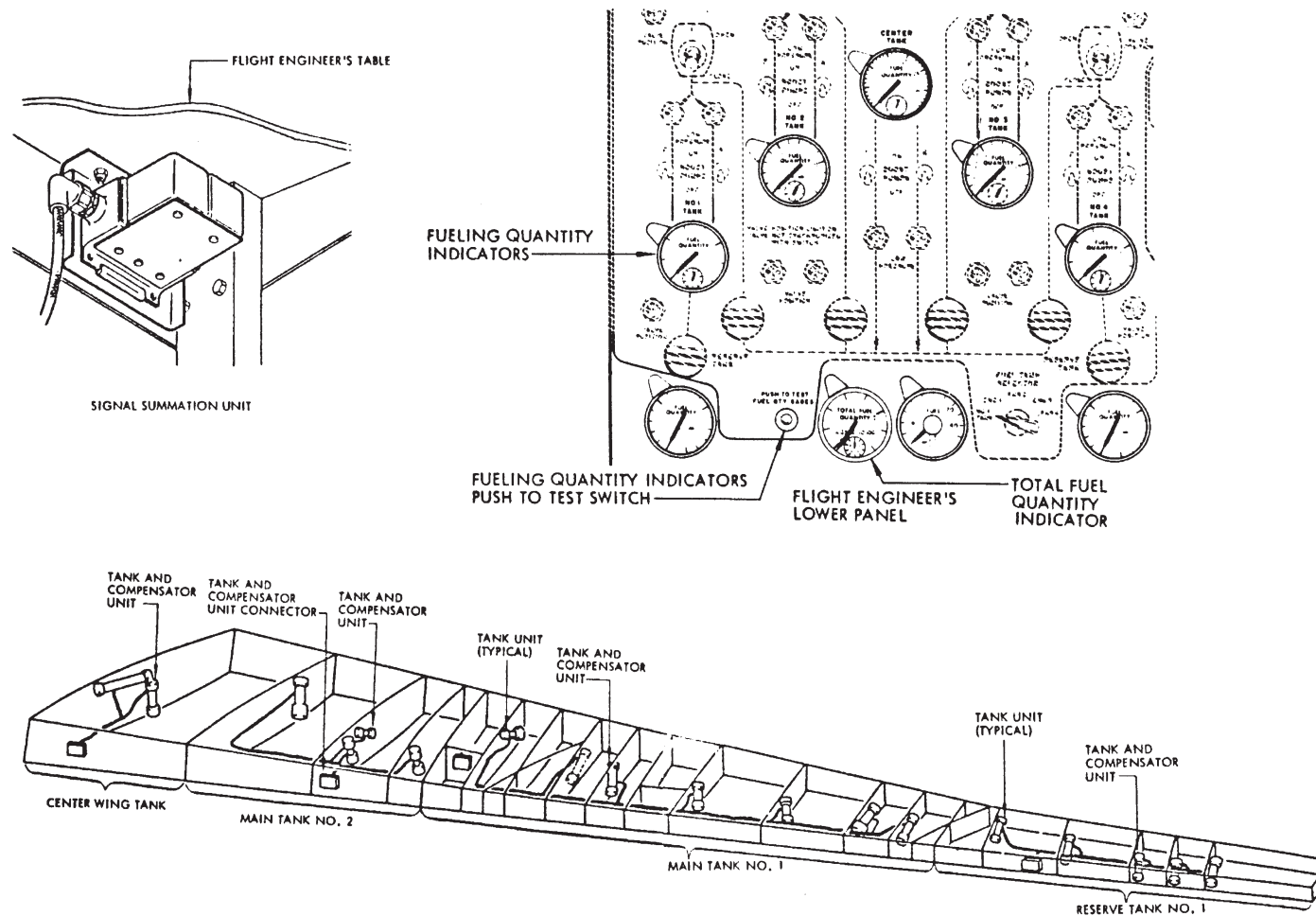
FUELING LEVEL CONTROL FLOW DIAGRAM

8. FUEL QUANTITY INDICATING SYSTEM.

The fuel quantity indicating system shows the weight of fuel aboard the airplane. The quantity in kilograms appears on indicators at the flight engineer's station. System components are located in the control cabin, fuel tanks and at the two fueling stations. Control cabin equipment consists of seven individual fuel quantity indicators, a signal summation unit, a fuel quantity indicator unit and a fuel quantity push to test switch. Fuel tank components consist of tank units and compensator tank units.

The overall system consists of seven individual systems, one for each tank. Each individual tank system consists of an indicator, a compensator tank unit and tank units as required. Tank units for each tank are connected in parallel and positioned so that only usable fuel is measured. Fuel is the variable dielectric. Capacitance values in each tank are added to give a single capacitance value, which is transmitted to each fuel quantity indicator.

The fuel quantity indicator shows continuously the weight of fuel remaining in each tank. A signal from each indicator is transmitted to the signal summation unit which gives an output signal to the total fuel quantity indicator. This shows a continuous reading of total usable fuel remaining.



FUEL QUANTITY INDICATING SYSTEM EQUIPMENT LOCATION

8.1. Tank Units.

The tank units are variable capacitors located throughout each fuel tank to sense quantity of fuel in each tank. The tank unit consists of two concentric electrodes which are rigidly spaced at intervals throughout their length by insulating centering spacers. The inner electrode consists of main body insulated material with two separately conducted surfaces around its outside face. One conducting surface is grounded, the other is connected to the amplifier input of the system bridge circuit. This conducting surface is, proportionate to tank contour, so that the submerged conducting surface has a relation to fuel level in the tank. This conductive surface is profiled for an accurate linear indication in the cruise flight attitude. Opening at each end of the unit permits fuel to assume the same level between the electrode as that in the tank. Tank units are located so that errors due to airplane attitudes are kept to a minimum.

Tank units are bolted to structure at the wing ribs. Electrical connections to tank units are made at the tank unit terminals. Tank unit leads, within a given tank, form a harness (two harnesses in wing center tank) which terminate at a connector on the front spar of the wing. There is one tank and compensator tank unit connector for each main and reserve tank, and two for the wing center tank.

Access to tank units is made through fuel tanks access panel and rib access openings. Access to tank and compensator unit receptacles is made through wing leading edge access panels.

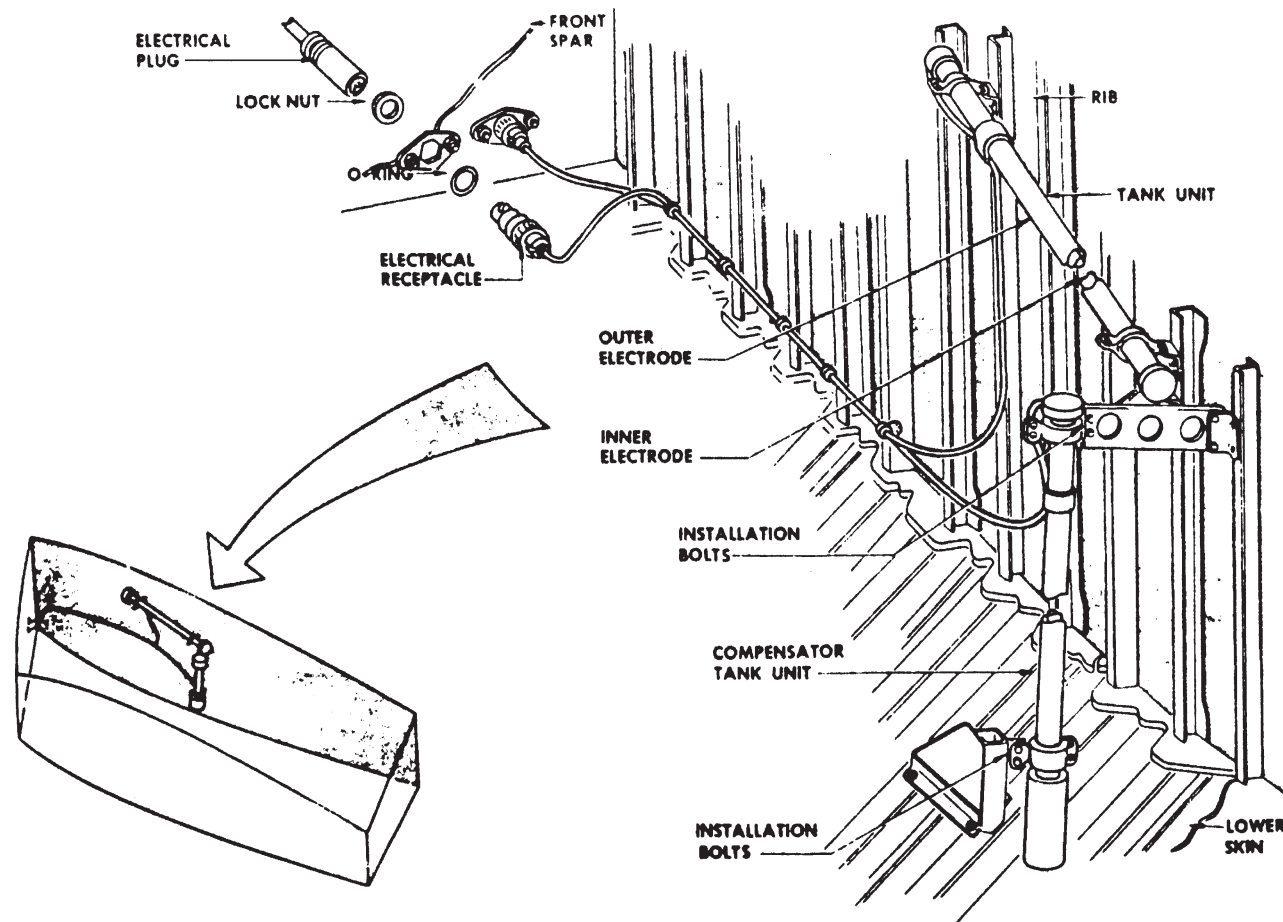
Tank units in each tank are connected in parallel for sensing fuel quantity. The fuel is the variable dielectric. Capacitance of the tank units, in any one tank, add up to give a single capacitance which changes with fuel level and provides a continuous signal to the fuel quantity indicator.

