ORION

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ORION

FUELING, DEFUELING, FUEL TRANSFER — DESIGN AND OPERATION

editor ROY BLAY

assistant editors DON WADSWORTH • WAYNE CRADDUCK

art VIRGINIA ROBINS • ROBERT BROOKS

FRONT AND BACK COVERS Air Development Squadron One (VX-1 of the Navy's Operational Test and Evaluation Force) is presently working with the P-3A, developing and refining procedures that will aid the operating squadrons in realizing the full potential of the new ASW weapon system, whether it is employed independently or in coordination with other forces. VX-1 has a many-sided job finding how best to execute proven tactics, investigating and developing new tactics, evaluating needed air crew skills, and establishing the training requirements necessary to provide competent ground and air crews. In this mission, **Airdevron One's** highly trained and widely experienced organization, including representatives from the Royal Navy, the Royal Air Force, and the Royal Canadian Navy and Air Forces, is aided by industry and military specialists in almost every skill and technological aspect of ASW.

To test that supporting facilities, equipment, and materials are adequate, Squadron personnel who maintain the aircraft have talents and skills representative of those to be found in operational squadrons, and are given special schooling only insofar as new and unique equipment requires. Improvements predicated on such tests will further reliability and ensure that the excellence of the new aircraft is preserved in fleet operation.

VX-1's Key West, Florida base, close to the Gulf Stream and Submarine Squadron 12 has a near-ideal testing ground at hand. The **JA** (squadron identification) is often seen far from home, too, conducting tests and demonstrating ASW techniques and equipment to our own and Allied forces. Much of the P-3 capability is security-classified, but we can mention that one flight made by a VX-1 aircraft started at Honolulu, averaged 425 mph for more than 11 hours, and landed with a considerable part of its range unused at Norfolk, Virginia — 5000 statute miles from Hawaii.

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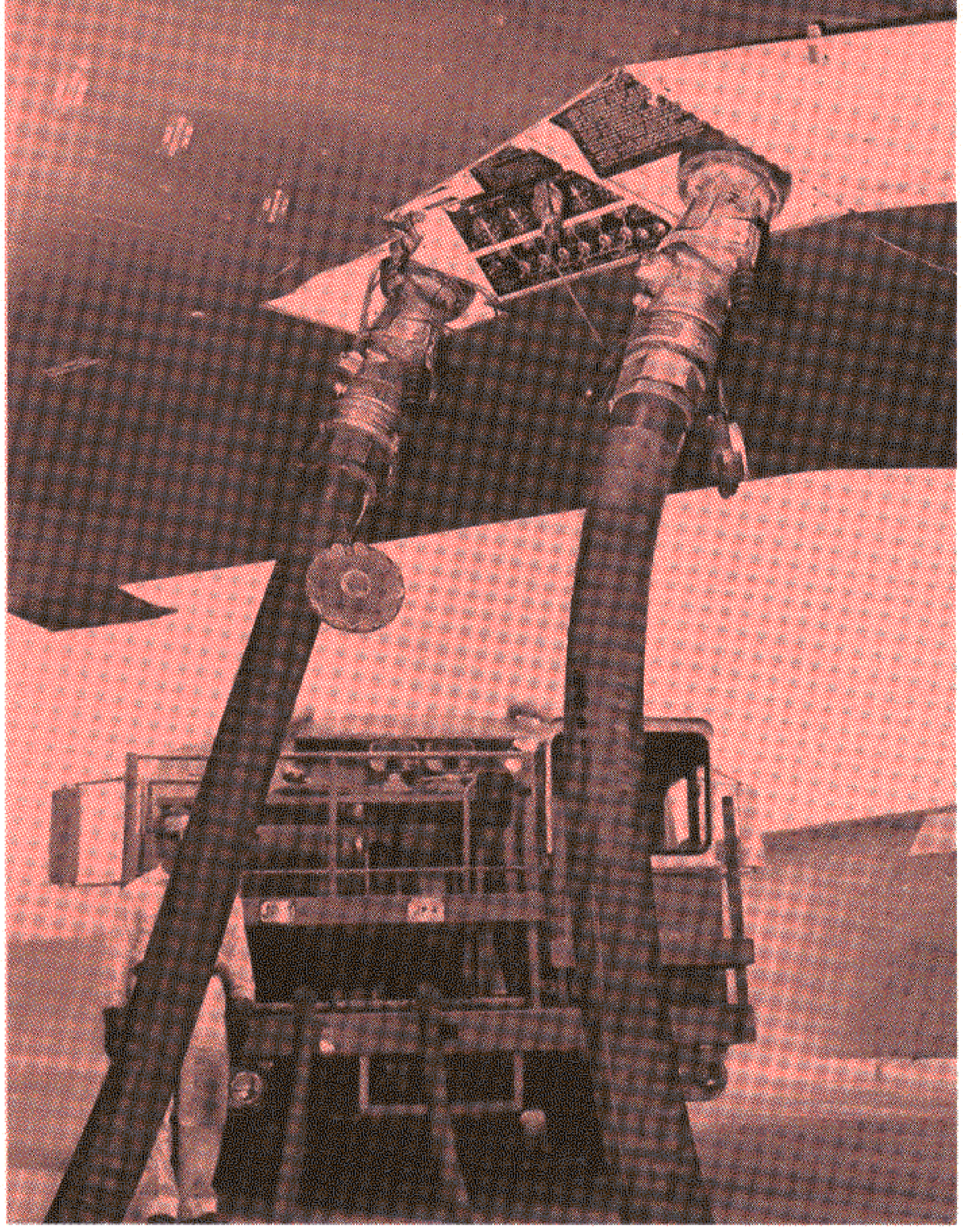


Fueling, Defueling, and Fuel Transfer

INTRODUCTION

IT IS OUR INTENT to describe in separate articles, and in some detail, the major Orion systems in the Orion Service Digest. Such articles, we feel, will serve as a valuable liaison medium to carry the reasoning and thought of the designers and builders to those who maintain and operate the aircraft.

The scope of this article is too limited to qualify it as a complete "Aircraft Fuel System" article. It deals mainly with three sub-systems (fueling, defueling, and fuel transfer), describing supplementary sub-systems only insofar as necessary to provide background for the principal subjects. Fueling is discussed first, and in greater detail, due to the fact that the fueling components are used for defueling, and most of them are also used for fuel transfer. This multipurpose concept greatly simplifies the task of explaining the latter two sub-systems — just as integrated systems simplify aircraft — but we wish to point out that when sub-systems are so closely-knit, every one concerned with one of them is unavoidably concerned with the other two, and should know something of the design and operation of all three.

These relatively simple sub-systems are nevertheless important to aircraft operation, and the designers have given a great deal of thought to make them both fail-safe and fool-proof in every detail of design. Furthermore, step-by-step procedures for fueling and defueling have been worked out and are placarded adjacent to the pressure fueling facility. But in one respect these systems are unique. Nearly all other aircraft systems are operated exclusively by personnel who have a substantial background of aircraft experience, and have had specialized training in the systems and functions which bear directly on their jobs. We strongly recommend this for our subject systems also. Whenever possible fueling, defueling, and transfer operations should be performed (or closely supervised) by an ADJ or better-qualified rate who is familiar with the airplane. However, in some situations and at some locations this will not always be feasible, and fueling, defueling, and even fuel-transfer may be done by personnel who have no other contact with the Orion and have little access to information which will help them to understand the reasons behind the placarded procedures. Consequently, they may not

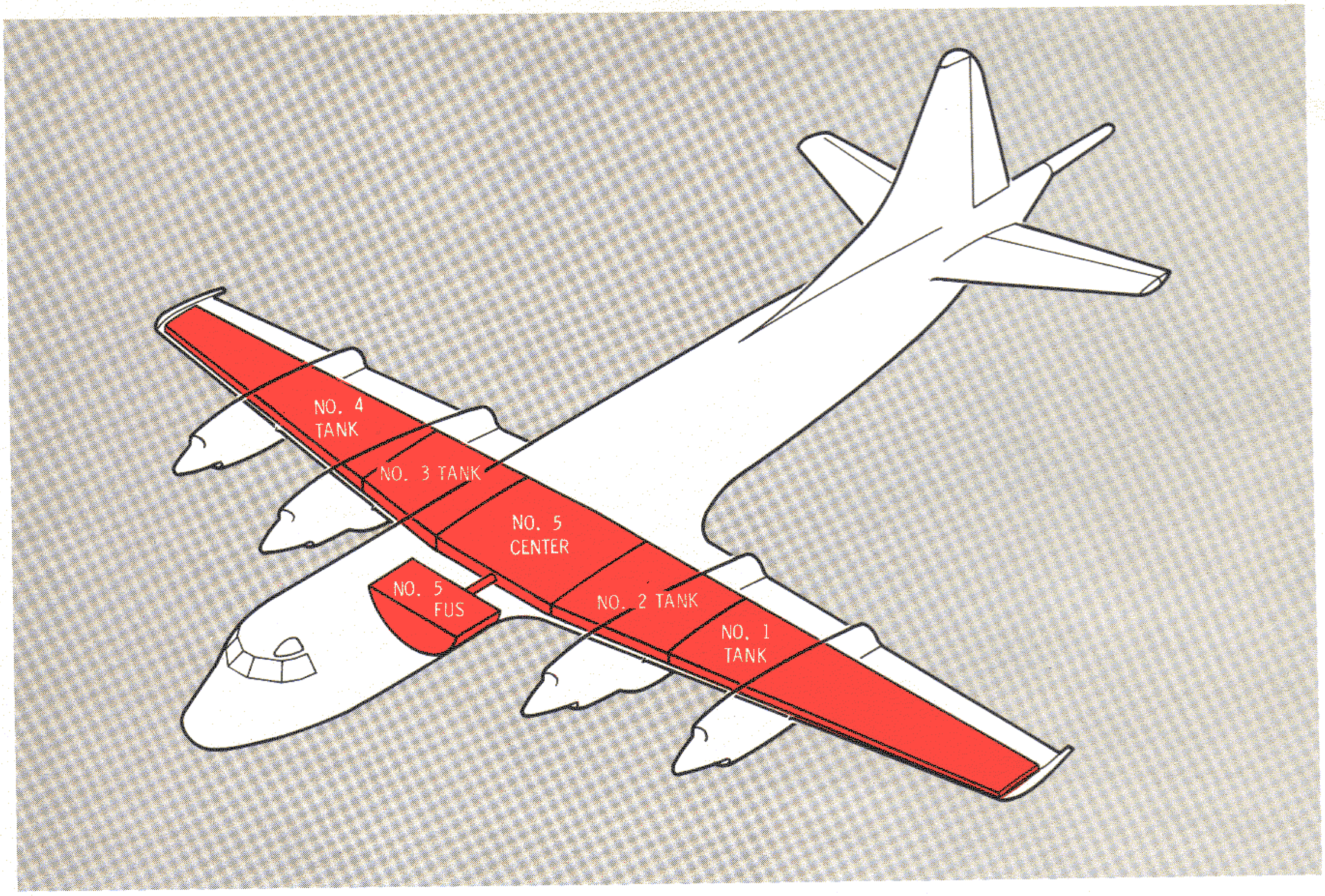


Figure 1 Orion Fuel Tanks

appreciate the real importance and inherent responsibility of their task and adopt ill-advised short-cuts or a nonchalant attitude that can lead to tragic results.

At this writing, we do not know of any untoward incidents stemming from improper procedure or operation, and we feel that the Orion design offers a high order of protection against such incidents. However, we *do* know that every mass-produced aircraft has some history of damage incurred during servicing, and that when fuel is pumped into — or out of — aircraft tanks though a closed system, the damage history might easily include outright destruction of aircraft and sometimes fatalities which would not have occurred if all those who work on or with the aircraft fuel system were better informed as to the system design and its operation.

The purpose of this article is to supply this needed information. Since service, maintenance, and operating personnel are all involved, we hope that this issue of the Digest will be freely disseminated to all those who can benefit from it. Such information has enduring value for purposes of review, and especially for orienting newly-assigned personnel. Note that our magazines are punched for a loose-leaf binder to facilitate their being filed for future reference. Of course, we cannot foresee modifications which may be made hereafter, nor can we foresee the procedural changes that modifications or the necessity for non-standard operation may dictate. The Flight and Maintenance Instruction Manuals and the Maintenance Requirements Cards will be kept current and are to be considered as the final authority, but barring extensive changes, all of the information in this article will apply most of the time, most of it will apply all of the time.

THE FUEL SYSTEM is comparatively simple, considering that it serves a long-range, four-engine aircraft. As shown in Figure 1, tankage extends from wing-tip to wing-tip, and from the wing front spar beam to the aft spar beam. These tanks are integral; that is, they are created by sealing the primary wing structure and providing chordwise bulkhead partitions to separate the tanks.

In addition to the integral tanks, a bag-type (bladder-cell) tank is installed in the belly forward of the wing center section, immediately aft of the bomb bay. For most purposes, this tank may be regarded as an extension of the integral center-section tank — indeed the two compartments are identified collectively as No. 5 Tank. In this article, we will use this nomenclature where the context allows, but since it is often necessary to distinguish between the two compartments, we will then refer to the center section compartment as No. 5 Ctr. Tank, and the fuselage bag compartment as No. 5 Fus. Tank.

Maximum fuel capacity of the aircraft is 9200 U.S. Gallons. This corresponds to 59,800 lb of JP-4 fuel at its nominal density of 6.5 lb per gallon. JP-4 is considered to be the normal fuel for the Orion. JP-5 is an acceptable alternate fuel, but it is a somewhat denser fuel — indeed a full load of cold JP-5 could weigh 65,000 lb or more — and the extra weight can be an important factor in respect to loading and operating limitations.

Tanks 1 and 2, in the left wing, and 3 and 4, in the right wing are engine-feed tanks; each tank normally supplies fuel to the corresponding engine. These four tanks are of nearly equal capacity (10,439 lb in each outboard tank; 10,861 lb in each inboard tank) so that there is little occasion to cross feed engines unless engines are shut down during flight.

Engine Feed Normally, the feed line to each engine is pressurized by an ac electric motor-pump mounted in an open-top surge box at the inboard lower-aft corner of each engine-feed tank. These pumps have dual pumping elements of the centrifugal tapered screw type. One element scavenges fuel from a low point forward of the surge box, keeping the surge box flooded, thus ensuring that little fuel is unusable even in a prolonged nose-down descent such as the normal approach attitude. The other pumping element, the booster element, in turn maintains pressure constantly in the engine feed line so that normally a pressurized supply will be provided for a third centrifugal pump mounted on — and driven directly by — the engine.

The fuel feed system has been carefully designed so that engine feed can be maintained in the event a motor pump or its power supply fails. If the booster-scavenge pump is inoperative, the engine-driven boost pump can draw fuel through a bypass line directly from the surge-box (thus by-passing the inoperative booster-scavenge pump). Each surge-box has a flapper check valve in its forward wall that allows tank fuel to gravity-flow* to the bypass inlet of the engine-feed line.

The four engine-feed systems are tapped, as shown in the Figure 2 diagram, by a cross-feed system which has five electrically operated valves: four cross feed shutoff valves, and one cross-ship cross feed shutoff valve. The output of each tank-mounted boost pump is more than adequate for two-engine supply, and it can be directed through the cross feed system to supply

*If fuel level is low, it will be necessary to make a level-attitude descent to maintain gravity-flow of fuel into the surge box when the booster-scavenge pump is inoperative.

