INTRODUCTION

TERMINAL LEARNING OBJECTIVE:

At the completion of this lesson you will be able to:

ACTION: Analyze hydraulic systems malfunctions.

CONDITIONS: Given TM 55-1520-238-23 and TM 1-1520-238-T series manuals.

STANDARDS: Determine by selecting from a list, the corrective actions for abnormal condition(s), in accordance with TM 1-1520-238-T series and TM 55-1520-238-23 series manuals.

SAFETY REQUIREMENTS: In addition to the specific safety requirements of this lesson plan, aviation shop and flight line safety standards established in the technical manuals will be reinforced.

WARNING

Solvents and chemicals, including hydraulic fluid, are flammable and toxic to eyes, skin, and respiratory tract. Skin and eye protection is required. Use solvents and chemicals only with adequate ventilation. If solvents or chemicals touch the eyes or skin, flush with water and seek medical aid immediately.

WARNING

The hydraulic system operates at 3000 psi. Do not perform maintenance on system until hydraulic pressure is removed from the helicopter. Be certain that trapped hydraulic pressure is released before loosening any connections. Failure to do so could result in death or serious injury. If injury occurs, get medical aid immediately.

WARNING

CONTROL MOVEMENTS

Maintenance personnel must be warned verbally prior to moving the collective stick, cyclic stick, or directional pedals. Any control activated can result in sudden component movement that can sever or crush fingers or hands.

CAUTION

Even though vegetable-base fluid is not authorized in Army aircraft, it might by chance get into the maintenance shop. Never use this fluid when working with hydraulic systems. It deteriorates the synthetic rubber seals used in systems designed for petroleum- or synthetic-base fluids. Vegetable-base fluid is readily distinguished by its bluish color.

McDONNELL DOUGLAS
TRAINING SYSTEMS

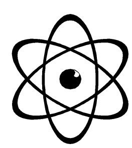
HYDRAULIC PRINCIPLES

07-93-105

A. Basic hydraulic principles. It is important to understand the operational characteristics of hydraulic systems. The fundamental principles of energy, force, torque, motion, velocity, load, resistance, inertia, acceleration, power, pressure, orifices and pressure, flow, series and parallel circuits, absolute and gauge pressure, viscosity, and heat, are essential to fully understand the hydraulic systems installed on the AH-64A.

McDONNELL DOUGLAS
TRAINING SYSTEMS

ENERGY



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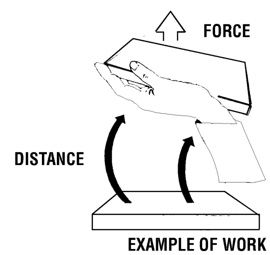
1. Energy

a. Simply defined, *energy is the ability to do work*. Although energy manifests itself in the form of mechanical, electrical, sound, light, heat, or chemical, its origin is usually from natural resources such as oil or coal. The law of conservation states that *energy can neither be created nor destroyed*, although it can be converted from one form to another.

b. In a hydraulic system, the energy input is called a *prime mover*. Examples of prime movers are electric motors and internal combustion engines. Prime movers and hydraulic pumps do not create energy, they simply put it into a form that can be utilized by a hydraulic system.

WORK

WORK = FORCE (lbs.) x DISTANCE (ft.) = (ft. - lbs.)



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c. In defining energy, the term work is used. Simply stated, *work is done when something is moved*. If a book is lifted from a table work is done, however, there are two components which must exist if work is to be done on the book.

(1) First, a force must be exerted upon it in the form of a push or a pull. This force must be equal in magnitude to the weight of the book and opposite in direction. Therefore, a force has the units of pounds (lbs.) and the pounds of force required to do any type of work must be known.

(2) Second, if the book is moved, it must be moved a distance that can be measured in inches, feet, or miles. Thus, the other unit of work is defined as a distance measured in inches, feet, or miles.

d. If enough force in pounds (lbs.) is exerted to move an object through a distance (ft.), then work is done.

e. WORK = FORCE (lbs.) x DISTANCE (ft.) = (ft. - lbs.)

FORCE

F = ma

Where F = force in (lbs.)

$$m = \text{mass in (slugs)} = \frac{w}{g} = \frac{\text{weight}}{32.2\ \text{ft/sec}^2}$$

$$g = \text{acceleration due to gravity} = 32.2\ \text{ft/sec}^2$$

a = acceleration (ft/sec)

07-93-108

2. Force

a. In hydraulics, the load is the object work is to be done upon. By definition, *load is resistance to work*. Any force which resists the movement of an object is resistance. Resistive forces can be frictional, inertial, or forces due to acceleration.

b. Although frictional forces are well understood, inertial forces are somewhat more complicated. *Inertia is the tendency of a body in motion to stay in motion, or if at rest to stay at rest, unless acted on by an external force.* Inertial forces are directly related to the mass or weight of an object. The heavier an object is, the more force is required to start that object moving or to stop it once it's in motion.

c. On high speed equipment it is often necessary to move relatively heavy objects from rest to high speed (or vice versa) in a short amount of time. This requires fast acceleration (or deceleration) rates. The forces required for this acceleration must be taken into consideration. Isaac Newton's second law of motion states that the force required is simply the product of the object's mass multiplied by the required acceleration rate. In the English system, mass is the weight of an object in pounds divided by the acceleration due to gravity.

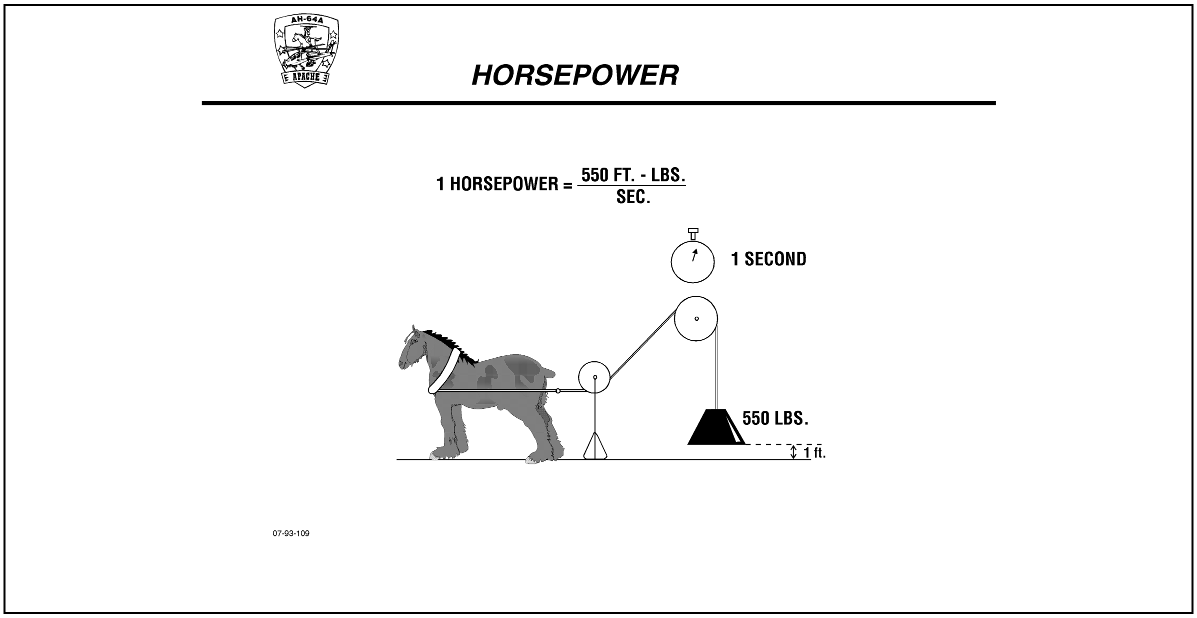
d. $F = ma$

Where: F = force in (lbs.)

M = mass in (slugs) $= \frac{w}{g} = \frac{\text{weight}}{32.2 \text{ ft/sec5}}$

g = acceleration due to gravity = 32.2 ft/sec^2

a = acceleration (ft/sec)

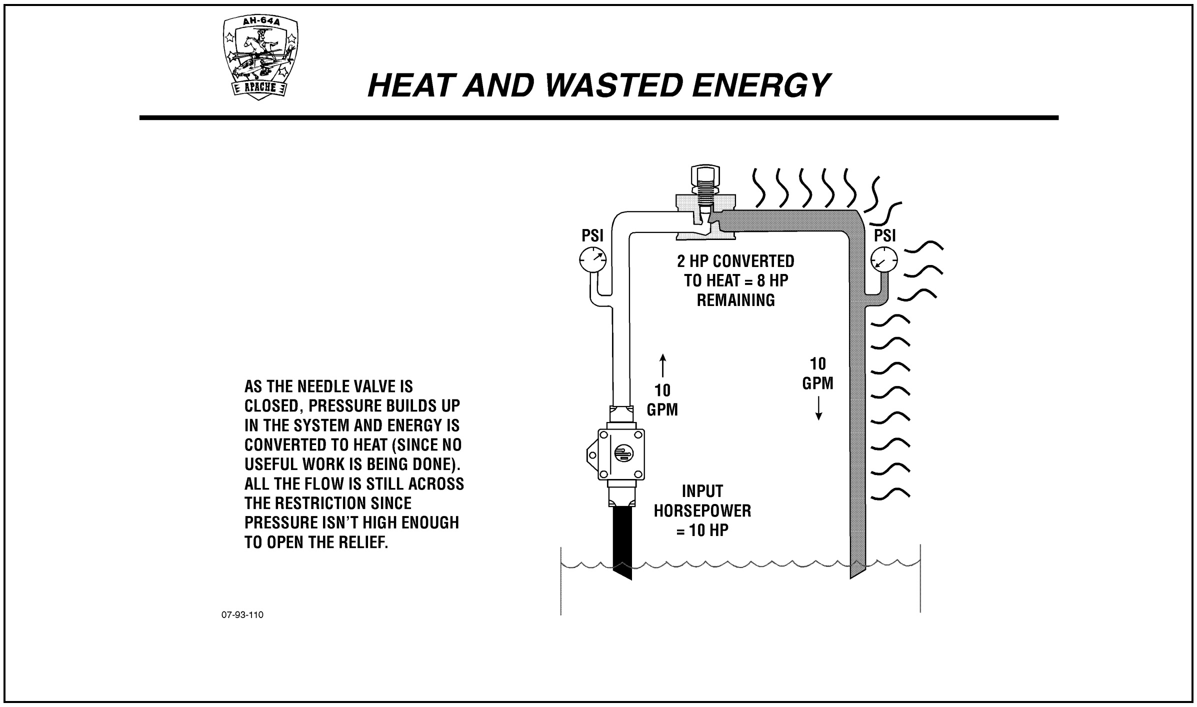


3. Power

a. *Power is defined as the rate of doing work*. Assuming a book weighs 1 pound and is lifted 3 feet off the table, 3 ft. - lbs. of work has been done. It does not matter how fast (1 second) or how slow (1 year) the book is lifted, the same amount of work is always done. It does, however, take more power to lift the book in a lesser amount of time. Consequently, the units of power are defined as the amount of work (ft. - lbs.) per unit of time (seconds).

b. The common method of measuring power is known as horsepower. Horsepower is defined as the amount of weight (lbs.) a horse could move one foot in one second. By experiment it was found that the average horse could move 550 lbs. a distance of one foot in one second.

c. $1 \text{ Horsepower} = \frac{550 \text{ ft. - lbs.}}{\text{sec.}}$



4. Heat and Wasted Energy

a. Energy, that is not used to do useful work, can be considered wasted. Although energy cannot be destroyed, it can be converted into heat or noise, which is useless in performing work within a hydraulic system.

b. Since hydraulic systems are one of the most compact means of transmitting energy, a huge amount of power can be converted into heat in a short period of time.

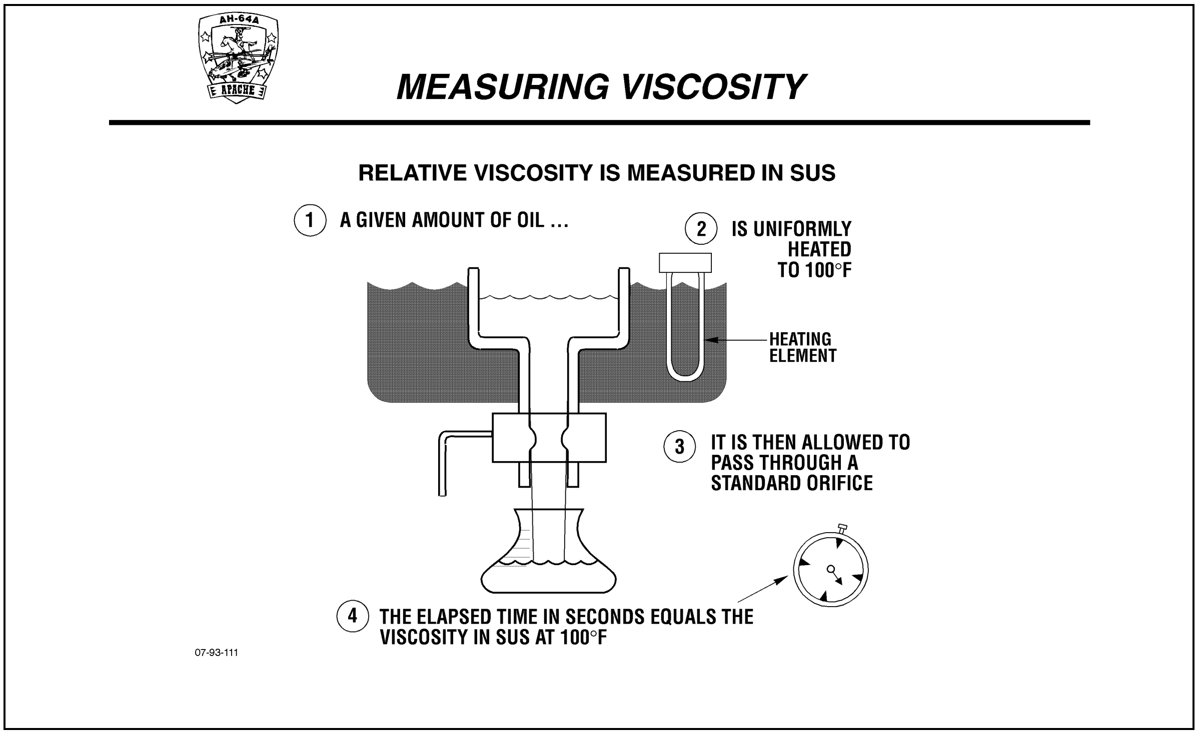
c. Wherever there is a flow from point A to point B in a hydraulic system, with any decrease in pressure, there is an equivalent loss of horsepower between points A and B. Since the decrease in pressure occurs without doing useful work (causing mechanical motion), a percentage of the input power is wasted. This wasted horsepower shows up in the hydraulic system in the form of heat.

d. Hydraulic reservoirs, pipes, hoses, and components radiate heat into the ambient air. Assuming that the heat generation rate from a system is low, it is possible that there is enough radiating surface to maintain stable oil temperature within prescribed limits. For maximum oil life, the system should not operate above 140EF. Ideal hydraulic system oil temperature for the AH-64A is 125EF.

e. A well-designed system with proper cooling can still have a problem if the minimum temperature of the oil is not considered. On cold morning start-ups, the oil may not be fluid enough to fill the expanding chambers in the pump. With inadequate filling, the pump cannot pump its rated volume, and serious cavitation problems may occur.

f. The critical minimum temperature at which a hydraulic system can be started is affected by several factors. On the mechanical side, the capability of the pump to pump viscous fluids and its ability to create suction are important. The second determining factor on the minimum cold start-up temperature of a system is the type of oil used. Two oil ratings that must be considered are the overall viscosity at operating temperature, and viscosity index.

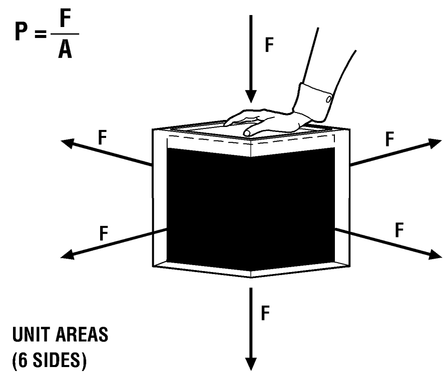
5. Viscosity and Viscosity Index



a. A fluid's viscosity is a measurement of its resistance to flow. Relative viscosity is nothing more than the measurement of time necessary to pass a given amount of selected fluid through a standard orifice at a prescribed temperature. The saybolt universal second (SUS), a name derived from the type of viscometer used, is the time measurement of fluid passing through an orifice (usually at 100EF). Thicker fluids take more time to flow through this orifice than thinner ones, thus thicker fluids have a higher SUS number.

b. Heated viscous fluids become thinner. The resistance of an oil to change viscosity with a change in temperature is denoted by an arbitrary measurement called the viscosity index. A fluid that is quite thick when cold and very thin when hot, has a low resistance to viscosity change, thus it is assigned a low viscosity index number. A fluid that has a relatively stable viscosity for a given change in temperature has a high resistance to a change in its viscosity, therefore it is given a high viscosity index number.

PRESSURE IN HYDRAULIC SYSTEMS TRANSMITS FORCE



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6. Pressure and Flow

a. For work to be done by a hydraulic system, there must be motion. Since motion in itself is mechanical, there must be some type of interface between the hydraulic system and the mechanical motion of the load. The simplest form of interface is a linear actuator known as a hydraulic cylinder.

b. A hydraulic cylinder is nothing more than a closed cylindrical container having a sealed, but movable, piston connected to a piston rod. The rod protrudes through one end of the cylinder for the transmission of force and motion to the load.

c. To consider how motion is produced, think of the cylinder with the piston rod fully retracted. As oil flows into the retracted end of the cylinder, the piston begins moving upward to allow room for the increased oil volume in the cylinder housing. It stands to reason that the faster the cylinder is filled, the faster the piston and rod assembly extend.

d. In hydraulics, flow rate is normally represented by the number of gallons that can move into a container in a given amount of time. By convention, flow rate is expressed in gallons per minute (or gpm). It is important to realize that the speed, or the rate of doing work, is dependent upon flow rate without regard to pressure. Of course, the size of the actuator must be taken into account since, for a given amount of flow, larger actuators move slower than smaller ones.

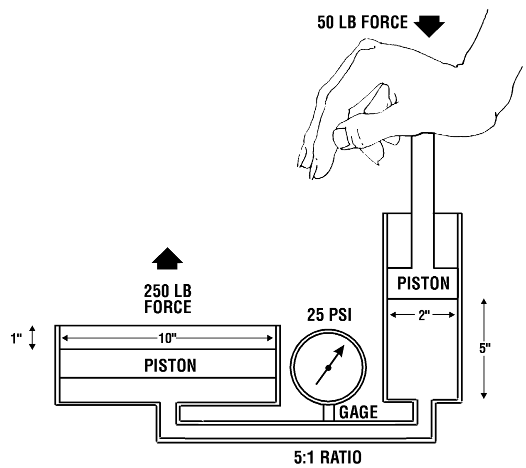
e. By definition, pressure is nothing more than a force, usually represented in pounds, exerted over an area that is normally represented in square inches (PSI).

f. Pascal's Law states that if a force is exerted over an area of fluid in a closed container, this pressure is exerted perpendicular to, undiminished in all directions, and on every unit area of that container.

It is this principle that allows the transmission of energy through a fluid and at the same time get a multiplication of force. It is important to note, however, that to multiply force with a hydraulic system, distance and speed must be sacrificed. For example, to lift 250 pounds with 50 pounds of force (an example shown in the figure), the smaller piston must be moved 5 times farther than the larger piston. The smaller piston must move farther, therefore taking more time.

g. A common myth is that hydraulic pumps pump pressure. The only thing a pump does is to create a flow of fluid. Its maximum pressure rating only determines how much resistance to flow the pump can withstand.

PRINCIPLE OF MECHANICAL ADVANTAGE



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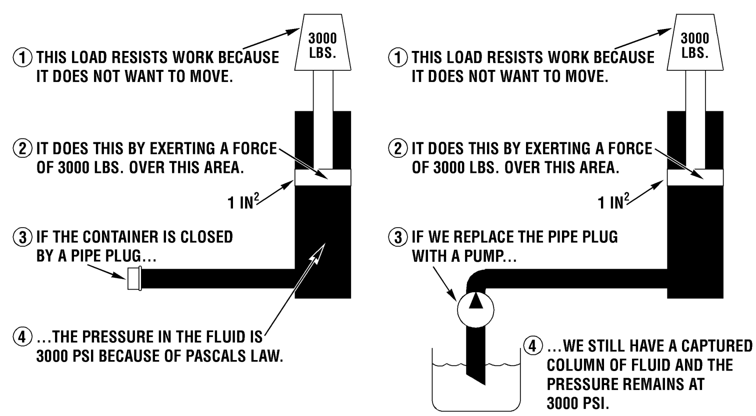
GENERATION OF PRESSURE



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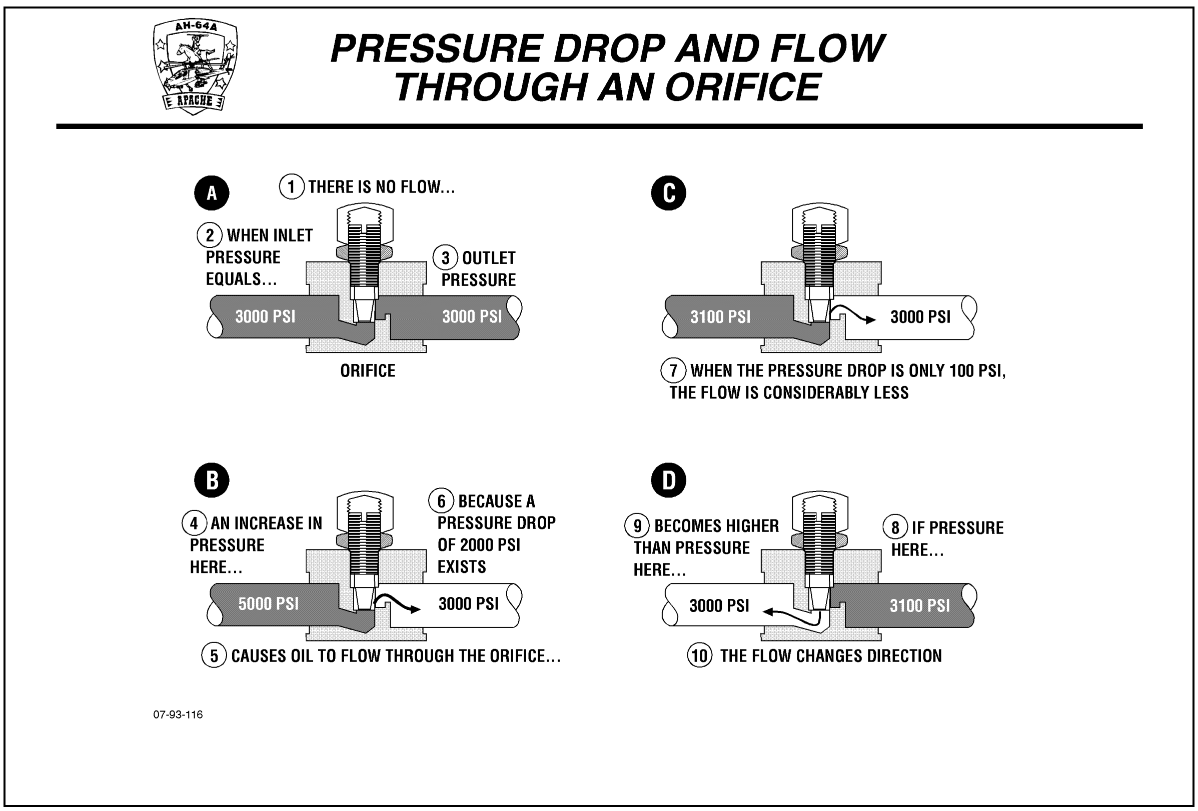
h. It was stated earlier that a load is resistance to work. If work is done on a load with a hydraulic cylinder, then the load exerts a force that resists the motion of the piston in the hydraulic cylinder. Since the load exerts a certain amount of force in pounds, and the piston in the cylinder has a certain area (n^2) there is force over the area, or pressure. If the cylinder has a piston area of one square inch, and supports a 3000 pound load on a blocked column of fluid, then by applying Pascal's Law there is a fluid pressure of 3000 psi. If, instead of a blocked column of fluid, the cylinder is connected to a hydraulic pump, then the 3000 psi is transmitted back to the pump. For the pump to create a flow, it must be able to withstand (and overcome) this 3000 psi resistance.

i. Resistance to flow results in pressure. A load is resistance to work, and in turn, a resistance to flow in a hydraulic system, but there are two other forms of resistance. These forms of resistance to flow are:

(1) The friction of moving oil through pipes, hoses, tubing, valves, and components.

(2) The resistance induced by orifices in the stream of the fluid, such as flow controls.

7. Orifices and Pressure



a. Orifices in hydraulic systems are much like doorways in crowded hallways. The higher the flow rate in people/minute, or the smaller the doorway, the more crowded it becomes at the entrance.

b. With hydraulics, when oil moves through a restriction (orifice), work is being done to the oil. In doing this work, pressure decreases because it creates the force required to push the oil through the restriction. For a given orifice, a pressure decrease from orifice inlet to orifice outlet is always accompanied by a proportional increase in flow. The pressure decrease across an orifice can be affected by three variables (assuming constant oil viscosity):

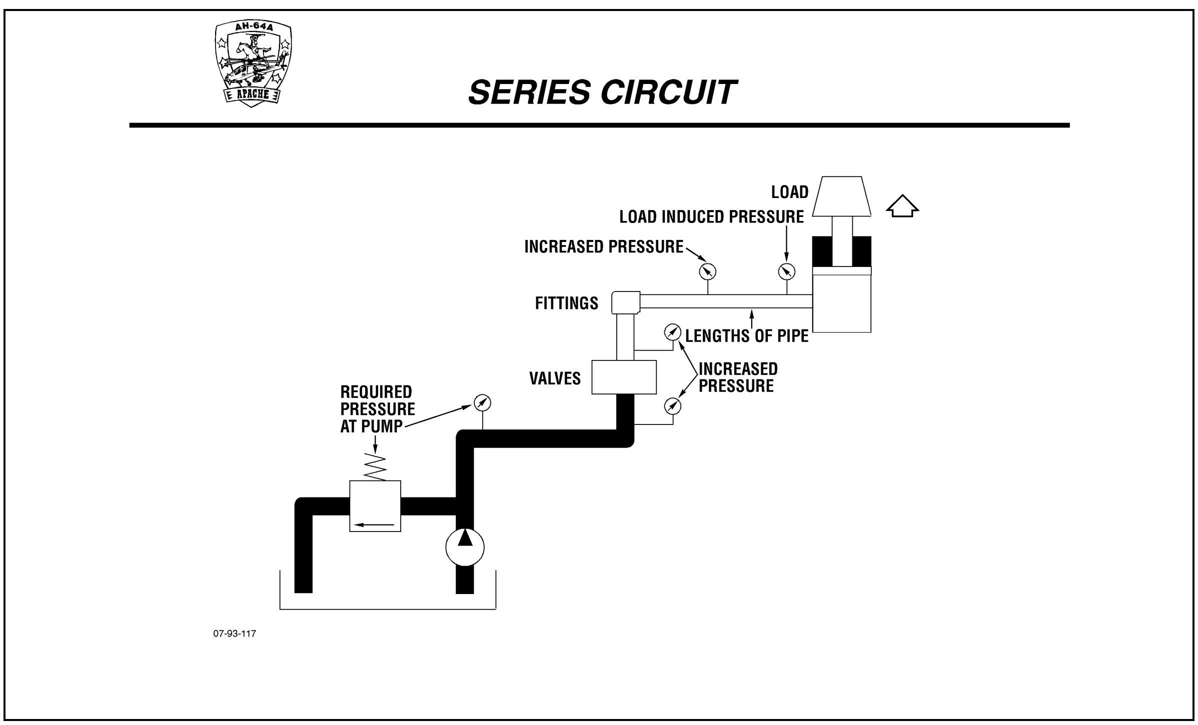
(1) An increase in load pressure at the orifice outlet increases downstream pressure, and assuming orifice inlet pressure remains at the system relief valve setting, the result is a decreased pressure difference from inlet to outlet. This means less flow, so the system slows down with the increased load.

(2) An increase in the orifice inlet pressure, by raising the system relief valve setting, has the effect of increasing the pressure decrease across the orifice. Assuming constant load pressure, the system speeds up.

(3) By opening and closing the restriction (orifice), the resistance to flow is changed. The less the resistance, the less the pressure loss from orifice inlet to orifice outlet.