8.2. Compensator Tank Units.

The compensator tank unit in each tank acts as a sensing element to maintain linear relationship between fuel dielectric properties and fuel density. Each compensator tank unit is composed of two independent capacitors, a tank unit and a compensator. The tank unit portion corresponds to the description given in the preceding paragraphs. The compensator portion consists of a group of concentric tubes spaced and insulated from each other by insulation spacers. The compensator is attached to the lower end of the tank unit and is situated at the lowest usable level of fuel. The access panels, connectors and mountings for compensator tank units are the same as for tank units.

The compensator portion of a compensator tank unit is part of the balance side of the capacitance bridge. Changes in temperature and fuel characteristics affect the capacitance of the compensator which is usually completely immersed in fuel. The compensator alters balance conditions for the bridge circuit to allow for these changes.

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TYPICAL TANK UNIT AND COMPENSATOR TANK UNIT INSTALLATION

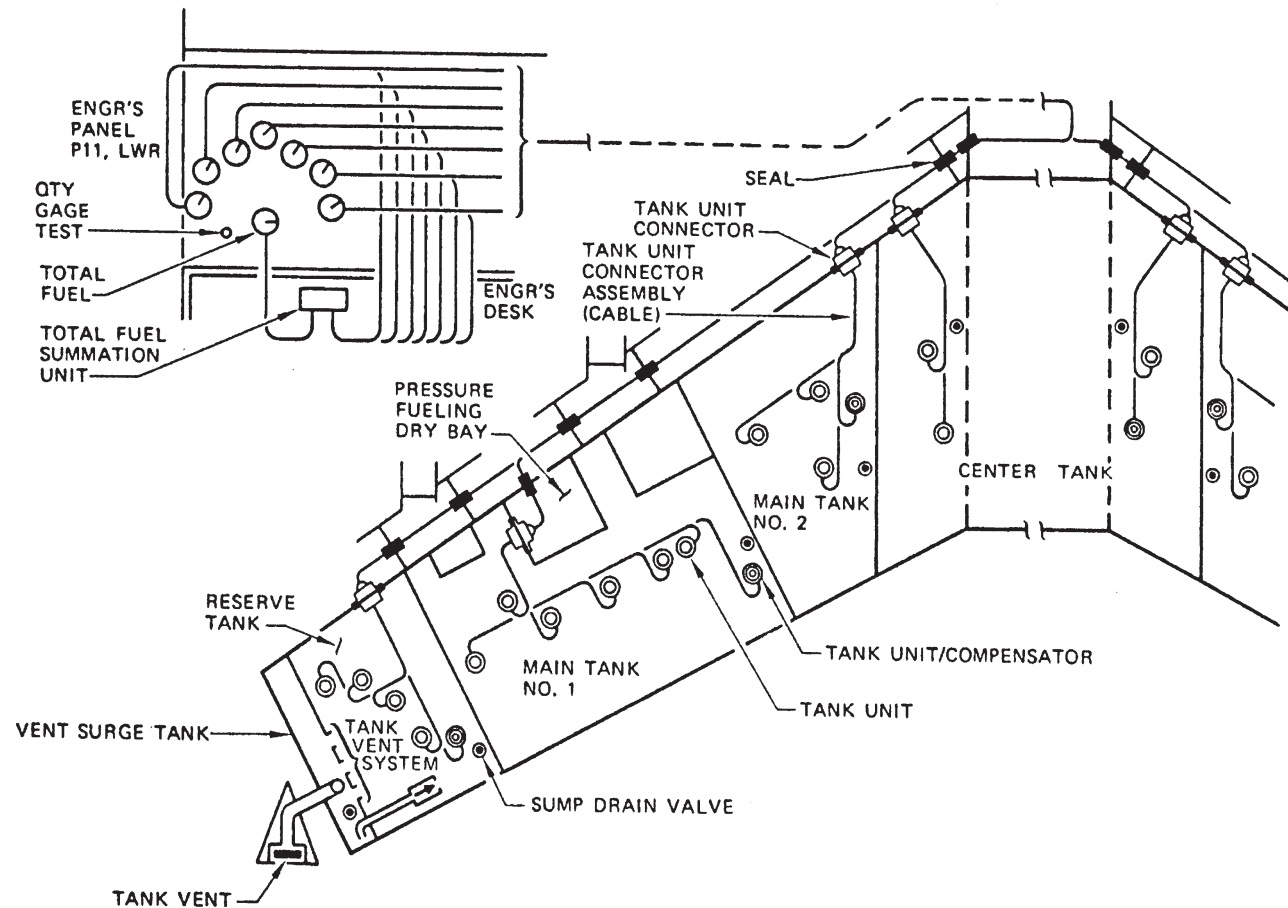
8.3. Fuel Quantity Indicators.

The fuel quantity indicators, located on the flight engineer's lower panel, show weight of fuel in kilograms, in each of the seven fuel tanks.

The indicator used for each individual tank indicating circuit consists of a self balancing capacitance bridge circuit, a three stage transistor amplifier, a reversible two phase induction motor, gear trains, pointers, a main dial and a vernier dial. All indicators are hermetically sealed and electrical connections are made through a plug at the rear of the indicator. Full and empty adjustment screws are located on the back of each indicator.

The indicators use 115 volt ac power for the bridge and line phase of the induction motor. Indicator pointers are driven by the same shaft as the potentiometer wiper of the self balancing bridge circuit and rotate with the wiper to provide continuous indication of fuel quantity. A signal from the balance potentiometer wiper of each individual tank system indicator is transmitted to the signal summation unit.

Indicator operation is tested with a fuel quantity indicators push to test switch located on the flight engineer's lower panel. The switch, when pressed, grounds the tank unit portion of the circuit for each fuel quantity indicator. This unbalances the bridge circuit and causes the indicator pointer to drive toward zero. When the switch is released, the dial pointers return to their original position.



FUEL QUANTITY INDICATING SYSTEM

8.4. Signal Summation Unit.

The signal summation unit sums balance voltage signals from each fuel quantity indicator and gives an output signal to the total fuel quantity indicator. The unit is a voltage summator consist of two hermetically sealed ratio units. Each ratio unit contains either three or four voltage summing networks consisting of a tailored voltage divider for each individual tank system indicator. A cover plate on one side of the unit protects adjustment screws for the voltage dividers.

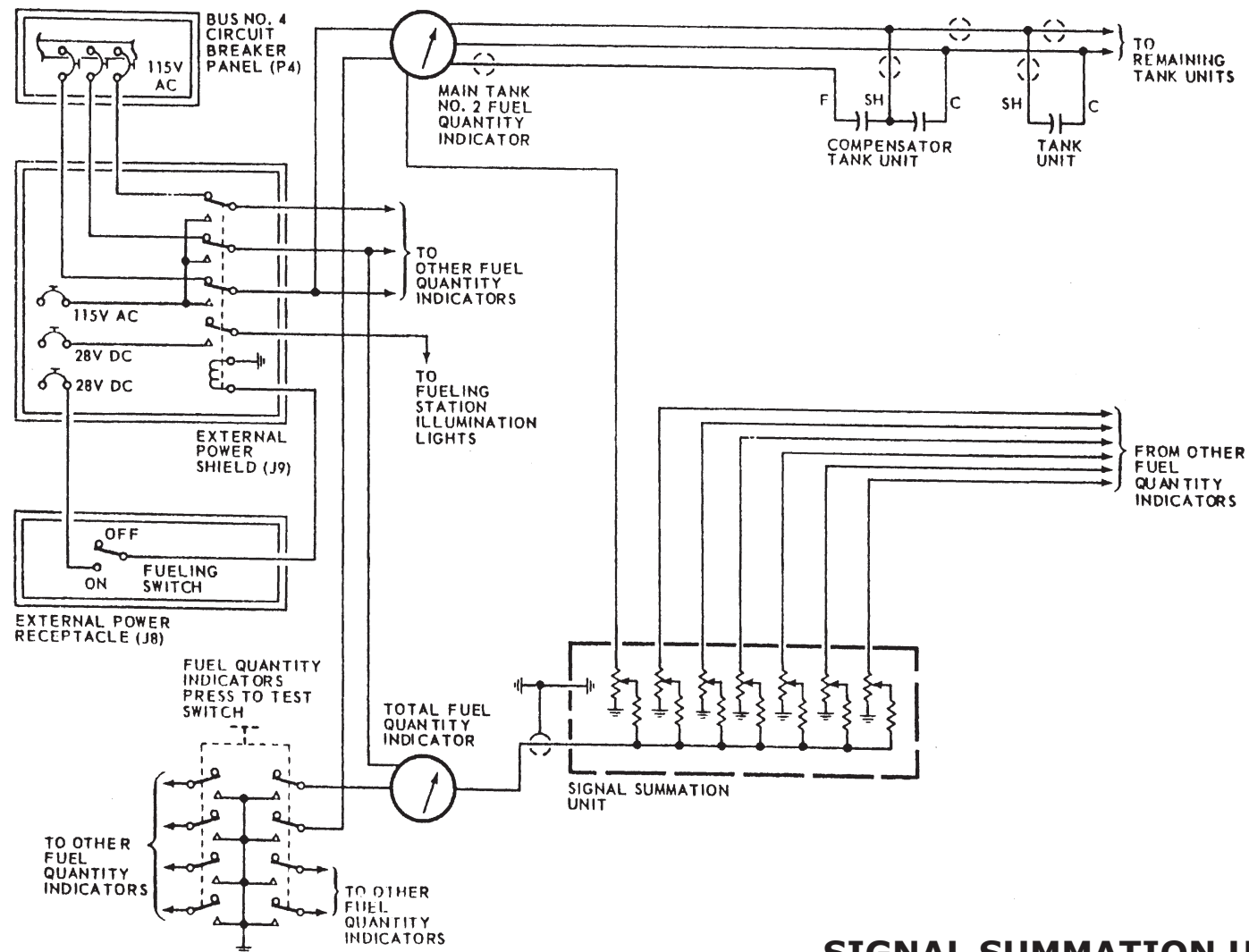
The signal summation unit is mounted on a bracket underneath the flight engineer's table in the right rear corner.