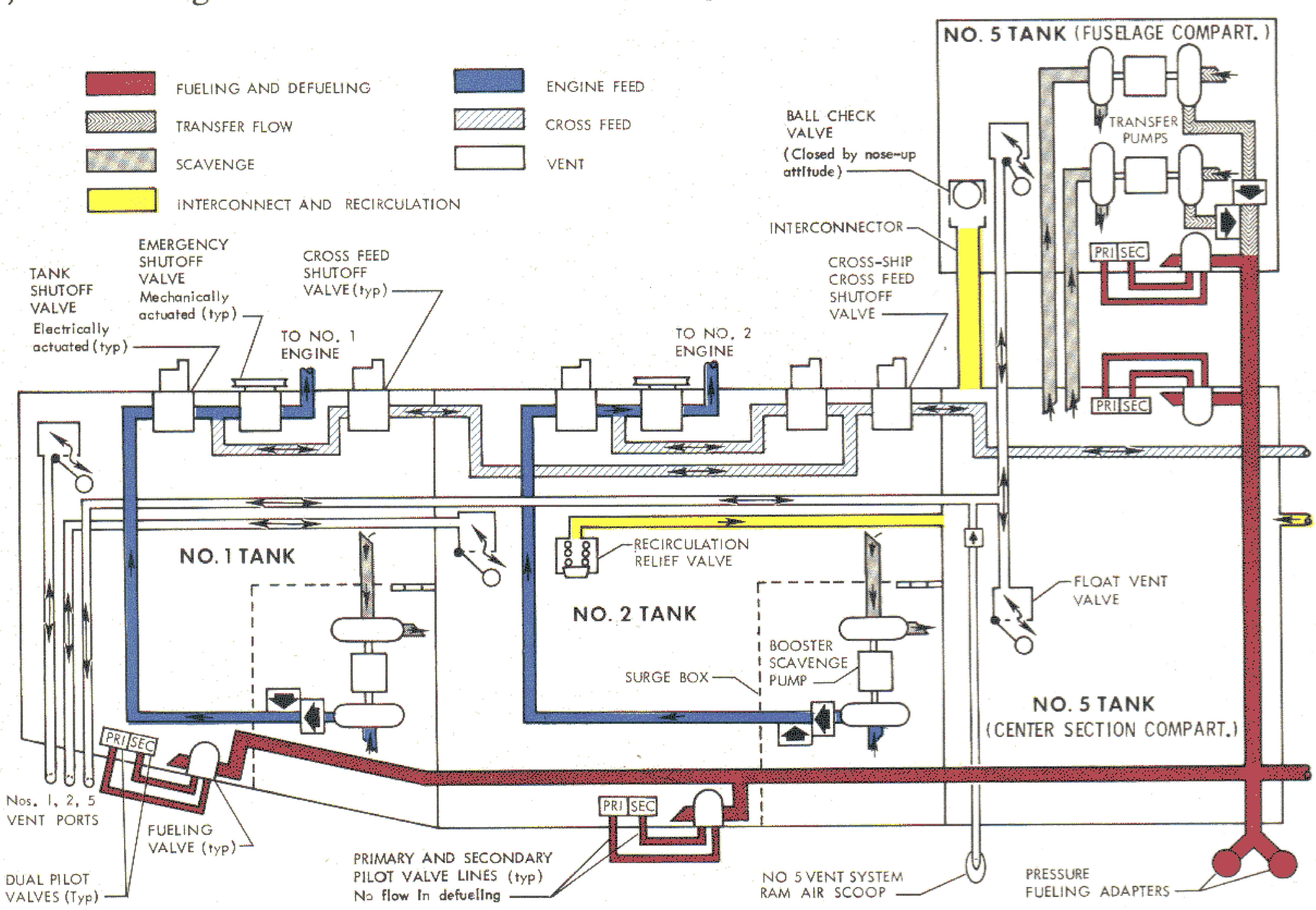


Figure 2 Fuel Tank Plumbing and Flow Schematic. Tanks 3 and 4 are not shown, but are like 2 and 1 except for Cross-ship Shutoff Valve and No. 5 Tank vent line.

any combination of engines. There is no provision for transferring fuel from any engine-feed tank to another tank.

Conventional filler-wells are provided for the four engine-feed tanks, so that these tanks can be serviced when pressure-fueling is unavailable, and a dip stick can be used at the filler-wells to determine fuel quantity manually.

Auxiliary Fuel No. 5 Tank capacity (17,199 lb of JP-4) accounts for about 29% of the maximum fuel supply, but it is regarded as an auxiliary tank that is fueled for flights which are too long to utilize the engine feed tanks alone. It has no filler well for gravity fueling. A sight-gauge type slip tube is mounted in the bottom of the No. 5 Ctr. Tank for manual measurement of fuel quantity.

When fuel is carried in the No. 5 Tank, it is expended as quickly as possible by transferring it continuously into the four engine-feed tanks during the early part of the flight. Two transfer pumps — identical to the booster-scavenge pumps used in the engine feed systems — are used to transfer the No. 5 Tank fuel. They are mounted at the low point of the No. 5 Tank, which, as can be seen in Figure 1, is the bottom of the No. 5 Fus. Tank. This area may be regarded as a surge box for the transfer system. Fuel above the level of the interconnect can flow freely into the No. 5 Fus. Tank from the No. 5 Ctr. Tank, and in addition the scavenge elements of the two transfer pumps work constantly during fuel transfer, scavenging No. 5 Ctr. Tank to maintain a head of fuel at the booster elements of the transfer pumps. The booster elements pump the auxiliary fuel to the engine feed tanks, utilizing the pressure fueling manifold and the engine-feed tank fueling valves for the purpose. These four fueling valves are controllable from the flight station Fuel Management Panel, where, for obvious reasons, they are identified as Nos. 1, 2, 3, and 4 Transfer Valves.

Tank Venting — always a vital system on aircraft — is especially important on pressure fueled aircraft such as the Orion. Vent valve assemblies are located in domes atop the two No. 5 Tank compartments, and at the top outboard end of each wing tank. Vent plumbing is routed outboard from the valve assemblies through the wing tanks to discharge ports, fitted with flame-arresters, mounted in the bottom wing skin near the tip.

The vent valve assemblies have float operated valves that close to prevent fuel surges from being spilled during turning maneuvers, and open to allow free venting when the tank is less than full. When the tank is full, the free vent is blocked by the float

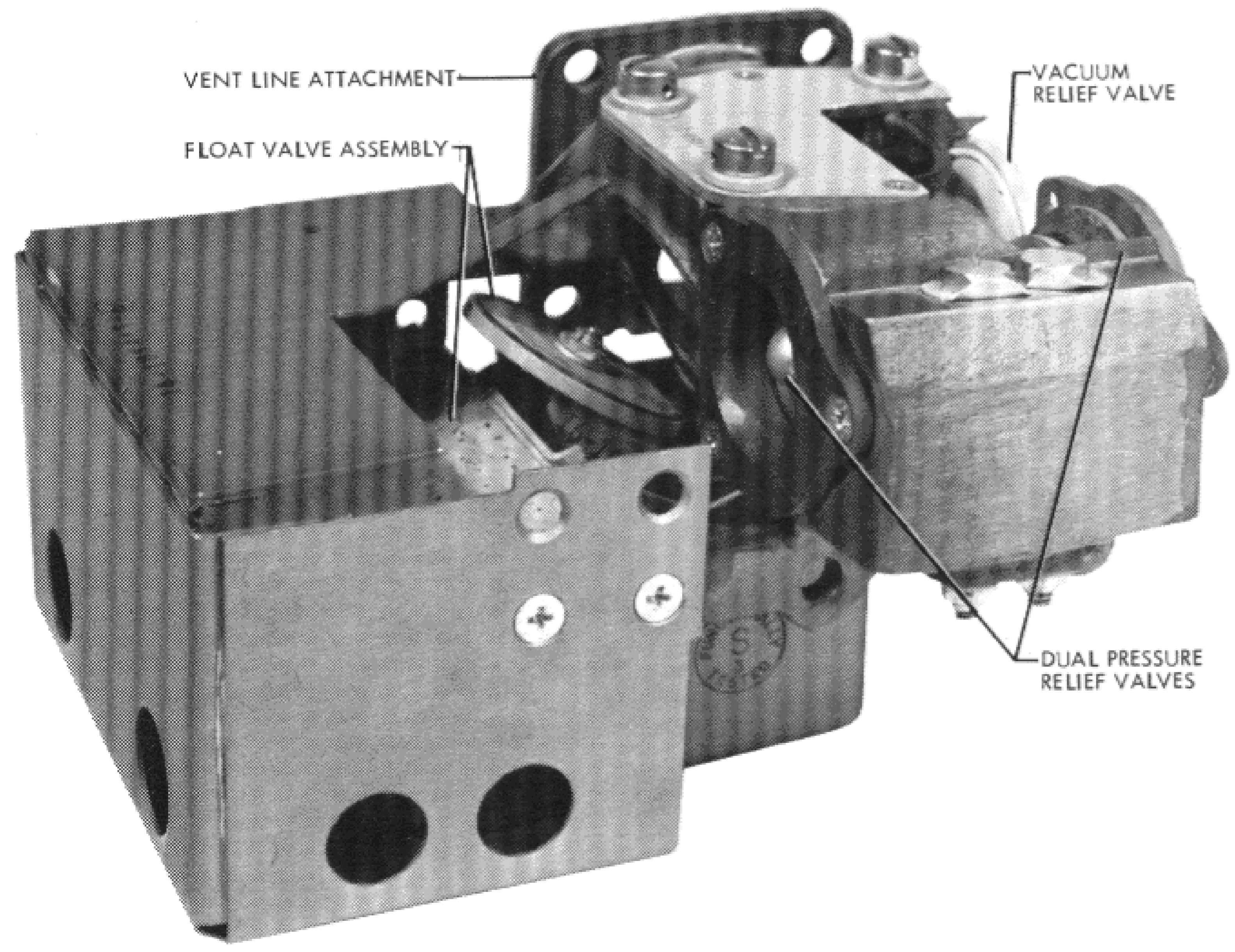


Figure 3 Float Vent Valve Assembly

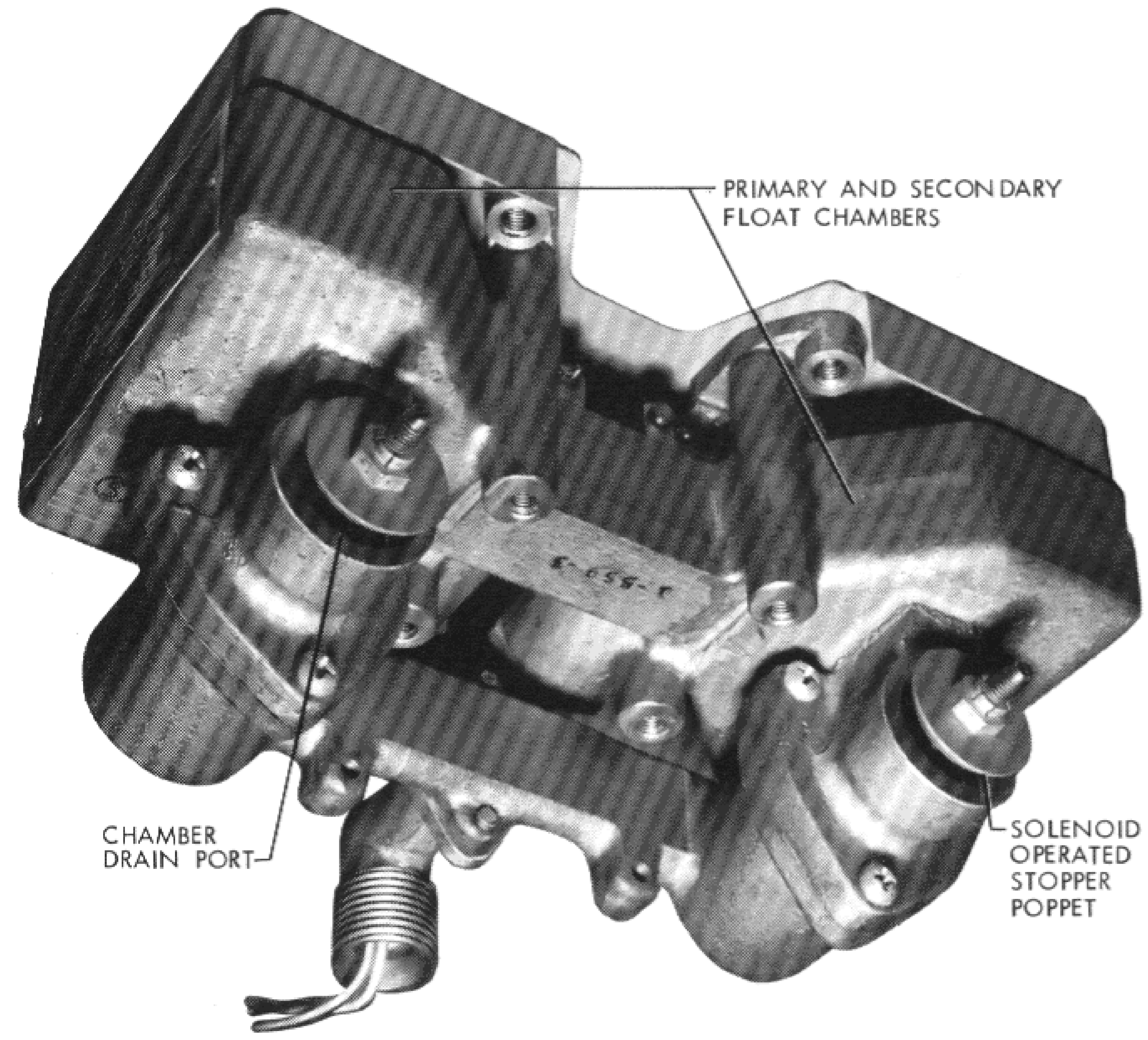


Figure 4 Dual Pilot Valve Assembly

valve, but pressure and vacuum relief valves in each vent valve assembly crack (open) at plus 1.2 psi and minus 0.1 psi, respectively, to limit tank differential pressure.

The two No. 5 vent lines are interconnected, and plumbed to a port at the left wing tip. The No. 5 Fus. Tank is, of course, located in an unpressurized area of the fuselage. Negative internal pressure, so small as to be insignificant to an integral tank, will collapse a bag tank, and No. 5 Tank vent is designed to ensure that this does not occur. Ram air is admitted through a scoop just forward of the inboard end of the left wing flap, ducted forward through a check valve, and discharged into the No. 5 vent line. Ram air from the intake will circulate through the vent line and overboard at the wing tip vent port, but due to a restrictor in the line a small back pressure will be maintained in the No. 5 Fus. bag at all times during flight. During the maneuver most likely to collapse the bag — a rapid descent from high altitude — the positive pressure in its vent line ensures that pressure in the bag will never lag significantly behind the increasing atmospheric pressure.

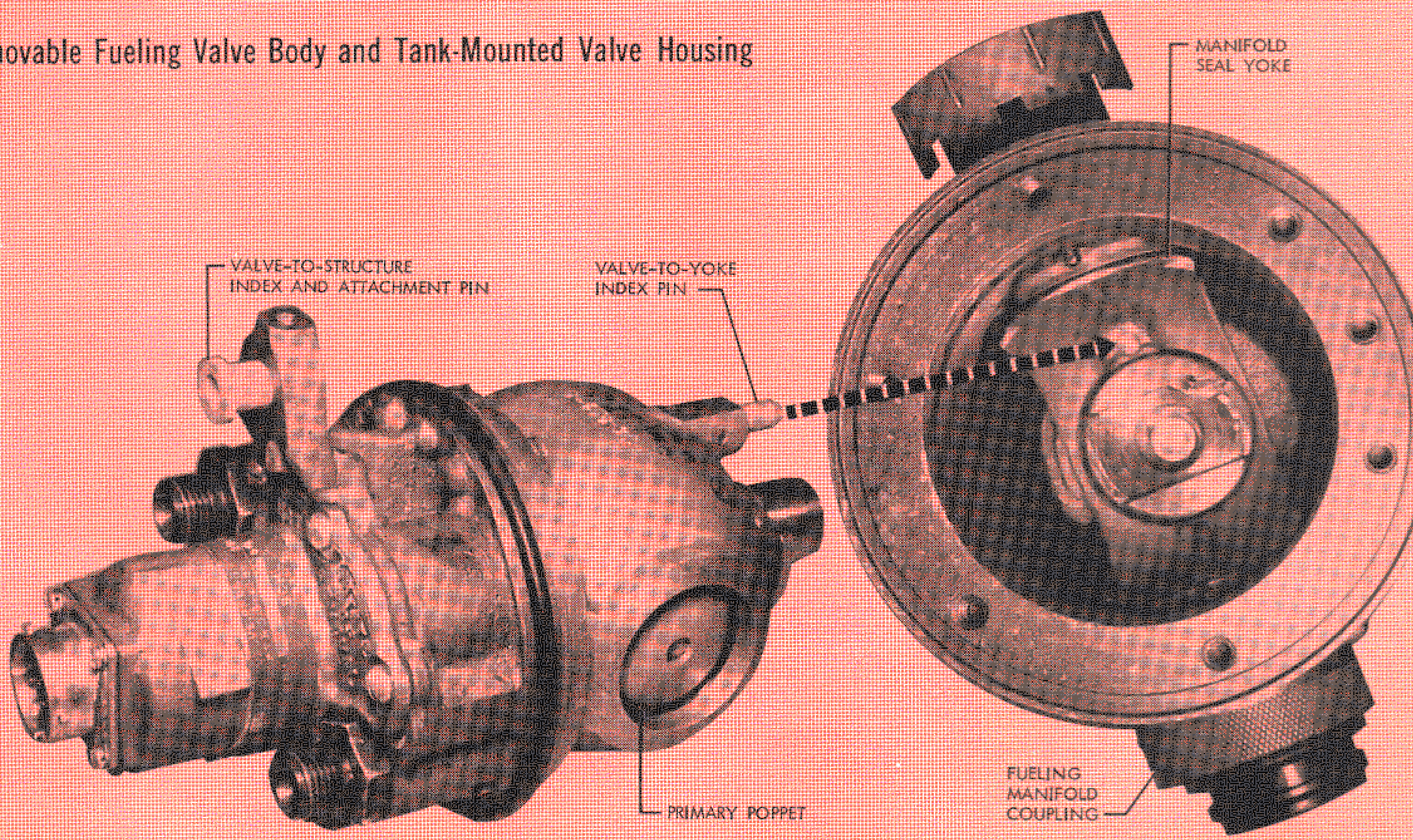
Quantity Indicating is of the capacitor probe type. Multiple probes — 5 in each outboard tank, 3 in each inboard tank, 3 in No. 5 Tank — are top mounted in the wing tanks, bottom mounted in the No. 5 Tank. Indicators for the five tanks are provided on a Fueling Control Panel at the pressure fueling facility and on the Fuel Management Panel in the flight station. The latter panel also has a drum-type totalizer. All the quantity indicators are calibrated in pounds.