8. Series and Parallel Circuits

a. Resistances in series is cumulative. In any hydraulic circuit, each length of pipe,

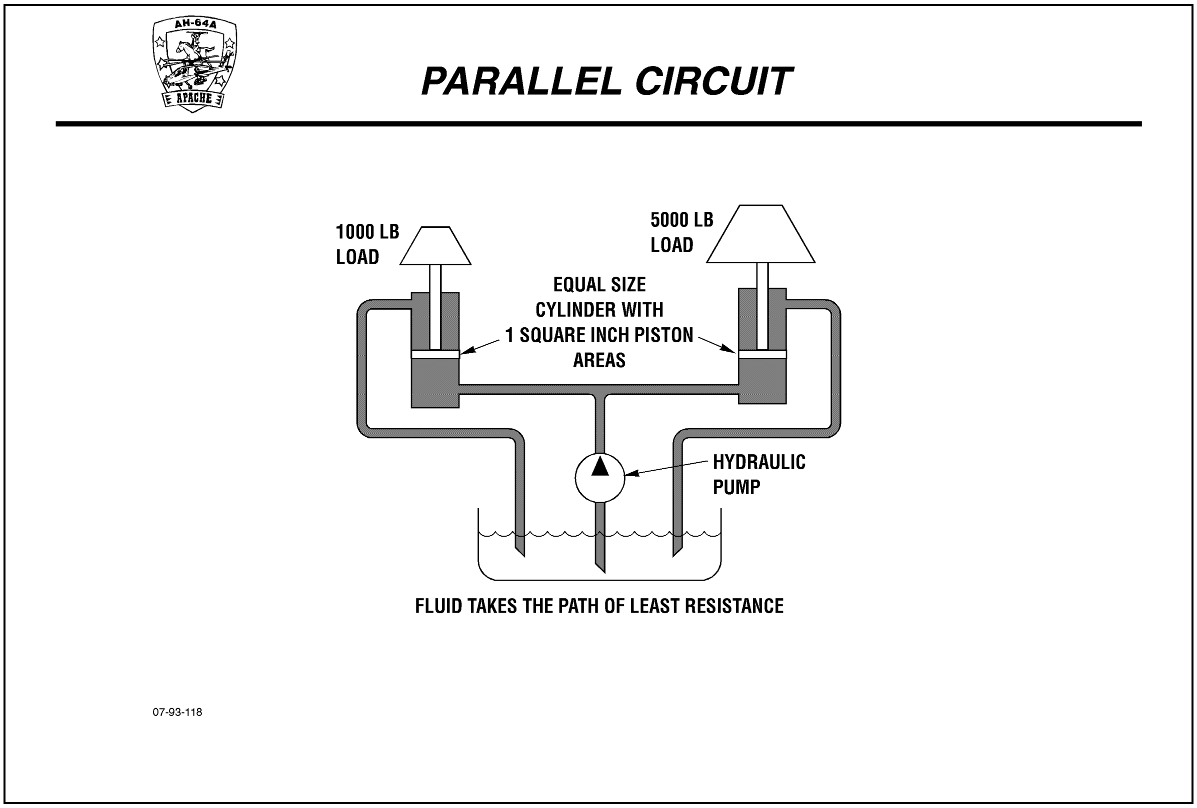


every fitting, valve, and component, adds its part to the total resistance to flow.

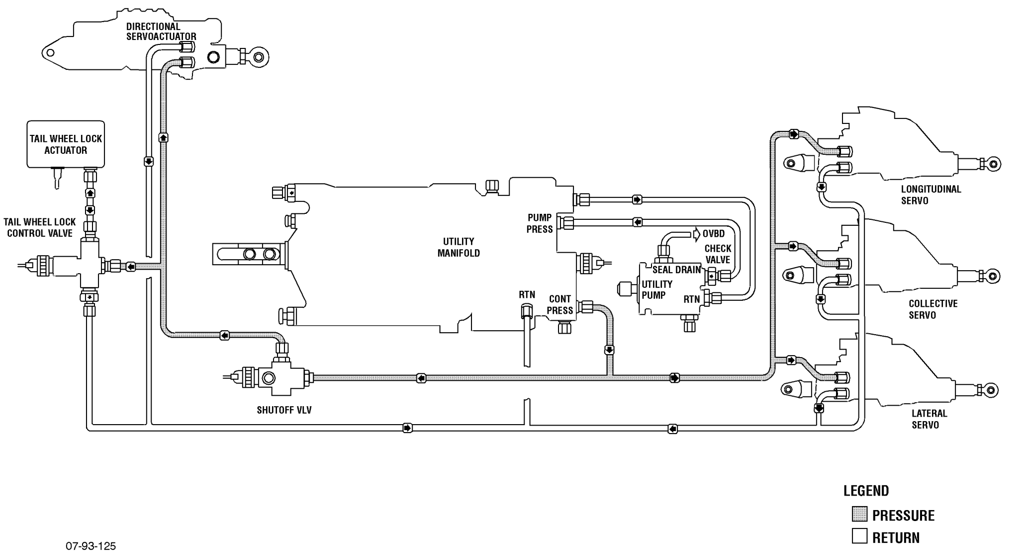
It was stated before that resistance to flow results in pressure. Therefore, pressure required at the pump, is the sum of all component induced load pressures, plus all the individual pressure drops created by piping, fittings, and valves.

b. It should be noted that when a system becomes static, pressure equalizes at the relief valve setting.

c. In a parallel circuit, fluid flows through the path of least resistance when there is more than one possible path in the system.



EXAMPLE OF A PARALLEL CIRCUIT



d. An example of a parallel circuit in the AH-64A utility hydraulic system follows:

(1) Hydraulic fluid is pressurized by the utility hydraulic pump and then routed to the utility hydraulic manifold.

(2) The manifold directs the pressurized fluid to the main rotor servoactuators, tail wheel lock actuator, and directional servo actuator via hydraulic pressure lines.

(3) After leaving the manifold, the pressurized hydraulic fluid flows through a common pressure line to a T-fitting. At the T-fitting, fluid flows forward to the main rotor servoactuators and aft to the tail wheel lock actuator and directional servoactuator. This is the parrallel circuit.

(4) If the pressure line is severed in the tail boom, (aft of the shut-off valve) there will not be any resistance to flow in that portion of the parallel circuit. Since fluid will flow through the path of least resistance, the hydraulic fluid will flow in the dirction of the severance leaving very little pressurized fluid flow for the main rotor servoactuators. If the shut-off valve is closed, resistance to flow will go to maximum and all fluid flow will be forward to the main rotor servoactuators.

TORQUE

TORQUE = FORCE x RADIUS

T = F x r
T = TORQUE IN LB - IN:
F = FORCE IN LBS
r = RADIUS IN INCHES

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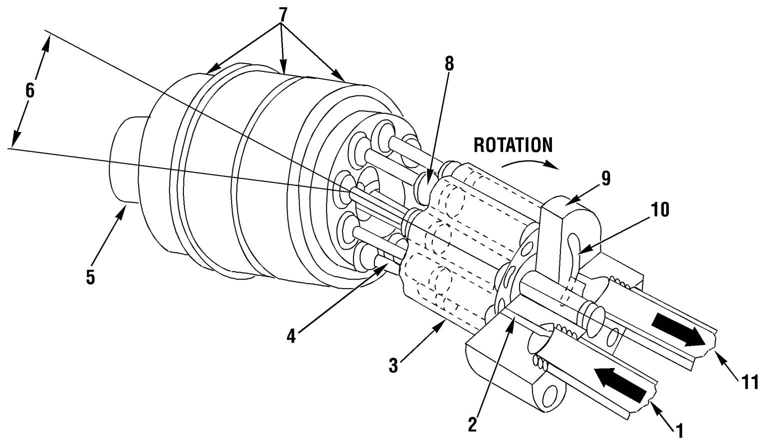
9. Rotary Motion With Hydraulic Motors

a. To understand hydraulic motors, torque must be defined. Simply stated, torque is the twisting effort of a rotational device. In general, the torque capabilities of hydraulic motors are applicable to hydraulic systems.

b. Torque is equal to the load multiplied by its distance from the center of rotation (T = force x radius). The torque of a hydraulic motor is synonymous to the thrust of a hydraulic cylinder. Consequently, both a torque and a force can exist without causing motion (doing work). Likewise, the pressure at the inlet of the hydraulic motor only builds to a sufficient level to cause a torque that produces motion. In other words, the torque load is the load that resists rotary motion and thus determines the torque produced by the motor.

HYDRAULIC MOTOR CUTAWAY



1. INLET PORT
2. VALVE PLATE INLET SLOT
3. CYLINDER BLOCK
4. PISTON ROD
5. OUTPUT SHAFT
6. DISPLACEMENT ANGLE
7. SHAFT BEARINGS
8. PISTONS
9. VALVE PLATE
10. VALVE PLATE OUTLET SLOT
11. OUTLET PORT

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c. With hydraulic cylinders, the pressure level is determined by the load and the square inch area of the piston in the cylinder. Likewise, with hydraulic motors, the pressure level is determined by the torque load and the size of the hydraulic motor.

d. The size of a hydraulic motor is determined by its displacement in cubic inches per revolution (in^3/rev). The displacement is the amount of oil the motor moves in making one complete revolution. As with hydraulic cylinders, a larger motor produces more torque at a given pressure level than a smaller one.

ABSOLUTE AND GAUGE PRESSURE

GAUGE PRESSURE + 14.7 PSI = ABSOLUTE PRESSURE

07-93-120

10. Absolute and Gauge Pressure

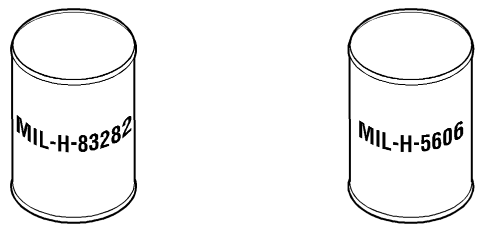
a. There are two basic methods of measuring pressure. First, readings which take into account atmospheric pressure, and second, readings that ignore atmospheric pressure and start the scale at zero when the ambient pressure is actually 14.7 psi.

b. Absolute pressure readings use a vacuum as their zero base. Atmospheric pressure on this scale is 14.7 psi or 29.92 in.-hg.

c. Gauge pressure readings are always 14.7 psi lower than absolute pressure, since a standard pressure gauge reads 0 psi at sea level.

d. Gauge Pressure + 14.7 psi = Absolute Pressure

HYDRAULIC FLUIDS



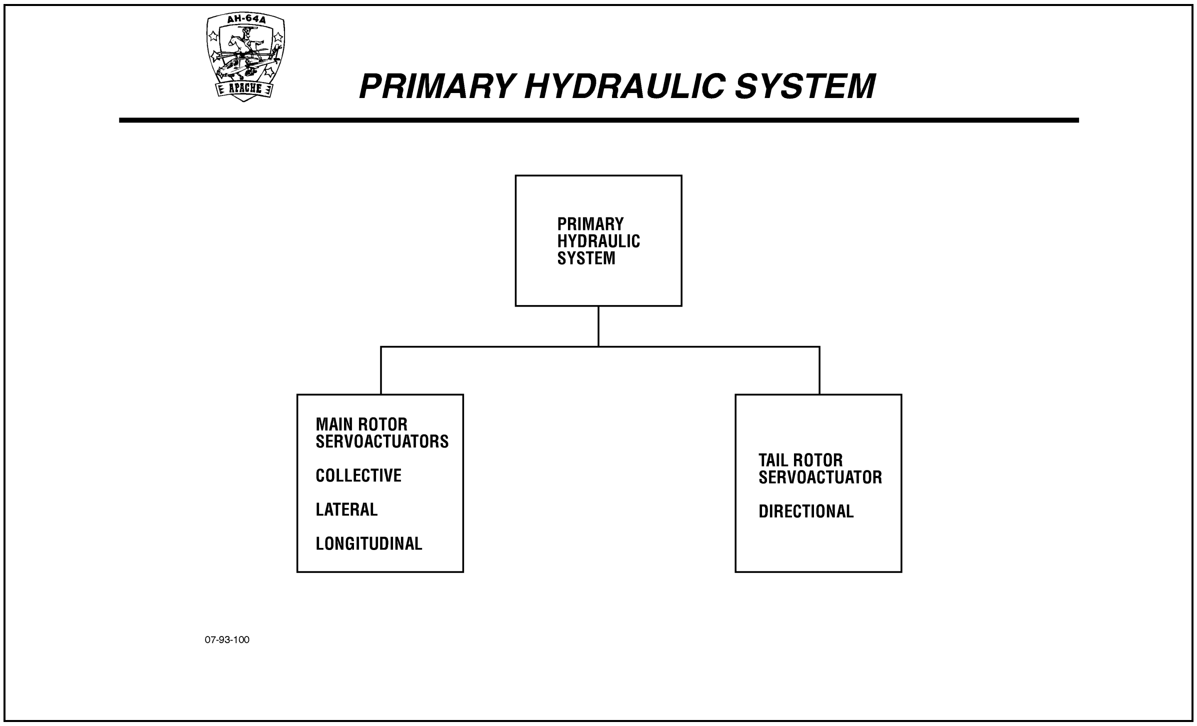
- SYNTHETIC HYDROCARBON BASE
- 400°F HIGH TEMPERATURE LIMIT
- 401°F FLASH POINT
- FIRE RESISTANT

- PETROLEUM BASE
- 275°F HIGH-TEMPERATURE LIMIT
- 180°F FLASH POINT
- USED FOR COLD WEATHER OPERATIONS

07-93-123

11. Hydraulic fluids

a. Hydraulic fluids are classified generally as petroleum base, synthetic base, and vegetable base. Vegetable-base fluid is no longer authorized in Army aircraft. For most operations, the Army is converting from petroleum-base fluid MIL-H-5606 to MIL-H-83282, which has a synthetic hydrocarbon base. There are several reasons for this change. MIL-H-83282 contains additives that provide better anti-wear characteristics and help stop oxidation and corrosion. It also has an operational high-temperature limit of 400EF as compared to 275EF for MIL-H-5606. Flash point, fire point, and spontaneous ignition temperatures of MIL-H-83282 exceed those of MIL-H-5606 by more than 200EF. Also, tests show that MIL-H-83282 stops burning when the outside source of flame or heat is removed. MIL-H-83282 is compatable with all materials used in systems presently employing hydraulic fluid MIL-H-5606. MIL-H-83282 may be combined with MIL-H-5606 with no bad effects except a reduction of fire-resistance properties. Amounts of MIL-H-5606 exceeding 3 percent by volume will compromise the fire resistant performance of MIL-H-83282. Although MIL-H-83282 exceeds the performance of MIL-H-5606 at normal temperatures, the viscosity of MIL-H-83282 increases at low temperatures. For this reason, MIL-H-5606 is still used for cold weather operations.



A. Primary hydraulic system purpose.

1. Provides hydraulic power to the primary side of the flight control servoactuators (lateral, longitudinal, collective, and directional).

2. Only the primary side of the flight control servoactuators have electrohydraulic servovalves that allow the digital automatic stabilization equipment (DASE) and backup control system (BUCS) to affect the flight controls.

3. Failure of the primary hydraulic system results in the loss of DASE and BUCS.

B. Primary hydraulic system characteristics.

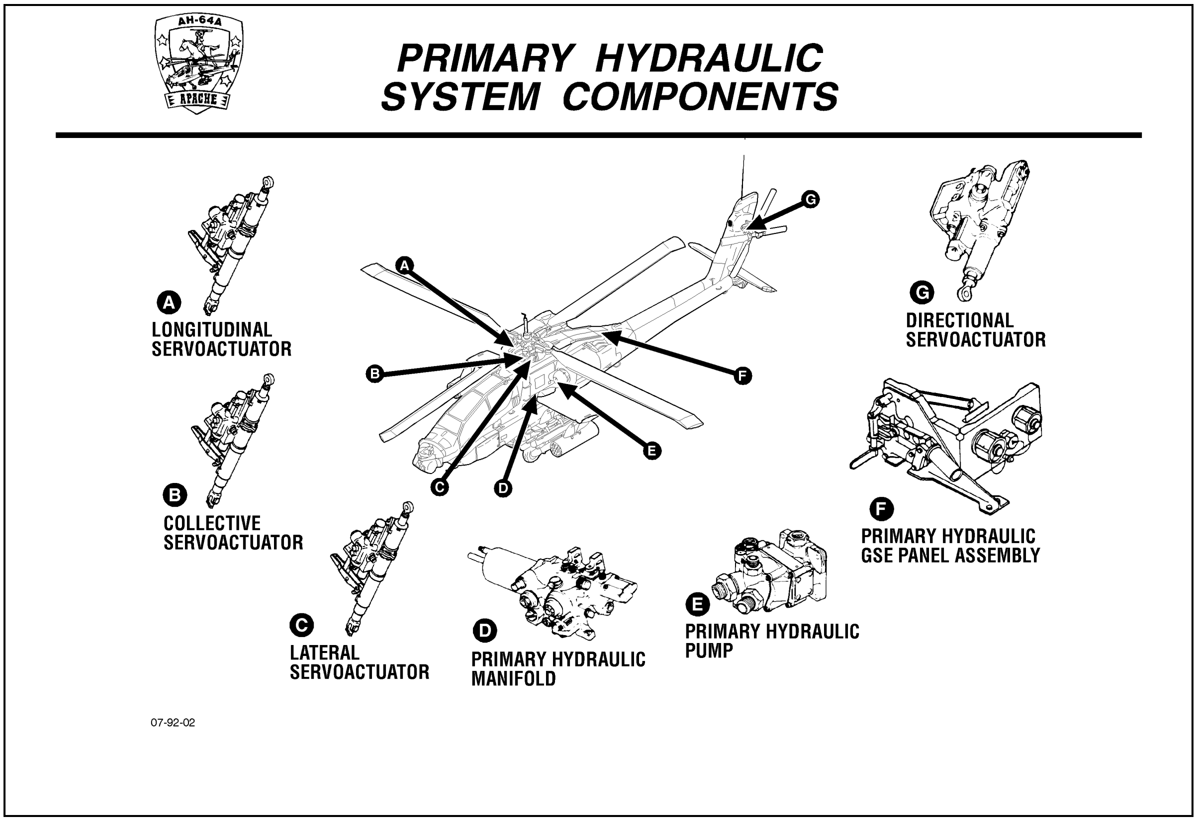
1. Provides 3000 pounds per square inch (psi) hydraulic fluid pressure to hydraulically operated components within a system temperature range of -64EF to +275EF (-53EC to +135EC),

2. Has a flow rate up to 6.0 gallons per minute (gpm).

3. Fluid capacity is approximately 3 quarts and uses:

a. MIL-H-83282, synthetic hydrocarbon base hydraulic fluid, when outside air temperatures are -25EF (-32EC) and above.

b. MIL-H-5606, petroleum base hydraulic fluid, for outside air temperatures below -25EF.



A. Primary hydraulic system components

1. Major components:

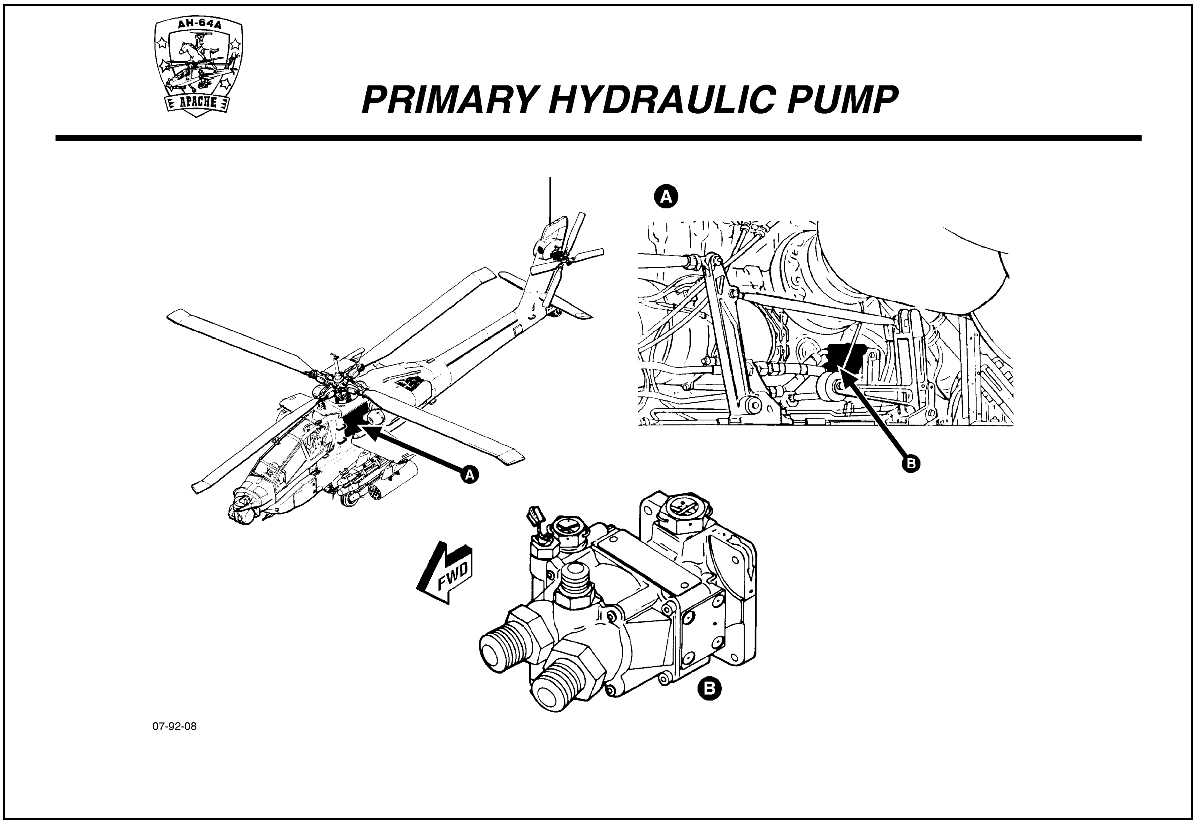
a. Primary hydraulic pump

b. Primary hydraulic manifold

c. Flight control servoactuators

d. Primary heat exchanger (if installed)

e. Primary ground support equipment (GSE) panel

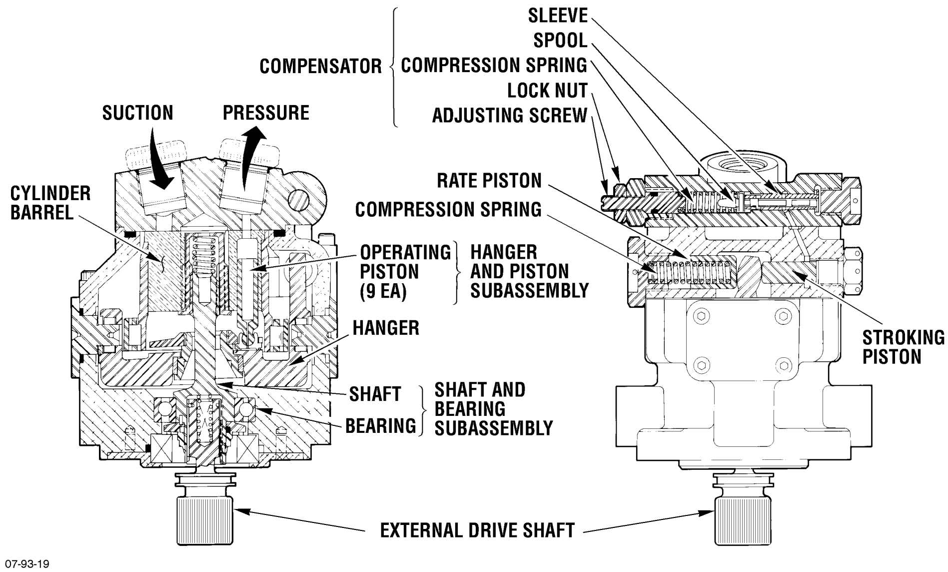


2. Primary hydraulic pump

   a. Draws low pressure fluid from the primary reservoir and provides pressurized hydraulic fluid to the primary hydraulic manifold.

   b. Located on the left-forward drive pad of the main transmission accessory geartrain housing.

HYDRAULIC PUMP FUNCTIONAL DIAGRAM



c. Constructed of steel with an external drive shaft to mate with the accessory geartrain. The shaft is designed to shear under excessive loads.

d. Constant pressure, variable delivery, piston-type pump with a rated discharge pressure of 3000 psi, flow rate of up to 6.0 gpm and a rated speed of 12,635 rpm.

e. The pump incorporates the following fluid ports:

1) Suction port: incorporates a fitting that adapts the **2** inch suction line to the **d** inch pump fluid port.

2) Pressure port: incorporates a one-way check valve assembly to isolate the GSE operating circuit. This prevents GSE pressurized hydraulic fluid from entering the pump during GSE operation.

3) Case drain. High pressure hydraulic fluid which leaks past the pistons and cylinder barrel collect in the case of the pump. Rather than leaking back to the suction side of the pump, the leakage fluid is returned to the manifold via the case drain. The leakage fluid also serves two purposes: it lubricates bearings and other moving members within the pump, and helps cool the pump by absorbing heat prior to returning to the manifold.

4) Seal drain. Hydraulic fluid leakage from the external drive shaft seal, exits the pump through the seal drain and is vented overboard.

f. Pump components and operation

1) External drive shaft

a) Transmits rotary mechanical motion to the shaft and bearing subassembly.

b) Splined at both ends, mating with the shaft and bearing subassembly and the output gear in the main transmission accessory geartrain.

2) Shaft and bearing subassembly

a) Transmits rotary mechanical motion from the external drive shaft to the cylinder barrel.

b) Splined at both ends to mate with the external drive shaft and cylinder barrel.

3) Cylinder barrel

a) A cylindrical barrel with nine cylinders to house nine pistons.

b) Provides a working area for developing fluid pressure.

4) Hanger and piston subassembly

a) Consists of a hanger and nine operating pistons. The revolving cylinder barrel causes the piston subassembly to rotate, moving the operating pistons up and down to produce a pump and suction action.

b) Pistons in the revolving cylinder barrel draw fluid into the pump through the suction port and discharge fluid at the pressure port at a rate dependent on hanger angle.

5) Compensator

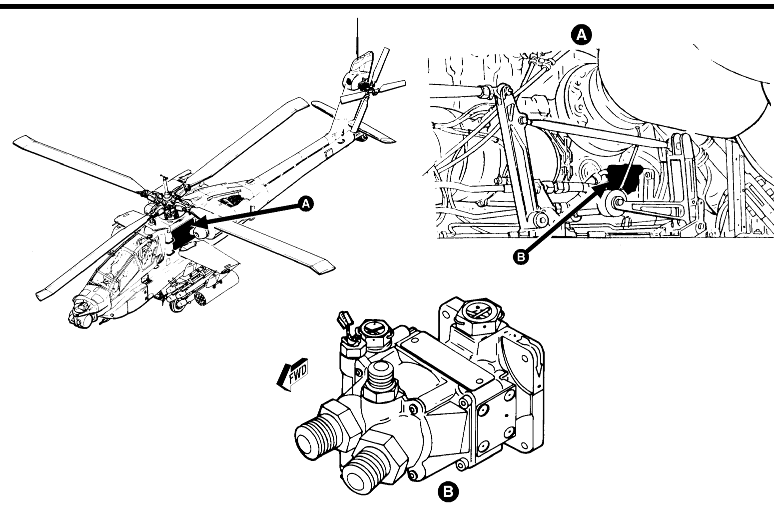
a) Controls pump output pressure.

b) Consists of an adjusting screw, locknut, compression spring, spool, and sleeve.

(1) The adjusting screw and compression spring adjust the compensator pressure setting.

(2) The spool and sleeve control the flow of fluid to the stroking piston varying the stroke of the nine operating pistons in the cylinder barrel.

PRIMARY HYDRAULIC PUMP



6) Stroking piston

a) Changes the angle of the hanger to maintain a predetermined pump output pressure.

b) Fluid pressure extends the stroking piston to change the angle of the hanger toward the no-flow piston.