8.5. Total Fuel Indicator.

The total fuel quantity indicator, located on the flight engineer's lower panel shows a total fuel quantity reading which is the sum of all individual fuel indicator readings. The indicator uses a resistance bridge circuit and balances signal summation output against a potentiometer arranged similarly to the motor driven potentiometer in a fuel quantity indicator. The instrument has empty adjustment only.

Total fuel quantity indicator operation can be tested with the fuel quantity indicators push to test switch on the flight engineer's lower panel.

The switch, when closed, unbalances the bridge circuit in the indicator and causes the dial pointer to drive toward zero. When the switch is released, the dial pointer should return to its original position.

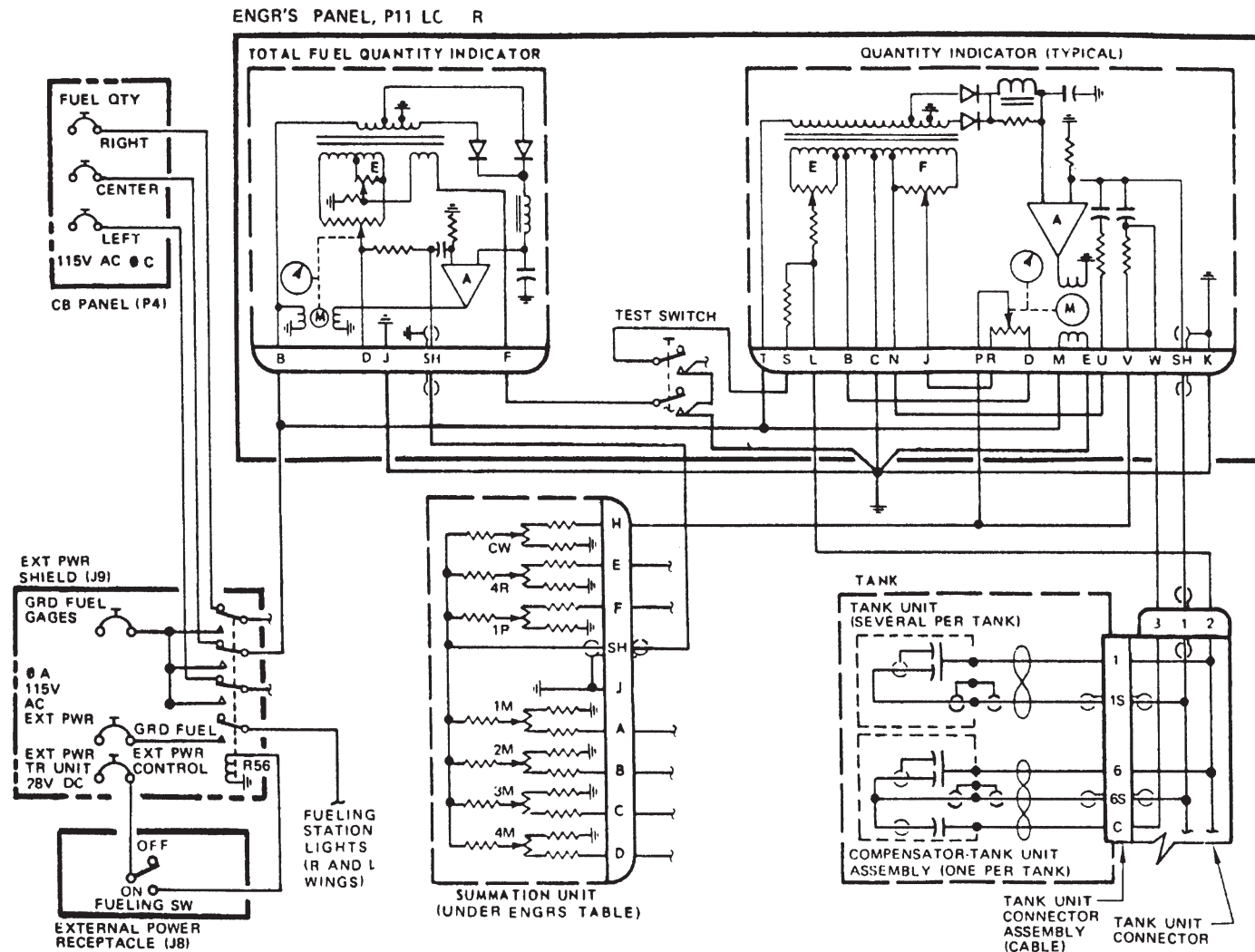


SIGNAL SUMMATION UNIT

8.6. Operation.

Power for operation of the fuel quantity indicating system is 115 volt ac supplied through FUEL QUANTITY circuit breakers an ac bus N°4 circuit breaker Panel (P4). Closing the circuit breakers delivers power to the individual tank system circuits and total fuel quantity indicator circuit through transformers in the indicators.

The tank units act as variable capacitors. Their capacitance value is determined by fuel level and properties of the fuel. They are connected into a capacitance bridge so that current through the tank unit side of the bridge is compared to a current of opposite phase in the balancing side of the bridge. A change in fuel level alters capacitance value of the tank unit and causes unbalance in the bridge circuit which is detected by a phase sensitive amplifier. This amplifier controls an induction motor which moves a rebalance potentiometer wiper Jin the reference side of bridge until a null point is again established in the system. The indicator dial pointer is connected to the potentiometer wiper and shows a fuel quantity reading corresponding to the null balance point.



FUEL QUANTITY INDICATING SYSTEM SCHEMATIC

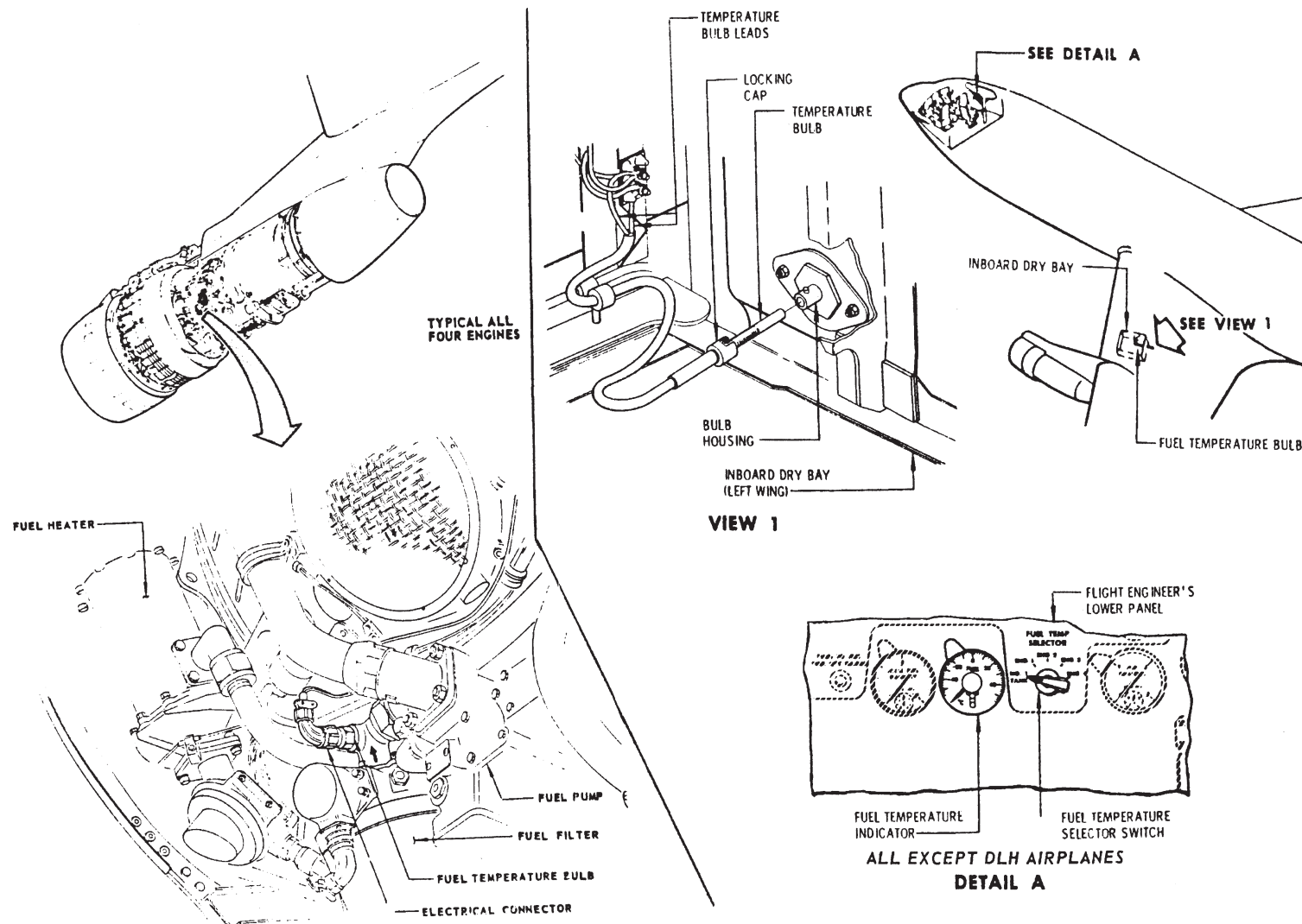
9. FUEL TEMPERATURE INDICATING.