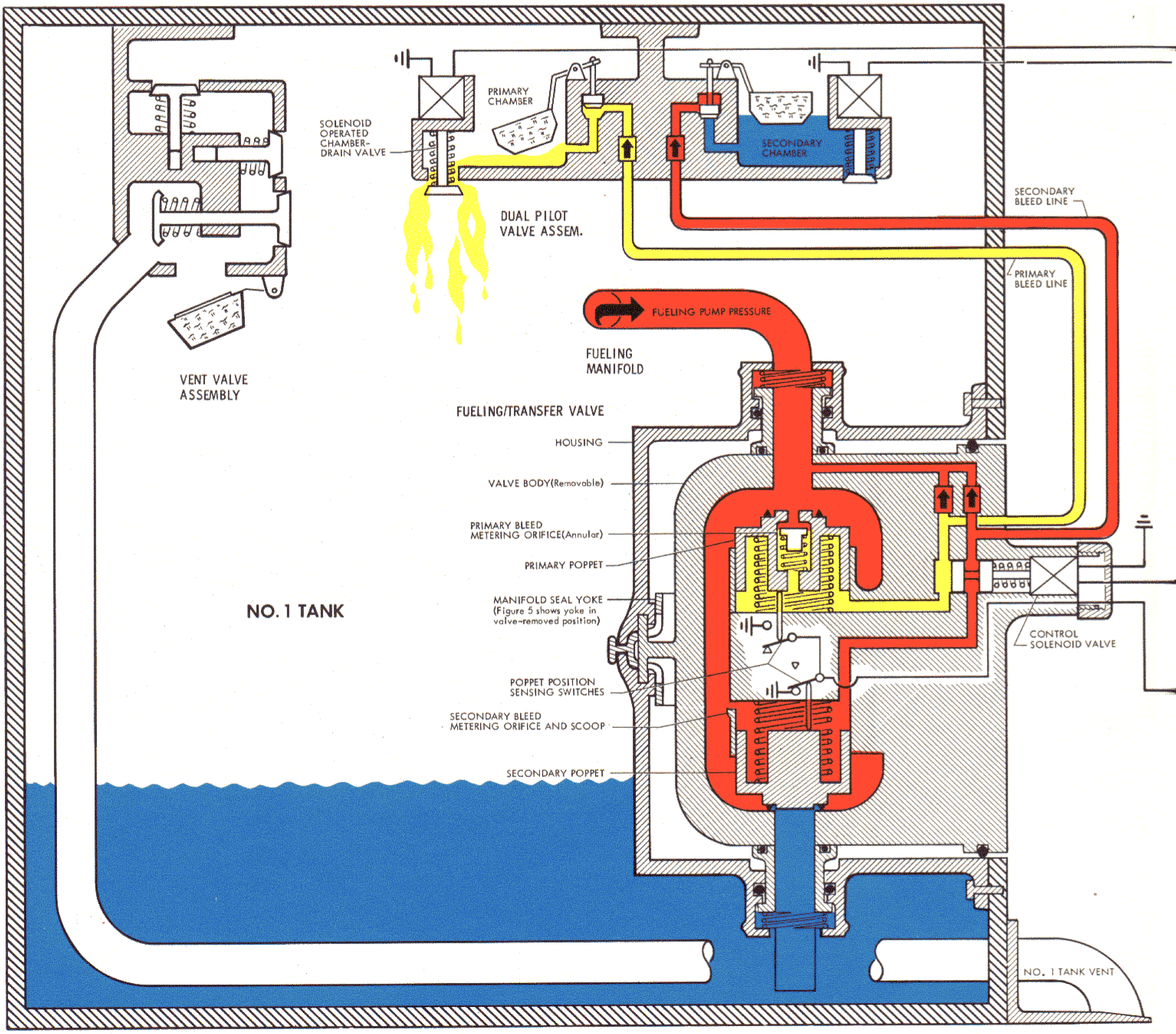
PRESSURE FUELING

The pressure fueling facility shown on the title page is located inboard of No. 3 Engine in the lower aft wing-to-fuselage fillet. The two fueling connectors, suitable for MS29520 Type D-1 hose nozzles, allow accelerated servicing when two fuel trucks are available. The two supply lines are joined into a single large diameter tube which passes into No. 5 Ctr. Tank through the aft shear beam web as shown in Figure 2. Inside the No. 5 Ctr. Tank the main tube is joined to a fueling manifold which has three branches — a left, right, and forward branch. The left and right branches run spanwise inside the wing tanks to fueling valve housings bolted to the aft shear beam in each engine-feed tank. The forward branch goes to a fueling valve housing for the No. 5 Ctr. Tank mounted on the forward shear beam. It continues through the forward beam, a dry bay, and enters the No. 5 Fus. Tank through the aft tank bulkhead and bag wall, terminating at the No. 5 Fus. fueling valve housing which is mounted on the aft bulkhead. (Actually, tubing continues on to the two transfer pumps, but these lines carry no flow in fueling or defueling and are not a part of the fueling manifold). An open tube extends from each fueling valve housing to the bottom of the respective tank, enabling almost all of the fuel to be removed when the valves are used for defueling.

The fueling valves are identical units. They are spring loaded to the closed position, have a solenoid valve for manual control, and a dual pilot valve control which provides two separate and automatic closure controls for the fueling valve when the tank is full. The design is such that pressure (either positive or vacuum) must be applied to the fueling manifold before the valves can be opened, and no valve can be opened by positive manifold pressure if its tank is already full. Fueling valves utilizing a similar theory of operation have been used for years on other pressure-fueled airplanes, but the Orion fueling valves are somewhat different in their "plug-in" design which allows a valve to be removed without defueling the tank. The valve body, containing all the moving parts, can be turned in the permanently mounted housing (this positions the temporary sealing yoke shown in Figure 5 to block the flow of fuel from the fueling manifold) and extracted through the access hole in the shear beam or tank bulkhead. This plug-in concept is used with most of the tank-mounted components on the Orion in order to simplify routine maintenance. It is an especially valuable feature of the fueling valves, for these valves must function properly for normal defueling, and if a malfunctioning valve could not be removed as described, defueling to effect a minor repair would be an onerous task.

Figure 5 Removable Fueling Valve Body and Tank-Mounted Valve Housing





DETAILED OPERATION — FUELING AND PILOT VALVES

The tank-mounted components of one engine-feed tank and the principal electrical circuitry concerned with the fueling, defueling, and transfer operations are shown in simplified schematic form in Figure 6. The vent system is entirely automatic and mechanical, and is shown only for purposes of reference and orientation.

The Fueling and Defueling placards adjacent to the Fueling Control Panel contain the procedural steps necessary to enable a relative stranger to the Orion to accomplish either task. It is highly desirable, however, that the operator understand the reasons for these steps so that he can do the job safely and intelligently in every circumstance, and the key to such understanding lies in knowing the details of operation of the fueling valve.

The body of the fueling valve contains two poppets, designated as primary and secondary, which are arranged in series, that is, fuel must first pass the primary, then the secondary poppet before it is discharged into the tank.

In effect, the poppets are floating pistons, lightly spring loaded to the closed position. In order to open the valve it is necessary to reduce the pressure force on the inner face of each poppet below the pressure force (or the sum of two pressure forces) acting on the outer poppet face (or faces). During fueling, this is done by allowing a metered bleed of fuel to flow

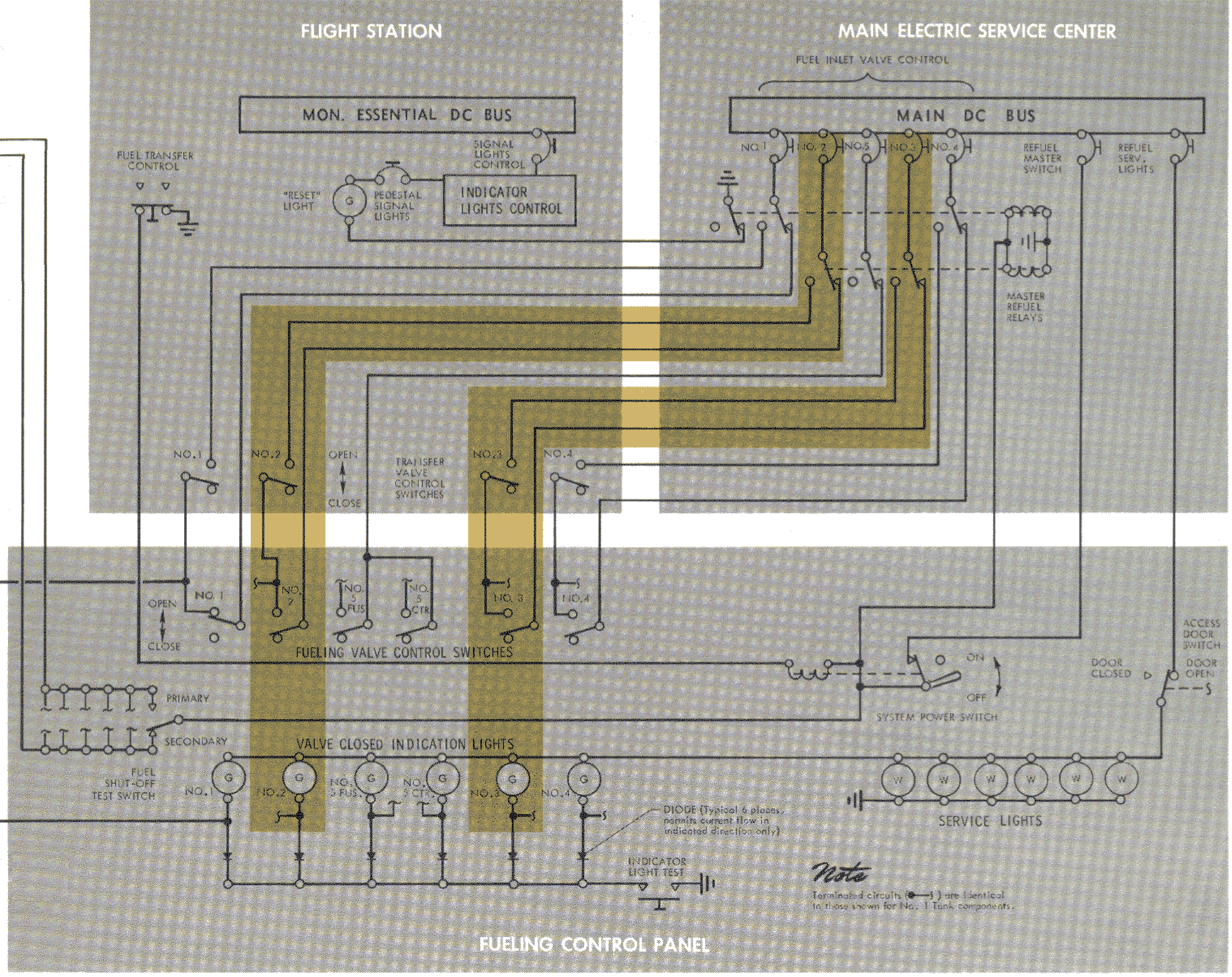


Figure 6 Fueling/Transfer Valve Master Schematic. Condition shown is the conclusion of the Secondary Fuel Shutoff Test, just prior to fueling.

freely from the cavity behind each poppet and spill into the tank through the float chamber drains of a dual pilot valve assembly mounted at the top of the tank. If either or both of these bleeds are blocked, one or both poppets will close and stop the fueling flow to that tank.

The fueling valve control solenoid operates a valve which blocks both bleeds (and, therefore, fueling flow) when the solenoid is de-energized, or allows both bleeds to flow to the pilot valve when the solenoid is energized by turning the Fueling (or Transfer) Valve Control Switch to "OPEN."

When the tank approaches full, the rising fuel floods the two pilot valve float chambers and the float operated valves close, blocking both bleeds and causing both fueling valve poppets to close.

To enable the operator to test that the automatic fill-and-shutoff feature is operable without filling the tank, a Fuel Shutoff Test switch is provided. By selecting "PRIMARY" or "SECONDARY," the operator plugs the related float chamber drains by means of solenoid operated stopper valves. When the bleed fills the chambers, the floats will rise and shut off fueling flow exactly as if the fuel tanks were full. This is the situation pictured in Figure 6. The secondary bleed has filled the float chamber and full fueling pressure has been trapped behind the secondary poppet, causing it to close and stopping the fueling flow even though the primary bleed continues to flow and the primary poppet is open.

Note that a position sensing switch provided for each poppet closes when the poppet is closed; opens when the poppet is opened. The switches are wired in parallel so that when either switch (either poppet) is closed, a green Valve Closed Indication light on the Fueling Control Panel will be illuminated.

DEFUELING Examination of the Figure 6 schematic will reveal that if defueling suction is applied to the fueling manifold, the fueling valves will operate just as they do in fueling, except that the bleed flow from behind the two poppets is drawn through individual passages (fitted with check valves) in order to create a low pressure (a negative gauge pressure) behind the poppets. The pilot valves have no function in defueling except that they contain check valves which prevent air from being drawn backwards through the pilot valve bleed lines and "spoiling" the partial vacuum behind the poppets. Two other check valves of importance to defueling are discussed under "Fuel Transfer System Design."

About 10 in. Hg (minus 5.0 psig) suction is required to open the fueling valves for defueling, but once flow is established, a substantially lesser vacuum will suffice to hold them open.

THE FUELING OPERATION

In pressure fueling the Orion, the operator has an incidental responsibility in addition to that of safely and correctly provisioning the aircraft. When the engine-feed tanks are to be filled and auxiliary fuel is to be carried in No. 5 Tank, the fueling operator has the opportunity to "preflight" a major portion of the fuel transfer system. In the normal course of servicing the fuel tanks, he — and only he — can test the automatic fill-and-shutoff feature of the pressure fueling system under conditions where a malfunction will not result in over flowing the tank, and if a malfunction is discovered during fueling, it can generally be evaluated and rectified, if need be, without delaying the takeoff.

In the following discussion we have listed the fueling procedural steps chronologically as they are on the fueling placard, but we have added some additional detail and interjected a great deal of explanatory text which could not be included in the confines of a placard:

— Make-ready for fueling

There is nothing particularly unique about Orion fueling preparations. An external power source must be connected. Both ac and dc power is required; ac being needed for the quantity gauging system, dc for fueling system control and indication. Unneeded electrical and electronic components should be deenergized. Radar gear is regarded to be particularly hazardous as an ignition source (the P-3 Maintenance Instruction Manual decrees that no radar be operated within 120 feet of the aircraft during fueling operations) and of course all potential ignition sources should be removed, especially from the vicinity of the tank vent ports at the wing tips.

Inspect the vent ports to see that they are unobstructed. Aircraft accidents occur regularly because somebody, generally with the best of intentions, has found an ingenious way to plug tank vent ports. The Maintenance Instruction Manual specifies further that monitors be stationed on work stands at the wing tip ports to observe (or more accurately, to feel) that vapor is expelled freely as the tanks are fueled. Although this may seem an extreme precaution, it is the most feasible way of ascertaining that the full extent of the tank vent systems is unobstructed.

— Open fueling panel access door

— Ascertain that all Fueling Valve Control Switches are in "CLOSED" position

As shown on the Figure 6 schematic, an access door switch automatically illuminates the service lights (White) and provides power to the six (Green) Fueling Valve Closed Indication lights for the individual fueling valves. Since the two spring loaded poppets and their position sensing switches in each fueling valve should be closed at this time, all the green indicator lights should illuminate immediately when the access door is opened.

An unlit lamp can be tested for defects by pressing the Indicator Light Test switch provided for that purpose. If an unlit lamp responds to the Test switch, it is an indication, but not positive proof, of serious trouble in the related fueling valve. The poppets seat on rubber, and generally they are seated securely by full fueling manifold pressure acting, together with the spring load, on the large inner face of the poppet. If the fueling valve was last closed during defueling or very low-pressure fueling, the poppets may be effectively closed, but they may have closed so softly that the position sensing switches did not close. If the fuel level in the related tank is low enough so that there is no danger of accidentally overflowing the tank, the valves can be seated securely by applying normal fueling pressure to the fueling manifold, being ready to remove the pressure immediately if the quantity gauge indication rises, proving that the fueling valve is indeed open. Needless to say, a jammed-open fueling valve must be remedied before pressure fueling, or before flight if the flight requires transfer from the No. 5 Tank.