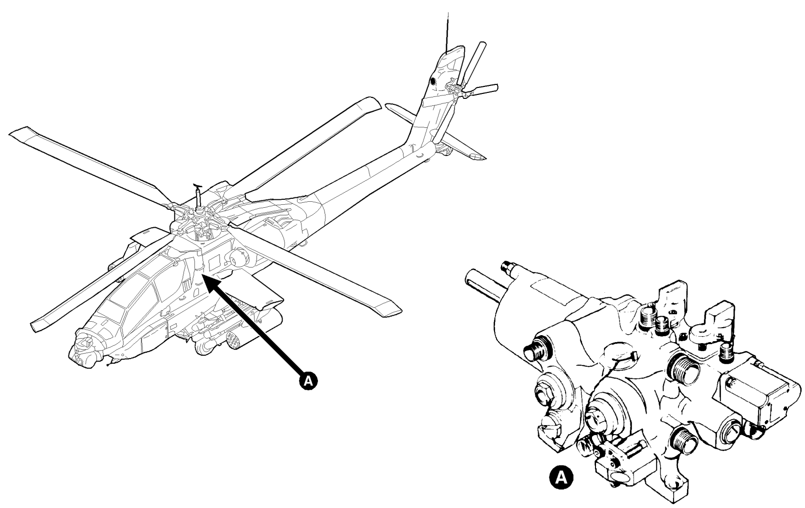
7) Rate piston and compression spring

a) Pre-loads the hanger to the full flow position.

b) Consists of a spring, plug, and rate piston.

c) Spring tension exerts a constant force on the rate piston to force the hanger toward the full flow position and to retract the stroking piston during periods of increased flow demand.

PRIMARY HYDRAULIC MANIFOLD



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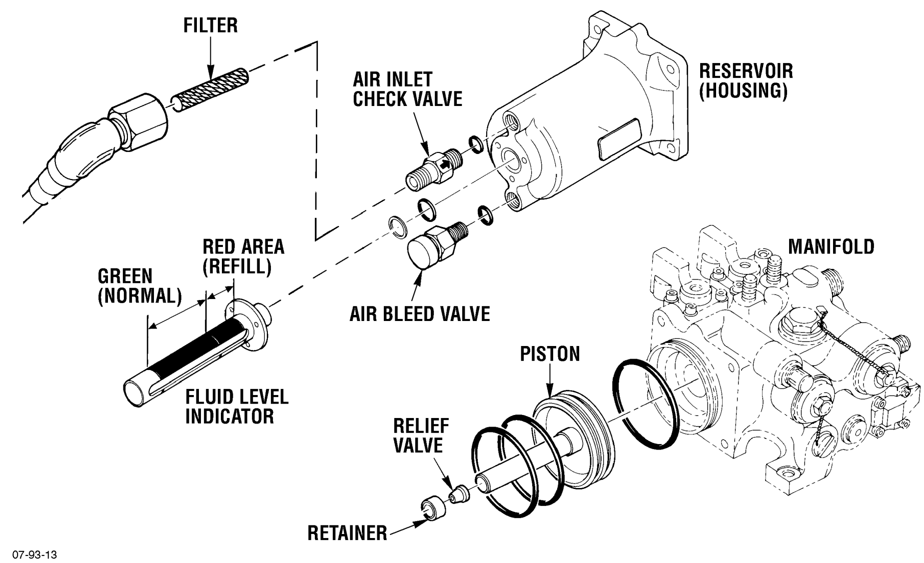
3. Primary hydraulic manifold

a. Stores, filters, supplies, and regulates hydraulic fluid for the primary hydraulic system.

b. Made of aluminum alloy and is located on the main transmission deck, forward and left of the main transmission.

c. Incorporates an air pressurized reservoir to help prevent pump cavitation.

PRIMARY HYDRAULIC MANIFOLD RESERVOIR



d. Primary hydraulic manifold reservoir components and descriptions

1) Primary hydraulic manifold reservoir

a) Stores low-pressure hydraulic fluid for system use.

b) Pressurized to 30 psi by the pressurized air system (PAS).

c) Prevents fluid foaming and pump cavitation.

d) Fluid capacity is 1 pint.

2) Piston assembly

a) Separates air and hydraulic fluid inside the reservoir and aids in reservoir fluid pressurization.

b) An integral piston rod extends and retracts within the fluid level indicator. A relief valve at the end of the piston rod allows the release of pressure buildup between the O-rings on the piston.

3) Fluid level indicator

a) Provides a visual indication of reservoir fluid level. The fluid level reading is taken at the end of the reservoir piston rod.

b) Color-coded green for normal operation and red for refill.

4) Air inlet check valve

a) Permits one-way airflow into the reservoir to maintain reservoir air pressure.

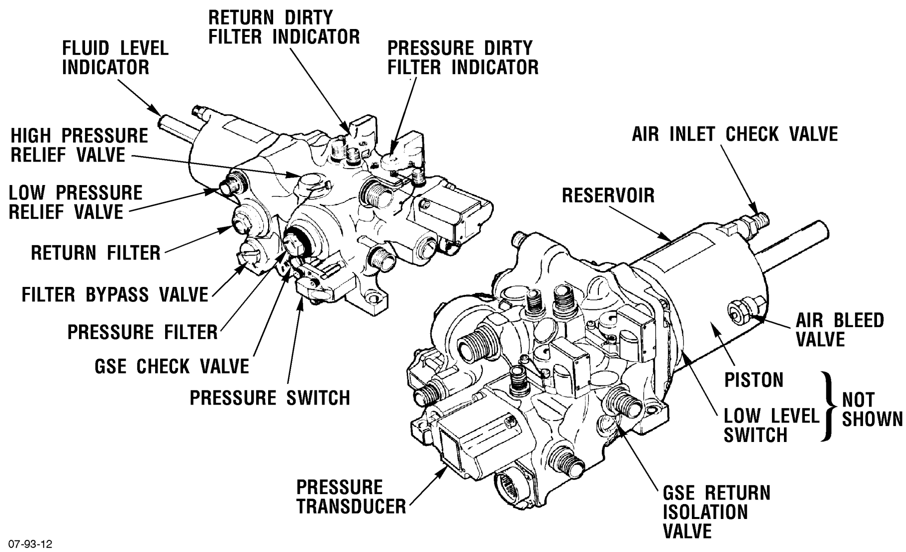
b) An in-line filter is installed into the PAS line and check valve to remove contaminates from inlet pressurized air.

5) Manual air bleed valve

a) Relieves reservoir air pressure for maintenance purposes.

b) Valve opens when the button is pushed.

PRIMARY HYDRAULIC MANIFOLD COMPONENTS



e. Primary hydraulic manifold components and descriptions

1) Low-level switch

a) Illuminates the OIL LOW PRI HYD caution light on the pilot's caution/warning/advisory (C/W/A) panel.

b) Consists of a piston, spring, cap, and microswitch. The piston assembly extends from the manifold into the reservoir.

c) At the minimum permissible operating volume (approximately 1.5 cubic inches or 2.71 fluid ounces), the reservoir piston contacts the switch piston causing the switch to close.

2) Low pressure relief valve

a) Relieves excess reservoir fluid pressure and provides the reservoir with a self-bleeding capability. An air bleed passage leading to the relief valve is located at the highest point of the reservoir to aid in bleeding off trapped air.

b) Cracks at 215 psi to dump fluid overboard. Provides for a full flow of 12 gpm at 450 psi.

c) Closes at 150 psi.

3) Drain port

a) Provides a means for draining hydraulic fluid from the reservoir and manifold.

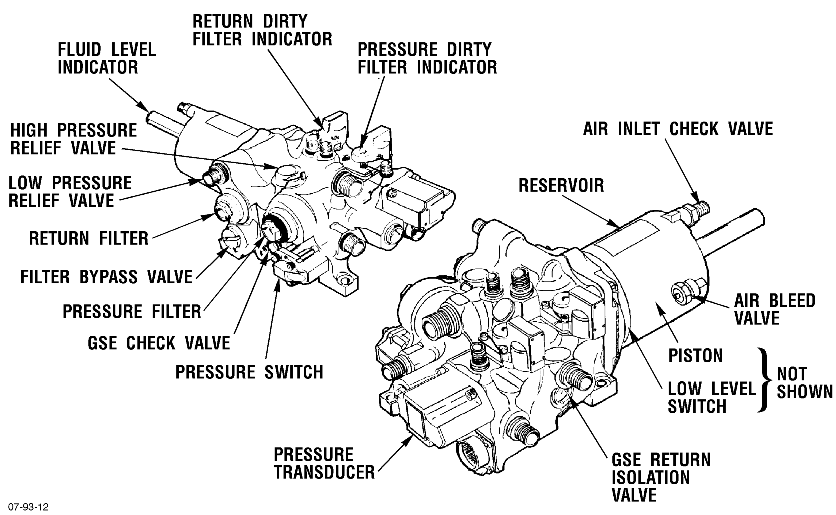
b) Located on the bottom of the manifold.

4) Pressure switch

a) Closes to illuminate pilot's PRI HYD PSI and CPG's PRI HYD caution lights when hydraulic pressure decreases below 1250 psi.

b) Opens to extinguish pilot's PRI HYD PSI and CPG's PRI HYD caution lights at 2050 psi, increasing.

PRIMARY HYDRAULIC MANIFOLD COMPONENTS



5) Pressure filter

a) Removes particles from fluid entering the manifold with a replaceable, 15-micron filter element. (A micron is a millionth of a meter or about 0.00004 inch. A 5-micron filter will trap smaller particles than a 15-micron filter)

b) Modification Work Order (MWO) 1-1520-238-50-30, dated 21 September 1992, improves the filtration efficiency by replacing the 15 micron filters with 5 micron filters.

c) Has no bypass capability.

6) Dirty filter indicators

a) Pressure dirty filter indicator

(1) Red, pop-up, visual indicator indicates impending filter clogging in conjunction with an electrical switch that illuminates the pilot's OIL BYP PRI HYD caution light.

(2) Illuminates the caution light when the inlet pressure exceeds 70 " 10 psid from the outlet pressure on the pressure filter.

(3) Is operational above +115E F (+46EC) and is locked out below +85E F (+29EC).

b) Return dirty filter indicator

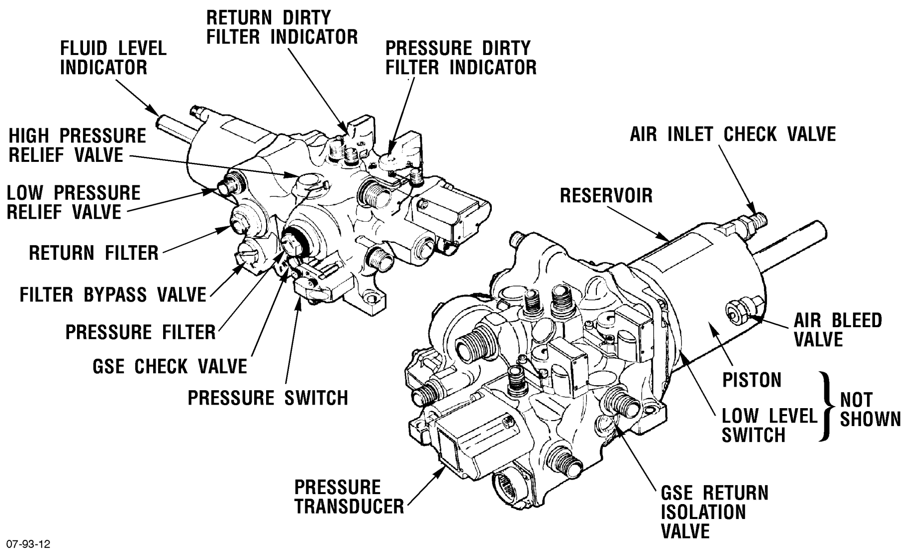
(1) Red, pop-up, visual indicator indicates impending filter clogging in conjunction with an electrical switch that illuminates the pilot's OIL BYP PRI HYD caution light.

(2) Illuminates the caution light when the inlet pressure exceeds 70 " 10 psid from the outlet pressure on the return filter.

(3) Is operational above +115E F (+46EC) and is locked out below +85E F (+29EC).

c) Electrical switches for the pressure and return dirty filter indicators are wired in parallel.

PRIMARY HYDRAULIC MANIFOLD COMPONENTS



7) Filter bypass valve

a) Allows return fluid to bypass the return filter when the filter is clogged.

b) The filter bypass valve opens at 100 "15 psid.

8) GSE check valve

a) Isolates GSE circuit during normal system operation.
b) Held closed by normal hydraulic system pressure as it enters the manifold.

c) Opens when GSE hydraulic pressure enters the manifold.

9) GSE return isolation valve

a) Isolates the GSE return port during normal system operation.

b) Held closed by normal hydraulic system pressure.

c) Opens when GSE pressure enters the manifold.

10) Pressure transducer

a) Monitors fluid pressure available to the servoactuators and sends a signal to the primary side of the dual hydraulic pressure gauge.

b) Provides a DC voltage output (1.37 VDC per 1000 psi), proportional to inlet pressure to the dual hydraulic pressure gauge.

11) High pressure relief valve

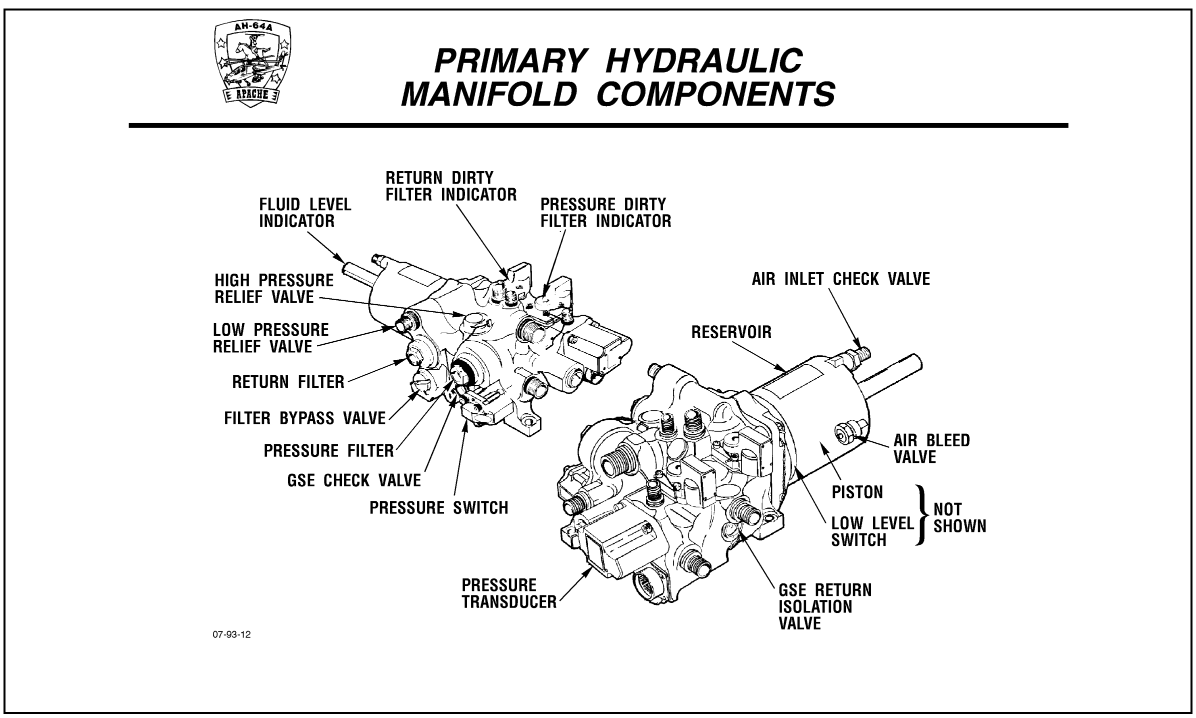
a) Relieves excess fluid pressure in the high pressure portion of the manifold into the return side of the manifold.

b) Protects system components from high pressures by opening and closing at the following pressures:

(1) Cracking pressure - 3500 psi

(2) Full flow - 3650 psi, maximum

(3) Reseat - 3300 psi, minimum

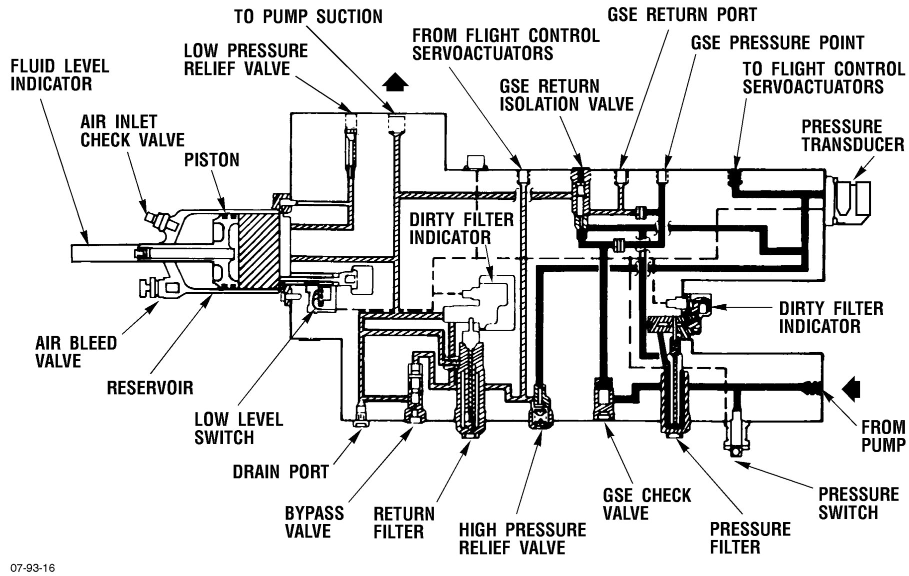


12) Return filter

a) Removes particles from fluid returning from the flight control servoactuators, before entering the manifold reservoir, with a replaceable 15-micron filter.

b) MWO 1-1520-238-50-30, dated 21 September 1992, improves the filtration efficiency of the primary hydraulic manifold by replacing the 15 micron filters with 5 micron filters.

PRIMARY HYDRAULIC MANIFOLD OPERATION



f. During normal operation, the primary hydraulic manifold operates in the following manner:

1) Pressurized air (30 psi) from the PAS manifold enters the reservoir through the air inlet check valve.

2) The pressurized air acts on the reservoir piston, creating low pressure hydraulic fluid, and helps prevent pump cavitation.

3) The low pressure relief valve cracks at 215 psi to relieve excess reservoir fluid and any trapped air.

4) Should the reservoir fluid level reach the minimum permissible operating volume (1.5 cubic inches/2.71 fluid ounces), the low-level switch is actuated to the closed position and the pilot's OIL LOW PRI HYD caution light illuminates.

5) The low pressure hydraulic fluid is drawn to the primary hydraulic pump, pressurized to 3000 psi, and then sent back to the manifold assembly.

6) High pressure hydraulic fluid enters the manifold and is sensed by the pressure switch, which opens at 2050 psi, increasing and extinguishes the pilot's PRI HYD PSI and the CPG's PRI HYD caution lights.

7) Should hydraulic pressure decrease to 1250 psi, the pressure switch will close, illuminating the pilot's PRI HYD PSI and the CPG's PRI HYD caution lights.

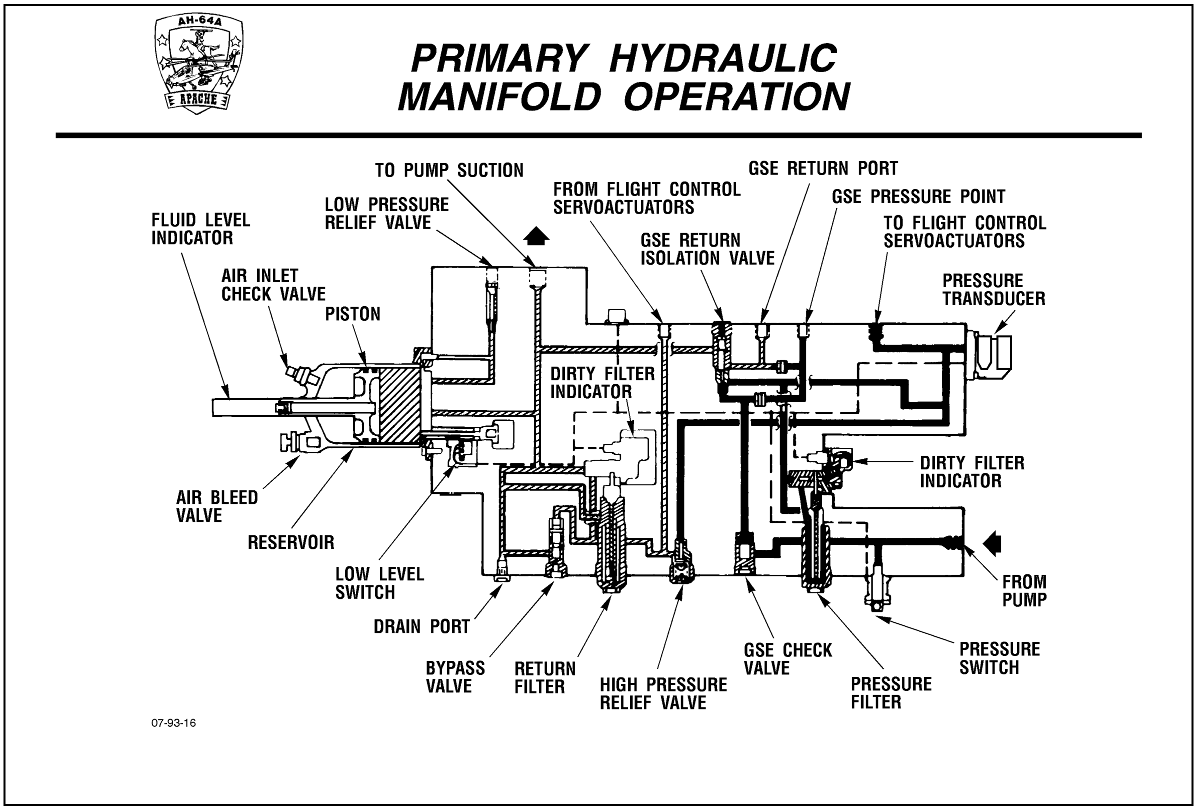
8) Pressurized fluid is filtered by the 5-micron filter element. If the filter becomes partially clogged, differential pressure (70 " 10) is sensed by an electrical switch in the dirty filter indicator. The switch closes, causing the pilot's OIL BYP PRI HYD caution light to illuminate and a pop-up visual indicator to extend.

9) Fluid is isolated from the GSE circuit during normal operation by the GSE check valves.

10) A high pressure relief valve returns excessive pressure to the return side of the manifold.

11) Prior to exiting the manifold, fluid pressure is monitored by the pressure transducer. It provides the signal to the primary side of the dual hydraulic pressure gauge in the pilot's station.

12) The manifold distributes high pressure hydraulic fluid to the using components.



13) Once the return fluid enters the manifold, it is filtered by the 5-micron filter element. If the return filter becomes partially clogged, differential pressure is sensed by an electrical switch in the dirty filter indicator. The switch closes, causing the pilot's OIL BYP PRI HYD caution light to illuminate, and a pop-up visual indicator to extend.

14) At a differential pressure of 100 " 15 psid, a bypass valve opens and allows the return fluid to be routed around the return filter back to the reservoir and pump.

g. During GSE operation the primary hydraulic manifold operates in the following manner:

1) A ground power unit sends high pressure fluid to the GSE pressure port. A flow limiting orifice restricts the flow to a maximum of 8 gpm at 3000 psi.

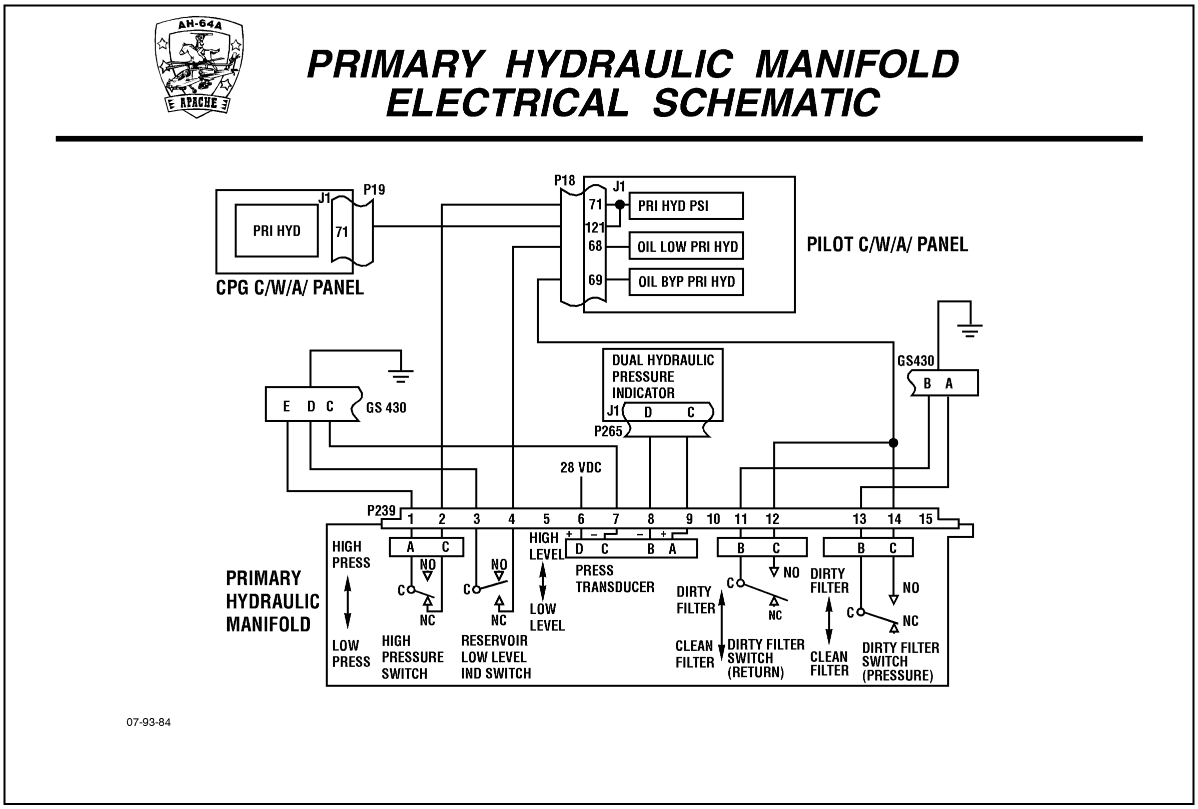
2) Pressure is sensed on the backside of the GSE return isolation valve piston and the check valve is held open mechanically.

3) This opens the reserve return system to the GSE return port so flow in equals flow out.

4) A pressure bleed orifice (.06 gpm at 3000 psid) between the GSE pressure and return port prevents hydraulic lock on the GSE return isolation, (which would prevent the check valve from reseating).

5) Normal operating leakage across the GSE check valve leaks back into the return system through the GSE return isolation valve, rather than building up and actuating the isolation piston.

6) GSE pressure flows through the GSE check valve and continues through the normal pressure and return manifold system.



h. Primary hydraulic manifold electrical description and operation

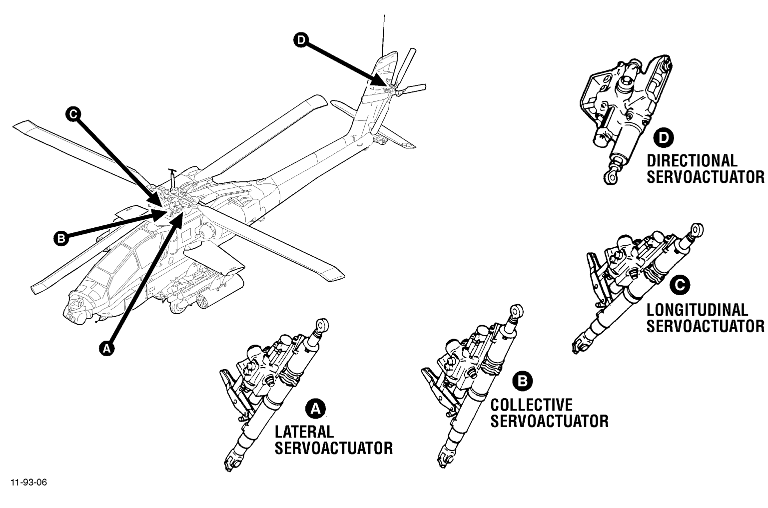
1) The pressure switch is a normally closed switch that opens when hydraulic pressure reaches 2050 psi, increasing (extinguishing the pilot's PRI HYD PSI and the CPG's PRI HYD caution light), and closes when pressure decreases to 1250 psi (illuminating the pilot's PRI HYD PSI and the CPG's PRI HYD caution light). The switch provides a ground, when closed, to illuminate the PRI HYD PSI caution light on the pilot's C/W/A panel and the PRI HYD caution light on the CPG's C/W/A panel.

2) The low-level switch is a normally open switch closes when the fluid level in the reservoir decreases to 1.5 cubic inches (2.71 fluid ounces). The low-level indicator switch, when closed, provides a ground to illuminate the pilot's OIL LOW PRI HYD caution light.

3) The pressure transducer supplies a signal to the dual hydraulic pressure indicator proportional to hydraulic pressure in the primary hydraulic system. Signal output is 1.37 VDC per 1000 psi.