The fuel temperature indicating system is used to monitor the temperature of the fuel where it leaves the fuel deicing heater on each engine and to indicate the fuel temperature of main tank N°1. A fuel temperature indicator is located on the flight engineer's lower panel. A temperature sensing bulb is located in the fuel deicing filter outlet on each engine and one in fuel tank N°1. A five position fuel temperature selector switch located adjacent to the indicator permits selection of fuel temperature readings from any of the five different locations.

9.1. Fuel Temperature Bulbs.

In main tank N°1 the temperature bulb is an armored, bayonet locking, type bulb. It has a temperature range of -50 to +300°C. The resistance at 0°C is 90.38 ohms. The bulb is contained in a housing which projects into main tank N°1 through the aft wall of the inboard dry bay. The housing is integral with the tank wall, and allows the bulb to be removed without draining the tank.

The temperature bulb in each of the engine fuel systems has the same electrical characteristics as that in main tank N°1. These bulbs are screwed into a tee on the fuel filter outlet in direct contact with the fuel and when removed cause draining of fuel lines in the power plant area.

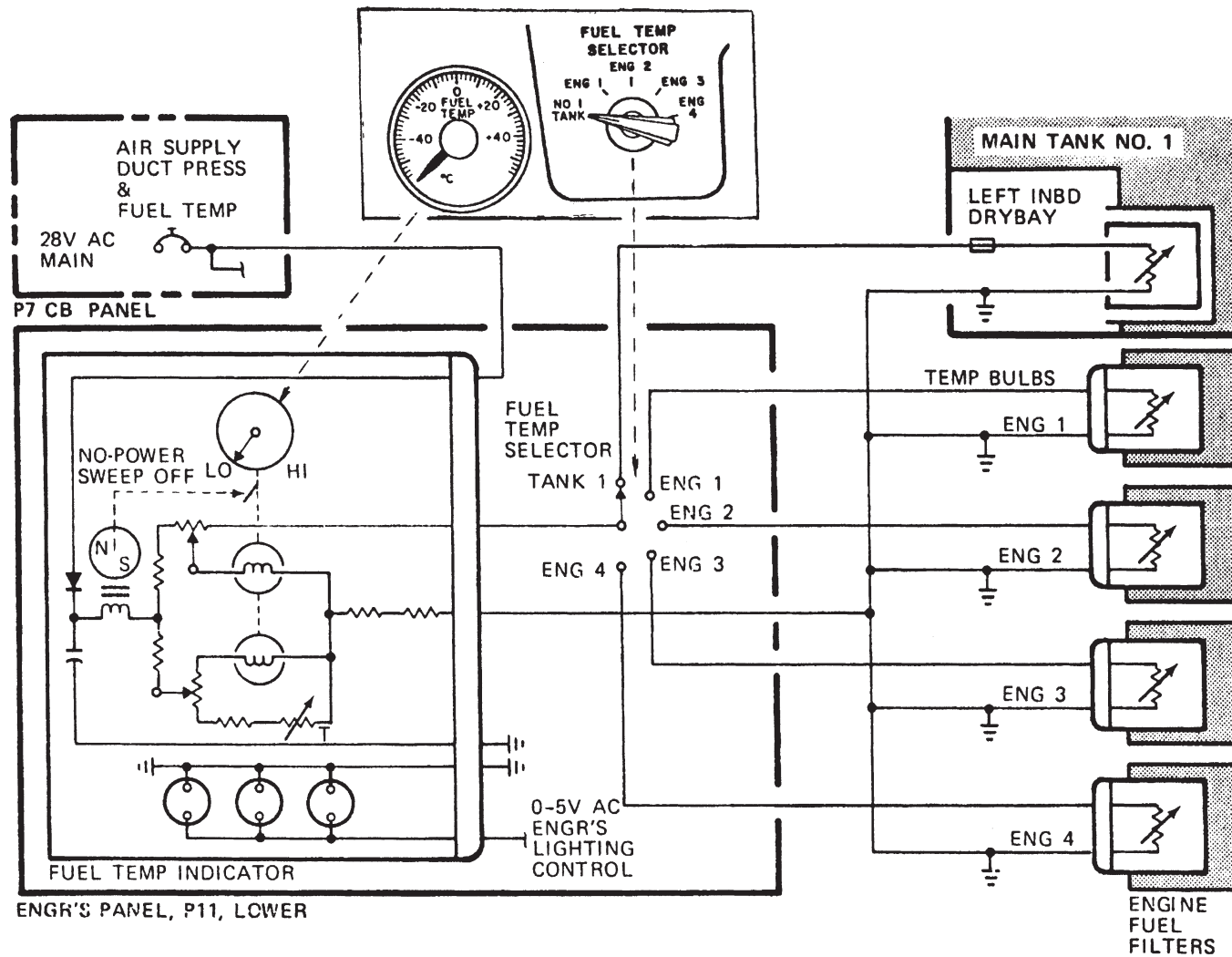


FUEL TEMPERATURE INDICATING

9.2. Fuel Temperature Indicator.

The fuel temperature indicator, located on the flight engineer's lower panel, is a resistance ratiometer instrument. The indicator is operated by the ratio of the currents through two coils in the meter movement. One of these currents is determined by the resistance of the temperature bulb. The indicator dial is calibrated in degrees centigrade. With power off, the pointer remains off scale at the low temperature end. Electrical connections are made to the indicator through a disconnect plug.

Each temperature bulb contains a resistance element whose resistance varies in proportion to changes in temperature. This element controls the current passing through the meter movement of the fuel temperature indicator. Power is supplied to the system through the 28-volt ac, circuit breaker panel (P7).



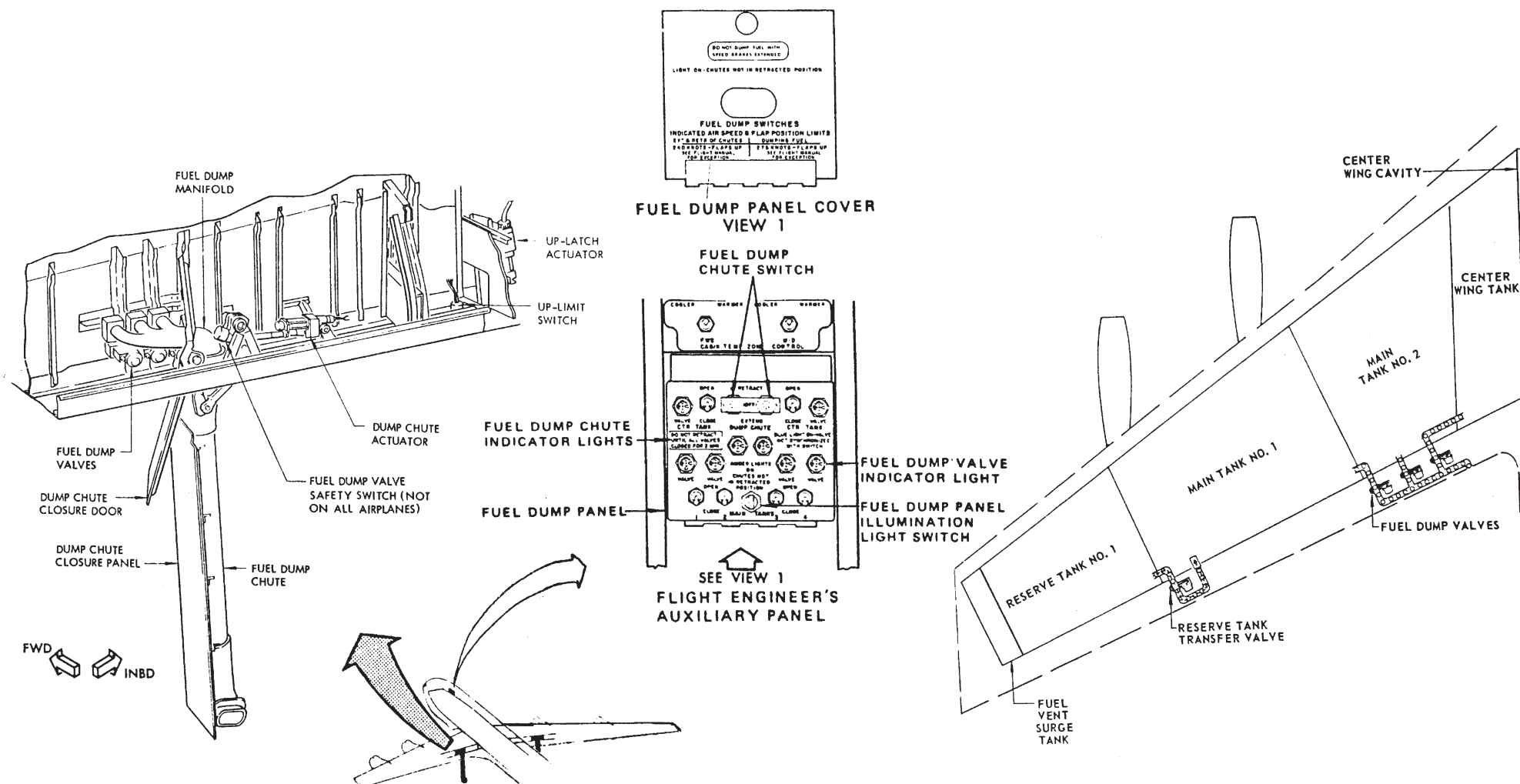
FUEL TEMPERATURE INDICATING SYSTEM CIRCUIT