A Gauge Test switch is also provided on the Fueling Control Panel. Pressing this switch will introduce an artificial signal into the quantity measuring portion of the five gauge circuits, causing the indicators to drive to the empty stop (a point slightly below the zero reading). Note that the test proves whether or

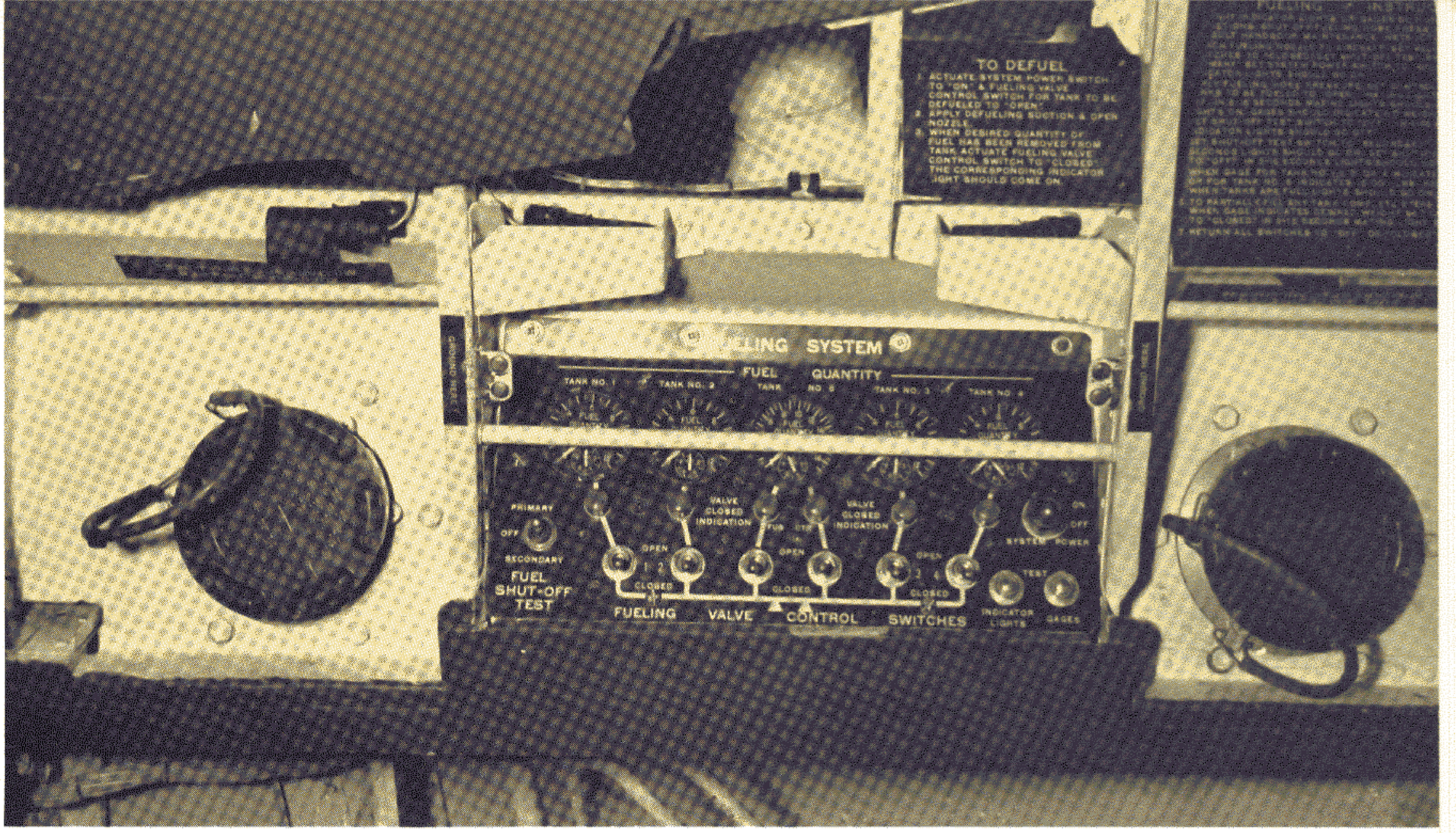


Figure 7
Fueling Control
Panel

not the instruments are operable; it cannot prove the accuracy of the readings.

— AFTER all static electrical bonds are in place attach fueling nozzle (or nozzles) to the aircraft

— Set System Power switch "ON"

— Hold Fuel Shutoff Test switch in "PRIMARY" position

The Test switch is a momentary type switch that is spring loaded to "OFF." It must be held in position during the shut-off test.

— Apply fueling pressure (45 to 55 psi)

— Check that all Valve Closed Indication lights remain lit

When held at "PRIMARY," the Test switch will close the primary chamber drain valves in all six pilot valves.

When fueling pressure is applied, the Indication lights may "blink" off and then back on almost immediately if there is air in the fueling valve. A valve which allows an appreciable fueling flow to enter the tank when its Control switch is at "CLOSED" is obviously uncontrollable from both the manually operated Fueling Valve and Transfer Valve switches, but it may respond normally to the pilot valve. In this case the malfunction would not necessarily be dangerous, but if either of the No. 5 Tank fueling valves cannot be closed electrically, fuel transfer will be seriously affected due to the fact that much of the transfer pump output will return through the open fueling valve into the No. 5 Tank (see Figures 2 and 11).

— Set Fueling Valve Control Switches to "OPEN" for tanks to be fueled

— Check that selected tanks Valve Closed Indication lights go out for 5 to 15 seconds, then relight

Selecting "OPEN" at the Fueling Valve Control Switches opens the primary and secondary bleed lines to the pilot valves in the selected tanks (see Figure 6). As fueling pressure, which has until now been trapped behind the primary poppets, bleeds off, the primary poppets will be unseated. Fueling pressure will gain access to the body of the valves, initiating the secondary bleeds. The secondary bleeds, allowed to flow freely from their metering orifice to the pilot valves, will not create pressure behind the secondary poppets. Therefore, when full fueling pressure acts upon the annular-land surface of the secondary poppets, the poppets will open, and fuel will flow into the tanks. Since both poppets are open, both poppet position sensing switches in each valve will be open, extinguishing the Valve Closed Indication lights for the selected tanks.

In about 5 to 15 seconds, the primary bleeds will have filled the applicable primary float chambers, the bleed flow will be shut off at the float valves and full fueling pressure will build up behind the primary poppets. With equal pressure on either side of the primary poppets, their spring load will force the poppets closed, illuminating the Valve Closed Indication lights.

— Turn "OFF" (release) Fuel Shutoff Test switch until applicable Valve Closed Indication lights go out, then select "SECONDARY"

— Check that all Valve Closed Indication lights are illuminated in about 5 to 15 seconds

This proves the operability of the secondary side of the pilot valves and completes the initial check of the fueling valves and the automatic shutoff function of the pilot valves. If the valves and indication lights

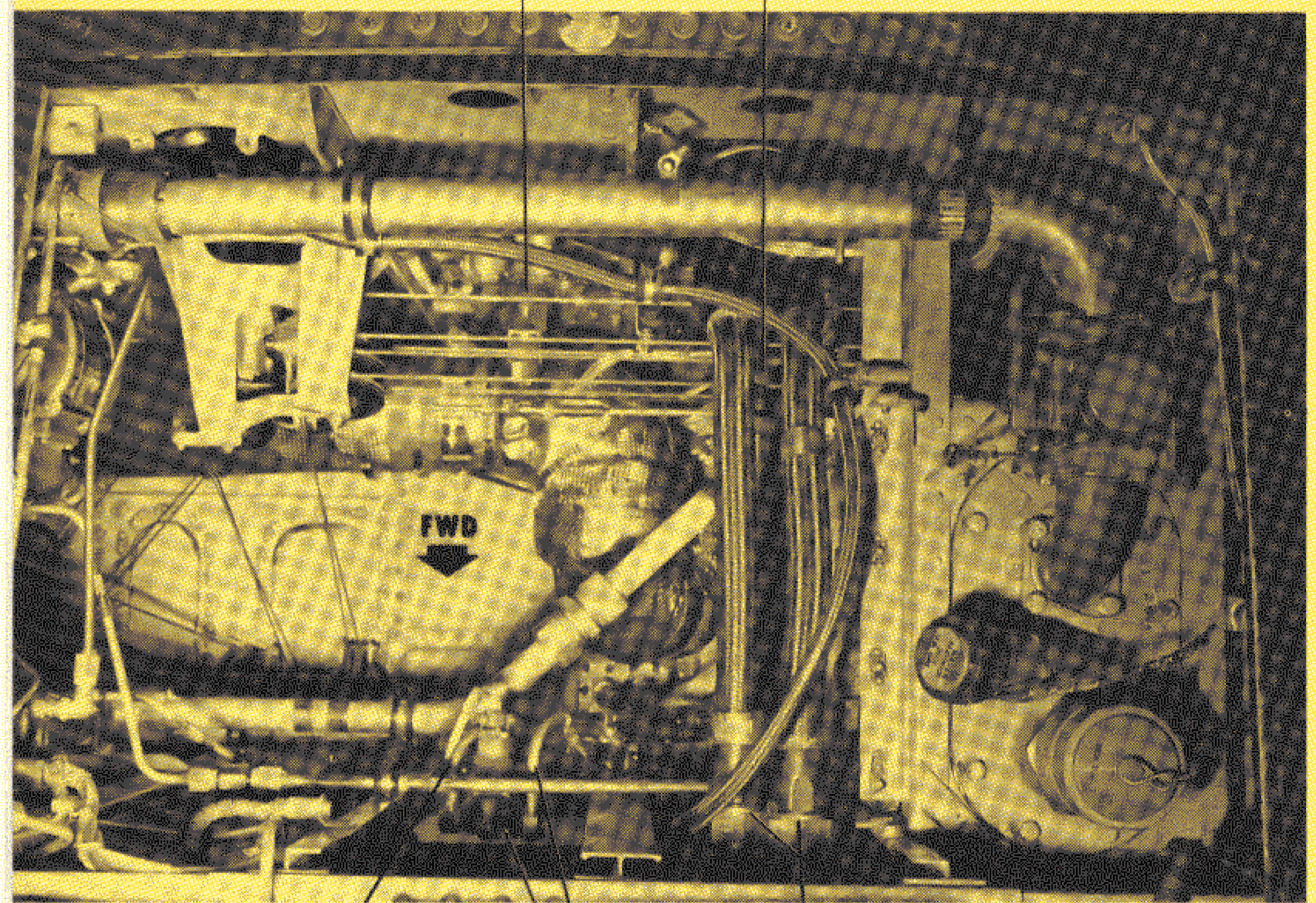


Figure 8 View Looking up through Water Alcohol Access Hatch. Interconnect tube is to the left, beyond view.

have all responded as outlined above, the operator may now:

— Turn "OFF" (release) the Fuel Shutoff Test switch

— Set the No. 5 Ctr. Fueling Valve Control Switch to "CLOSED" if less than 4000 lb of fuel is to be carried in No. 5 Tank

The appropriate Valve Closed lights should be extinguished, the inflow of fuel should register on the quantity gauges, and the vent monitors should report a satisfactory vapor flow from the related vent ports.

If a light does not respond as specified in this procedure, fueling should be terminated, and maintenance action should be initiated.

If a light indicates a malfunction, but the quantity gauge indicates that the fueling valve is operating properly, the trouble is most likely a maladjusted poppet position sensing switch; a problem of no great significance.

If one fueling valve poppet operates correctly and the other one does not, the trouble may lie either in the fueling valve or in the pilot valve. A method of pinpointing the trouble is given under "General Service Information."

The initial check of the automatic shutoff is made before any appreciable amount of fuel is added to the tanks. This ensures that a check will be made, even though the tanks are being "topped off" only, or that only a small amount of fuel is to be added. In many cases, however, well over a thousand gallons of fuel will be added to each tank after the initial shutoff test was made. The head of fuel in the tank, against which the secondary poppet must close, is now greatly increased, and a test made at this time will be more representative of the conditions which exist when the pilot shutoff must operate. Furthermore, if a solid contaminant has been carried into a valve with the high-rate fueling flow, it could easily interfere with the fueling valve poppet operation. Therefore, the operator should:

— Repeat the "SECONDARY" Fuel Shutoff Test when the tanks are about 1000 lb from full (9000 lb for the engine-feed tanks; 16,000 lb for No. 5 Tank)

— When tanks are to be only partly filled, set the Fueling Valve Control Switches to "CLOSED" when the desired level is indicated on the fuel gauge

— When tanks are to be completely filled, allow the pilot valves to close the fueling valves automatically

— Turbulence, pressure fluctuations, etc. can cause the Valve Closed Indication lights to blink on and off before the tank is completely full. Wait until the cycling stops before removing fueling pressure or turning Fuel Valve Control Switches to "CLOSED"

— When fueling is complete, observe that all Valve Closed Indication lights are illuminated; set all switches to "CLOSED" or "OFF"

FUEL LOADING When fuel is loaded into No. 5 Tank, there is one simple rule that must be observed. *If 4000 lb or less fuel is to be carried in No. 5 Tank, all of it must be loaded through the No. 5 Fus. fueling valve.*

A combination of factors involving the tank design and the requirements of the transfer system makes this obligatory, and we will digress to briefly explain these factors.

The interconnect between the No. 5 Ctr. and Fus. Tanks is located a few inches above the floor of the No. 5 Ctr. Tank for two reasons: First, it is necessary that cutouts in the wing front shear beam be well clear of the spar caps in this highly stressed member. Second, belly landings experienced by other aircraft with fuselage fuel tanks indicates that when tank interconnect ports are located in the tank floor (necessitating that the interconnect be routed below the level of the tank adjacent to the belly skin), the entire contents of both tanks are much more likely to be spilled, greatly increasing the fire hazard if such an emergency arises. Thus the location of the interconnect on the P-3A was chosen as optimum for strength, safety, and utility.

The Transfer System is discussed in more detail in the following pages, but in the present context it is important to realize that both transfer pumps are mounted on the bottom of No. 5 Fus. Tank; one at the forward end, one at the aft end. These pumps must be primed, that is, the pumping elements must be immersed before fuel can be scavenged from No. 5 Ctr. Tank and transferred to the engine-feed tanks.

Because of weight limitations, there will be many instances in which No. 5 Tank will be only partly fueled, and, unlike the engine-feed tanks, No. 5 Tank will ordinarily be completely empty when the airplane is to be fueled. The importance of this lies in the fact that there will generally be no residual fuel in No. 5 Fus. Tank to prime the transfer pumps. The Fueling Control Panel has a fueling valve control for No. 5 Ctr. Tank and one for No. 5 Fus. Tank, and a single No. 5 Tank quantity gauge which reports the combined content of the two compartments. Note that the fueling operator does not have individual quantity gauges to ascertain the fuel levels in the two compartments, and since the levels may vary considerably unless both compartments are filled to the level of the interconnect, the one simple rule must be followed during fueling to ensure that No. 5 Tank fuel will always be apportioned in such a way that the transfer pumps will be effective. We reiterate: *If 4000 lb or less fuel is to be carried in No. 5 Tank, the fuel should be loaded through the No. 5 Fus. fueling valve.* Otherwise, the transfer system may be completely useless, or it may function sporadically, depending upon the exact circumstances.

On the Orion every available cubic inch of tankage space is devoted to fuel storage, indeed less than 0.4% of the engine-feed tank volume is unused for fuel. Since JP-4 expands more than this (about 0.5%) per 10° F rise in temperature, it is inevitable that if the tanks are completely filled with cool fuel quite some time before takeoff on a hot day, the tanks will overflow through the vent ports at the wing tips — an obviously undesirable situation.

If maximum fuel load is to be carried and the fuel is appreciably cooler than ambient temperature, the tanks *must* be filled as near to takeoff time as possible to circumvent the thermal expansion overflow.

The thermal expansion overflow can be avoided if a less-than-maximum fuel load is to be carried by terminating fueling to the engine-feed tanks when the fuel level in each tank is 1000 lb below full, and loading 4000 lb extra fuel into No. 5 Tank to compensate for the shortage in the four engine-feed tanks.* In such a case, take particular care to load the compensatory fuel through the No. 5 Fus. fueling valve.

**The 1000 lb deletion from the engine-feed tanks is calculated to allow for the most unfavorable conditions, ie, cold fuel, a hot day, and a 5° ramp slope. It will require about a half hour to transfer 4000 lb of fuel, as must be done before takeoff. Under more favorable conditions a lesser fuel deletion will provide ample expansion space and the pre-takeoff fuel transfer will require proportionately less time.*

The compensatory fuel must be transferred from No. 5 Tank into the engine-feed tanks shortly before takeoff to obtain the minimum wing load in flight, and, as explained under "Transfer System Design," the greatest head of fuel obtainable must be provided for the transfer pumps if the fuel is to be transferred at a high flow rate.

Of course, the best procedure would be to simply keep the compensatory fuel in the fuel truck and arrange to "top-off" the tanks with the fuel truck pumps just before takeoff.

Except for the instances in which fuel is put into No. 5 Tank temporarily to provide more expansion space in the engine-feed tanks, *fuel is never to be put into No. 5 Tank unless the engine-feed tanks are to be completely filled.* Any deviation from this rule will involve deviations also from the normal rules of transfer system operation. That system was designed to automatically supplant engine-feed fuel as it is used from the engine-feed tanks, thus automatically maintaining symmetrical fuel load and obtaining the minimum wing load in flight. Permission for such non-standard operation has been sought, and engineering consideration is, at this writing, being given to this request. If authority to operate with part-loads in all tanks is granted, it will allow better aircraft utilization in isolated cases, but because of the many structural, design, and operating aspects involved it is not anticipated that this will become standard operating procedure.