4) The pressure dirty filter and return dirty filter indicators are identical and interchangeable. They are normally open switches that close at 70 " 10 psid. The switches are wired in parallel. When either switch closes, it provides a ground to illuminate the pilot's OIL BYP PRI HYD caution light.

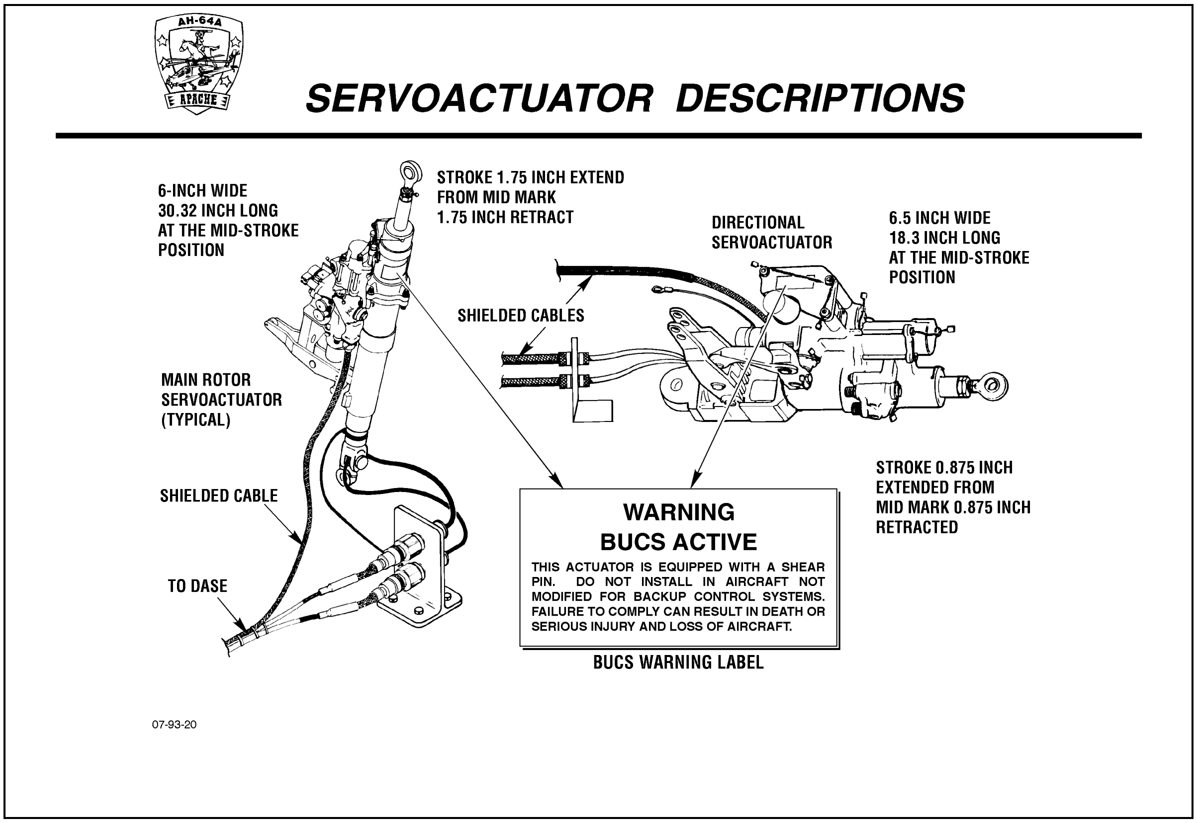
SERVOACTUATORS LOCATIONS



4. Longitudinal, lateral, collective, and directional servoactuators

   a. Convert mechanical inputs during normal operation, or electrical inputs during DASE or BUCS operation, into hydraulic pressure outputs that are sent to the main and tail rotor flight controls.

   b. The longitudinal servoactuator is mounted on the transmission deck in front and to the right of the transmission. The lateral servoactuator is mounted on the transmission deck in front and to the left of the transmission. The collective servoactuator is mounted on the transmission deck in front of the transmission. The directional servoactuator is mounted on top of the tail rotor gearbox.



c. Servoactuator descriptions

1) The lateral and collective servoactuators are identical.

2) The longitudinal servoactuator differs slightly from the lateral and collective servoactuators at the attachment points.

3) The main rotor servoactuators are approximately 6 inches wide and 30.32 inches long at the mid-stroke position.

4) The directional servoactuator is approximately 6.5 inches wide and 18.3 inches long at the mid-stroke position.

5) All are constructed of electroslag-remelt (ESR) steel for ballistic protection.

6) The tandem design of the servoactuators allows for separate primary and utility cylinder barrels. They have a common rod and piston assembly that utilize primary and utility system fluid, respectively.

7) The servoactuator modes of operation are:

   a) Mechanical. Controlled by mechanical flight control inputs through actuator input linkage.

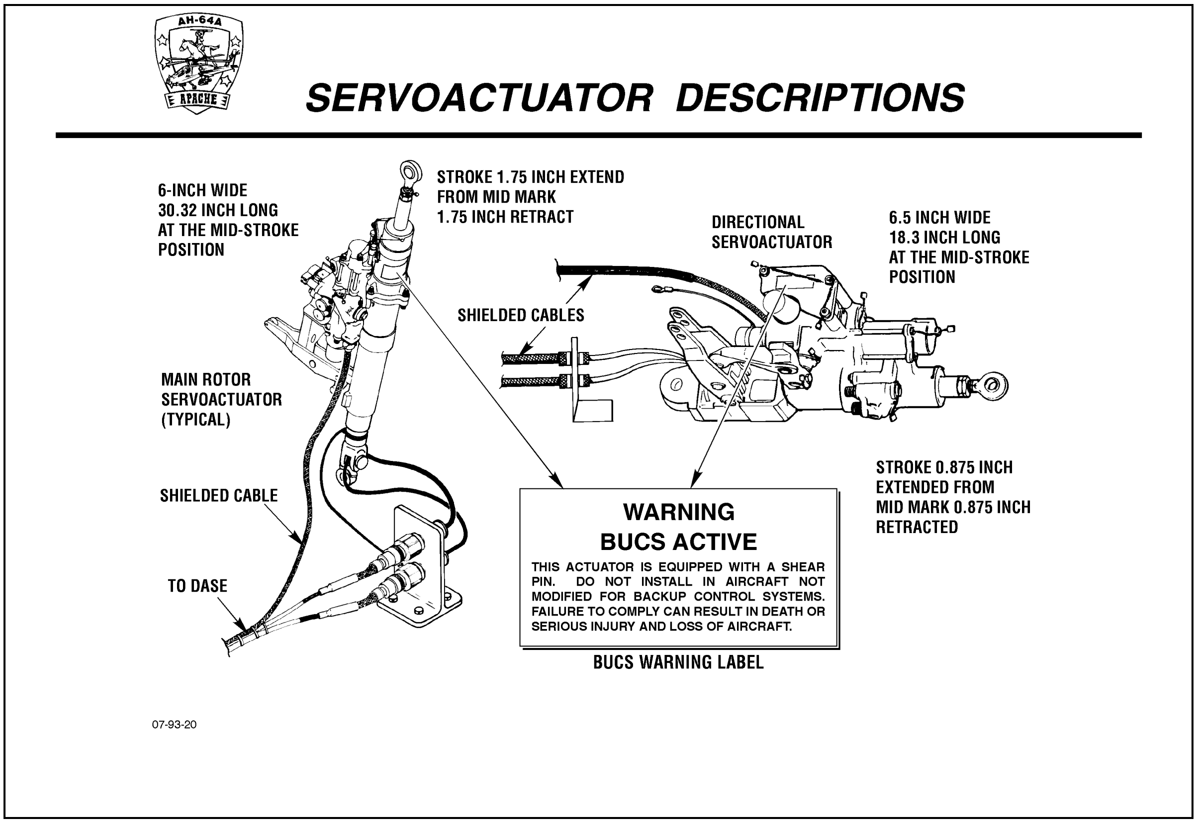
   b) Electrical. Controlled by electrical inputs from the DASE computer for the stability augmentation system (SAS), command augmentation system (CAS), or BUCS system.

8) BUCS "de-active" servoactuators have a part number suffix of XY, XYW, -3XYW, or -3XY.

9) BUCS "active" servoactuators have the part number suffix of XY, XYW, -3XYW, or -3XY removed, and have a red "BUCS ACTIVE" warning label. On the three main rotor servoactuators, the red "BUCS ACTIVE" warning label is located on the manifold and is attached by adhesive and existing hardware.

WARNING

BUCS "active" servoactuators must not be interchanged with BUCS "de-active" servoactuators. Serious injury and aircraft damage could result. All BUCS "active" servoactuators will be labeled with a red "BUCS ACTIVE" warning label with the following warning printed on it:



WARNING

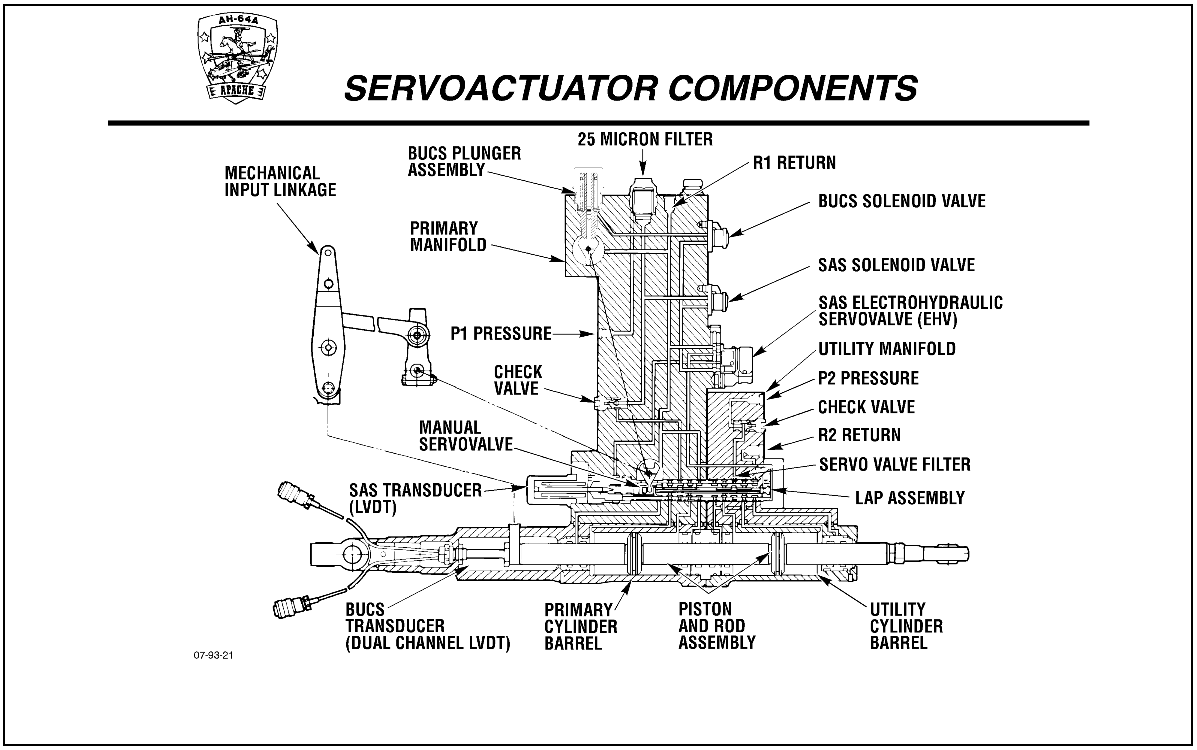
BUCS ACTIVE

This actuator is equipped with a shear pin. Do not install in aircraft not modified for backup control systems. Failure to comply can result in death or serious injury and loss of aircraft.

10) BUCS "active" aircraft begin at serial number (S/N) 88-0200 and subsequent. All aircraft prior to 88-0200 are BUCS "de-active".

11) BUCS "active" servoactuators have electromagnetic vulnerability hardening modifications installed to prevent electromagnetic interference (EMI) from entering the DASE computer. An airframe bonding cable is attached to each servoactuator. The servoactuator electrical cables are shielded and use EMI backshells.

12) The SAS and CAS systems are not affected by deactivation of the BUCS system.



d. Servoactuator components and descriptions

1) Primary manifold

a) Provides mounting for primary hydraulic system servoactuator components and distributes fluid within the servoactuator.

b) Contains a pressure port (P1), a return port (R1), and drilled passages that direct hydraulic fluid to and from the components mounted on the primary manifold.

2) Mechanical input linkage

a) Transmits crewstation mechanical flight control inputs to the lap assembly.

b) Mechanically locked-out during BUCS operation.

3) Piston and rod assembly

a) Converts hydraulic fluid power to linear mechanical motion.

b) Consists of a primary piston and a utility piston assembled together and held by a nut at one end. The pistons operate within their respective cylinder barrels.

c) Movement of the assembly is monitored by the BUCS transducer.

4) Primary and utility cylinder barrels

a) Provide a working area for fluid pressure to position the respective pistons.

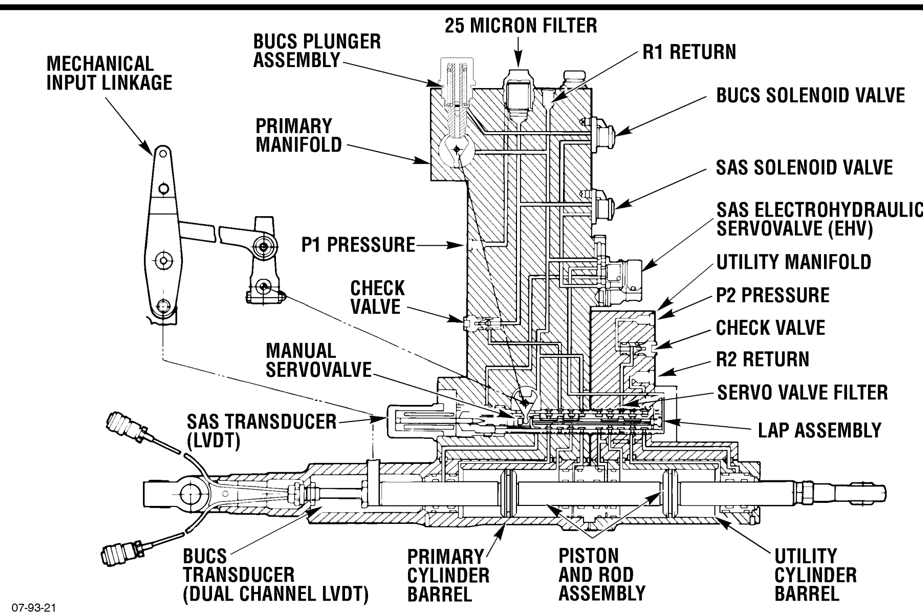
b) Pistons operate within a polished bore. Ports within the bore allow fluid to enter and leave the bore, as necessary.

5) Servovalve filter

a) Filters particles from fluid entering the utility side of the lap assembly.

b) Constructed of corrosion-resistant steel wire mesh, rated at 40 microns.

SERVOACTUATOR COMPONENTS



6) SAS solenoid valve

   a) The SAS solenoid valve provides on/off control of fluid pressure going to the BUCS solenoid valve and the SAS electrohydraulic servovalve (EHV).

   b) The normally closed solenoid valve is controlled by the respective (pitch, roll, or yaw) automatic stabilization equipment (ASE) engage switch on the pilot's ASE panel.

   c) Opened by the DASEC during BUCS operation.

7) SAS EHV

   a) Controlled by an electrical signal from the DASEC.

   b) Controls fluid flow to the stability augmentation portion of the lap assembly.

   c) Directs fluid pressure to position the stability augmentation actuator, utilizing fluid pressure provided by the open SAS solenoid valve.

8) SAS transducer. Generates electrical signals used by the digital automatic stabilization equipment computer (DASEC) to monitor lap assembly movement.

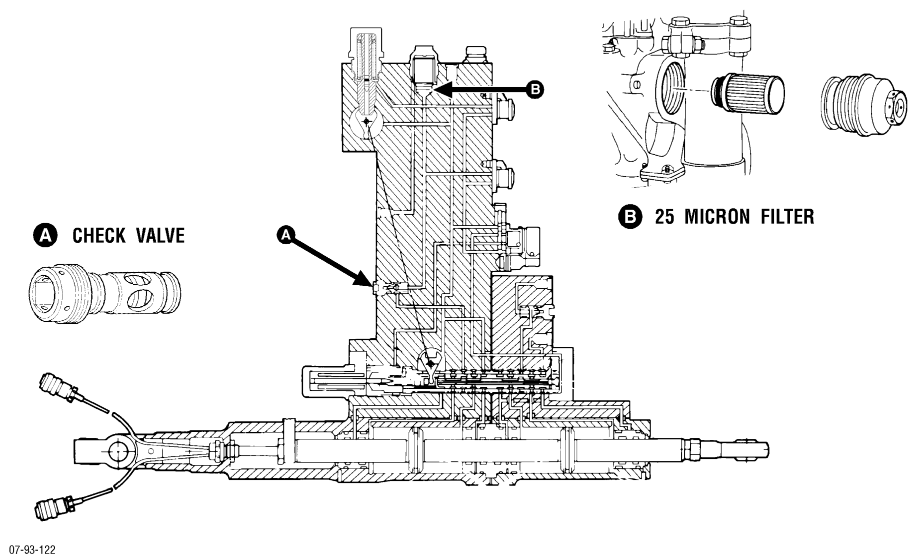
9) BUCS solenoid valve

   a) Provides on/off control of fluid pressure going to the BUCS plunger assembly.

   b) The normally closed solenoid valve is controlled by the DASEC.

10) BUCS transducer. Generates electrical signals used by the DASEC to monitor piston and rod assembly movement.

SERVOACTUATOR 25-MICRON FILTER AND PRIMARY CHECK VALVE



11) 25-micron filter

a) Removes particles larger than 25 microns from fluid entering the primary manifold.

b) Constructed of a cleanable steel wire mesh.

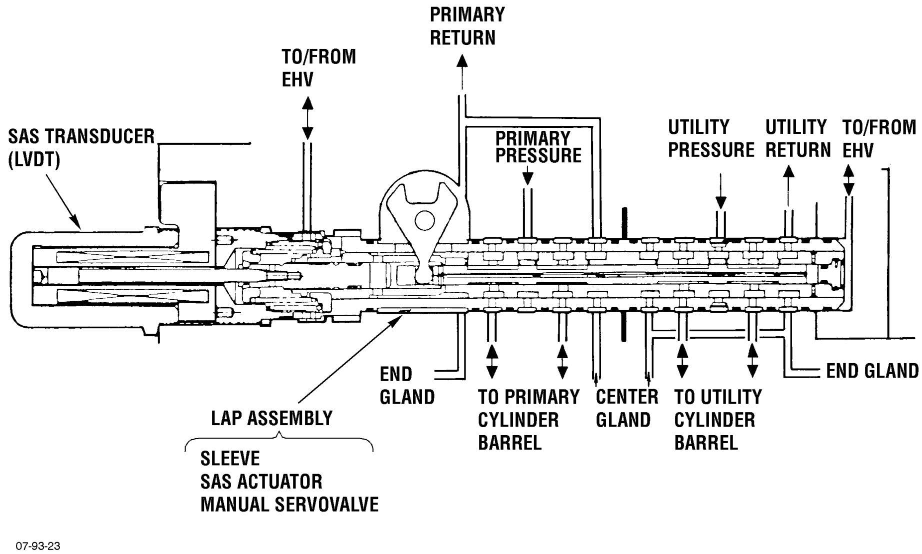
12) Primary check valve

a) Allows system pressure to enter the primary manifold and prevents reverse flow.

b) Eliminates transmission of servoactuator-generated pressure surges to the rest of the primary hydraulic system.

c) Cracking pressure is 2 to 8 psi.

SERVOACTUATOR LAP ASSEMBLY OPERATION



13) BUCS plunger assembly

a) Locks the mechanical input linkage in the neutral position during BUCS operation.

b) Is spring-loaded to the unlocked position. The BUCS plunger assembly is forced down to the locked position by fluid pressure routed through the energized BUCS solenoid valve. A bleed orifice in the center of the BUCS plunger assembly allows fluid pressure used to actuate the BUCS plunger to bleed off when the BUCS solenoid is de-energized.

c) The original plunger incorporated a single return spring and is identified by its low-profile cap. All aircraft with S/Ns prior to 88-0200 are BUCS "de-active" and have BUCS de-active servoactuators. These servoactuators have the low profile cap, but the plunger and spring are removed.

d) The modified plunger for BUCS active servoactuators incorporates dual return springs (for redundancy) and an anti-corrosion coating for more reliable operation. This style of plunger differs from the original by incorporating a high profile cap to house the larger spring assemblies.

14) Lap assembly

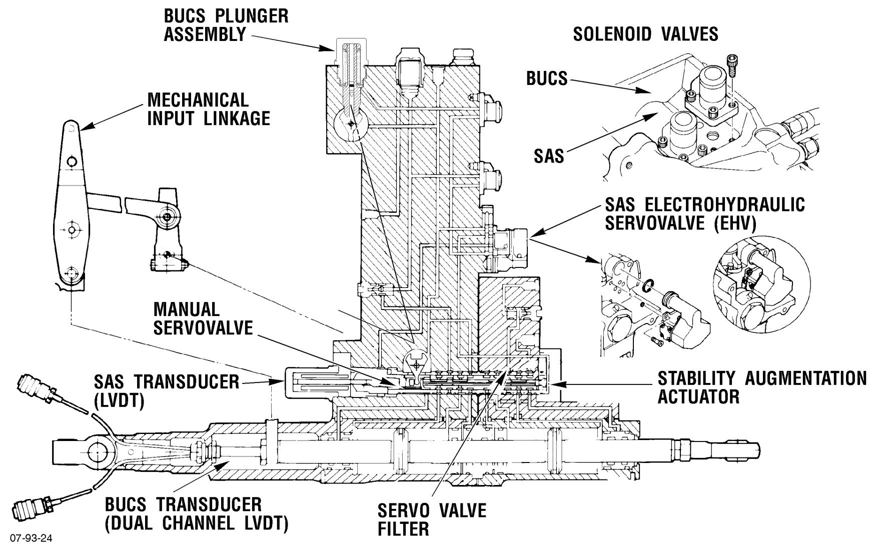
a) Controls fluid flow to and from the primary and utility cylinder barrels.

b) Consists of a sleeve and spool assembly, stability augmentation actuator, and a manual servovalve.

(1) The manual servovalve is controlled by inputs from the crewstation flight controls via mechanical input linkage, and provides 100% authority of servoactuator motion.

(2) The stability augmentation actuator is controlled by fluid pressure from the SAS EHV when the SAS solenoid is energized, and provides 10% bidirectional servoactuator authority in all axes except forward longitudinal where authority is 20%.

SERVOACTUATOR FUNCTIONAL DIAGRAM II



e. Servoactuator operation (normal and BUCS). During normal mode of operation, pressurized hydraulic fluid from the primary hydraulic manifold enters the servoactuator manifold through port P1. Fluid is filtered by a 25-micron filter and routed to the SAS solenoid valve and a one-way check valve. For ease of explanation, normal operation is divided into two modes: mechanical input and electrical input.

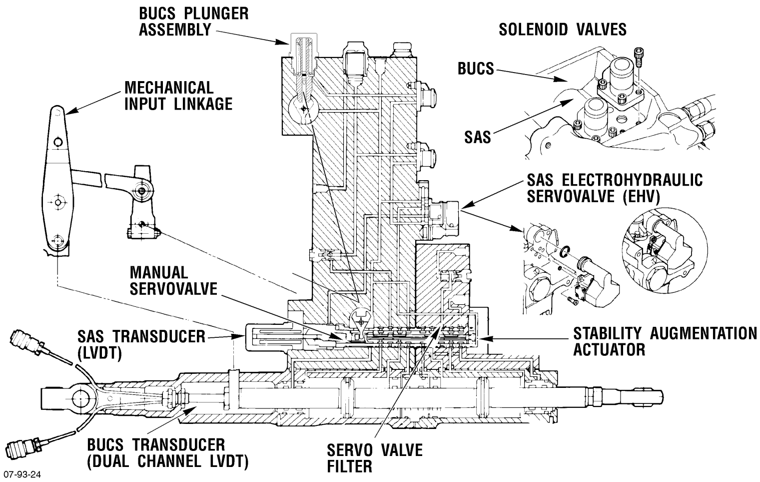
1) Normal operation, mechanical input. Pressurized fluid passes through the check valve and is routed to the lap assembly. The check valve cracks at 2 to 8 psi and prevents pressurized fluid from being forced back through the pressure port. Mechanical input linkage controls the position of the manual servovalve. When the pilot moves the controls, the mechanical input linkage moves, consequently moving the manual servovalve. The manual servovalve allows pressurized hydraulic fluid to pass through the lap assembly and enter the primary cylinder barrel on one side of the piston. The side of the piston the fluid enters is dependent upon the manual servovalve's direction of movement. Fluid entering the barrel causes the piston and piston rod to move. Fluid on the opposite side of the piston exits the barrel through the lap assembly and then exits the manifold through return port R1. The fluid then returns to the primary hydraulic manifold. Since the mechanical input linkage is attached to the piston rod, as the piston rod moves it causes the manual servovalve (via the mechanical input linkage) to "re-center". This shuts off fluid flow into the cylinder barrel and stops piston rod movement until another control input is made.

2) Normal operation, electrical input. Pressurized fluid enters the SAS solenoid valve and is allowed to flow to the SAS EHV if the applicable ASE channel is engaged. The EHV controls movement of the SAS actuator by routing fluid to one end of the SAS actuator or the other. The SAS actuator's direction of movement is determined by the DASEC. The SAS actuator allows pressurized hydraulic fluid to pass through the lap assembly and enter the cylinder barrels on one side of each piston. The side of the pistons the fluid enters is dependent upon the SAS actuator's direction of movement. As the fluid enters the barrels, it causes the pistons to be displaced and the piston rod to move. Fluid on the opposite side of the pistons exits the barrel through the lap assembly, return ports, and back to the respective hydraulic manifold. The SAS linear variable differential transducer (LVDT) monitors the position of the SAS actuator and generates electrical signals, for DASEC. The DASEC compares these signals to SAS and CAS commands, and causes the SAS actuator to "re-center" (via the SAS solenoid and the EHV) when the required servoactuator input is made. This shuts off fluid flow into the cylinder barrel and stops piston rod movement until another input is made. If the DASEC malfunctions and sends faulty signals to the EHV, undesired electrical inputs (resulting in undesired servoactuator movements) may occur. However, mechanical inputs provide 100% servoactuator authority in all axes and will override the electrical inputs.

2) During normal operation, the manual servovalve and stability augmentation actuator work together to control both primary and utility system fluids in the servocylinder. The position of the manual servovalve and stability augmentation actuator determine if fluid pressure is equalized or routed to the pistons and cylinder barrels.

3) BUCS operation. With BUCS engaged in any axis, ASE for that axis is disengaged, the pilot's ASE switch for that axis is disengaged, and the DASEC controls 100% of the hydraulic servoactuator. With the BUCS engaged, the DASEC applies electrical power to the SAS and BUCS solenoid valves on the respective servoactuator. Both valves are energized open. Hydraulic pressure is applied through the SAS and BUCS solenoid valves to the BUCS plunger. The plunger is forced to engage the output arm, locking out manual control for the affected axis. When the power piston moves, it will shear the BUCS shear pin, separating the servoactuator from the flight control linkage. With the manual control input locked, the EHV becomes the only source of control in the axis in which BUCS has engaged. When the pilot moves the controls, a signal is developed by the LVDT in the pilot's crew station and applied to the EHV, via the DASEC. The EHV, as directed by the DASEC, applies hydraulic pressure to the lap assembly. As the lap assembly moves, primary hydraulic system pressure is allowed to enter the cylinder barrel, extending or retracting the power piston. As the power piston moves, the BUCS LVDT develops a signal in opposition to the pilot's LVDT signal. The DASEC compares the two signals, and when the power piston has moved as much as required by the DASEC, the BUCS LVDT signal is equal to, and of an opposite polarity, to the pilot's LVDT signal. The resultant signal to the EHV is zero and the EHV returns the lap assembly to the neutral position, equalizing hydraulic pressure on the power piston. The power piston is

SERVOACTUATOR FUNCTIONAL DIAGRAM II



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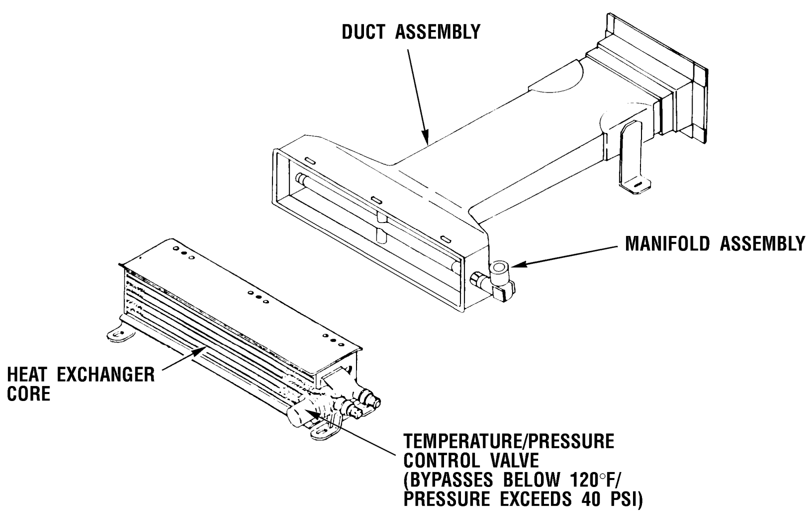
hydraulically locked in this position until the pilot moves the controls again, causing an imbalance between the pilot's and the BUCS LVDTs.