10. FUEL DUMP SYSTEM.

The fuel dump system provides the means by which fuel can be jettisoned in flight. Each wing contains an extendable chute which must be fully extended before fuel can be dumped. The fuel in the main tanks is dumped through the chute on the same side of the airplane as the tanks. Fuel from the center wing tank is dumped through both chutes. The reserve tank fuel is transferred to and dumped with the adjacent outboard main tank fuel.

The overall system consists of two fuel dump manifold, two dump chutes, two electrically operated dump chute actuators, two electrically operated latches and the corresponding mechanical and electrical controls. There are six fuel dumping lines with six fuel dump valves. The fuel dumping controls are on the flight engineer's auxiliary panel.

When the fuel dump switch, on the flight engineer's auxiliary panel is placed in the "EXTEND" position, a sequence of operations is initiated to unlatch and extend the fuel dump chutes. When the dump chutes are fully extended the dump valve safety circuits are armed to permit opening the dump valves. Placing the dump valve switches the flight engineer's panel in the "OPEN" position will now open the dump valves. With the dump valves open, all fuel in excess of an amount determined by a fixed standpipe is dumped overboard. Fuel dumping can be stopped by placing dump valve switch to "CLOSE".



FUEL DUMP SYSTEM EQUIPMENT

10.1. Fuel Dump Chute.

Two fuel dump chutes direct fuel away from the airplane. Each chute is constructed from a straight run of tubing with an elbow at each end.

The inlet elbow of the chute forms a telescoping swivel joint with the fuel dump manifold. A seal between the chute and the manifold is maintained by a concentric sliding primary O ring seal at the chute inlet. The inlet elbow contains the pivot points of the chute and a secondary seal which covers the manifold outlet to act as a valve when the chute is in the stowed position. The outlet elbow serves as a discharge nozzle of the chute.

The dump chutes are actuated by an electric motor driven actuator unit and are retractable in flight. When the fuel dump chute switch on the flight engineer's auxiliary panel is placed in the EXTEND or RETRACT position, the dump chute extends to the down position or retracts to the up, or stowed, position.

Rubber seals between mating surfaces of the dump chute closure panel and the wing surface reduce air turbulence and consequent aerodynamic drag.

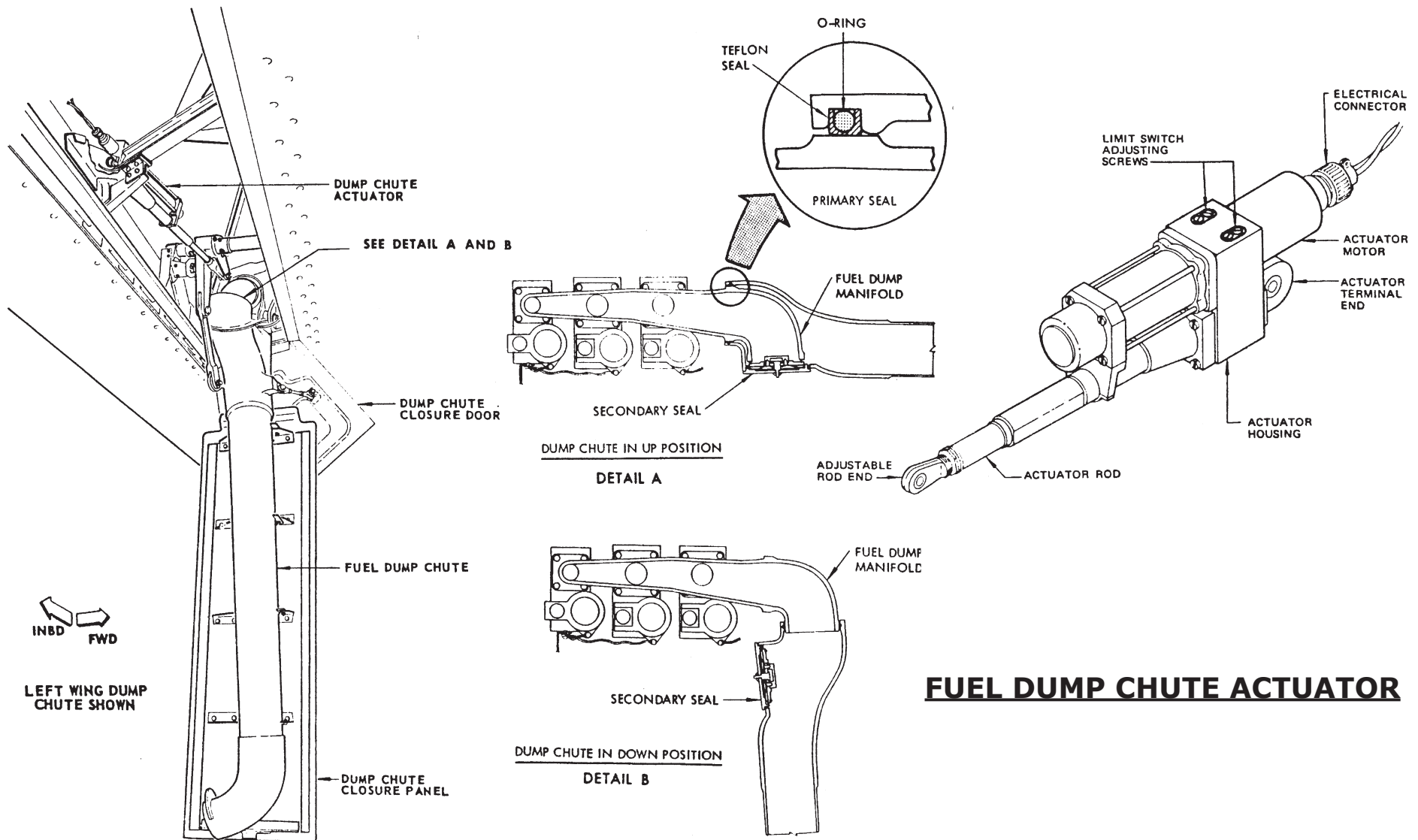
10.2. Fuel Dump Chute Actuator.

An electric motor operated actuator controls the chute operation.

The actuator controls the rate of dump chute extension and retraction.

The dump chute actuator assembly consists of a housing, reduction gear, motor, actuator rod and two actuator limit switches ; an extend limit switch for dump chute extension control and a retract limit switch which is bypassed. Chute retraction is terminated by a separate up limit switch attached to wing structure.

When the dump chute actuator circuit is energized, the motion of the actuator rod is transferred to the quadrant assembly and dump chute drag brace. This action extends and retracts the fuel dump chute. As the actuator rod approaches full extension, the extend limit switch within the actuator terminates the extension operation of the actuator. When the dump chute is fully retracted the dump chute up limit switch terminates the operation of the actuator. Limit switch actuation for dump chute extension is controlled by the extend limit switch adjusting screw on the actuator. The dump chute actuator is energized by 115 volts ac power.