When maximum fuel is carried, stores loading must be carefully considered and vice versa, for with maximum armament and search stores aboard and all tanks full of JP-4, the Orion will be many thousand pounds heavier than the 127,500 maximum gross takeoff weight for which it was designed. Overload gross weight operation (weight above 127,500 lb) requires that special flight and ground handling limitations be observed.

JP-5 may be used in the Orion as alternate fuel to JP-4. However, at a given temperature, JP-5 fuel is denser than JP-4 and the airplane would be badly overloaded if it were completely fueled with JP-5. If JP-5 is used, its exact density should be known, for it may be necessary to calculate fuel weight and load according to gallonage readings at the fueling truck and/or the engine-feed tank dipstick. Although the Orion quantity system is compensated to take into account the density range of JP-4 fuel, the gauging system and the No. 5 Tank sight gauge — which is calibrated to read the weight of JP-4 at nominal density — may yield deceptively low readings when JP-5 fuel is in the tanks.

GENERAL SERVICE INFORMATION

As stated previously, the wing tanks are almost completely filled during pressure fueling, possibly to a level higher than the caps on the wing top filler wells, depending upon the exact point at which the pilot valves close. For this reason the Orion should not be pressure fueled with the filler caps removed unless suitable precautions are taken to prevent overflow. Also, anyone attempting to "dipstick" the engine-feed tanks after they have been pressure fueled to capacity should be prepared for overflow when the caps are loosened.

We do not recommend that over wing filling and dipsticking be done as a matter of course, for traffic on the wings takes a steady toll of minor damage, and some contamination will inevitably enter the tanks through the open filler-wells. If it is necessary to walk on the wings, put down walk-way mats, wear wing socks, and *never* lean ladders against a wing.

Due to wing dihedral, the filler-wells must be located near the high outboard end of the engine-feed tanks. Consequently, dipsticking through the filler-wells will yield no reading unless the inboard tanks contain 4225 lb (650 gallons) or more fuel; the outboard tanks 8775 lb (1350 gallons) or more.

WARNING

High rate fueling flow can generate high static electrical charges in the fuel. In the Orion integral tanks, these charges should dissipate quickly, but to be certain that there is no potential for static sparks and explosions, the dipstick should not be used for at least three minutes after fueling has been terminated.

As mentioned previously, the bottom of No. 5 Fus. Tank and the No. 5 Ctr. Tank are both somewhat lower than the interconnect between the two compartments. Since there is but one sight gauge for the tank, true fuel measurement can only be taken manually when the fuel level is higher than the interconnect (more than 4000 lb, total content).

If a Fuel Shutoff Test reveals that a fueling valve does not respond properly to the pilot valve, it is sometimes difficult to determine whether the pilot valve or the fueling valve is at fault. As shown in Figure 2, the pilot valve lines are routed outside the tanks where they are readily accessible. By opening the appropriate line and either allowing the bleed to flow freely or blocking it while the fueling manifold is pressurized, the trouble can be traced to either the fueling or the pilot valve, but:

WARNING

TANKS OVERFILLED BY PRESSURE FUELING WILL ALMOST CERTAINLY BE OVERPRESSURIZED, AND EVEN IF THE TANK DOES NOT RUPTURE, THE WING MAY BE SERIOUSLY DAMAGED.

DO *NOT* INDUCE FUELING FLOW BY OPENING BLEED LINES UNLESS PROPER PRECAUTIONS ARE TAKEN TO PREVENT OVERFLOWING THE TANK.

The exposed pilot valve lines allow a good deal of time to be saved when trouble shooting is necessary, but because of the inherent chance that a tank will be overfilled, this procedure should *not* — repeat *not* be attempted by anyone other than an experienced mechanic who is familiar with fueling systems in general, and this one in particular.

If an unexpected delay is experienced after the tanks are filled, fuel may drip from the wing tip vents due to thermal expansion of the fuel. This constitutes a fire hazard, and it is also likely to dissolve and erode a black-top surface. We suggest, therefore, that ample containers suitable for storage and disposal of flammable waste be kept available, and that these be secured in position to catch the overflow *before*, not after, the overflow occurs.

Defueling Problems generally stem from the use of low capacity pumps or fueling hoses that collapse when used for defueling. Little can be done about collapsed fueling hose except to replace it with hose that will support the maximum vacuum the pump will generate, but the fueling operator (or to be more accurate, the defueling operator) can generally compensate for relatively inefficient pumping equipment. Bear in mind that: the head of fuel in the tank aids in opening the fueling valves; a better vacuum is needed to open the valves than is needed to keep them open; the fueling valves farthest from the fueling facility will have the least vacuum to operate on after defueling flow has been initiated. Any or all of these factors may be important when defueling multiple tanks. If trouble is encountered in opening many valves in sequence, they can generally be opened by setting all the Valve Control Switches to "CLOSED," then setting them to "OPEN" simultaneously. A valve which tends to close as the head of fuel in its tank diminishes will often perform perfectly if it is interchanged with a valve nearer the Fueling Panel.

Note that each pilot valve contains two check valves (12 in all) and that the transfer system incorporates two check valves of a unique design (see Figure 11). If any of these valves fail to seat properly, defueling from one or all tanks may be difficult or impossible due to air back-flowing and "spoiling" the fueling manifold vacuum needed to open the fueling valves. As before, the pilot valve lines can be blocked to facilitate trouble shooting.

SUMP DRAINING is closely related to the fueling operation, and although it is beyond the scope of this article to explore fully the many problems associated with water contaminated fuel, we would be remiss if we did not point out some aspects that make sump draining particularly important on a turbo-prop patrol plane such as the Orion.

In the course of a long range, turbine powered, Navy patrol mission, ranging from the warm humidity of near sea level atmosphere to the extremely cold upper atmosphere, some atmospheric water vapor will condense within the fuel tanks; more will be absorbed directly by the jet fuel (which has a much higher affinity for water than does avgas) and free water will settle and accumulate on the tank floor. As specified on the Maintenance Requirement Cards, every fuel tank sump must be drained at each Daily and Preflight inspection, but we feel that draining for maximum effect is largely a matter of good judgement, and the ground crew can often make additional timely sump drainings, bearing in mind that:

> The maximum amount of water will be drained when the tank fuel is cold (but not so cold as to freeze water) and has not been disturbed for a long period of time. Conversely, the least water will be removed if sumps are drained when fuel is warm (warm fuel tends to absorb free water from the sumps and hold it in solution), or agitated (fuel pumps tend to emulsify the water and fuel). When warm, dry fuel is added to the tanks, the residual fuel will be both warmed and agitated but nevertheless a post-fueling sump drain can sometimes avert an accident. If the added fuel was badly water-contaminated, the residual fuel may cool it enough to cause water to precipitate.

The higher incidence of water in jet fuel tanks, due to the natural causes mentioned previously, has given rise to a phenomenon that can become truly troublesome to maintenance of tank mounted components and the jet-fuel tanks themselves. Microscopic spores live and propagate in the free water accumulations in jet fuel tanks, growing eventually to form a slimy mat—familiarly known as "green slime," although it is more likely to be of a brownish hue. Note that once the mat-like colony has formed it may adhere, generally (though not necessarily) to the tank floor, and it cannot be removed by draining fuel. In some cases, the colonies penetrate the protective coating applied to integral tanks at the factory, and a corrosive process takes place causing pits and craters to form that are extremely dangerous in such vital primary structural members. In other cases, screens and filters have been clogged with slime, and tank quantity probes made inaccurate.

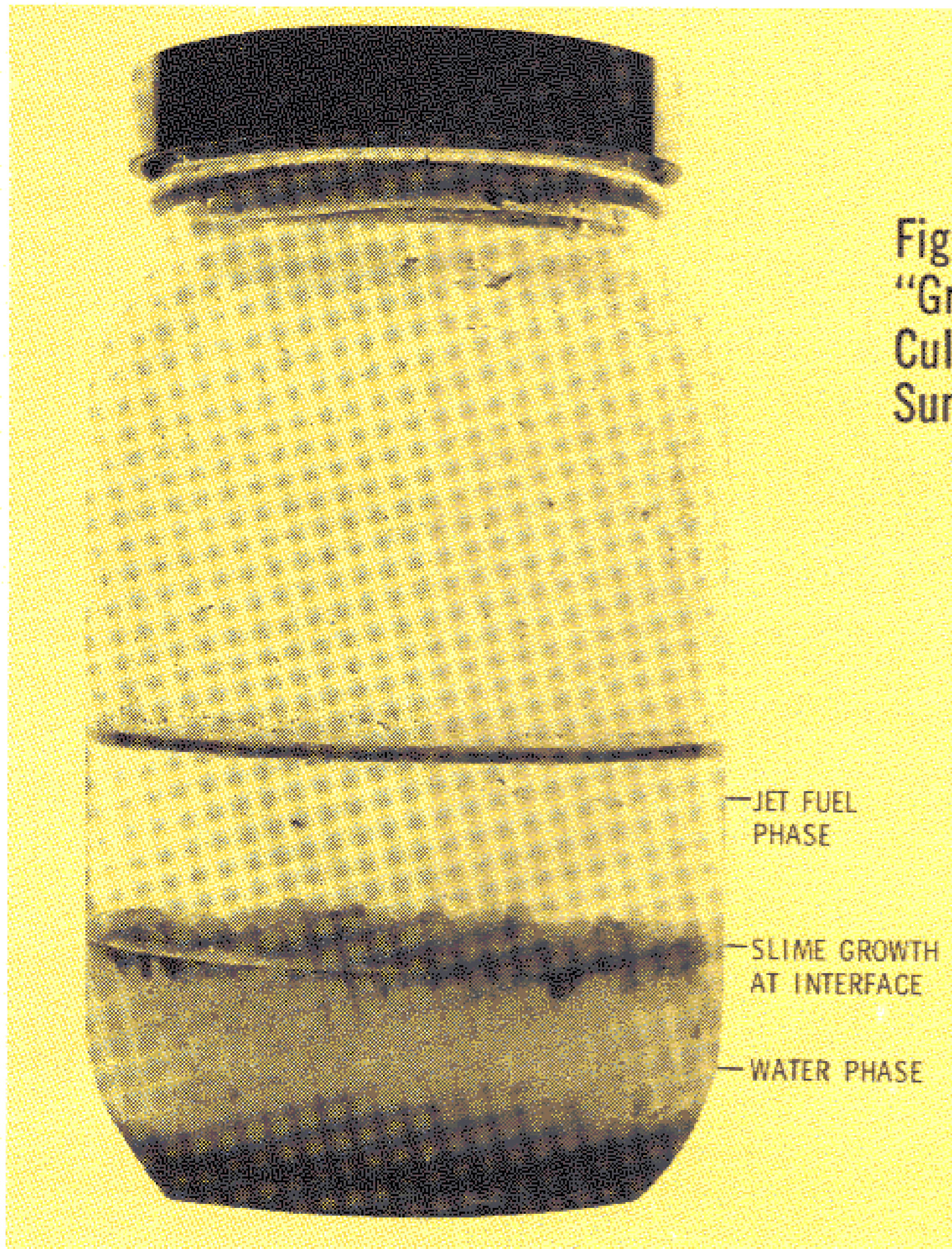


Figure 9 "Green Slime" Cultured in Sump Drain Sample

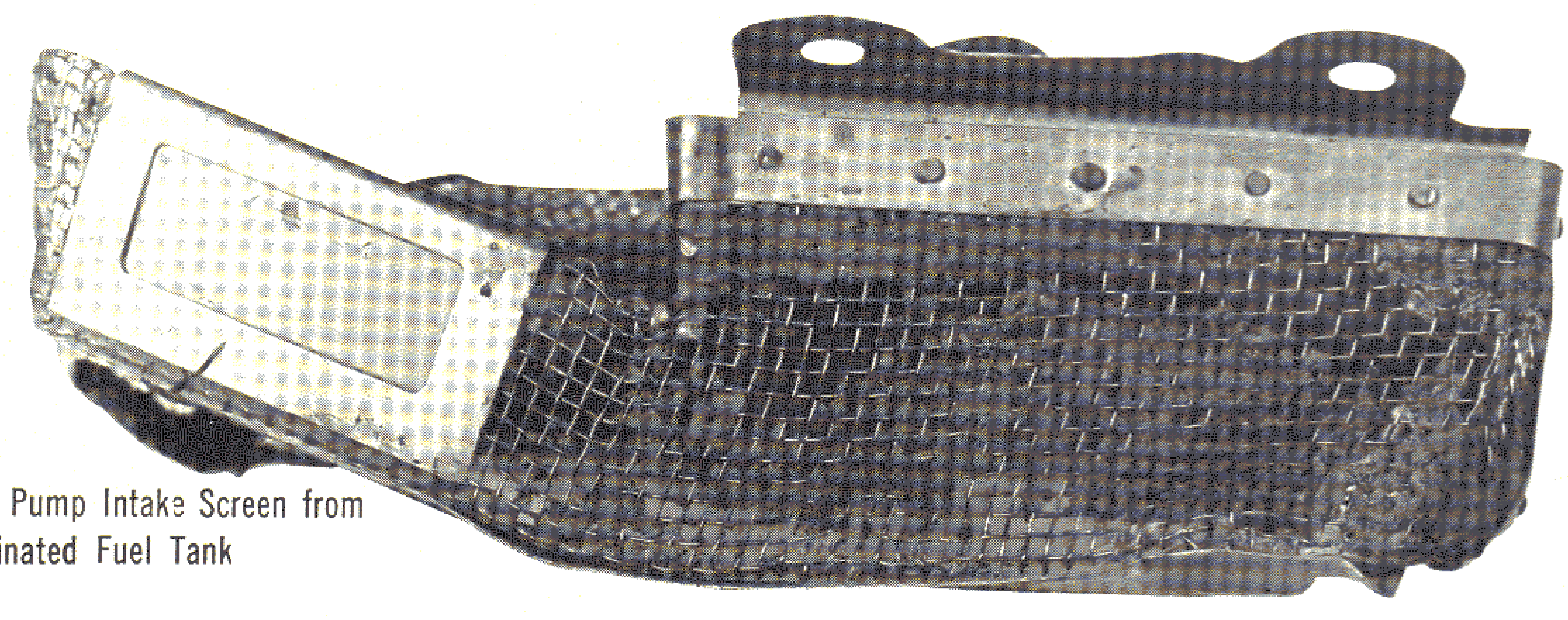


Figure 10 Booster Pump Intake Screen from Contaminated Fuel Tank

Thus, frequent and effective sump draining is required not only to eliminate the usual hazards of water in engine fuel, but also as an extremely important part of preventive maintenance on the Orion. The "green slime" problem can be reduced, or eliminated if all the free water in which the spores incubate is removed by sump draining.

Directions and techniques for sump draining and contaminant identification are given in BUWEPS Instruction 10340.1.

FUEL TRANSFER SYSTEM

DESIGN Figure 11 shows a profile view of the two No. 5 Tank compartments and the transfer pumps and plumbing in schematic form. Orientation is essentially correct, but we have exaggerated certain features to more clearly illustrate some important aspects.

As mentioned previously, the two transfer pumps are identical to the booster-scavenge pumps used in the engine-feed tanks for reasons of interchangeability. They are mounted somewhat differently, however. The engine-feed tank pumps are bottom-mounted, but they are removable through the wing top, and they are provided with plug-in type mounts in order that a pump requiring maintenance after flight can be easily replaced, generally without removing any fuel. Access to the No. 5 Tank is, of necessity, from the bottom, and the transfer pumps are somewhat more difficult to replace.

As shown in Figure 11, the scavenge and the booster elements of the two pumps are both centrifugal screw type elements, mounted on the same drive shaft; the booster element being the larger of the two. The scavenge elements are rated to pump 2000 lb per hour against a 5-psi back pressure; the booster elements are rated to pump 5000 lb per hour against an 18-psi back pressure, and since they are not positive displacement pumps, they will supply proportionately more fuel when operating against a lesser back pressure.

As mentioned previously, the No. 5 Fus. Tank is, in effect, a surge box for the auxiliary fuel. The two scavenge elements of the transfer pumps draw fuel into No. 5 Fus. Tank from the bottom of No. 5 Ctr. Tank. The booster elements (the lower elements of the two pumps) then draw fuel through their screened inlets and pump it through check valves (in a dual check valve assembly) into the fueling manifold and to the four engine-feed tank fueling valves. Maximum transfer pressure is limited to about 13-psi by pressure relief-bypass valves, one of which is located in each pump's booster discharge line between the pump and the dual check valve assembly.

The dual check valve is of interesting design for, as an examination of the Figure 2 schematic reveals, if they were ordinary check valves they would allow an uncontrollable flow from No. 5 Fus. Tank if defueling suction was applied to the fueling manifold, and it would be impossible to defuel any of the other tanks. A cross-section schematic of one of these check valves is shown in Figure 11. The function of the valve can be seen, but in summation we may say that these valves will open only when pressure in the boost pump lines is higher than pressure in the No. 5 Fus. Tank. They will not open in response to low pressure (suction) in the fueling manifold.