HEAT EXCHANGER/EDUCTOR ASSEMBLY MAJOR COMPONENTS



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5. Primary heat exchanger

   a. Cools primary hydraulic system fluid returning to the primary reservoir.

   b. Consists of a heat exchanger core assembly, PAS manifold assembly, and a duct.

      1) The core assembly cools hydraulic fluid returning to the primary reservoir. If the hydraulic fluid is below +120EF (+49EC) or exceeds 40 psi, a bypass valve, mounted on the core, routes fluid around the heat exchanger.

      2) The PAS delivers air pressurized to 30 psi to the heat exchanger's PAS manifold assembly. Four nozzles on the manifold direct air through the duct and overboard, creating a low pressure area on the outboard side of the heat exchanger core.

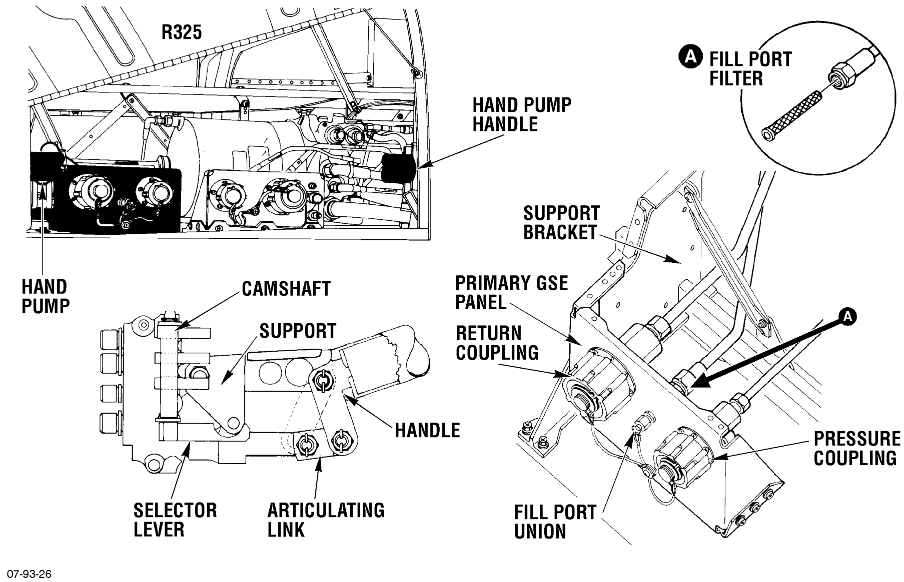
      3) The low pressure area draws ambient air across the cooling fins of the heat exchanger core, thereby reducing the temperature of the hydraulic fluid.

   c. Originally installed on helicopters with serial numbers 82-23355 through 86-9011. If installed, the primary heat exchanger is located on the aft equipment bay deck, on the left side of the catwalk.

   d. MWO 1-1520-238-50-30, dated 27 July 1992, calls for the removal of the primary heat exchanger because flight and environmental chamber testing have shown the effectiveness of the primary heat exchanger to be minimal. Improved system reliability, reduced fluid friction losses, and cost savings are achieved by heat exchanger removal.

   e. After removal of the primary heat exchanger, the hydraulic lines to and from the heat exchangers are removed. A new hydraulic line is installed from the system return line to the manifold return port. The PAS line is removed and capped at the PAS manifold.

PRIMARY HYDRAULIC GSE PANEL ASSEMBLY



6. Primary hydraulic GSE panel assembly

   a. Provides connections for external hydraulic power application, a method of servicing the primary and utility reservoirs, a method of bleeding the primary reservoir, and a method of charging the accumulator with fluid.

   b. Installed on the aft equipment bay deck, aft of the APU, and outboard of the utility manifold. It is accessible through panel R325.

   c. Primary hydraulic GSE panel assembly components and description

      1) Pressure coupling

         a) Mates with the auxiliary ground power unit (AGPU) pressure hose coupling.

         b) A quick-disconnect type of coupling, made of aluminum.

      2) Return coupling

         a) Mates with the AGPU return hose coupling.

         b) A quick-disconnect type of coupling, also made of aluminum.

      3) Fill port union. Provides a connection for drawing fluid from a bulk container to service the hydraulic systems.

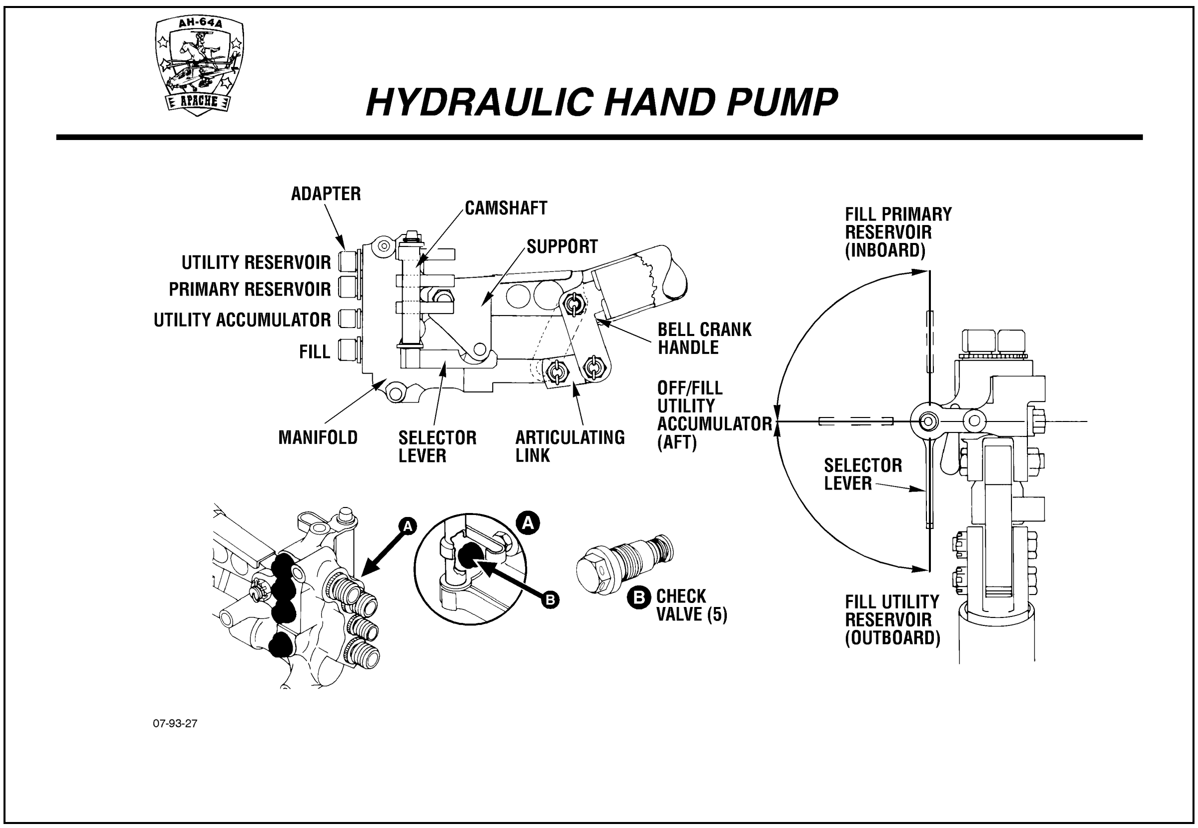
4) Fill port filter. An in-line filter installed in the fill-tube assembly. Constructed of stainless steel woven wire mesh. Rated at 17 microns

5) Hand pump handle

   a) Provides the necessary leverage to operate the hand pump.

   b) When not in use, is stowed to the crossbeam support of access panel R325.

   c) Approximately 25.5 inches (64.8 cm) long with a maximum travel of 18 inches (45.7 cm).



6) Hydraulic hand pump

a) Provides a means for drawing hydraulic fluid from a bulk container and directing the fluid to the primary reservoir, utility reservoir, or the accumulator. It can be used to pressurize the accumulator, also.

b) Mounted to a support bracket on the aft end of the GSE panel.

c) A single-action ram, hand-operated pump. One power stroke per second equals a flow rate of 0.4 cubic inches (0.72 fluid ounces) per second.

d) Descriptions of the major components of the hydraulic hand pump are given below.

e) Manifold

(1) Distributes hydraulic fluid to the selected system.

(2) Provides mounting for the selector lever, camshaft, check valves, and handle support.

f) Check valves

(1) Isolate the appropriate internal passages in the manifold for distribution of fluid to the selected system.

(2) Spring-loaded, poppet-type valves with a cracking pressure of 0.5 to 1.5 psi.

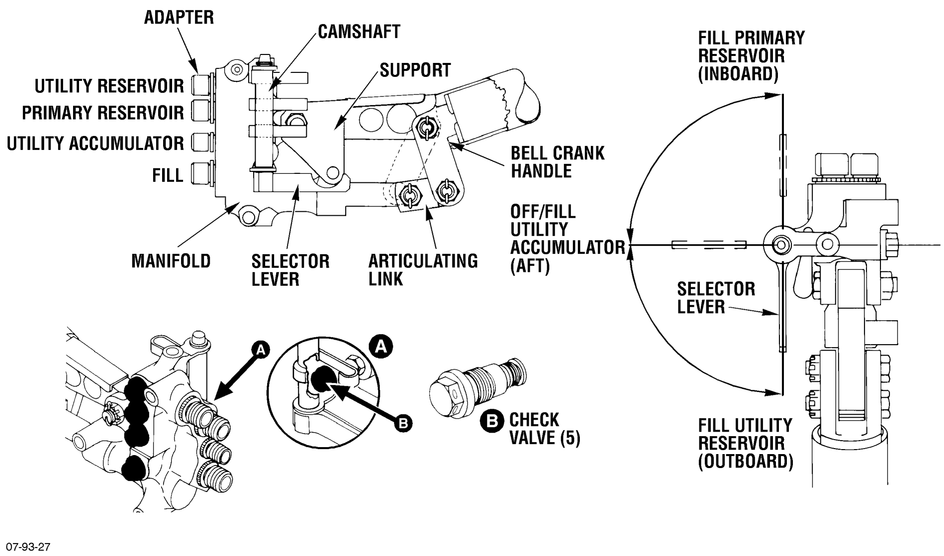
g) Selector lever

(1) Allows maintenance personnel to select the system that needs servicing. The lever is attached to the camshaft assembly which opens or closes the mechanical check valves in the manifold.

(2) Three-position lever

(a) If the lever is facing inboard, it allows the primary reservoir to be filled.

HYDRAULIC HAND PUMP



(b) If the lever is facing aft, it allows the utility accumulator to be filled or is considered to be off.

(c) If the lever is facing outboard, it allows the utility reservoir to be filled.

h) Bellcrank handle

(1) Interfaces with the support to provide the input force to articulate the pump.

(2) Provides a means of attaching the hand pump handle.

i) Support

(1) High side loads on the hand pump piston have resulted in excessive external leakage. During depot repair/overhaul, the support is installed on the hand pump, reducing side loads.

(2) Interfaces with the bellcrank handle to provide rigidity in the plane of motion.

(3) Assists in reducing side loads on the piston.

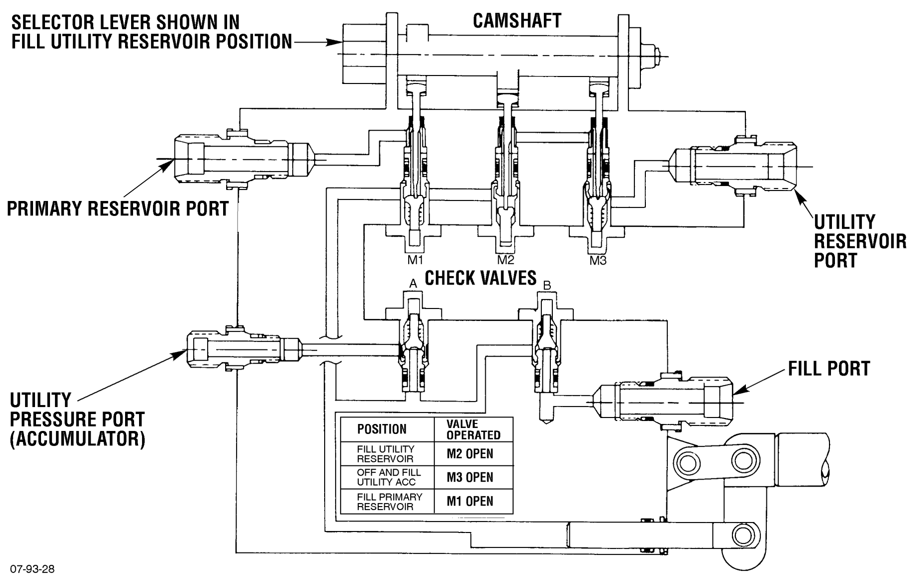
j) Articulating link

(1) Interfaces the bellcrank handle with the pump piston.

(2) Installed during depot repair/overhaul, the articulating link allows the piston to self-center, reducing side loads and external leakage.

NOTES

HAND PUMP OPERATION



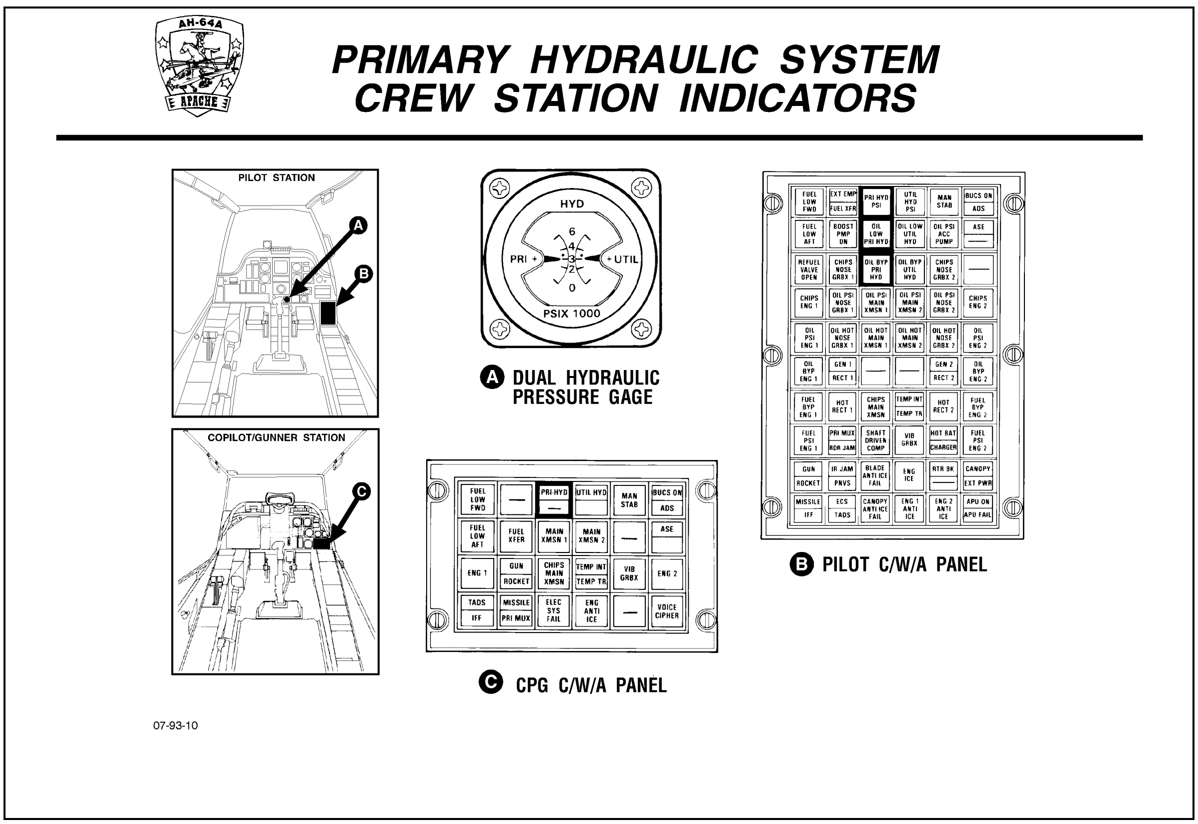
d. Hand pump operation

1) Prior to using the hand pump to service any of the systems, the utility hydraulic accumulators must be properly serviced with nitrogen.

2) With a hydraulic servicing unit connected to the fill port of the GSE panel, low-pressure fluid is allowed to enter the pump manifold by overriding the spring poppet of check valve B.

3) Positioning the selector lever outboard rotates the camshaft, causing the M2 check valve to be mechanically opened. The pump is then stroked by hand, forcing out the fluid. The fluid is forced to open M3 and be delivered to the utility reservoir.

4) Check valve A remains closed due to the accumulator pressure acting on the back side of the poppet.



A. Primary hydraulic system crewstation indicators

1. Voltage source for the primary hydraulic system crewstation indicators is 28 VDC from the emergency bus.

2. Dual hydraulic pressure gauge

    a. Provides a visual indication of the primary and utility hydraulic system pressures.

    b. A dual-scale dial, with a pointer for each scale, mounted to the lower center portion of the pilot's instrument panel. Each number on the dial equals hydraulic pressure in thousands of pounds.

3. Pilot's PRI HYD PSI caution light

    a. Indicates that the primary hydraulic system oil pressure is below 1250 psi. Illuminates at 1250 psi, decreasing and extinguishes at 2050 psi, increasing.

    b. A full-segment amber light located on the pilot's C/W/A panel.

4. Pilot's OIL LOW PRI HYD caution light

    a. Indicates that the primary hydraulic system fluid is at minimum operating level.

    b. A full-segment amber light located on the pilot's C/W/A panel.

5. Pilot's OIL BYP PRI HYD caution light

    a. Indicates that a pressure differential of 70 " 10 psid has been detected in either the pressure or return filters of the primary hydraulic system.

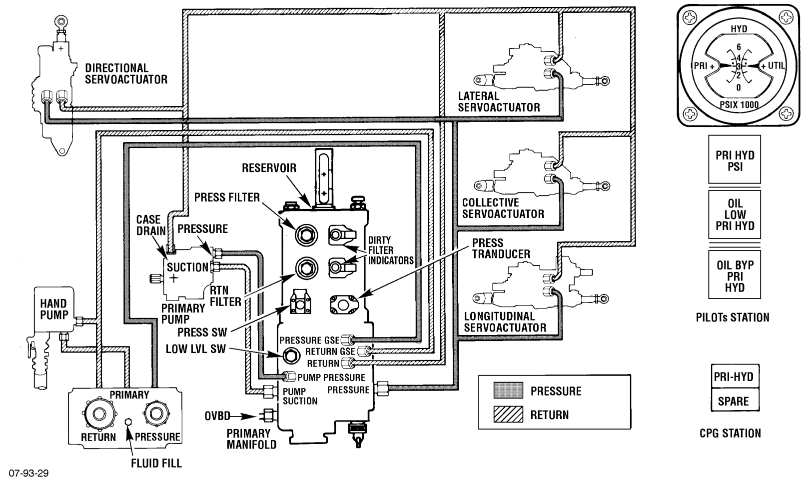
    b. A full-segment amber light located on the pilot's C/W/A panel.

6. CPG's PRI HYD Caution Light

    a. Indicates that the primary hydraulic system oil pressure is below 1250 psi. Illuminates at 1250 psi, decreasing and extinguishes at 2050 psi, increasing.

    b. A half-segment amber light located on the CPG's C/W/A panel.

PRIMARY SYSTEM OPERATION



B. Primary hydraulic system operation

1. During normal operation, pressurized air (30 psi) from the PAS manifold enters the primary reservoir through the air inlet check valve. The pressurized air acts upon the reservoir piston, creating low pressure hydraulic fluid and helps prevent pump cavitation.

2. Should the reservoir fluid level reach the minimum permissible operating volume (1.5 cubic inches/2.71 fluid ounces), the low-level switch closes and illuminates the pilot's OIL LOW PRI HYD caution light.

3. The primary hydraulic pump is driven by the transmission accessory gear train at 12,635 rpm. The low-pressure hydraulic fluid is drawn from the reservoir to the primary hydraulic pump by pump suction, pressurized to 3000 psi, and then returned to the primary hydraulic manifold.

4. The fluid returned to the manifold is sensed for pressure by the pressure switch and either illuminates or extinguishes the pilot's PRI HYD PSI and the CPG's PRI HYD caution lights.

5. The pressurized fluid is filtered by a 15-micron filter (or 5-micron if MWO 1-1520-238-50-27 has been applied). If the filter is partially clogged, differential pressure of 70 " 10 psid is sensed by an electrical switch in the dirty filter indicator. The switch closes, causing the pilot's OIL BYP PRI HYD caution light to illuminate and the pop-up visual indicator on the manifold to extend.

6. Fluid is isolated from the GSE ports during normal operation by the GSE check valve. A high pressure relief valve returns excessive pressure to the return side of the primary hydraulic manifold.

7. Prior to output to the flight control servoactuators, the fluid pressure is monitored by the pressure transducer. The pressure transducer provides signals to the primary side of the pilot's dual hydraulic pressure indicator.

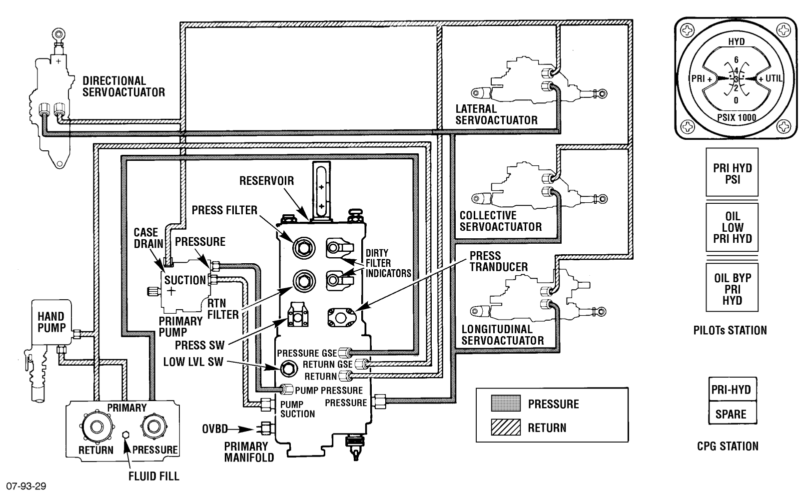
8. The manifold then distributes high-pressure hydraulic fluid to the longitudinal, collective, lateral, and directional servoactuators.

9. Fluid returning from the servoactuators is cooled by the heat exchanger (if installed) before returning to the primary hydraulic manifold.

10. Returning fluid is filtered by a 15-micron filter (or 5-micron if MWO 1-1520-238-50-27 has been applied). If the filter is partially clogged, differential pressure of 70 " 10 psid is sensed by an electrical switch in the dirty filter indicator. The switch closes, causing the pilot's OIL BYP PRI HYD caution light to illuminate and the pop-up visual indicator on the manifold to extend.

11. During GSE operation, an AGPU sends high pressure hydraulic fluid to the GSE pressure port. A flow limiting orifice limits the flow to a maximum rate of 8 gpm at 3000 psi.

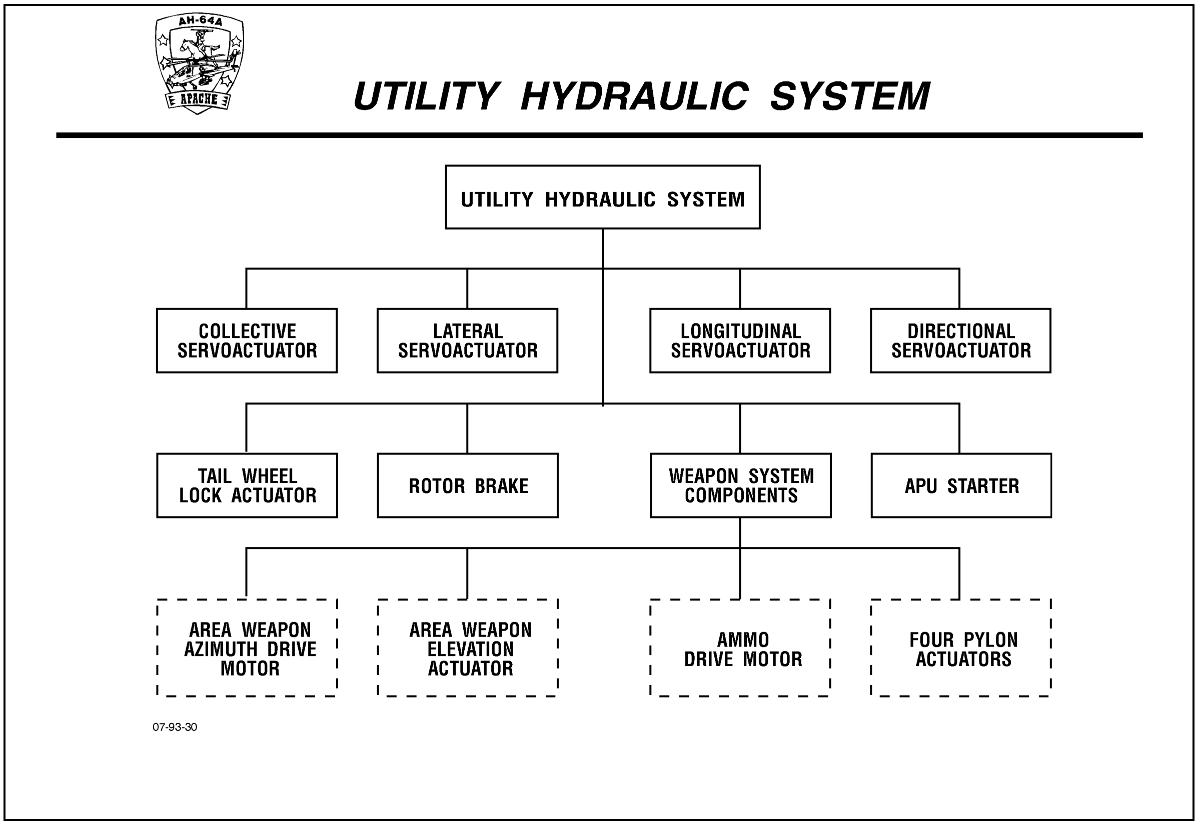
PRIMARY SYSTEM OPERATION



12. The GSE pressurized fluid is circulated through the manifold pressure filter and then out to the servoactuators.

13. Fluid returning from the servoactuators enters the manifold through the return port and is directed through the return filter.

14. The GSE return isolation valve allows the return fluid to travel back to the AGPU through the GSE return port.



A. Utility hydraulic system purpose

1. Provides hydraulic power to the utility side of the flight control servoactuators, rotor brake actuator, auxiliary power unit (APU) start motor, tail wheel lock actuator, AWS elevation actuator, AWS azimuth drive motor, ammunition carrier drive motor, and the pylon actuators.

2. Provides a source of stored, high-pressure hydraulic fluid for emergency operation of the flight control servoactuators.