10.3. Fuel Dump Chute Uplatch.

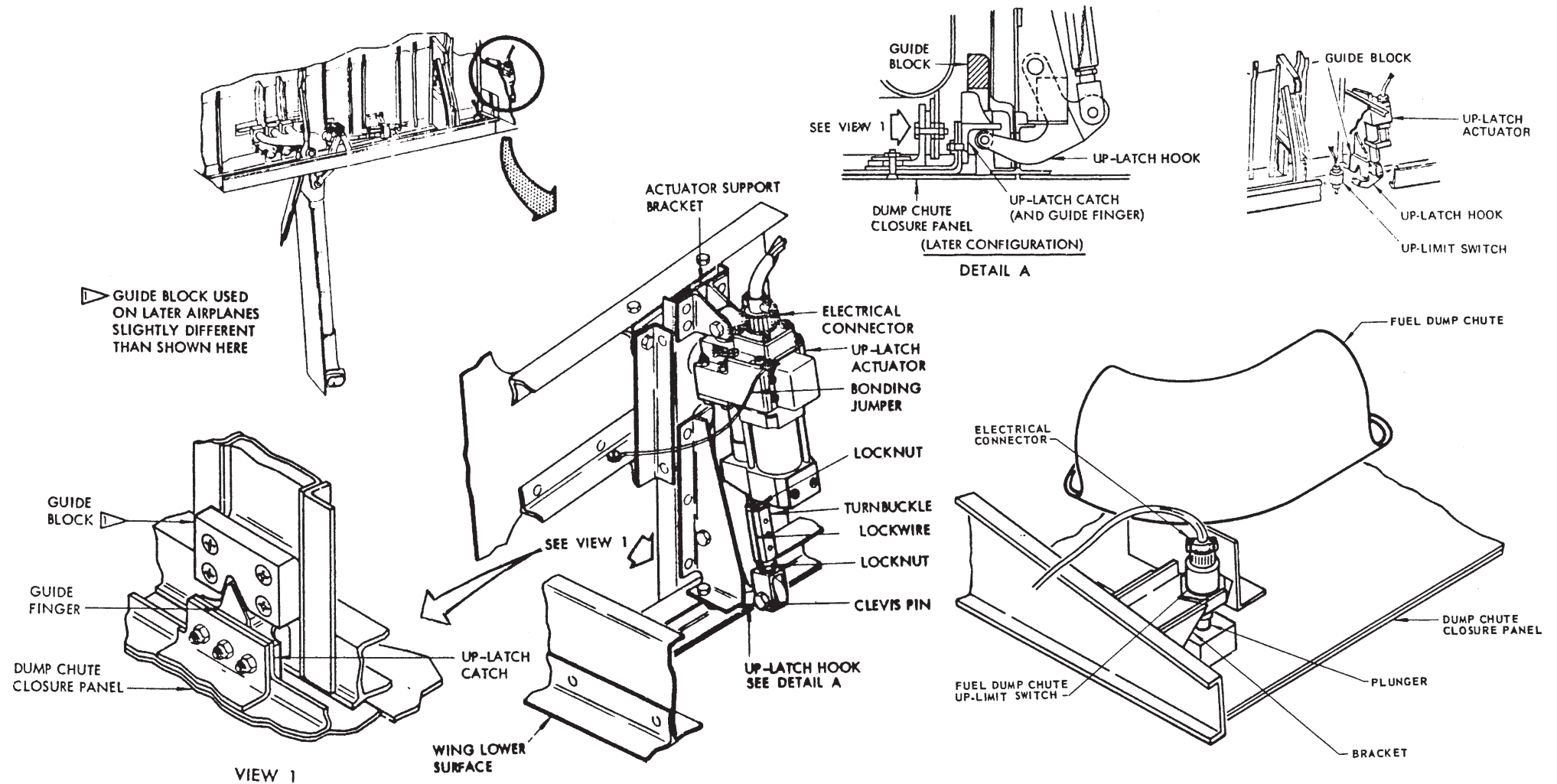
The fuel dump chute uplatch is an electrically operated unit that locks the dump chute in the stowed position. The latch unit consists of a catch attached to the closure panel, a hook assembly and an electrical actuator attached to the wing structure.

When the uplatch actuator circuit is energized the extension or retraction of the actuator rod engages or disengages the hook and catch. Limit switches inside the uplatch actuator control the extension and retraction of the actuator rod ; in addition, the back contacts of the retract limit switch energize the extend circuit of the dump chute actuator when the latch is unlatched. A secondary switch in the actuator is used to energize the dump chute position light when the uplatch is not in the latched position.

10.4. Fuel Dump Chute UPlimit Switch.

The fuel dump chute up limit switch is a plunger operated microswitch. it is mounted on a bracket attached to the trailing edge structure of the wing and is actuated by the dump chute closure panel. The switch controls the dump chute indicator lights and the amount of retraction of the dump chute.

When dump chute is fully retracted the switch plunger is depressed de-energizing the dump chute indicator lights and the retract circuit of the dump chute actuator. When the dump chute leaves the stowed position, the switch energizes the dump chute indicator lights and arms the retract circuit of the dump chute actuator. The energizing and de-energizing of the dump chute position lights by this switch only occurs when the uplatch actuator is in the latched position.



FUEL DUMP CHUTE UP LATCH

10.5. Fuel Dump Valve Safety Switch.

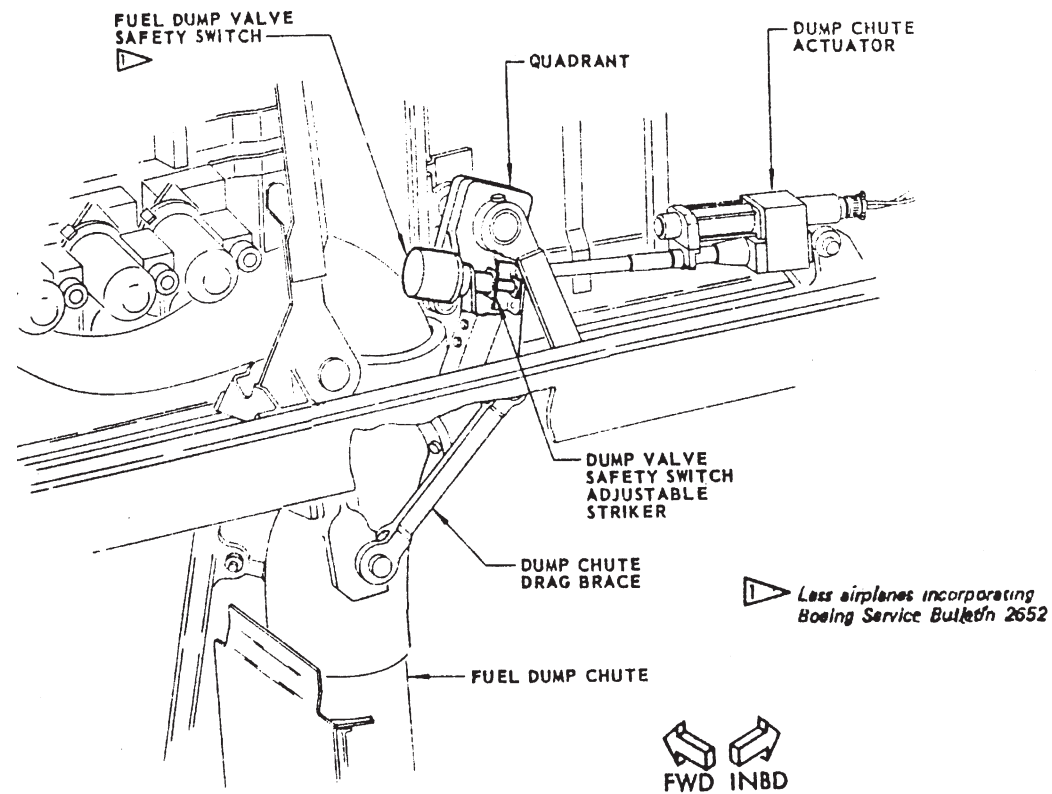
(early model airplanes without safety relay).

A fuel dump valve safety switch actuated by the dump chute prevents the dump valves from being opened until the dump chute is fully extended.

The switch is actuated by an adjustable striker on a bracket attached to a quadrant arm. The safety switch itself is fastened to a bracket attached to the wing structure. Motion of the quadrant carries the striker into contact with the safety switch plunger. The striker is so adjusted that the safety switch is actuated when the dump chute is fully extended.

10.6. Fuel Dump Safety Relay.

The fuel dump valve safety relays, located on the j23 relay shield in the lower 41 section, prevent the dump valves being opened until the dump chutes are fully extended. The relays are energized by 28 volt dc power and are controlled by the extend limit switch in the dump chute actuator. When the actuator is fully extended, the extend limit switch completes the circuit to energize the relay and arm the dump valve circuits.