If the transfer valves (Nos. 1, 2, 3, and 4 fueling valves) are closed and the transfer pumps are running, the booster discharge will bypass through the pressure relief valves back into No. 5 Fus. Tank, but the scavenge elements will continue to draw fuel from No. 5 Ctr. Tank into the No. 5 Fus. Tank. This excess will flow freely back to No. 5 Ctr. Tank, bypassing the ball-check valve (shown in Figure 11) if the aircraft attitude is level. A 6° nose-up attitude will cause the ball-check valve to seal off the normal interconnect flow in order that the transfer system "surge box" not be drained so low that the pumps cavitate. With the ball-check valve seated, No. 5 Fus. Tank fuel cannot return to No. 5 Ctr. Tank unless it is above the top of the standpipe (see Figure 11) which is teed into the interconnect line just aft of the ball-check valve assembly.

If the four transfer valves are open and the fuel level in the four engine-feed tanks is considerably less-than-full, the valves will accept fuel at a high flow rate. The high capacity booster elements of the transfer pumps may succeed in evacuating considerably more

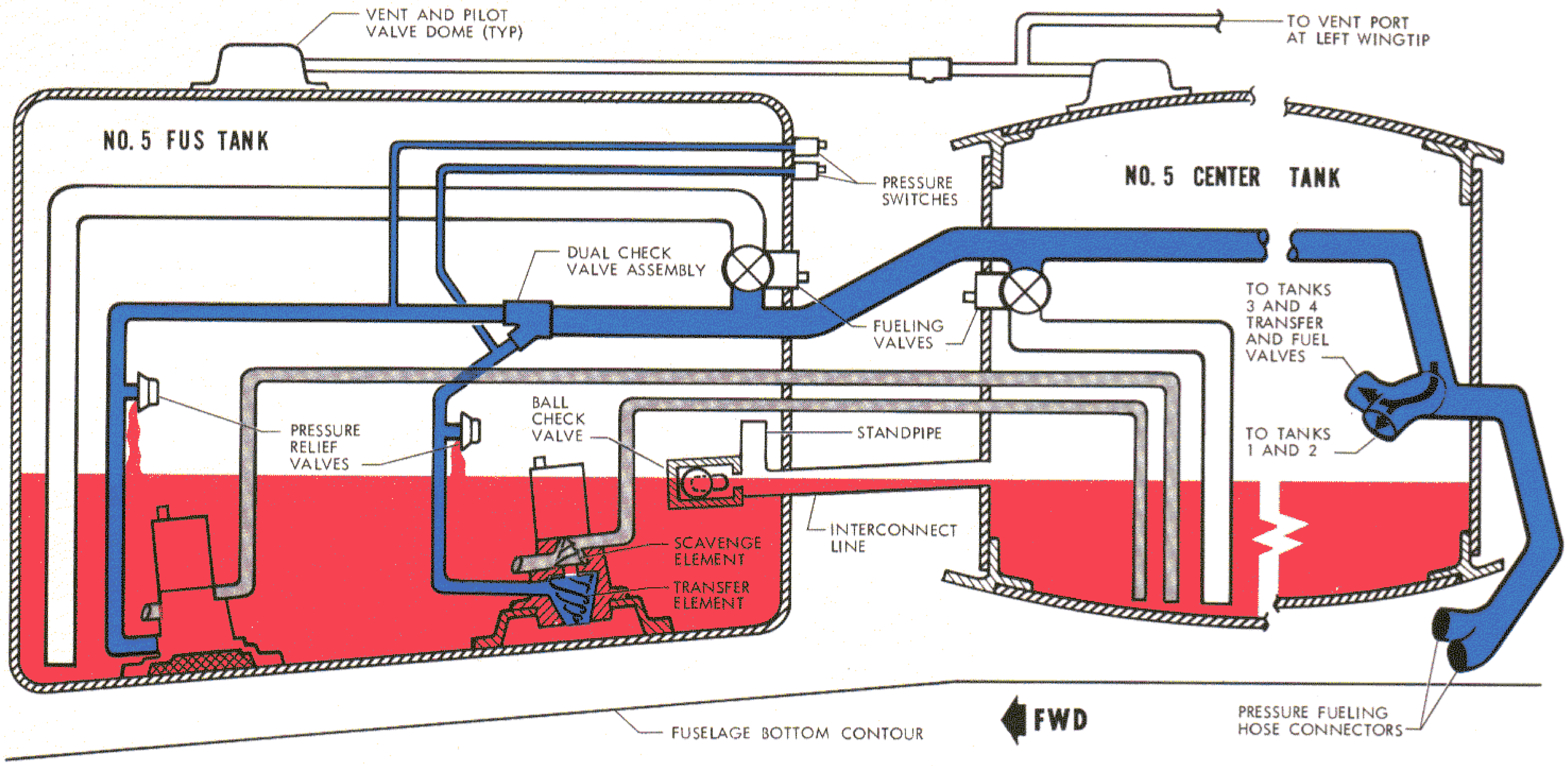
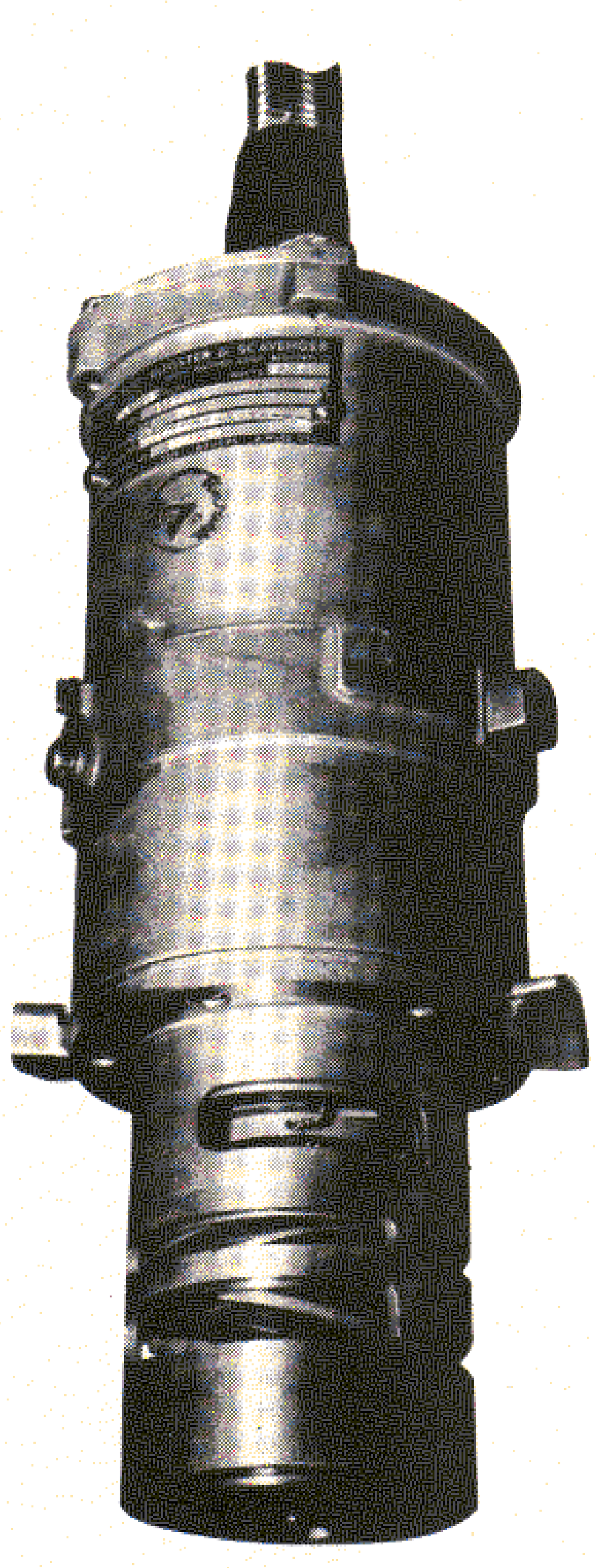
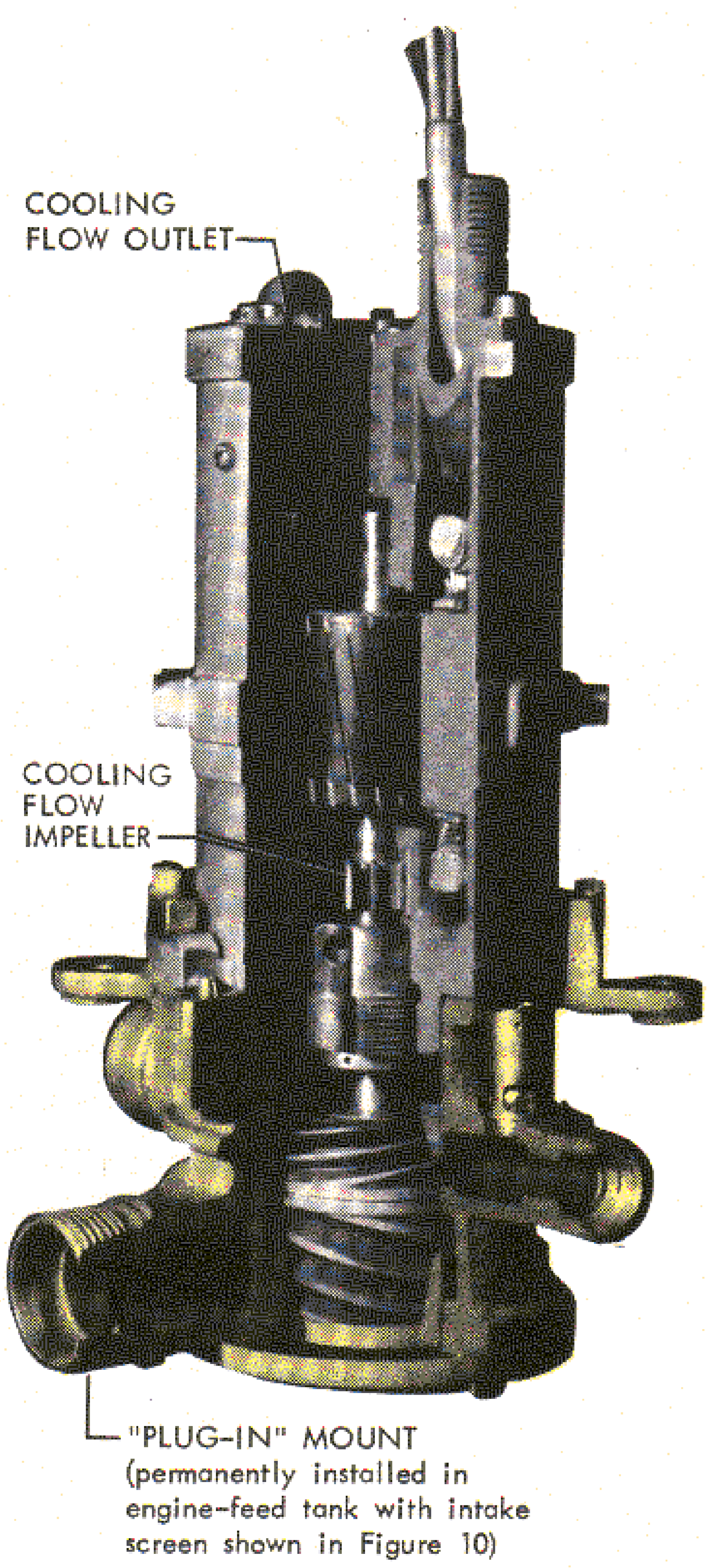
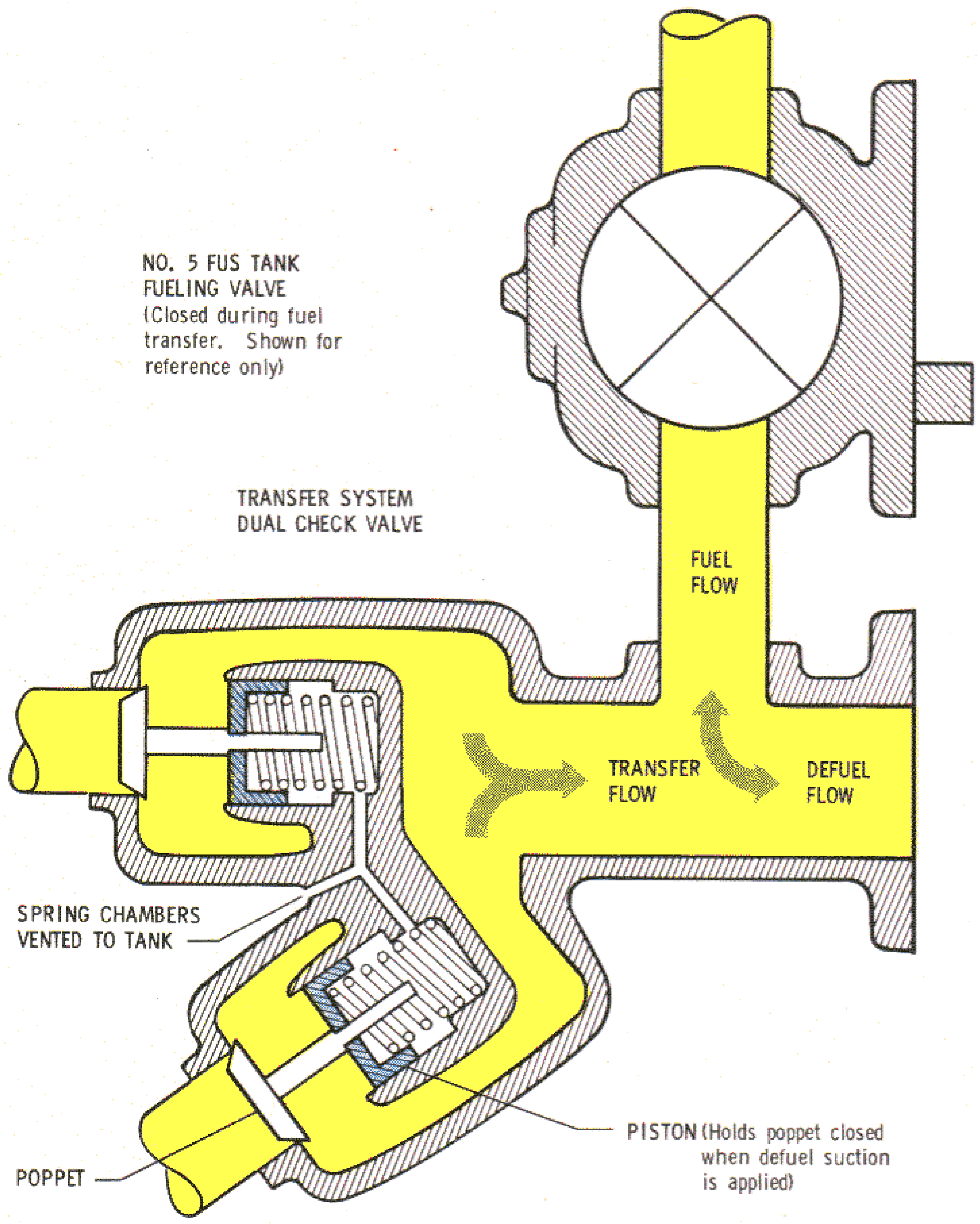


Figure 11 Schematic of Transfer System Operation with No. 5 Tank Fuel at 4000-lb Level. Details of pump and schematic of dual check valve operation shown below.