3. Contains a return accumulator for fluid pressure dampening during area weapon system (AWS) operation.

B. Utility hydraulic system characteristics

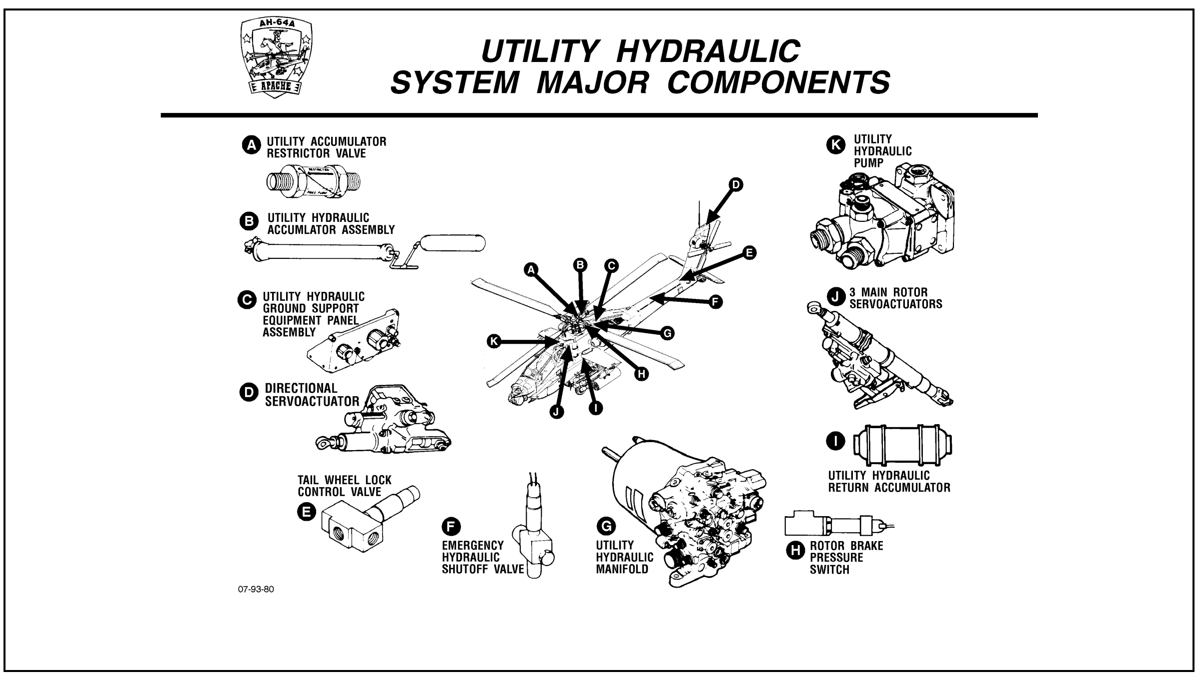
1. Provides 3000 psi pressurized hydraulic fluid to hydraulically operated components within a temperature range of -64EF to +275EF (-53EC to +135EC).

2. Has a flow rate of up to 6.0 gallons per minute.

3. The system's fluid capacity is approximately 2.6 gallons and uses:

a. MIL-H-83282, synthetic hydrocarbon base hydraulic fluid, for outside air temperatures of -25EF (-32EC) and above.

b. MIL-H-5606, petroleum base hydraulic fluid, for outside air temperatures below -25EF.



A. Utility hydraulic system components

1. Major components:

a. Utility hydraulic pump

b. Utility hydraulic manifold

c. Flight control servoactuators

d. Utility hydraulic accumulator assembly

e. Rotor brake actuator

f. APU start motor

g. Tail wheel lock control valve

h. Tail wheel lock actuator

i. Emergency hydraulic shut-off valve

j. AWS elevation actuator

k. AWS azimuth drive motor

l. Ammunition carrier drive motor

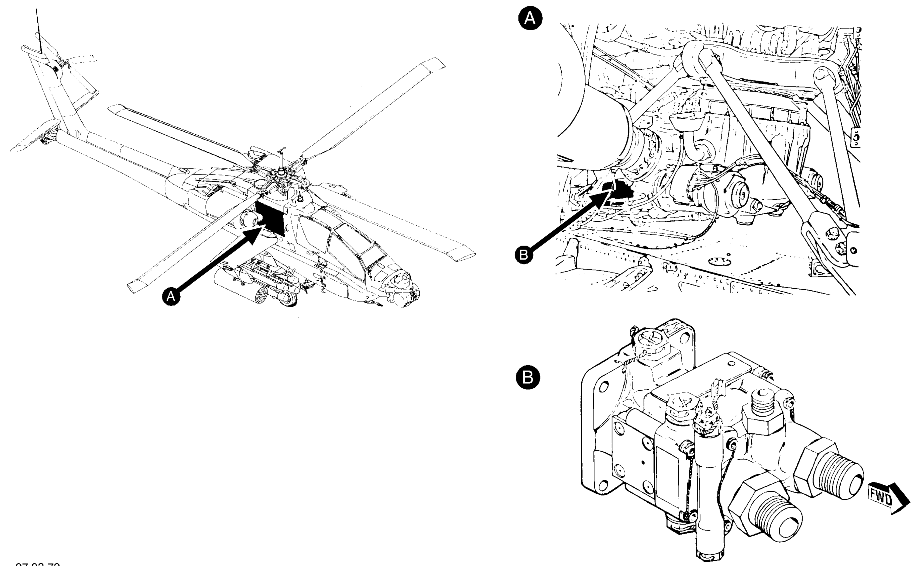
m. Utility hydraulic return accumulator

n. Pylon actuators

o. Utility heat exchanger

p. Utility GSE panel assembly

UTILITY HYDRAULIC PUMP LOCATION



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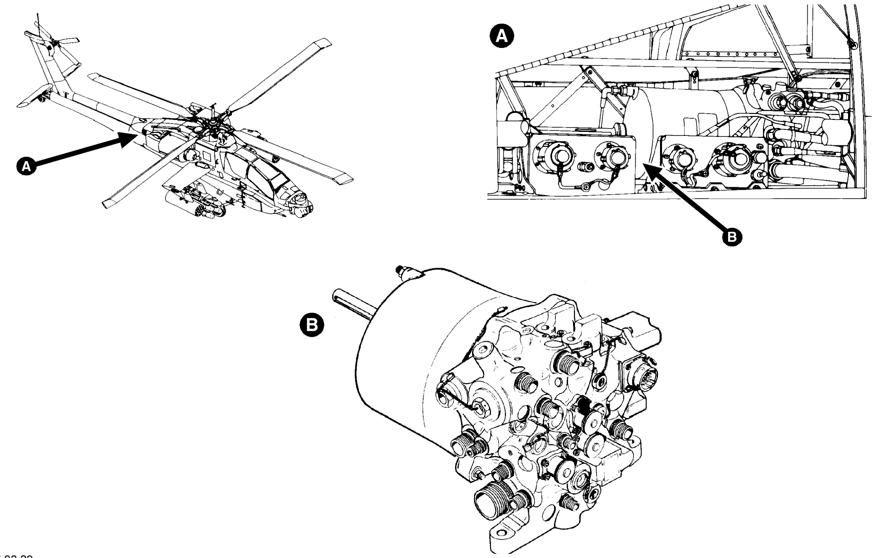
2. Utility hydraulic pump

   a. Pressurizes and transfers fluid for system operation.

   b. Located on the right, forward drive pad of the main transmission accessory geartrain housing.

   c. The utility hydraulic pump functions the same as and is interchangeable with the primary hydraulic pump.

UTILITY HYDRAULIC MANIFOLD



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1. Utility hydraulic manifold

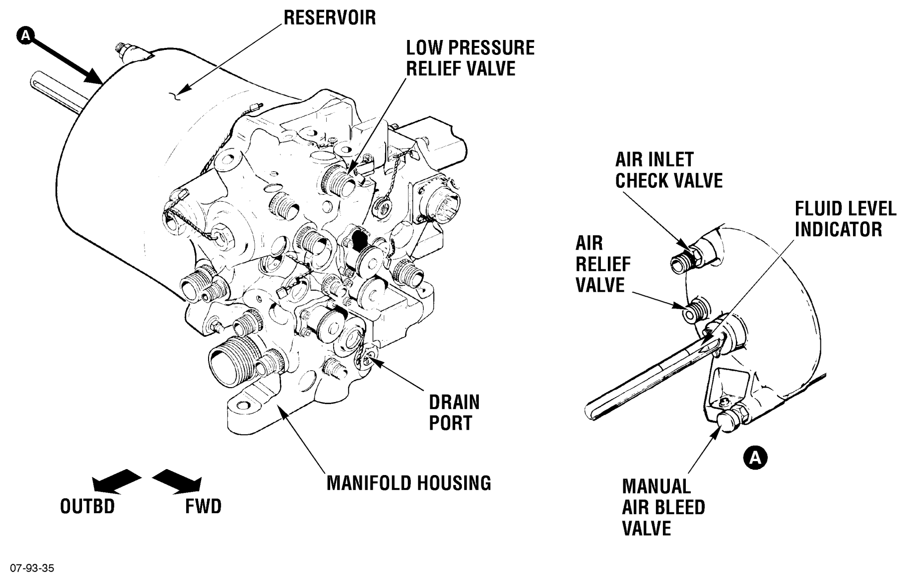
   a. Stores, filters, supplies, routes, and regulates hydraulic fluid for the utility hydraulic system. Operates in the same basic manner as the primary manifold.

   b. Located on the right side of the aft equipment bay deck, aft of the APU, and inboard of the GSE panels. Accessible through access panel R325.

   c. Made of an aluminum alloy with drilled passages for fluid routing. It measures approximately 23 inches long, 10.5 inches wide, and 8.7 inches high.

   d. Incorporates an air-pressurized reservoir to help prevent pump cavitation.

UTILITY HYDRAULIC MANIFOLD COMPONENTS



e. Utility hydraulic reservoir components

1) Utility hydraulic reservoir

a) Stores low-pressure hydraulic fluid for system use.

b) Mounted to the utility hydraulic manifold.

c) Reservoir fluid capacity is 1.3 gallons.

d) The fluid in the reservoir is pressurized to 30 psi by the PAS. The air pressure prevents fluid foaming and pump cavitation.

2) Piston assembly

a) Separates the air and hydraulic fluid inside the reservoir and aids in reservoir fluid pressurization.

b) Is two-piece, aluminum alloy assembly (linear actuator piston rod and piston body) that moves back and forth inside the reservoir depending on the amount of fluid present.

3) Fluid level indicator

a) Provides a visual indication of reservoir fluid level.

b) Color-coded green for normal operation and red for refill.

c) The fluid level reading is taken at the end of the reservoir piston rod.

4) Air inlet check valve

a) Maintains reservoir air pressure by permitting one-way flow of air into the reservoir.

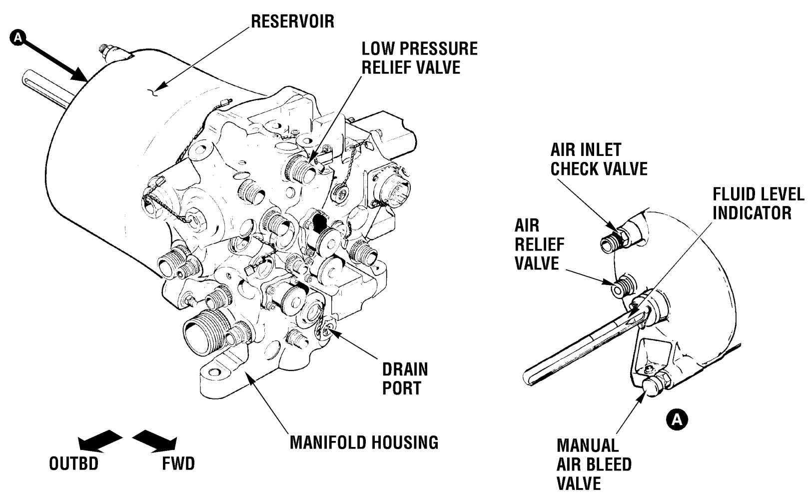
b) An in-line filter is installed into the PAS line and check valve to remove contaminants from the inlet pressurized air.

5) Manual air bleed valve

a) Provides a means of relieving reservoir air pressure for maintenance purposes.

b) Opens when the button is pushed.

UTILITY HYDRAULIC MANIFOLD COMPONENTS



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6) Air relief valve

a) Relieves excessive reservoir air pressure due to large volume displacement cycles.

b) Installed in the end of the reservoir housing next to the fluid fill indicator.

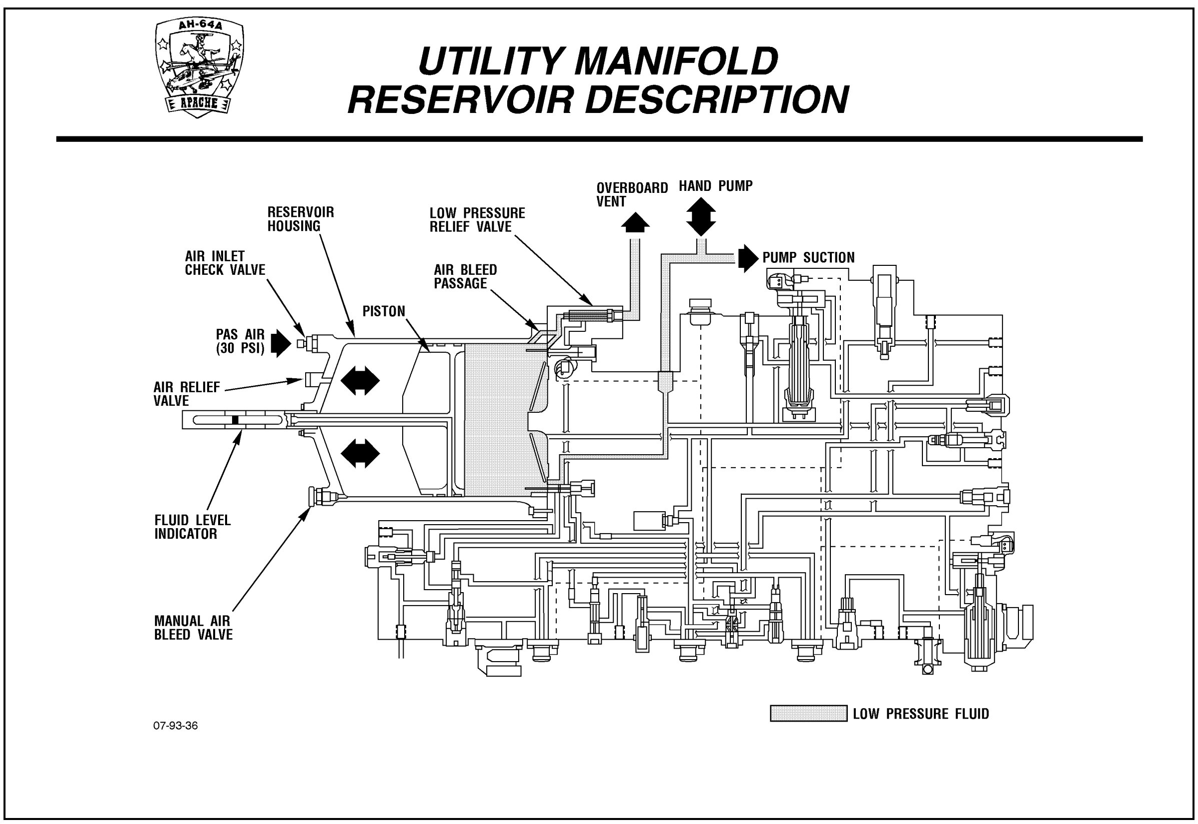
c) The valve cracks at 105 psi and reseats at 94 psi.

7) Low pressure relief valve

a) Relieves excess reservoir fluid pressure and provides the reservoir with self-bleeding capability. The relief flow dumps through the overflow port.

b) Cracks at 215 psi to dump fluid overboard and closes at 150 psi. Full flow is 12 gpm at 450 psi.

8) Drain port. Provides a means for draining hydraulic fluid from the manifold/reservoir to facilitate maintenance.



f. Normal utility manifold reservoir operation

1) Air pressure of 30 psi from the PAS enters the reservoir through a one-way air inlet check valve, and maintains air pressure behind the piston.

2) The reservoir air pressure side is protected from over-pressurization by an air relief valve that opens at 105 psi and closes at 94 psi.

3) Air on the fluid side of the reservoir is bled through an air bleed passage to the low- pressure relief valve.

4) The low-pressure relief valve protects the reservoir from high fluid pressures by dumping excess fluid pressure overboard.

5) During system fluid servicing:

a) Fluid enters the reservoir inlet, filling the chamber in front of the piston.

b) As fluid continues to enter the reservoir, the piston moves back.

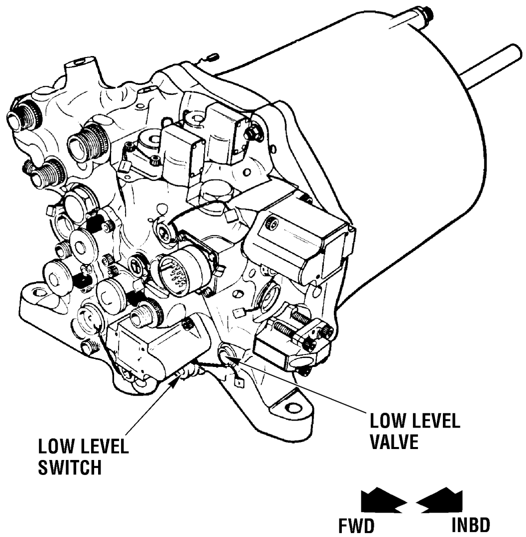
c) The air behind the piston is compressed and acts as a spring behind the piston.

d) The end of the reservoir piston rod is visible inside the fluid level indicator, providing an indication of reservoir fluid level.

e) A manual air bleed valve is used to manually relieve reservoir air pressure during system maintenance.

g. Utility hydraulic manifold components and descriptions

UTILITY HYDRAULIC MANIFOLD LOW LEVEL SWITCH AND VALVE



h. Low-level switch

a) Illuminates the OIL LOW UTIL HYD caution light on the pilot's C/W/A panel. This indicates utility hydraulic system fluid is at the minimum operating level.

b) Provides a 28 VDC signal to actuate the emergency hydraulic shut-off valve, shutting off fluid flow to the tail wheel unlock actuator and the utility side of the directional servoactuator.

c) Consists of a piston, spring, cap, and microswitch.

d) Mounted in the forward, lower portion of the manifold, the piston assembly extends from the manifold into the reservoir. As the fluid level decreases, the reservoir piston moves in the direction of the extended switch piston. When the reservoir piston contacts the switch's piston, it forces it to retract, causing the switch to close.

e) Operation of the utility system manifold's low-level switch is identical to the primary system manifold's low-level switch.

1) Low-level valve

a) The low-level valve provides on/off control of pilot pressure to open or close the auxiliary isolation valve.

b) Installed in the forward lower portion of the manifold and extends out into the reservoir.

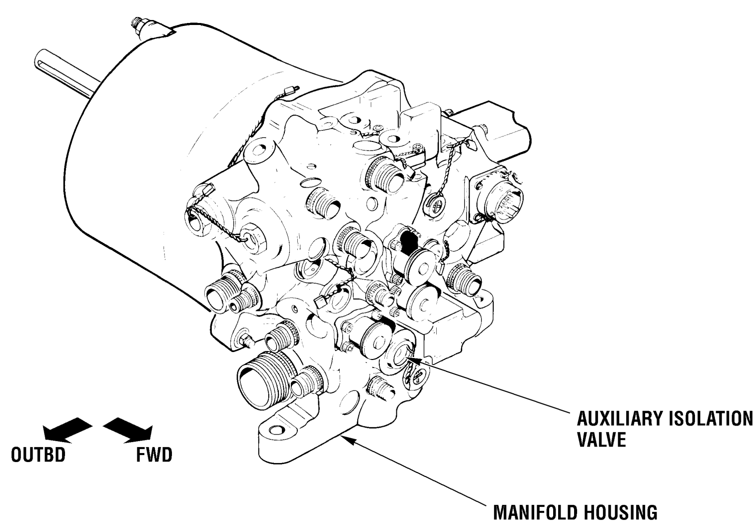
c) Consists of a piston, spring, and cap assembly.

d) The low-level valve, when moved by the reservoir piston, prevents system operating pressure (3000 psi) from being routed to the auxiliary isolation valve, allowing it to close and shut off pressurized fluid to the auxiliary components.

2) Auxiliary isolation valve

a) Located on the front/lower portion of the manifold housing.

AUXILIARY ISOLATION VALVE LOCATION



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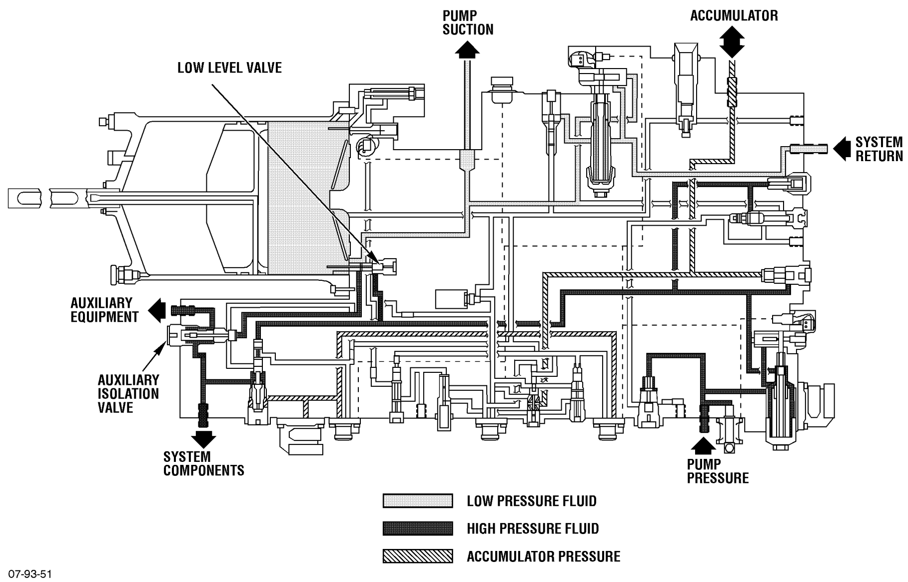
AUXILIARY ISOLATION VALVE OPERATION

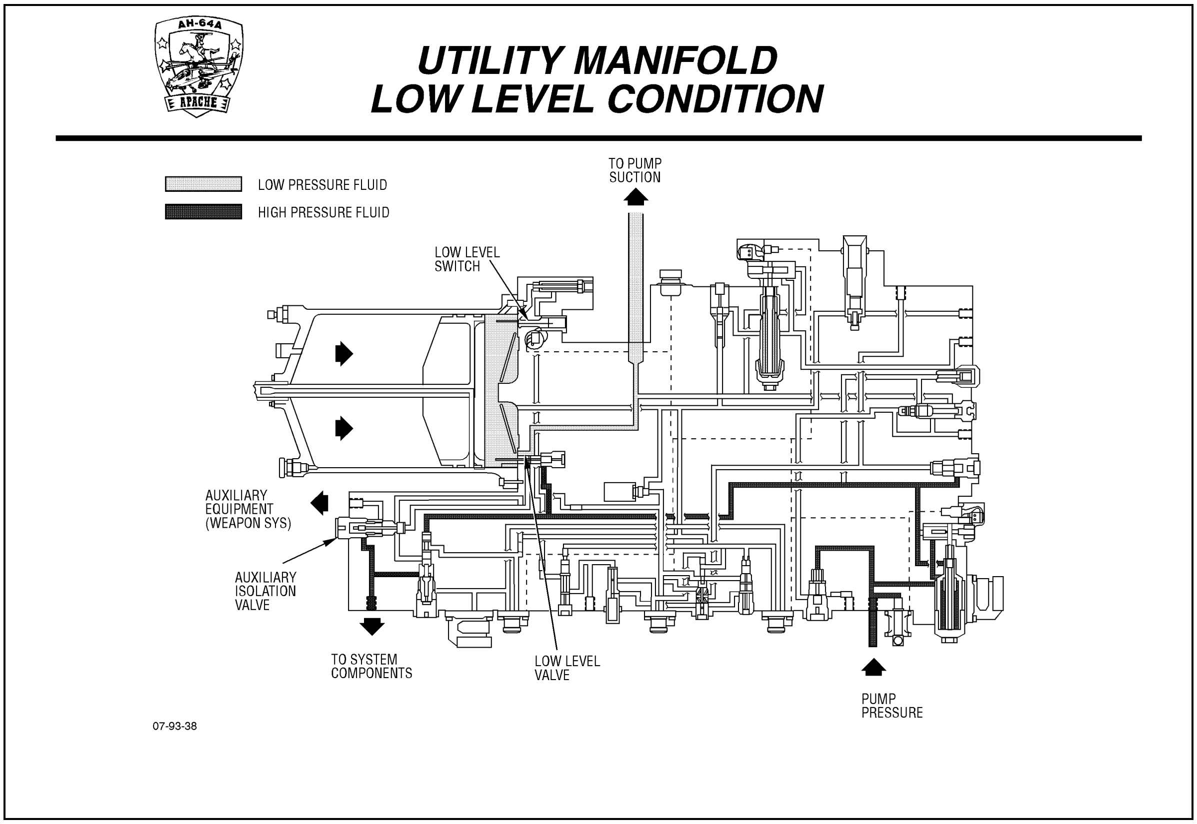


b) Consists of a check valve and a piston.

c) Automatically eliminates fluid pressure to auxiliary components (AWS elevation actuator, AWS azimuth drive motor, ammunition carrier drive motor, and pylon actuators) during an emergency (loss of system pump pressure) or low fluid level conditions in the reservoir.

d) During normal system operation, pump pressure routed through the open low-level valve becomes pilot pressure to open the auxiliary isolation valve and allow fluid to flow through to the using components.

e) During emergency hydraulic operations, or a low fluid level condition in the reservoir, the valve closes, preventing fluid flow to auxiliary components.



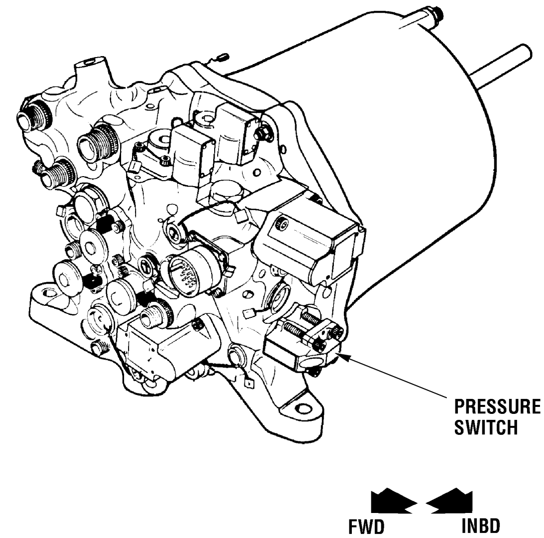
3) When a utility manifold low level condition occurs:

a) The low-level switch and low-level valve are operated by the reservoir piston when a low fluid level condition exists (approximately 7.0 fluid oz.).

b) When the reservoir piston contacts the low-level switch, the OIL LOW UTIL HYD caution light illuminates on the pilot's C/W/A panel. The low-level switch also provides a 28 VDC signal to the emergency hydraulic shut-off valve solenoid causing the valve to close. When closed, the valve prevents the flow of pressurized hydraulic fluid to the tail wheel lock control valve, tail wheel lock actuator, and the utility side of the directional servoactuator.

c) The low-level valve, when moved by the reservoir piston, prevents system operating pressure (3000 psi) from being routed to the auxiliary isolation valve, allowing it to close and shut off system fluid pressure to auxiliary components.

UTILITY MANIFOLD PRESSURE SWITCH



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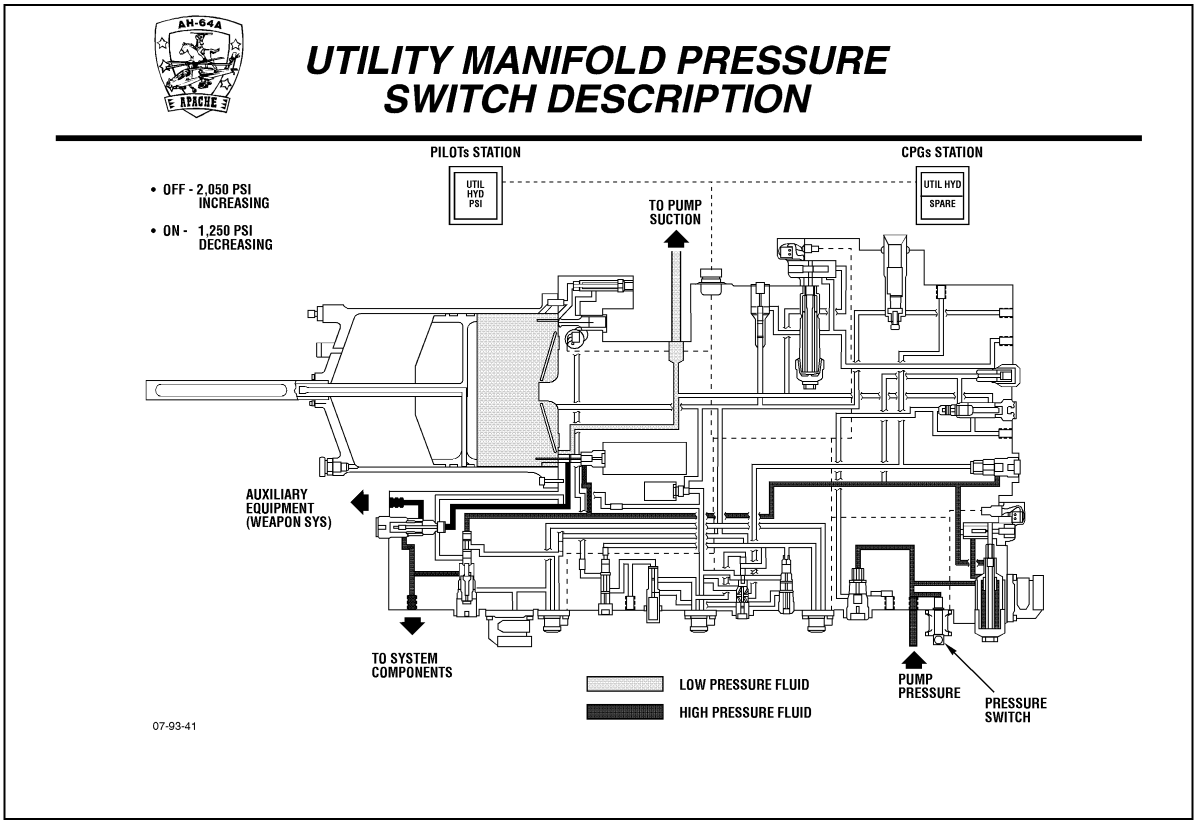
4) Utility manifold pressure switch

a) Located on the lower left side of the manifold housing.



b) Provides a signal to the crewstations' C/W/A panels, indicating low hydraulic system pressure. The switch provides an indication of hydraulic pump health.