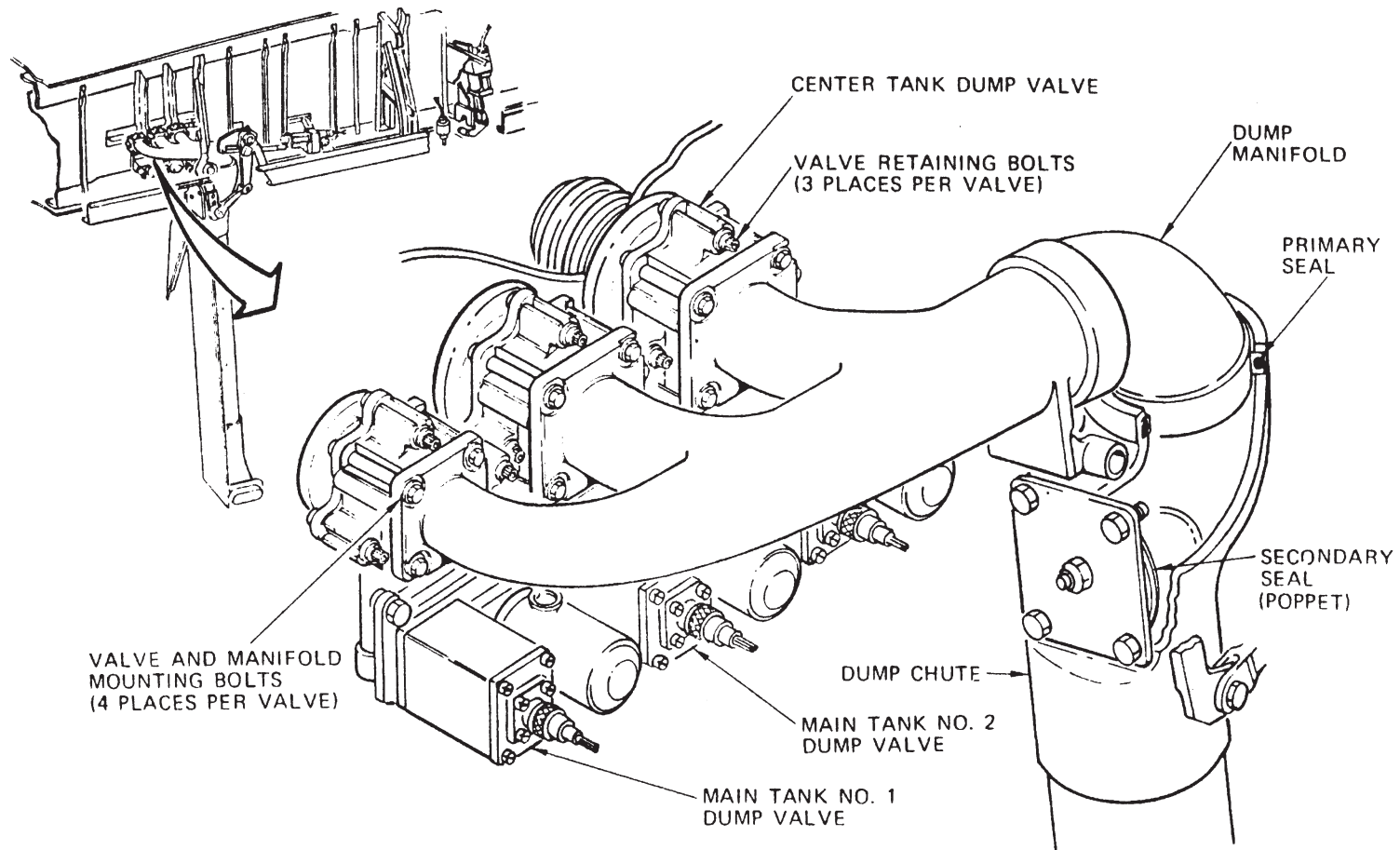
FUEL DUMP VALVE SAFETY SWITCH

10.7. Fuel Dump Valves.

Six electric motor operated dump valves (three on each wing) control fuel jettisoning from the fuel tanks. One valve is inserted in each fuel dump line at the inlets to the dump manifold. The valve assembly consists of a valve housing, a sliding gate and an electric motor. The dump valve motors are powered by 28 volt dc power and controlled by switches on the flight engineer's auxiliary panel and through the dump valve safety switches or relays which prevents opening of valves until the dump chute is fully extended.

10.8. Fuel Dump Chute Unlatched Relay.

A fuel dump chute unlatched relay located on the J23 relay shield in the lower 41 section is provided for each dump chute. When the dump chutes are closed and latched, the dump chute unlatched relays are de-energized and power is removed from the dump valves, preventing the re-opening of the valves.



FUEL DUMP VALVE INSTALLATION

10.9. Operation.

The fuel dump system is controlled from the flight engineer's station, all switches and indication lights being on the flight engineer's auxiliary panel. Operation of the system is initiated by placing the fuel dump chute switches in the EXTEND position, this completes the circuit to the unlatch side of the uplatch actuator. The actuator rod of the uplatch actuator retracts and disengages the uplatch hook assembly from the latch on the dump chute closure panel. As the uplatch reaches the full unlatched position, the secondary switch in the actuator energizes the dump chute position lights and the limit switch inside the actuator cuts the power to the uplatch actuator, this completes the circuit to the dump chute actuator and the chute starts to extend. As the chute leaves the stowed position the dump chute uplimit switch is actuated, arming the retract circuit of the dump chute actuator. The dump chute actuator continues to extend the dump chute until the EXTEND limit switch, inside the actuator, cuts the power to the actuator. As the dump chute reaches the fully extended position the dump valve safety switch is actuated or the dump valve safety relay is energized to arm the valve circuits. The valves are then opened by placing the dump valve switches in the OPEN position. The

blue indicator lights adjacent to the switches will be illuminated during opening of the valves and will be de-energized when the valves fully open. Fuel will now be dumped overboard until a predetermined amount of fuel remains in the tank, or the valves are closed by the crew.

Fuel is dumped from the main and center wing tanks when the valves are opened. When a main tank dump valve circuit is energized, it overrides the adjacent reserve tank transfer valve circuit. and the transfer valve opens allowing fuel to flow from the reserve tank to the adjacent main tank.

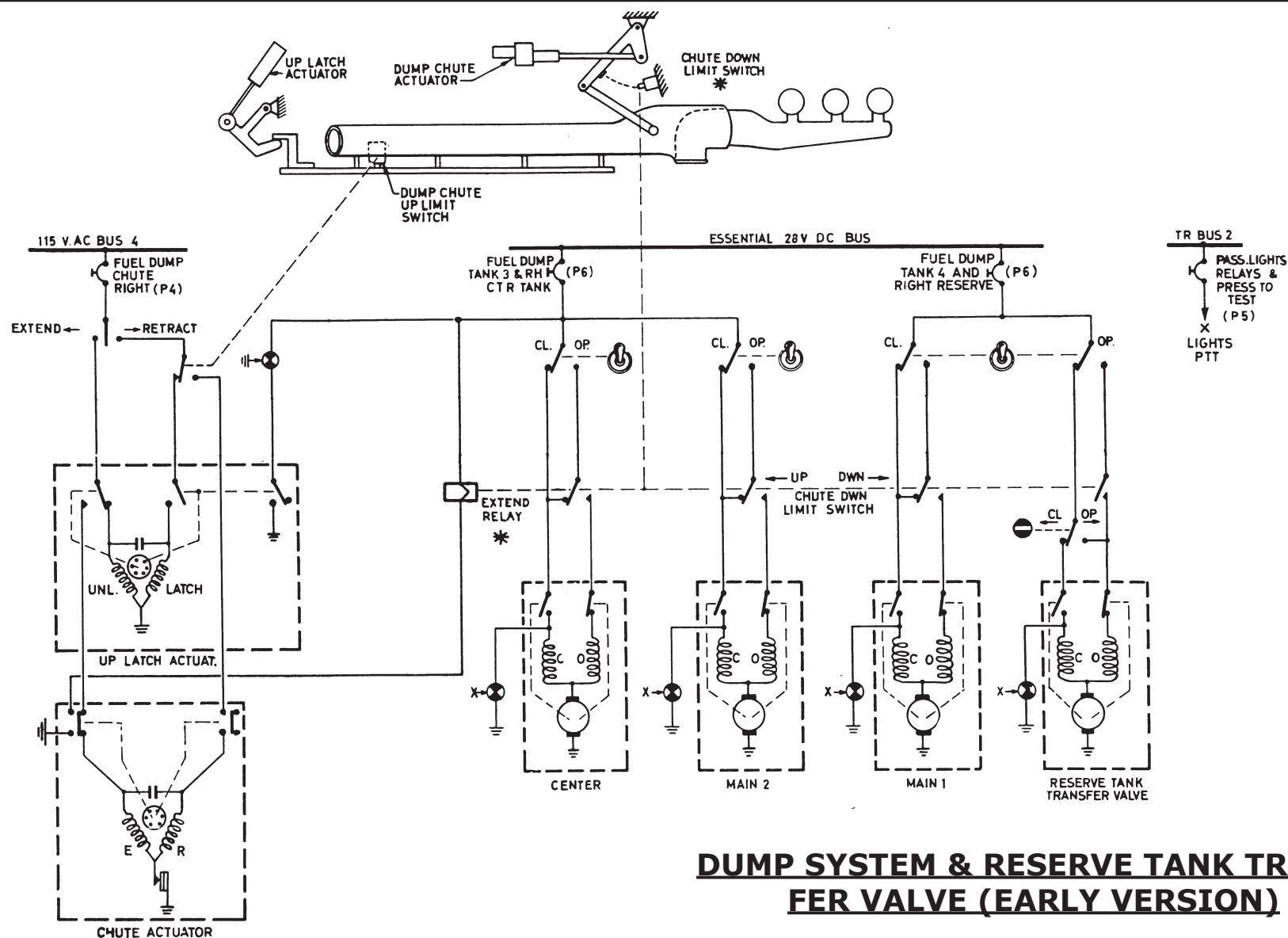
The predetermined amount of fuel remaining in the tanks after dumping is shown in the following chart.