BOOSTER/SCAVENGE PUMP (Interchangeable, all tanks)





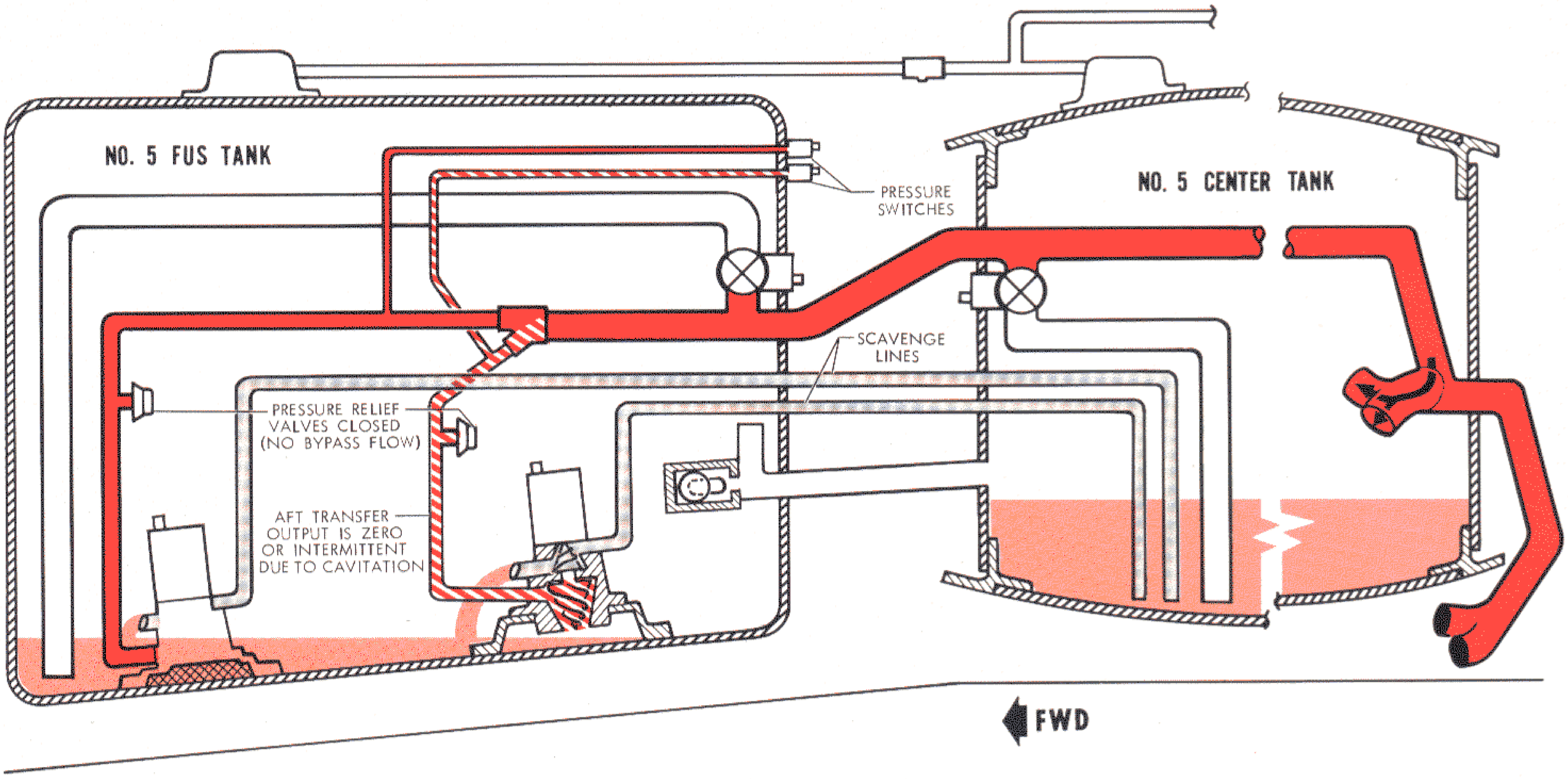


Figure 12 Sporadic Cavitation of one Transfer Pump

fuel from the No. 5 Fus. Tank than the scavenge pumps replace. In this case flow through the interconnect from No. 5 Ctr. Tank will make up the difference so long as there is a head of fuel in No. 5 Ctr. Tank. But if there is less than 2000 lb of fuel in No. 5 Ctr. Tank, it will not gravity-flow through the interconnect and the aft transfer pump's booster element may cavitate. This situation is depicted in Figure 12, and (as mentioned previously in the "Fuel Loading" section) it is evident that if a small No. 5 Tank fuel load is to be transferred rapidly, the fueling operator must load all of it through the No. 5 Fus. Tank fueling valve to ensure that this tank has the maximum attainable fuel content when the transfer operation is initiated.

Two switches, located on the Fuel Management Panel in the flight station, control the transfer pumps. So long as the pumps maintain working pressure, advisory lights, adjacent to the two Transfer Pump control switches, will be extinguished. When the No. 5 Tank fuel has been transferred, the transfer pumps will cavitate; pressure switches will sense that output pressure has fallen below 3 psi, and the advisory lights will be illuminated.

The transfer pumps could supply higher pressure, but they are purposely limited by the relief valves in their discharge lines as part of a triple-safety scheme to ensure that the engine-feed tanks are never overpressurized. If both the primary and the secondary automatic shutoff should fail to modulate the flow into the engine-feed tanks (the transfer valves should admit just enough fuel to replace that being used by the engines) the short, large-diameter vent lines for the outboard tanks can easily discharge the excess fuel from the pressure-limited transfer system without overpressurizing the tanks. The inboard tank vent lines are necessarily about 25 feet longer than the outboard vent lines, and it is questionable that they alone could carry off the necessary flow of fuel without imposing a higher tank pressure than the normal maximum for which the wing structure was designed. For this reason, Tanks No. 2 and 3 are fitted with a recirculation valve — a pressure relief valve which

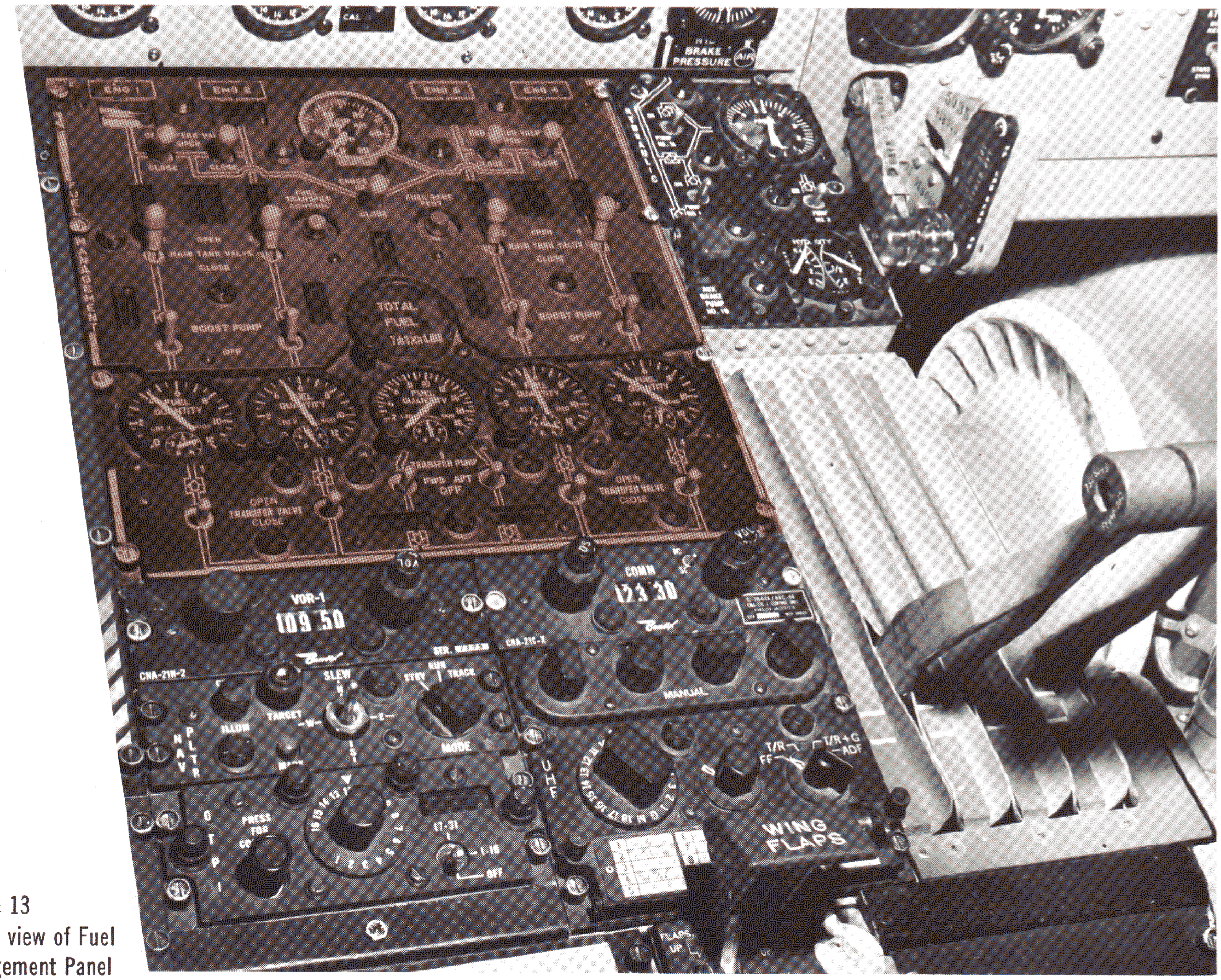


Figure 13
Pilot's view of Fuel Management Panel

cracks at 1.2 psi — and a recirculation tube which will carry excess transfer input back to the No. 5 Ctr. Tank.

The flight crew can check that the transfer operation is proceeding as it should by observing the reaction of the fuel quantity gauges, but we have not provided valve position indicating lights in the flight station for the four transfer valves. The valves cycle open and closed during in-flight transfer due to the action of the pilot valves, and four blinking advisory lights would be more disconcerting than informative.

Since time-lapse is required to check the transfer operation by observing the quantity gauges, it is conceivable that a flight could be under way before the crew discovers that the transfer valves are not operable from the flight station because someone neglected to turn "OFF" the System Power switch at the Fueling Control Panel. For this reason the Fuel Management panel has a "RESET" advisory light, and we have provided a self-latching type System Power switch whose holding coil can be de-energized by pressing a "Fuel Transfer Control" button on the Fuel Management panel (see Figure 13). When its holding coil is momentarily de-energized, the System Power switch returns to "OFF," de-energizing the master refuel relays. When these relays are de-energized, control power for the four engine-feed tank fueling valves is shunted to the Transfer Valve switches at the flight station, both No. 5 Tank fueling valve control circuits are disarmed, and the "RESET" advisory light is extinguished.

OPERATION Operation of the transfer system is surprisingly simple in comparison to the complicated procedures required on most long range aircraft.

If No. 5 Tank has been fueled, the flight crew will turn the Transfer Pump switches to "ON" and the Nos. 1, 2, 3, and 4 Transfer Valve switches to "OPEN." The transfer system will replenish the engine-feed tanks as fuel is expended by the engines, so that Tanks 1, 2, 3, and 4 will be kept completely full until No. 5 Tank is emptied.

It is important from a structural strength standpoint to complete the fuel transfer as quickly as possible. The simple, semi-automatic operation, maintaining at all times the maximum amount of fuel in the wing, was devised in early design work as one of the factors upon which the strength level of the wing was predicated. Fuel weight in the wing subtracts from the wing air loads to produce the net loads for which the wing is designed. Fuel carried in No. 5 Tank which could be transferred into the wing imposes an unnecessarily high stress level in straight-and-level (1-g) flight, and this unnecessary stress is multiplied when multi-g maneuvers are executed or gust loads are encountered. Common sense determines a single general rule that applies without exception: *Never carry fuel in No. 5 Tank that can be transferred into the engine-feed tanks.*

During ground transfer system operation, it sometimes happens that when No. 5 Tank contains about 4000 lb of fuel which is to be transferred into four engine-feed tanks simultaneously, the high transfer rate will empty the fuel from No. 5 Fus. Tank faster than the scavenge pumps can replace it. If this situation continues for some time, the aft transfer pump (which is the highest of the two transfer pumps), will cavitate, causing the "PRESS LOW" advisory light to come on, and the operator may conclude that the pump is malfunctioning. If this occurs, we suggest that the operator turn all the Transfer Valve switches to "CLOSED" for a short period. This will allow the scavenge pump elements to recover the head of fuel, and the "PRESS LOW" light will be extinguished. In a few minutes, the scavenge pumps will provide a sufficient head of fuel, and the fuel transfer can be completed

This situation will not occur in flight if the No. 5 Tank has been properly loaded, for in normal operation, the transfer system will carry off only enough flow to replace the combined engine-feed flow; a smaller flow than that provided by the scavenge pumps.

The situation *can* occur in flight if No. 5 Tank has been loaded improperly, or if one Transfer pump is inoperative. In either case, closing the transfer valves for a short period and keeping the pumps (or pump) operating will recover the head of fuel in No. 5 Fus. Tank as previously described.

Engineering Flight Tests proved that, should a malpractice or malfunction result in the cavitation of one or both transfer pumps while fuel remains in No. 5 Tank, a period of nose-down flight will bring most of the residual fuel from No. 5 Ctr. Tank into the No. 5 Fus. Tank, and the transfer flow will be re-established.

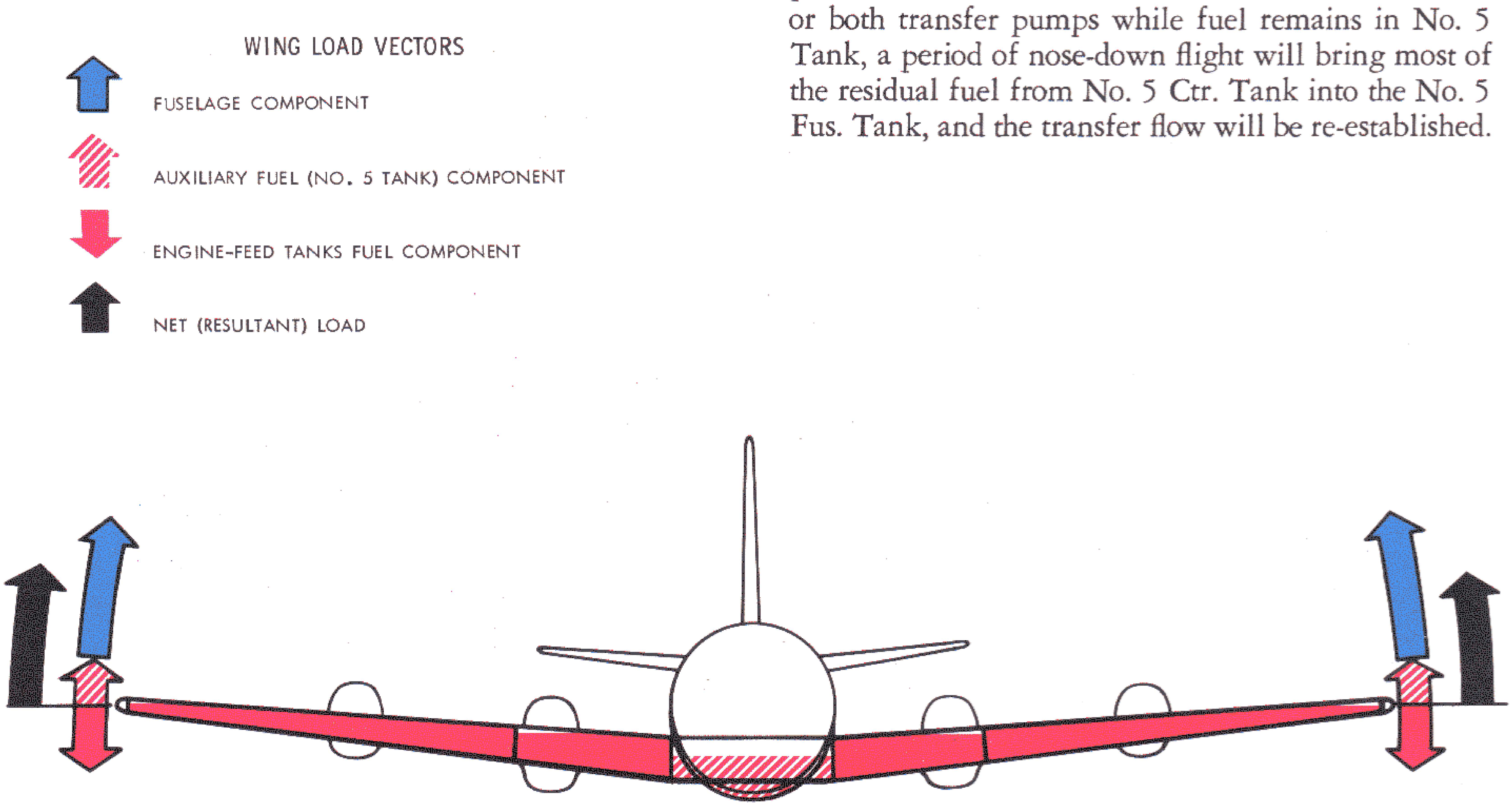


Figure 14 Effect of Fuel Weight Distribution on Wing Load In-flight, Carrying About 80% of