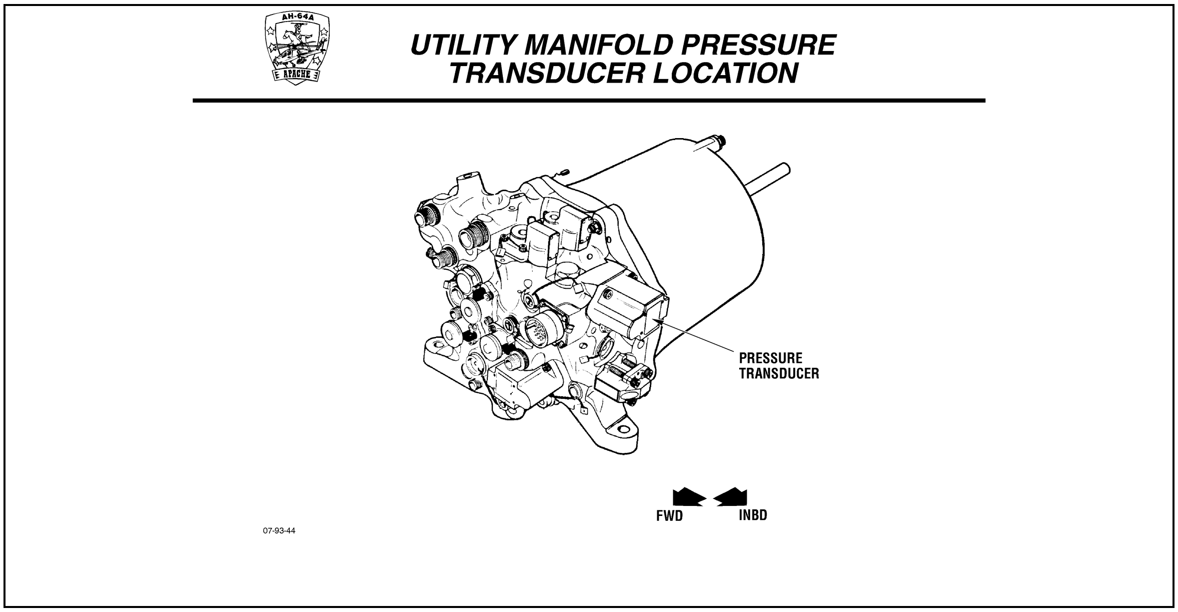
c) Is small, modular line replaceable unit (LRU) that contains a microswitch, spring, and piston assembly.

d) Electrical connector mates with an internally-wired electrical receptacle and a pressure sensing port in the manifold housing.

e) Opens at 2050 psi, increasing, extinguishing the pilot's UTIL HYD PSI caution light and the CPG's UTIL HYD caution light on the C/W/A panels.

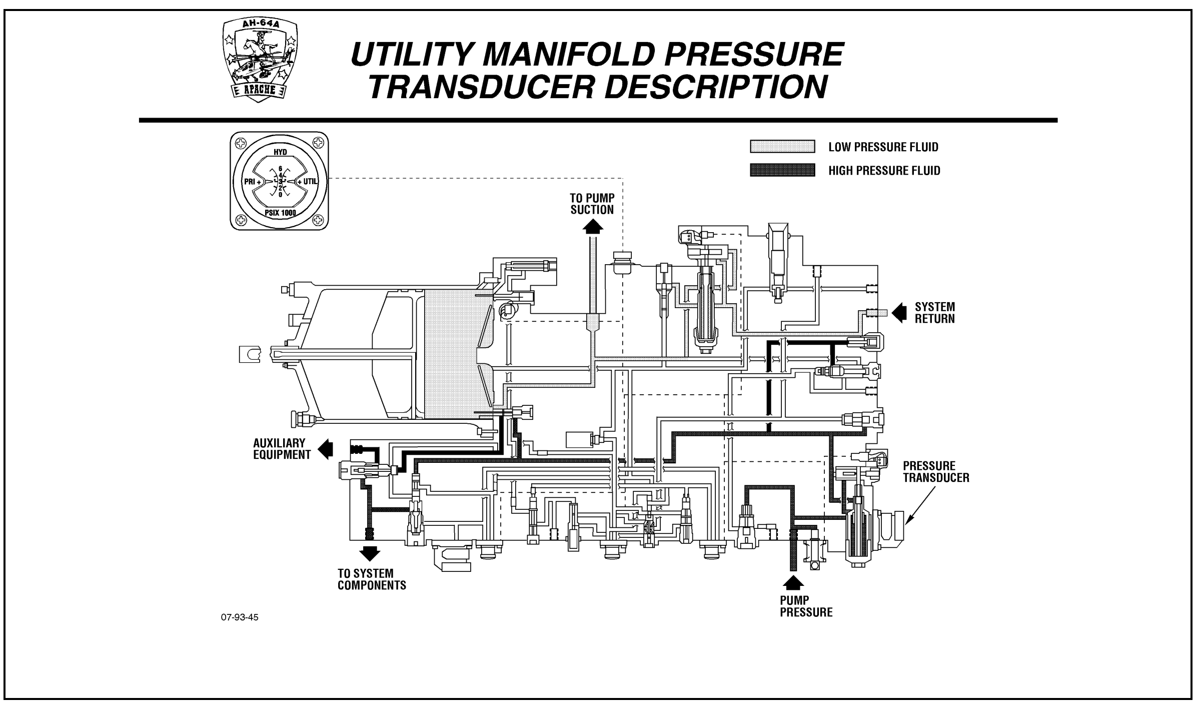
f) Closes at 1250 psi, decreasing, illuminating the pilot's UTIL HYD PSI caution light and the CPG's UTIL HYD caution light.

g) Operation of the utility system's manifold pressure switch is identical to the primary system's manifold pressure switch.



5) Pressure transducer

a) Located on the left side of the manifold housing.



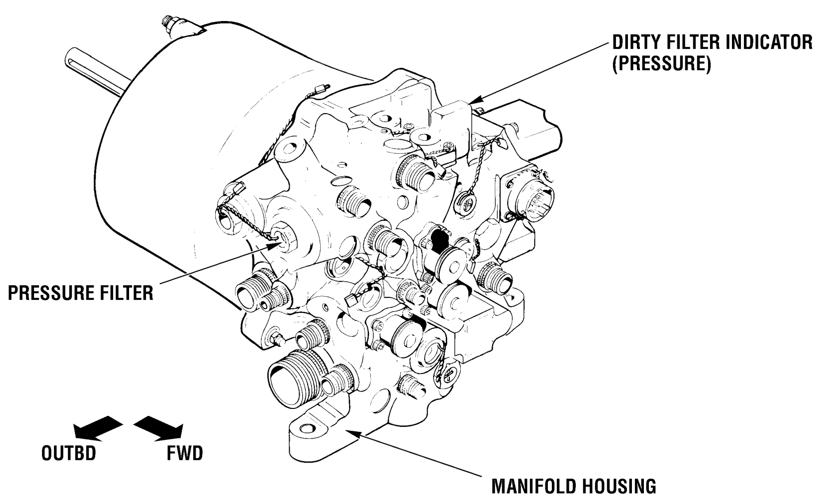
b) Modular type LRU with an electrical connector that mates with an internally-wired electrical receptacle and a pressure sensing port in the manifold housing.

c) Monitors fluid pressure available to the utility hydraulic system components and sends a signal to the utility side of the dual hydraulic pressure gauge.

d) Provides a DC voltage output proportional to inlet pressure (1.37 VDC per 1000 psi).

e) Operation of the utility system's manifold pressure transducer is identical to the primary system's manifold pressure transducer.

UTILITY MANIFOLD PRESSURE FILTER AND DIRTY FILTER INDICATOR



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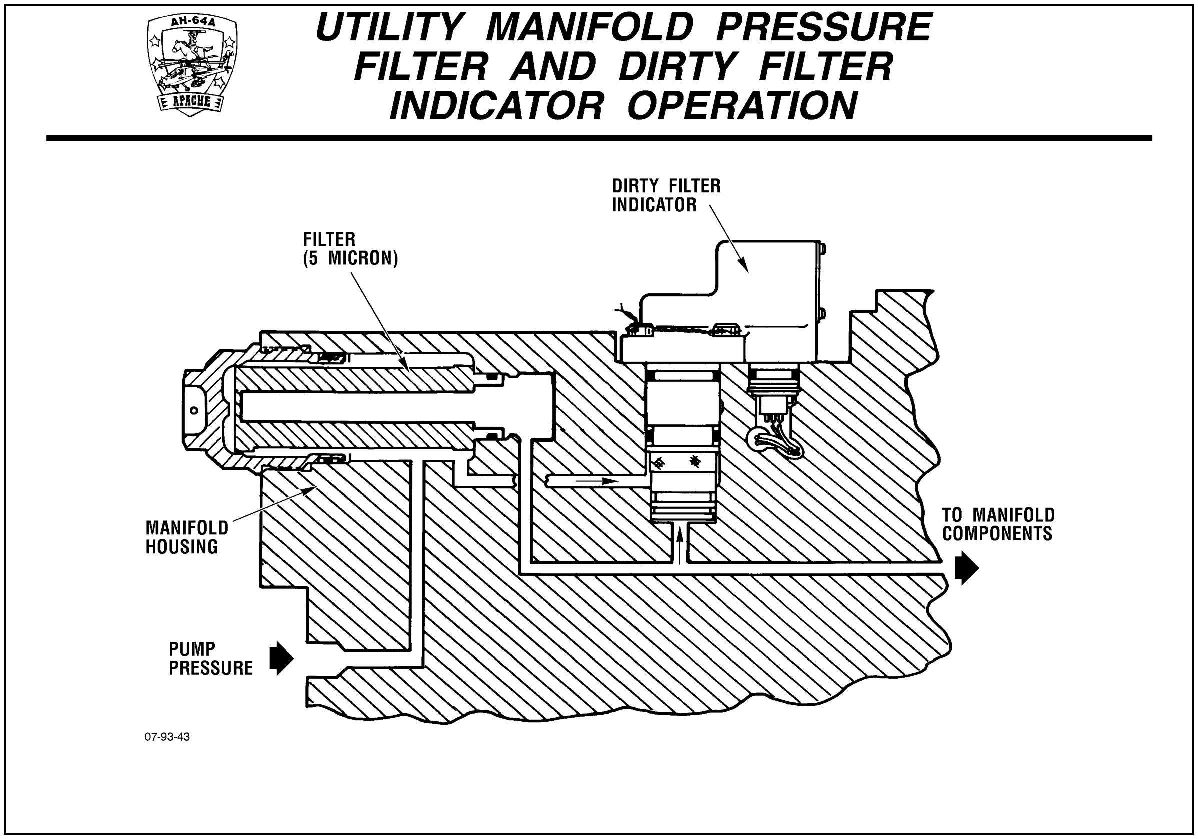
6) Pressure filter and pressure dirty filter indicator

a) The pressure filter is located on the upper right side of the manifold housing.

b) The dirty filter indicator is located on the upper right side of the manifold housing.



c) Pressure filter

(1) Removes particles larger than 15 microns from fluid entering the manifold with a replaceable 15-micron filter element.

(2) MWO 1-1520-238-50-30, dated 21 September 1992, improves the filtration efficiency by replacing the currently installed 15-micron filter with a 5-micron filter.

(3) The filter does not bypass. Unlike the return filter, the pressure filter does not have a filter bypass valve associated with it. If unfiltered fluid was allowed to enter the system it could possibly obstruct the small fluid ports within the servoactuator.

(4) Operation of the utility system's manifold pressure filter is identical to the primary system's manifold pressure filter.

d) Pressure dirty filter indicator

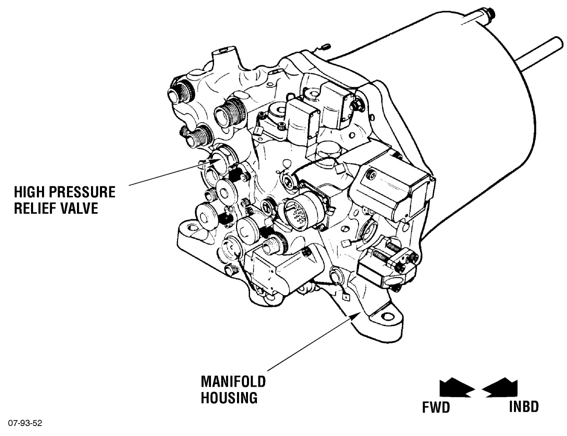
(1) Illuminates the OIL BYP UTIL HYD caution light on the pilot's C/W/A panel and provides a visual indication of filter clogging at the manifold.

(2) Incorporates an electrical switch and a small red pop-up visual indicator with a temperature lockout below + 85EF (+29EC).

(3) Senses differential pressure upstream and downstream of the filter. At temperatures above +115EF (+46EC), the pop-up visual indicator extends when the pressure differential exceeds 70 " 10 psid, closing the electrical switch, and illuminating the OIL BYP UTIL HYD caution light on the pilot's C/W/A panel.

(4) Operation of the utility system's manifold pressure dirty filter indicator is identical to the primary system's manifold pressure dirty filter indicator.

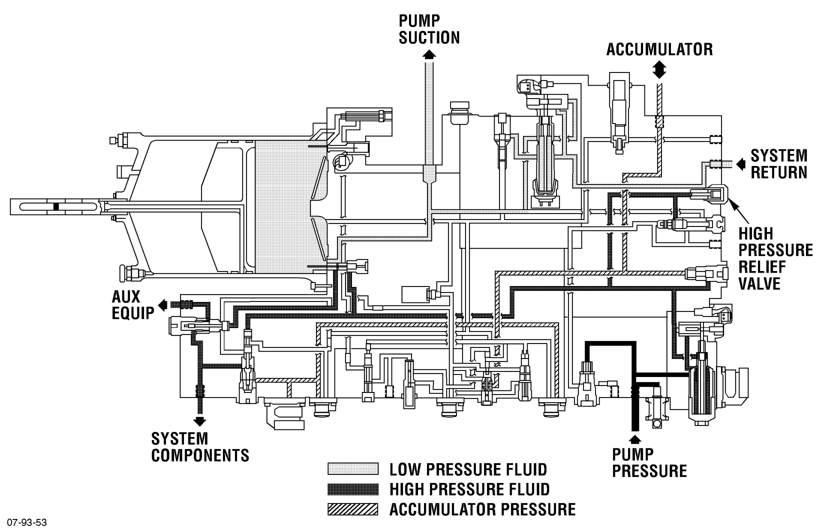
HIGH PRESSURE RELIEF VALVE LOCATION



7) High pressure relief valve

a) Located on the front of the housing on the right side.

HIGH PRESSURE RELIEF VALVE OPERATION



b) A piston and spring arrangement in a housing, calibrated to relieve excess pressure during system operation.

c) Relieves excess fluid pressure in the high pressure portion of the manifold by routing fluid to the return side of the manifold.

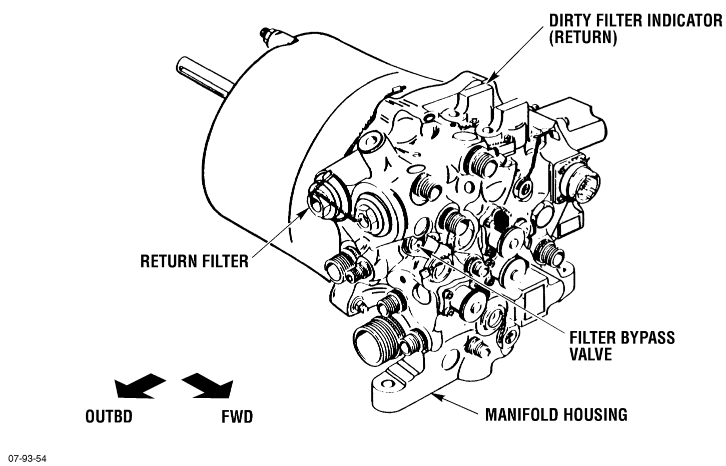
d) Senses pump output pressure within the manifold prior to routing it to system components and protects components, from high pressures by opening and closing at the following pressures:

(1) Cracking pressure - 3500 psi

(2) Full flow - 3650 psi, maximum.

(3) Reseat - 3300 psi, minimum.

RETURN FILTER, DIRTY FILTER INDICATOR AND FILTER BYPASS VALVE LOCATION



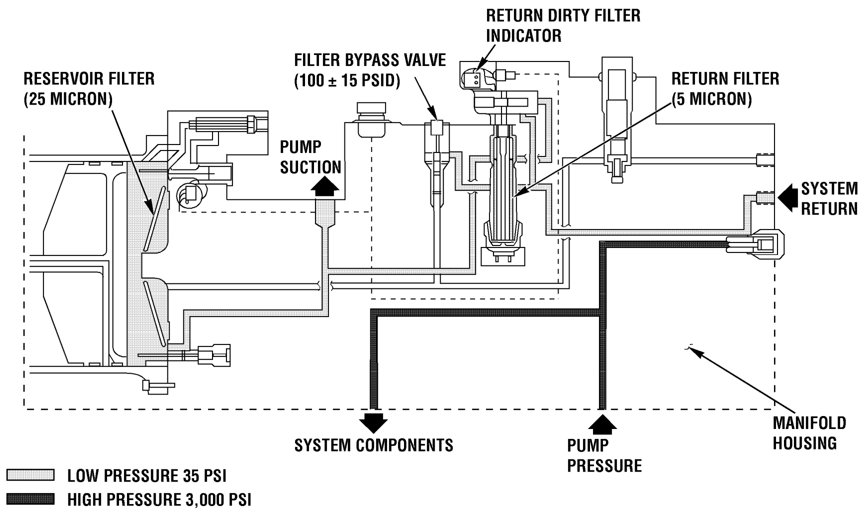
8) Return filter, return dirty filter indicator, and filter bypass valve

a) Return filter is located on the right side of the manifold housing.

b) The return dirty filter indicator is on top of the manifold housing.

c) The filter bypass valve is on the front of the manifold housing, right side.

RETURN FILTER, DIRTY FILTER INDICATOR AND FILTER BYPASS VALVE OPERATION



07-93-55

d) Return filter

(1) Removes particles larger than 15 microns from the fluid returning from the system components with a replaceable 15-micron filter element.

(2) MWO 1-1520-238-50-30, dated 21 September 1992, improves the filtration efficiency of the utility manifold by replacing the 15-micron filter with a 5-micron filter.

(3) Operation of the utility system's manifold return filter is identical to the primary system's manifold return filter.

e) Return dirty filter indicator

(1) Illuminates the OIL BYP UTIL HYD caution light on the pilot's C/W/A panel and provides a pop-up visual indication of filter clogging at the manifold.

(2) Incorporates an electrical switch and a red pop-up visual indicator with a temperature lockout below +85EF.

(3) The indicator senses pressure upstream and downstream of the filter. At fluid temperatures above +115EF and a fluid differential pressure of 70 " 10 psid, the pop-up visual indicator extends, closing the electrical switch and illuminating the OIL BYP UTIL HYD caution light on the pilot's C/W/A panel.

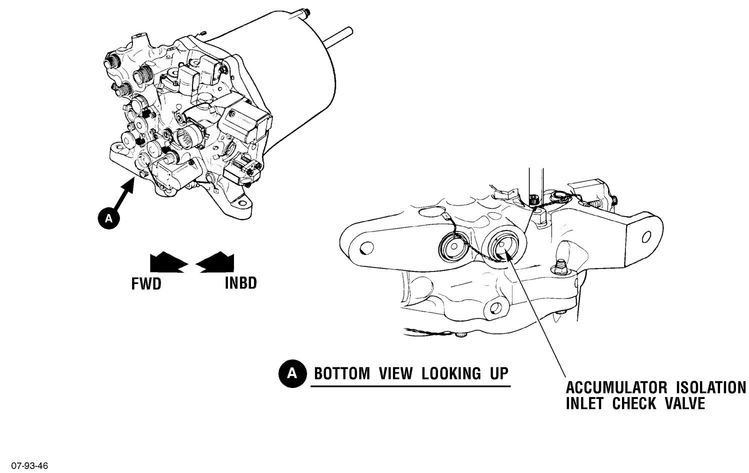
(4) Operation of the utility system's manifold return dirty filter indicator is identical to the primary system's manifold return dirty filter indicator.

f) Filter bypass valve

(1) Allows returning fluid to bypass the return filter when the filter is clogged.

(2) Opens at 100 " 15 psid.

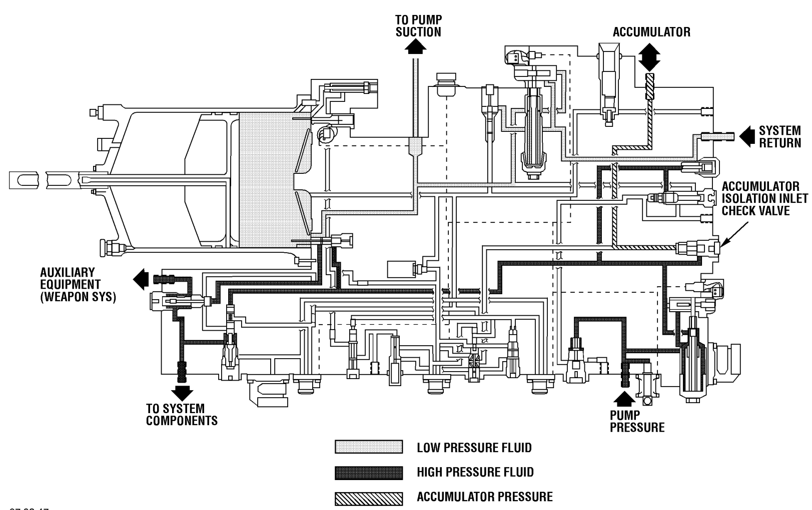
ACCUMULATOR ISOLATION INLET CHECK VALVE LOCATION



10) Accumulator isolation inlet check valve

a) Located on the bottom of the manifold housing.

ACCUMULATOR ISOLATION INLET CHECK VALVE DESCRIPTION

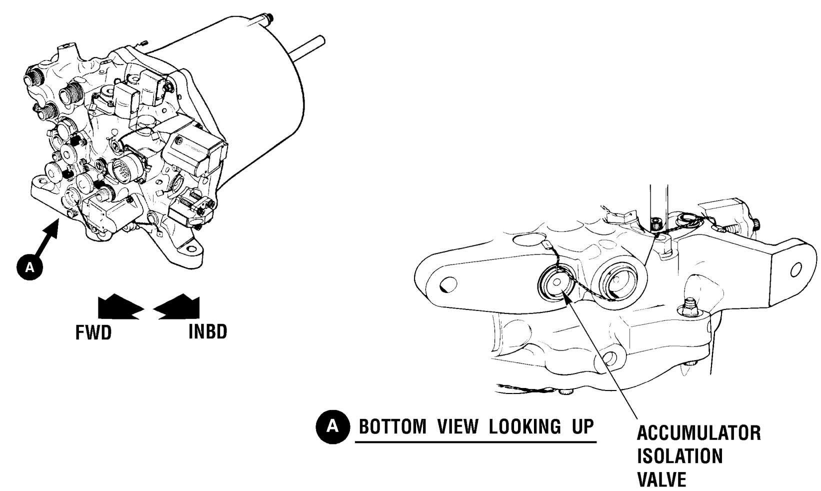


g) Allows the utility system pump pressure to repressurize the accumulator after an APU start.

h) A one-way check valve prevents accumulator pressure from entering the system when the pump is not operating.

i) Pump pressure unseats the check valve, allowing the accumulator to be pressurized to 3000 psi.

ACCUMULATOR ISOLATION VALVE LOCATION



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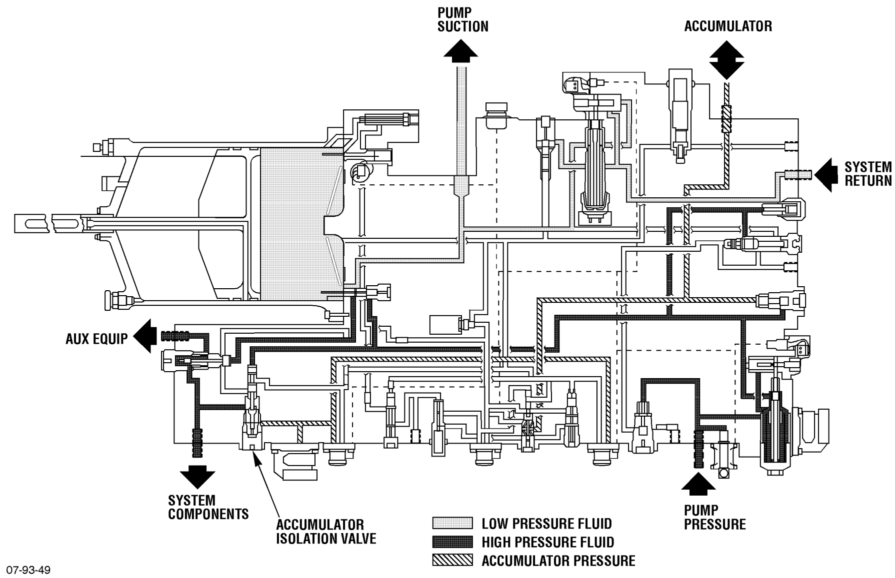
9) Accumulator isolation valve

a) Located on the bottom of the manifold housing.

ACCUMULATOR ISOLATION VALVE OPERATION



b) Allows pump pressure to flow to the servoactuators and auxiliary equipment.

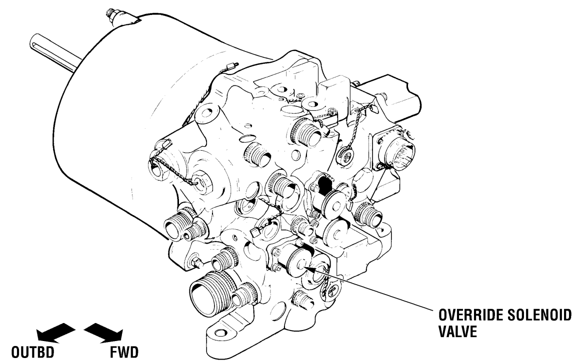
c) Consists of a check valve and a series of pistons.

d) Pump pressure acts on the valve to unseat the pistons, allowing fluid to pass through to the system components and the auxiliary isolation valve.

e) After shutdown of the aircraft or loss of pump pressure, the accumulator isolation valve maintains isolation of accumulator fluid from the rest of the system.

f) When the pilot's or CPG's EMERG HYD switch is moved from OFF to the EMERG HYD or ON positions, pressurized hydraulic fluid from the accumulator is allowed to pass through the accumulator isolation valve to the flight control servoactuators.