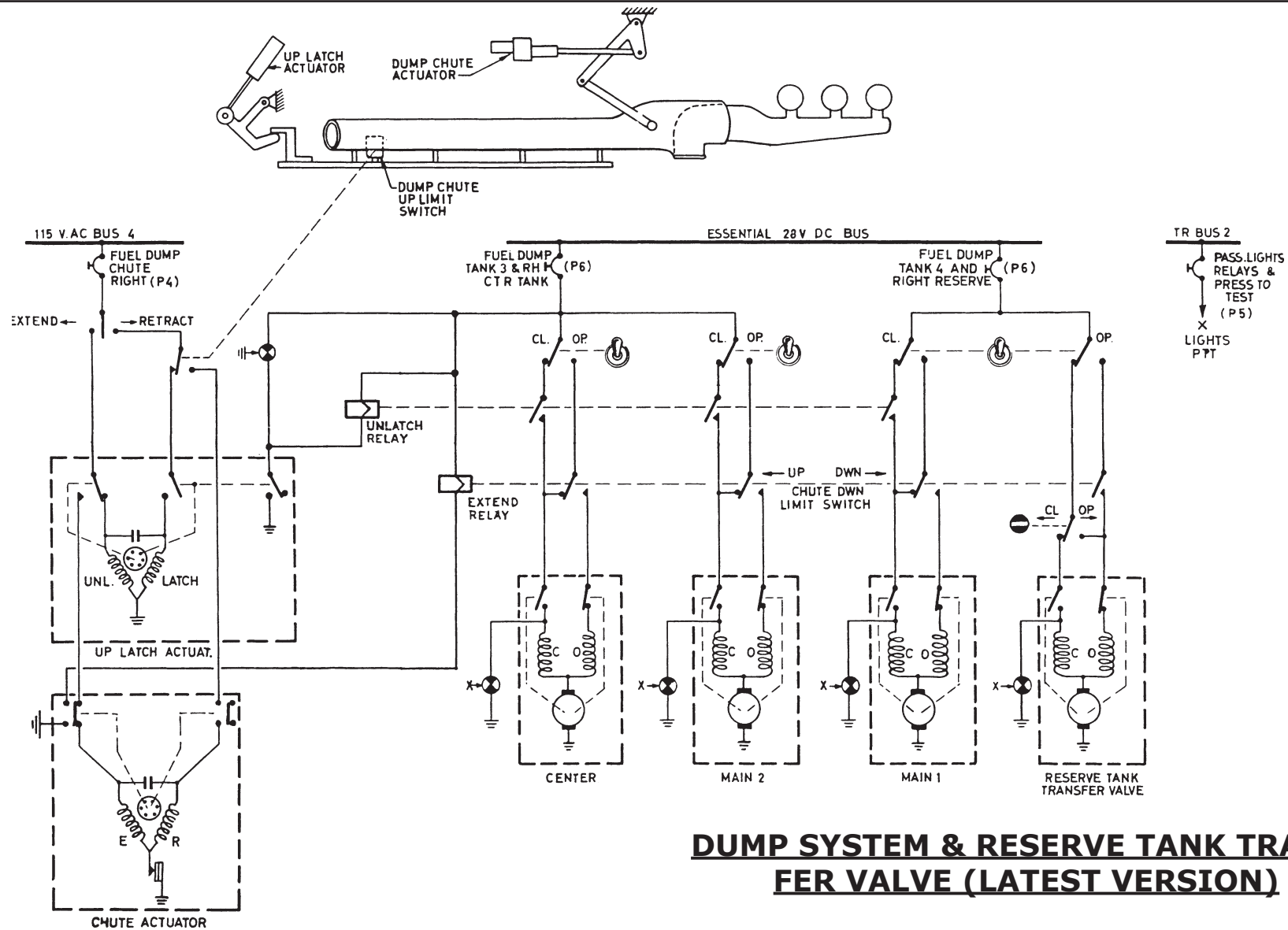
Pounds of fuel in tanks after dumping.

Tanks	Pounds.
Main Tank N°1	4,000
Main Tank N°2	3,650
Center Wing Tank	1,633
Main Tank N°3	3,650
Main Tank N°4	4,000
Total	16,933

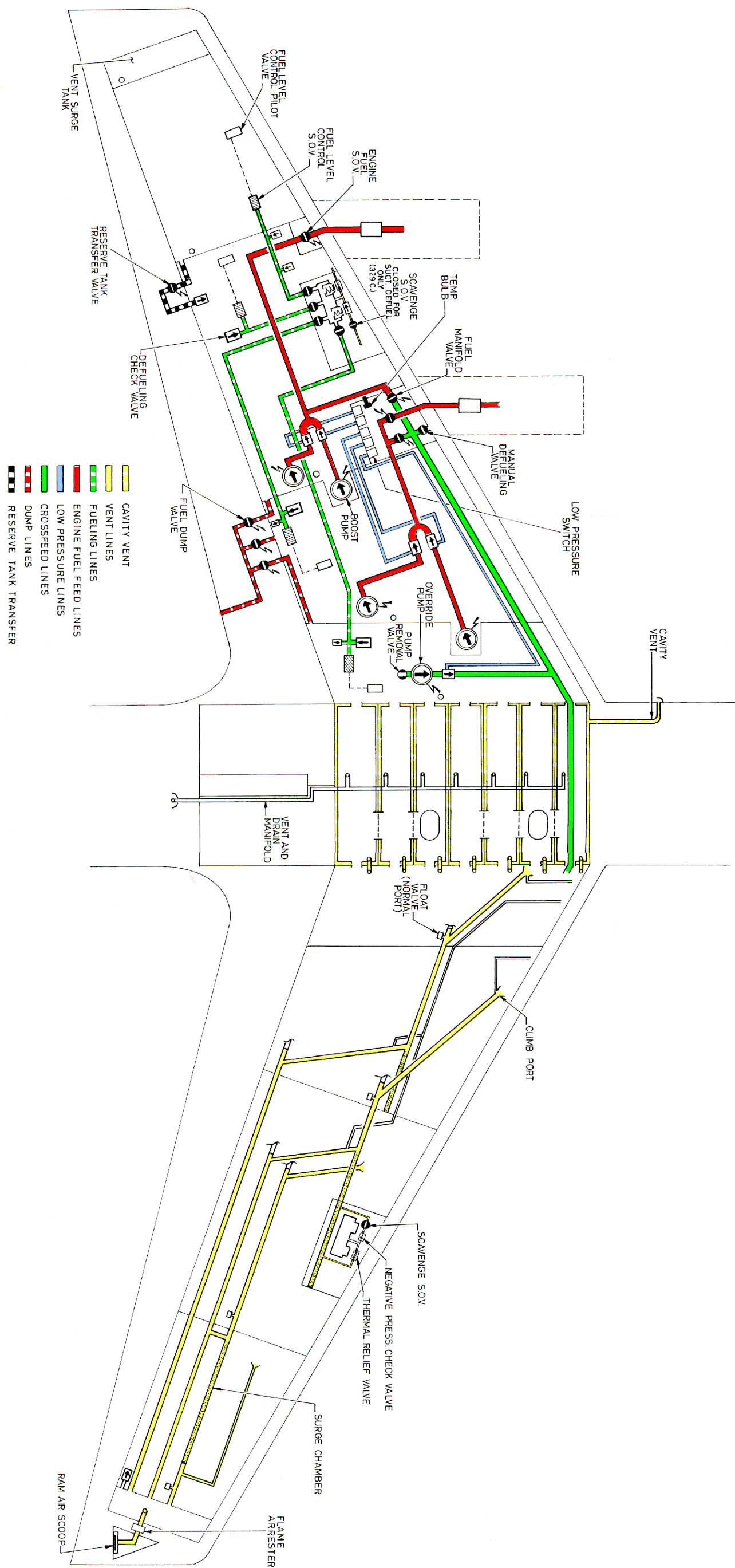
After dumping of fuel is completed, the dump valve switches are placed in the CLOSE position. The blue indicator lights are illuminated while the valves are closing and go out when valves are closed. After a period of 2 minutes, to allow all fuel to drain from the dump chute and manifold, the dump chute switch is placed in the RETRACT position. This energizes the dump chute actuator retract circuit and the dump chute is retracted. On airplanes fitted with a dump valve safety switch, as the dump chute leaves the fully extended position, the dump valve safety switch opens to de-energize the dump valve circuits, preventing reopening of the valves. On airplanes fitted with dump valve safety relays, as the dump chute leaves the fully extended position, the extend limit switch is opened to de-energize the safety relay. When the relay is de-energized it opens the circuit to the dump valves to prevent re-opening of the valves.

The dump chute continues to retract until the dump chute uplimit switch is positioned to de-energize the dump chute actuator and to energize the uplatch actuator to lock the chute in retracted position. As the actuator rod of the uplatch actuator extends, the hook assembly is engaged with the catch on the closure panel, when the hook assembly and the catch are fully engaged the limit switch inside the uplatch actuator opens to cut the power to the actuator, and the secondary switch in the actuator de-energizes the dump chute position light. On airplanes incorporating Boeing Service Bulletin 2652, a fuel dump chute unlatched relay cuts off power to the fuel dump valves when the dump chute is at the closed and latched position.





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FUEL SYSTEM SCHEMATIC

AVIATION
COMPETENCE
CENTRE



AVIATION
COMPETENCE
CENTRE