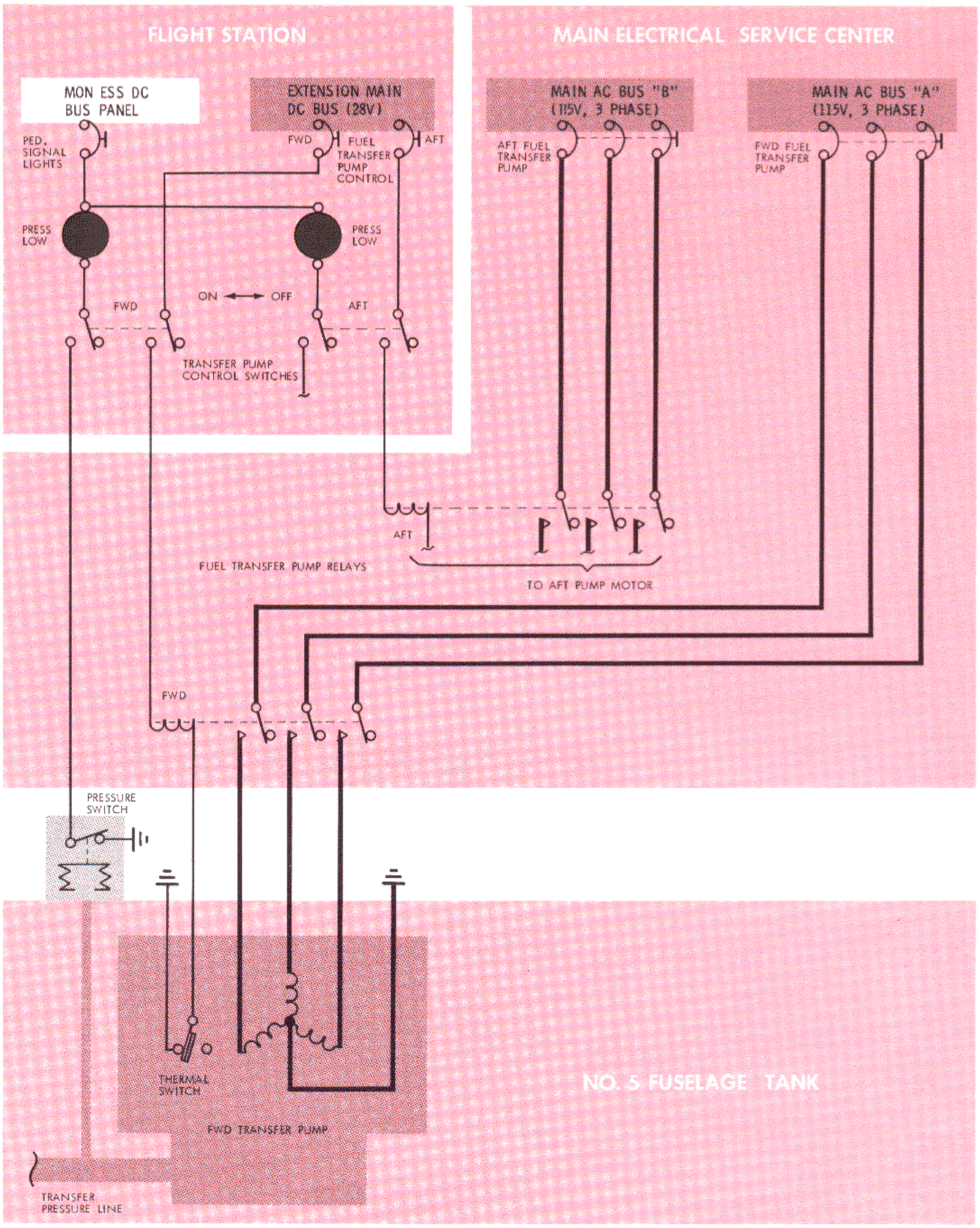
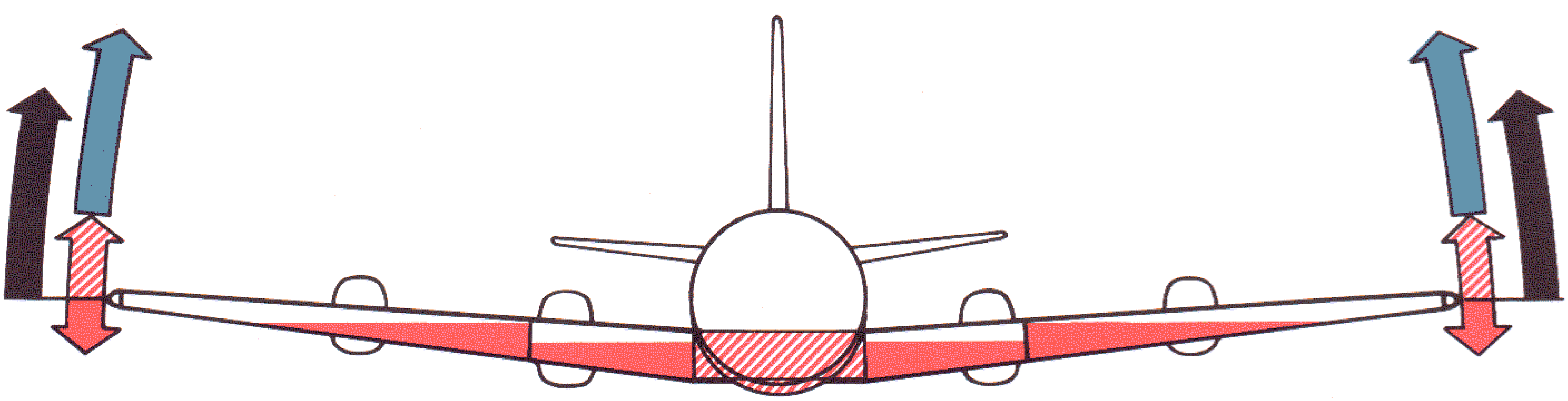


Figure 15
Transfer Pump Power, Control, and Warning Circuits



Maximum Fuel. Moment arrows show the principle, but are not drawn to scale.

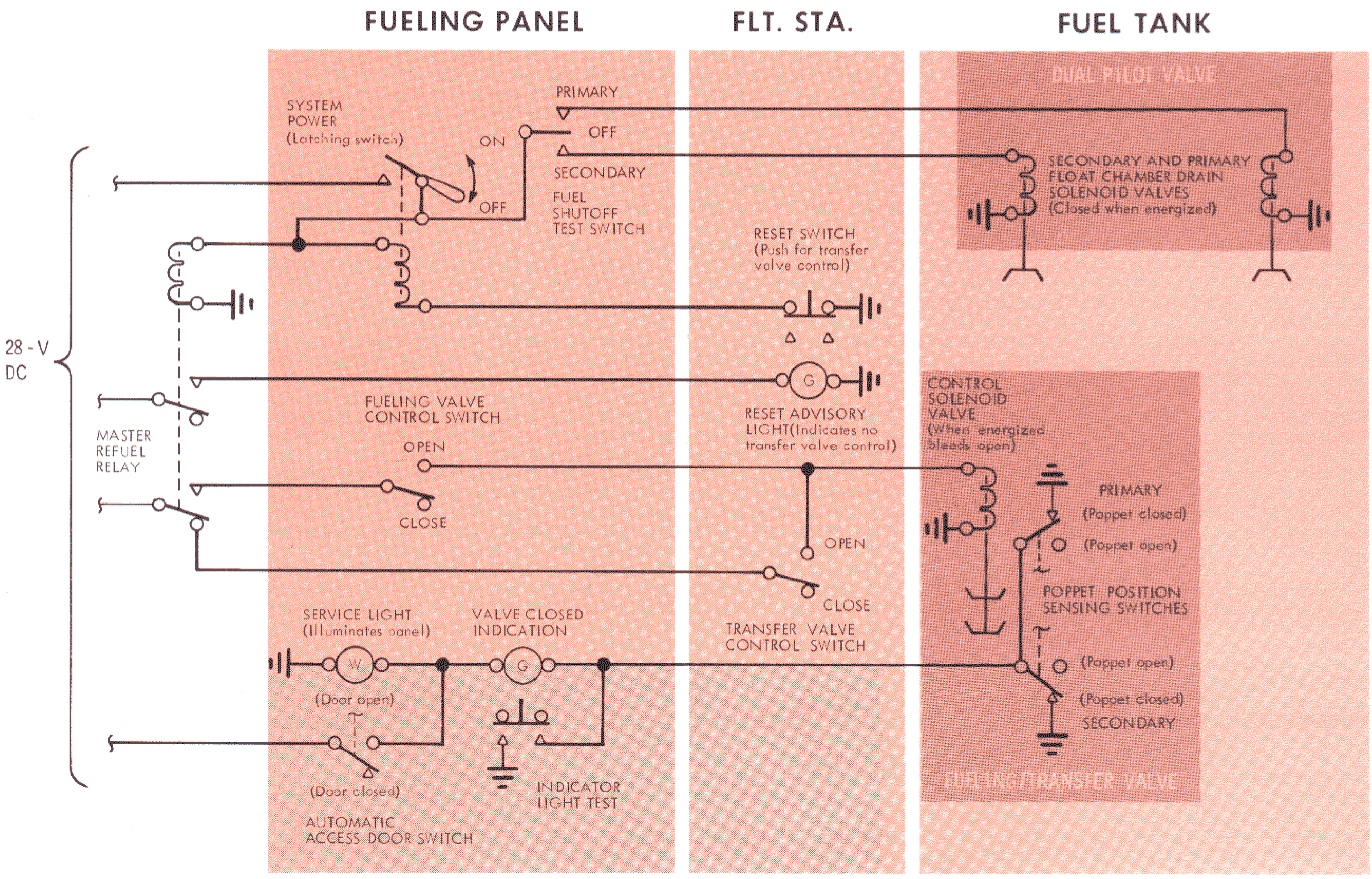


Figure 16 Simplified Fueling and Transfer Schematic

RECAPITULATION

The foregoing notes, explaining how and why certain aspects and actions are important, may obscure the exact distinction between the "sidelight" type of information and that which is directly important in preventing mishaps and ensuring trouble-free operation. These important aspects we have listed below. Also, Figure 16 depicts a simplified schematic of the fueling, defueling, and fuel transfer control circuitry for a typical engine-feed tank. Although the interrelation of circuitry for the other tanks cannot be seen in Figure 16, the scheme is more clearly defined by isolating a single circuit in this way.

FUELING High rate fuel flow generates static electicity. Be sure that fuel truck and airplane trail grounds and the truck-to-airplane ground wires are in good condition and in place before attaching fuel nozzles. Fuel can temporarily retain a static charge, and it is mandatory to allow a three minute settling period after fueling before using the wing tank dipstick.

If denser fuel (such as cold JP-5) is used, the weight indications on the sight gauge and the quantity gauges are both suspect, and in some cases it is necessary to calculate fuel load from density and gallonage readings to prevent overloading the aircraft.

In addition to the usual duties in provisioning the aircraft, the fueling operator has two related obligations to discharge during the fueling operation.

First, he must take every reasonable precaution to ensure against inflicting structural damage during fueling. This entails posting vent monitors and pretesting both modes of fueling valve control; that is, the direct control and the dual pilot valve shut-off action. He must report any vent overflow or valve malfunction he detects during fueling to the responsible authority. These reports are important because certain types of malfunctions that will only be evident to the fueling operator, may not affect the fueling operation, but render fuel transfer difficult or impossible.

The fueling and defueling placards are in the nature of check lists, and must be so regarded by the fueling operator. Check lists do not and cannot supplant human intelligence in allowing for every conceivable combination of circumstances.

Blindly following the minimum procedure outlined on the fueling placard will automatically accomplish all the essential checks, but the fueling operator is ideally situated to make other checks (such as checking the manual control as well as the automatic shutoff of all the fueling valves when all tanks are to be filled) to ensure on-time takeoff and trouble-free operation.

The operator should always follow the initial procedural steps in checking the pilot valve action in all tanks which are to be fueled, but he must thereafter "CLOSE" the No. 5 Ctr. Fueling Valve if less than 4000 lb of fuel is to be carried in No. 5 Tank, or the auxiliary fuel will be misloaded.

Quantity gauges are indicators, not certain proof of the volume of fuel in the tank. *Don't induce fueling flow into a tank by tampering with the pilot valve lines unless you KNOW FOR CERTAIN that the tank will accommodate more fuel.*

Drain the fuel tank sumps at each Daily and Preflight inspection. Any time tank fuel has been permitted a cooling and settling period it is likely that free water will collect on the tank floor which should be drained off before the fuel is disturbed.

TRANSFER Never carry fuel in No. 5 Tank which could be transferred into the engine-feed tanks. If fuel is put into No. 5 Tank to allow thermal expansion space in the engine-feed tanks while the airplane is parked, transfer to the engine-feed tanks as much as they will accept before takeoff.

Prolonged missions will necessitate auxiliary fuel being carried. In such cases, operate the transfer system constantly until No. 5 Tank fuel is exhausted. ▲▲

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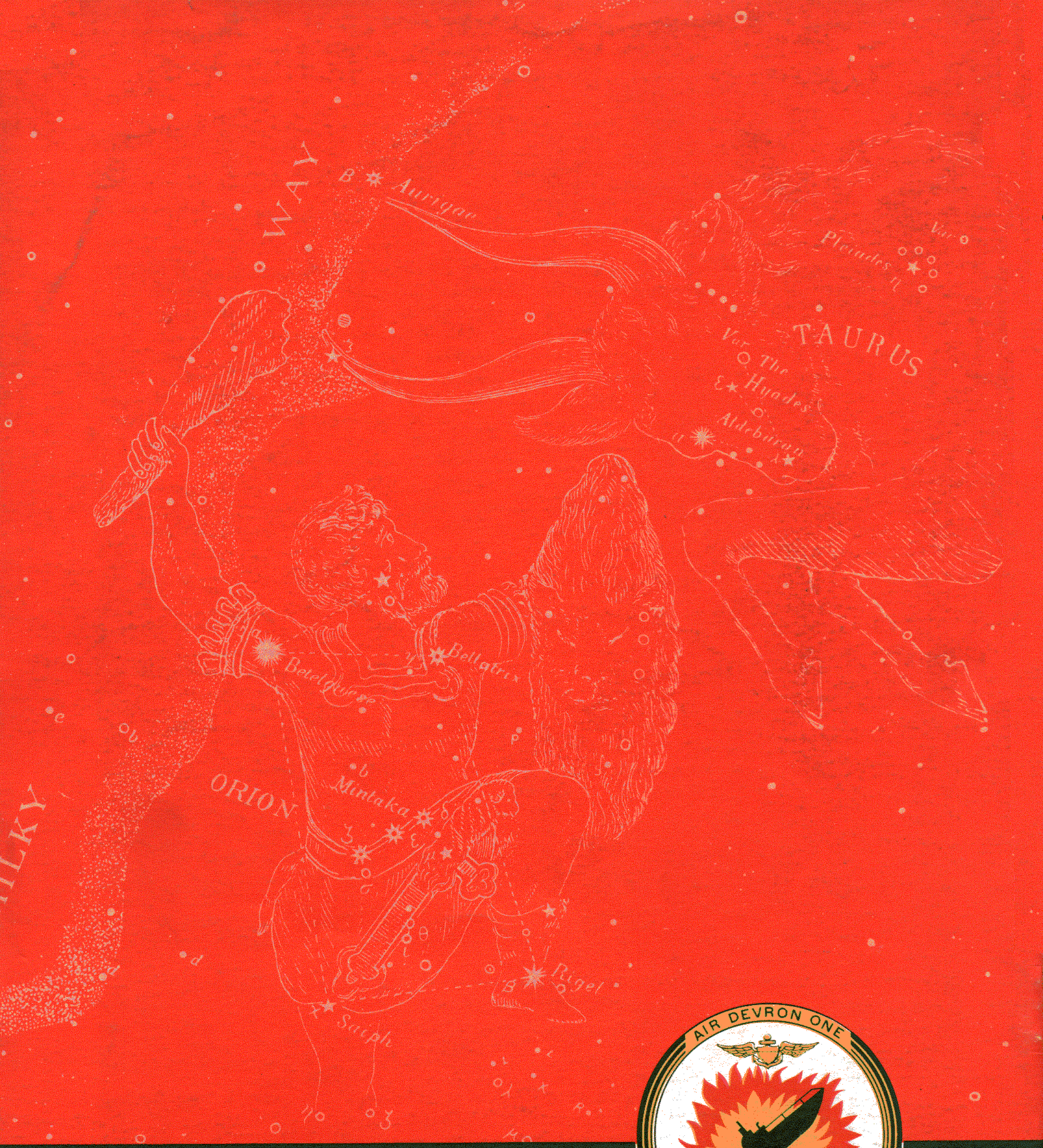
SERVICE REPRESENTATIVES, P-3 ORION

LOCATION	NAME	MAILING ADDRESS	TELEPHONE
Patuxent River NATC, Maryland	D. H. Horadam, Regional Rep.	P.O. Box 218, NATC Patuxent River, Maryland	Volunteer 3-3111 Ext. 645 or 251
Patuxent River NATC, Maryland	F. Hampton, Resident Rep.	P.O. Box 218, NATC Patuxent River, Maryland	Volunteer 3-3111 Ext. 645 or 251
Patuxent River NATC, Maryland	J. Gipson, Resident Rep.	P.O. Box 218, NATC Patuxent River, Maryland	Volunteer 3-3111 Ext. 7569
Patuxent River NATC, Maryland	T. Snelling, Resident Rep.	P.O. Box 218, NATC Patuxent River, Maryland	Volunteer 3-3111 Ext. 645 or 251
Honolulu, Hawaii	C. F. Wernle, Regional Rep.	C/O Lockheed Aircraft Service Inc. P.O. Box 1380, Honolulu, Hawaii	Hono 887595 or 4711, Ext. 42171
Norfolk NAS, Virginia	A. Barber, Resident Rep.	P.O. Box 8127, Ocean View Station Norfolk 3, Virginia	622-8211 Ext. 2685
Key West NAS, Florida	S. Brown, Resident Rep.	P.O. Box 1087, Key West, Florida	294-4417, Key West
Moffett Field NAS, Calif.	F. Hays, Resident Rep.	Lockheed P-3A Office Unit One, General Delivery Moffett Field, Calif.	961-1717 Mountain View, California
North Island NAS, San Diego	R. B. Hedin, Resident Rep.	P.O. Box 525 Coronado, California	435-6169 San Diego
Burbank, California	R. E. Kananen, Supervisor P-3 Project, Customer Service	Lockheed-California Company P.O. Box 551, Burbank, California	Thornwall 2-9151 or Triangle 7-2711 Ext. 4628 or 4307



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