OVERRIDE SOLENOID VALVE LOCATION



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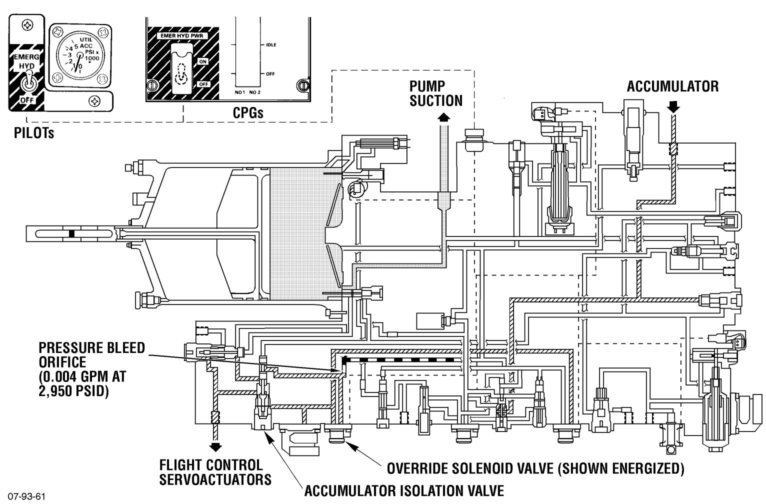
10) Override solenoid valve

a) Located on the front of the manifold housing, at the bottom.

OVERRIDE SOLENOID VALVE OPERATION (EMERGENCY HYD)



07-93-61

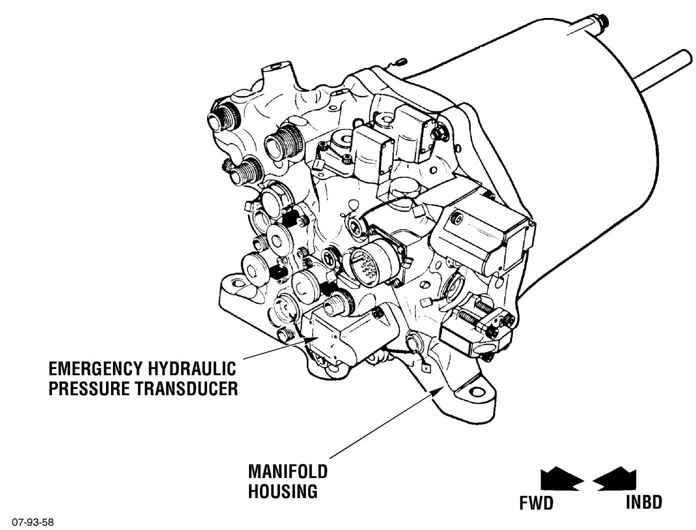
b) Allows accumulator pressure to enter the system for emergency flight controls operation.

c) A modular-type, normally closed valve, with an electrical connector that mates with the manifold internally-wired electrical receptacle.

d) During normal operation, accumulator pressure is held by the de-energized solenoid valve. When the pilot or CPG's EMERG HYD switch is moved from OFF to the EMERG HYD or ON positions, accumulator pressure is allowed to pass through the solenoid and actuate the accumulator isolation valve. This allows accumulator fluid to pass through the accumulator isolation valve to the flight control servoactuators.

e) A pressure bleed orifice restricts internal accumulator fluid flow to the return side of the system to 0.004 gpm at 2950 psid. This allows the pilot pressure that holds the accumulator isolation valve in position to bleed off.

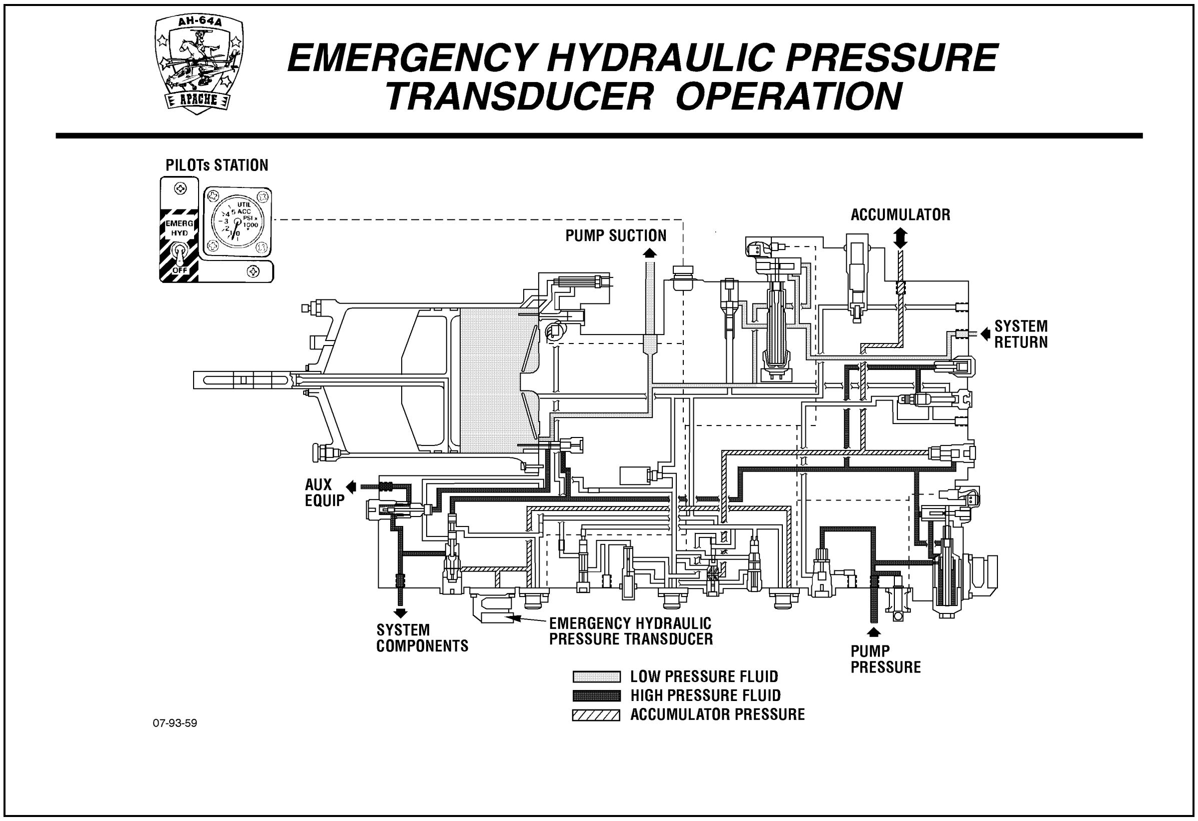
EMERGENCY HYDRAULIC PRESSURE TRANSDUCER LOCATION



11) Emergency hydraulic pressure transducer

a) Located on the front of the manifold housing, at the bottom.

b) Senses accumulator fluid pressure and sends a signal to the

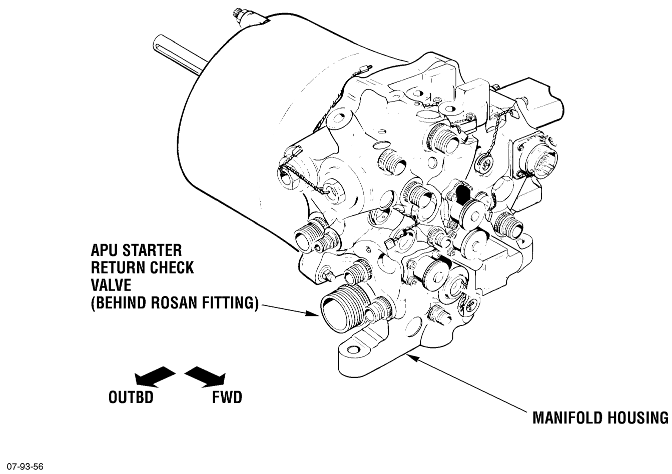


UTIL ACC hydraulic pressure gauge in the pilot's crewstation.

c) A modular type transducer that mates with the manifold internally-wired electrical receptacle and a pressure-sensing port in the manifold housing. It is interchangeable with the manifold pressure transducer.

d) During normal operation, accumulator fluid pressure is sensed by the transducer at the manifold. The transducer converts sensed pressure into electrical voltage (1.37 VDC per 1000 psi). Voltage output is transmitted to the UTIL ACC hydraulic pressure gauge on the pilot's instrument panel.

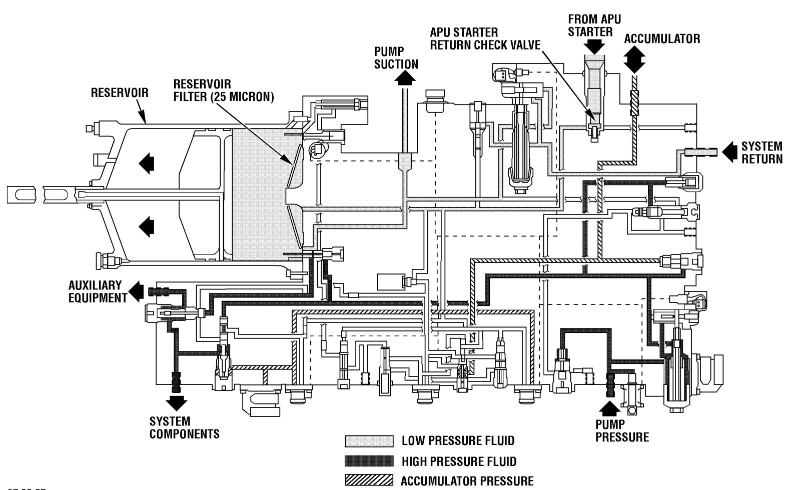
APU STARTER RETURN CHECK VALVE LOCATION



12) APU starter return check valve

a) Located inside the manifold fitting, on the right side of the manifold housing.

APU STARTER RETURN CHECK VALVE OPERATION

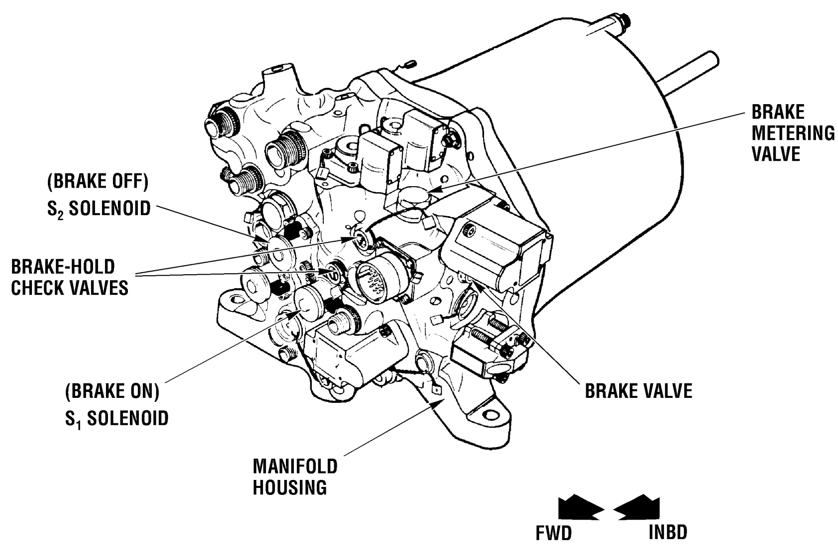


b) Allows fluid to enter the manifold from the APU starter and prevents reverse flow.

c) A one-way check valve that allows fluid to enter the manifold. Fluid entering the manifold from the APU starter flows through the check valve to the manifold reservoir.

d) Fluid entering the manifold reservoir passes through a 25-micron filter disc prior to being used again (the reservoir 25-micron filter also removes contaminants from return fluid that has been bypassed around the return filter).

UTILITY MANIFOLD ROTOR BRAKE COMPONENTS



07-93-62

13) Utility manifold rotor brake components

a) Provides the capability of controlling and directing fluid to the transmission accessory gearbox-mounted rotor brake.

b) Two brake hold check valves and S1 (brake on) and S2 (brake off) solenoids are located on the forward part of the manifold housing. A brake metering valve is located on top of the manifold housing. A brake valve is located on the inboard side of the manifold housing below the pressure transducer.

(1) The two check valves, metering valve, and brake valve contain a series of pistons, sleeves, and springs that control fluid routing when pressures are applied to different areas of the valves.

(2) The S1 and S2 solenoids are 28 VDC electrically operated valves that control fluid pressure for rotor brake operation.

c) A pressure switch is in-line between the manifold and rotor brake. The pressure switch is closed by fluid pressure to complete an electrical circuit to the pilot's C/W/A panel RTR BRK caution light.

d) Brake off operation

(1) A 28 VDC signal from the pilot's rotor brake control switch energizes the brake off S2 solenoid valve.

(2) Hydraulic pressure in the rotor brake circuit is bled to the reservoir through the brake off solenoid valve.

e) Brake operation

(1) When the pilot's rotor brake control switch is set to the BRAKE position, the 28 VDC signal to the brake off S2 solenoid valve is dropped, causing it to assume its normally closed position.

(2) Simultaneously, the pilot's control switch sends a 28 VDC signal to the (brake on) S1 solenoid valve, causing it to open. This allows accumulator pressure to open the brake valve and two brake hold check valves.

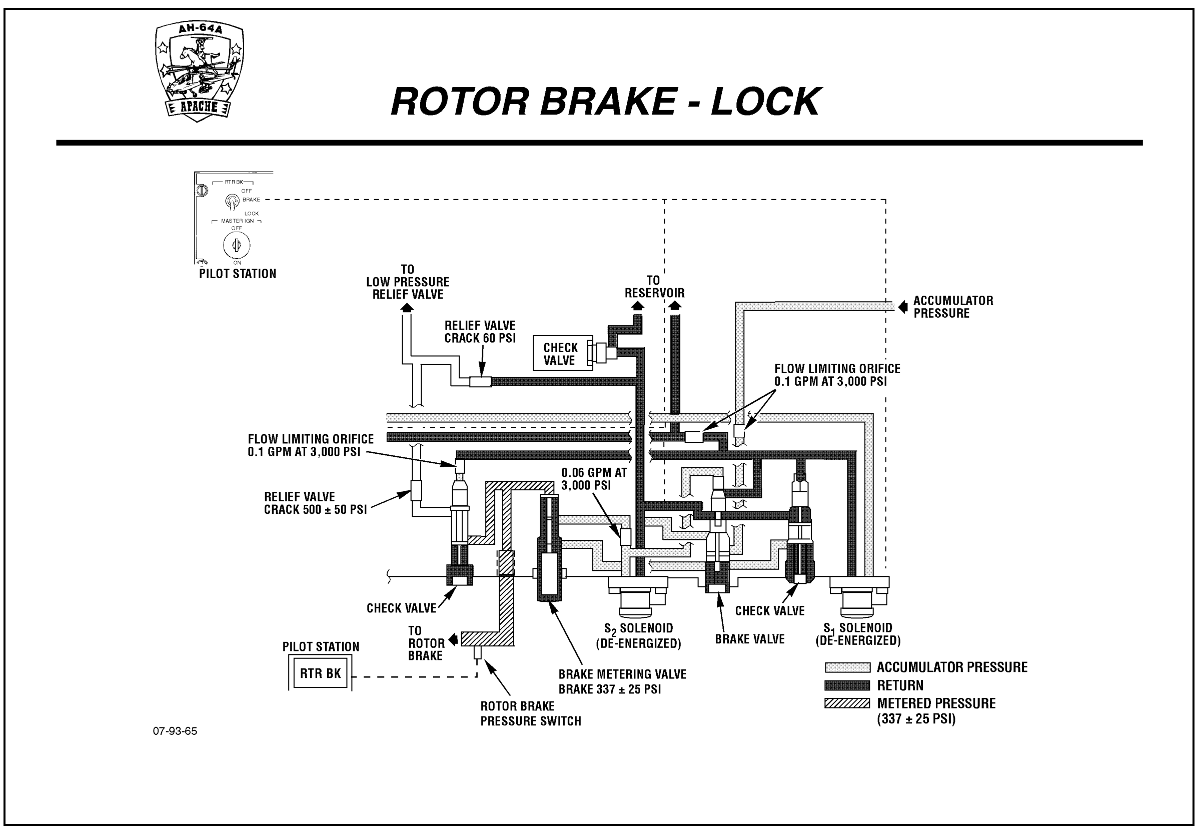
(3) Accumulator fluid flow through the brake valve is restricted to 0.1 gpm by a flow-limiting orifice. Fluid is routed through the brake metering valve reducing its pressure to 337 " 25 psi. It then enters the rotor brake actuator and slows down the rotation of the main rotor.

(4) The RTR BRK caution light on the pilot's panel is

illuminated by an in-line pressure switch. Pressure surges in the circuit are relieved by the rotor brake pressure relief valve, which opens at 500 " 50 psi to relieve excess pressure, and a relief valve that opens at 60 psi to route fluid back to the reservoir.

(5) A flow-limiting orifice allows accumulator pressure to bleed down when the rotor brake is left in the brake position, after the helicopter is shut down.

(6) Accumulator pressure is also routed through a 0.06 gpm flow-limiting orifice and back to the brake valve. This causes a self-sustaining opening pressure.



f) Lock operation

(1) When moving the pilot's rotor brake control switch to the LOCK position, the pilot should pause in the BRAKE position to allow the S2 (brake off) solenoid to de-energize. This allows pilot pressure to the brake valve to bleed off.

(2) The pilot's rotor brake control switch is set to the LOCK position and drops the 28 VDC signal to the brake on S1 solenoid valve, allowing it to resume its normally closed position.

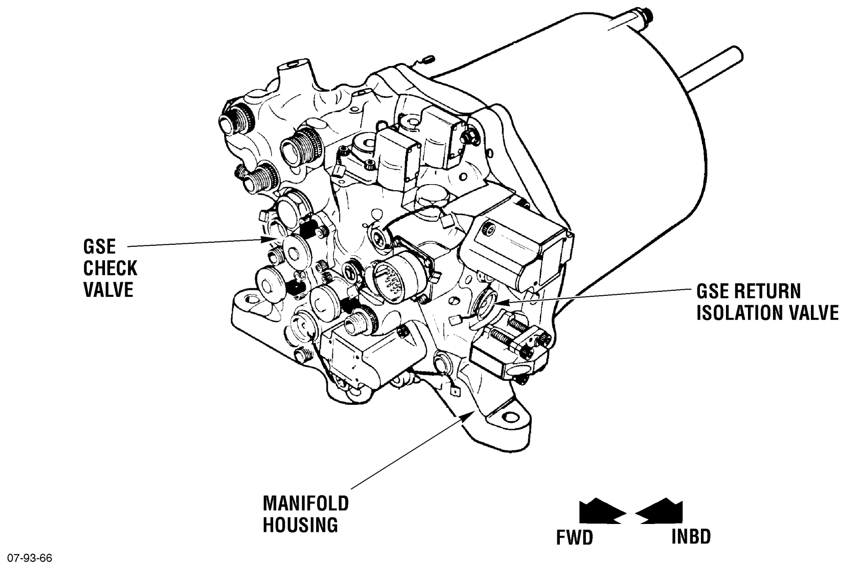
(3) Pressure to the two brake hold check valves is bled back to the reservoir through a 0.1 gpm flow-limiting orifice, allowing the two check valves to close.

(4) Closing the two check valves eliminates the pressure reducing capability of the brake metering valve from the braking circuit. This allows full accumulator pressure (about 3000 psi) to flow through the brake and metering valves to the rotor brake actuator.

(5) When the pilot's rotor brake control switch is again set to OFF, the brake off S2 solenoid valve is energized open. This allows the brake pressure to return to the reservoir, and extinguishes the RTR BRK light.

(6) The pilot pressure holding the brake valve open also returns to the reservoir, allowing the brake valve to close.

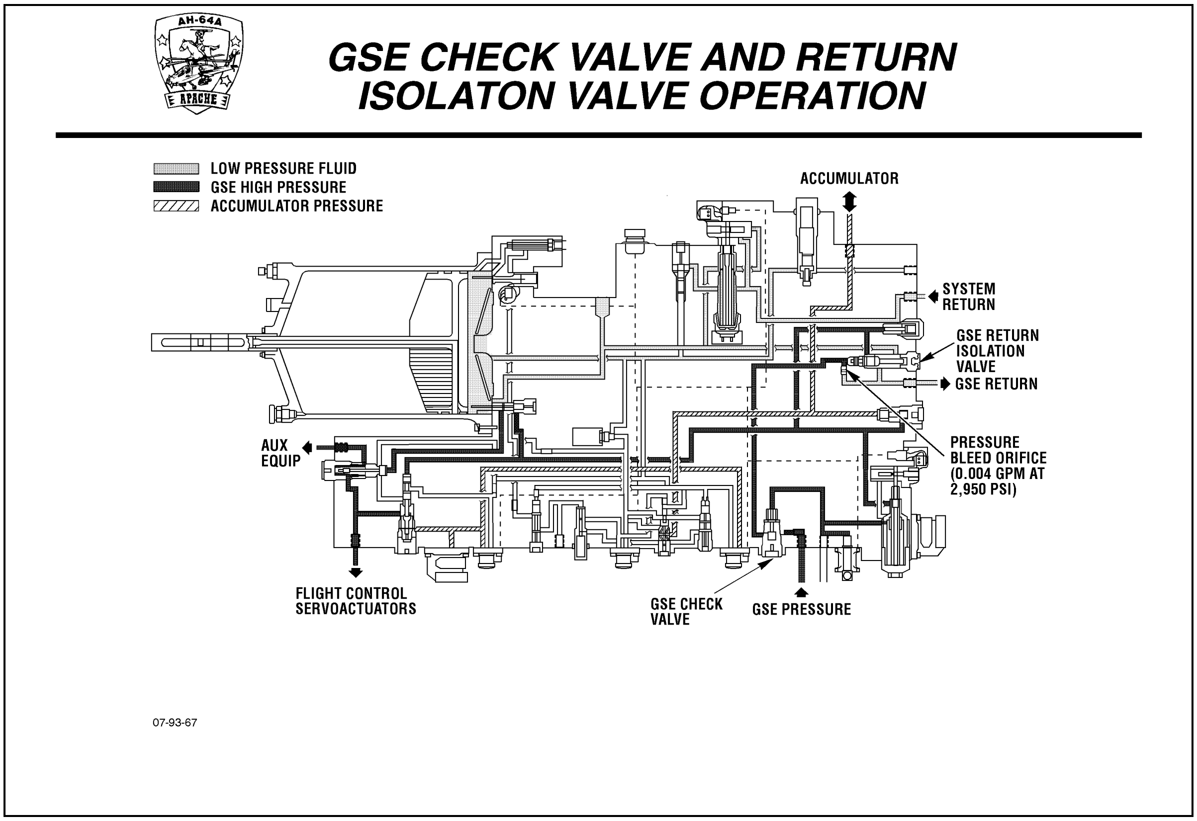
GSE CHECK VALVE AND RETURN ISOLATION VALVE LOCATION



14) GSE check valve and GSE return isolation valve

a) The GSE check valve is located on the front of the manifold housing, right side.

b) The GSE return isolation valve is located on the left side of the manifold housing.



c) GSE check valve

(1) Isolates the GSE circuit during normal system operation.

(2) Held closed by normal hydraulic system pressure entering the manifold and opens when GSE hydraulic pressure enters the manifold.

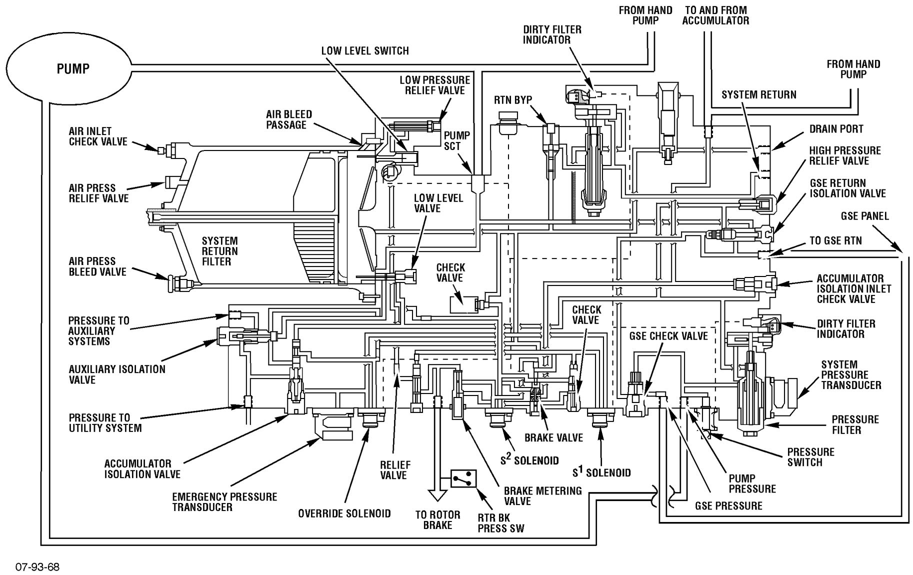
d) GSE return isolation valve

(1) Isolates the GSE return port during normal system operation.

(2) Held closed by normal hydraulic system pressure and opens when GSE pressure enters the manifold.

e) The GSE check valve and return isolation valve prevent pressurization of the GSE pressure and return lines during normal system operation (engines/APU running).

UTILITY HYDRAULIC MANIFOLD OPERATION



i. Utility hydraulic manifold operation

1) Pressurized air (30 psi) from the PAS manifold enters the reservoir through the air inlet check valve.

2) The pressurized air acts on the reservoir piston, creating low pressure hydraulic fluid and helps prevent pump cavitation.

3) For normal operation, a fluid level indication between 92 cubic inches down to 40 cubic inches (1.3 to 0.57 gallons) is satisfactory.

4) Excessive pressure on return fluid, and any trapped air, is routed out the air bleed passage and dumped overboard through the low-pressure relief valve. This relief valve starts to crack at 215 psi and reseats at 150 psi.

5) An air pressure relief valve at the end of the reservoir housing relieves excessive reservoir air pressure.

6) Low pressure hydraulic fluid is supplied to the hydraulic pump through the pump's suction port. The pump pressurizes the fluid to 3000 psi and returns it to the manifold.

7) Pressurized fluid in the manifold is used to lock the GSE check valve closed. This valve opens when an AGPU is connected to the system.

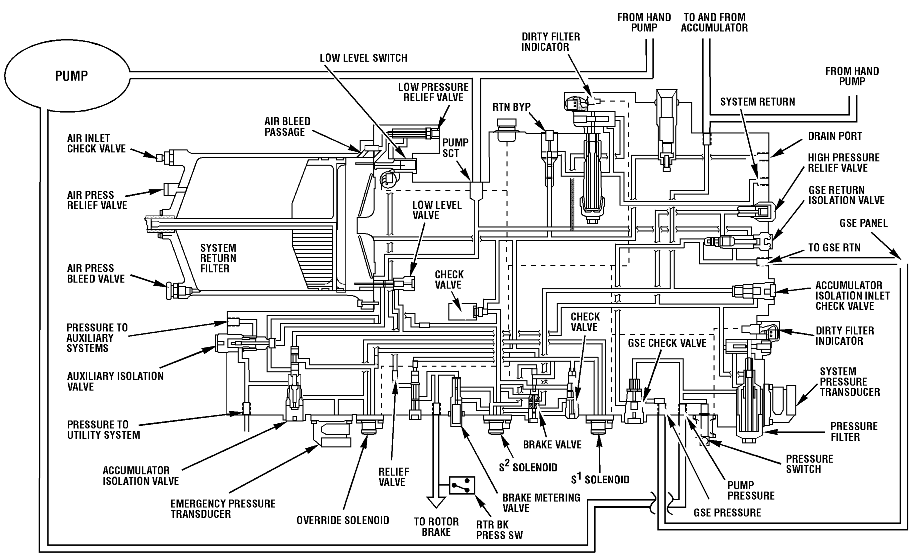
8) The input fluid is routed past a pressure switch that illuminates the UTIL HYD PSI caution light on the pilot's C/W/A panel and the UTIL HYD caution light on the CPG's C/W/A panel until 2050 psi, increasing, pressure is sensed, at which time the caution lights go out. They do not illuminate again until the switch senses 1250 psi, decreasing, pressure.

9) Fluid is filtered before being sent through the manifold. If a pressure differential of 70 " 10 psid is sensed, a dirty filter indicator pops up and causes the OIL BYP UTIL HYD caution light on the pilot's C/W/A panel to illuminate. The pop-up button can be reset without removing the filter bowl.

10) After being filtered, fluid is routed to:

a) The accumulator isolation inlet check valve. Pressure opens the valve. When closed, this is one of the two valves that retain pressure in the accumulator.

UTILITY HYDRAULIC MANIFOLD OPERATION



07-93-68

b) System pressure is sensed by the system pressure transducer and transmitted to the utility side of the pilot's dual hydraulic pressure gage.

c) The high pressure relief valve starts to crack at 3500 psi, with full relief flow at 3650 psi. It reseats at 3300 psi. This valve prevents excessive pressure in the system.

d) Low-level valve. Pressure enters the valve and is routed to the auxiliary isolation check valve to open the isolation valve. With a low fluid level sensed (7.0 fluid ounces), the low-level valve is closed by the reservoir piston, stopping pilot pressure flow to the auxiliary isolation check valve. The isolation check valve closes, stopping fluid flow to the auxiliary functions (AWS elevation actuator, AWS azimuth drive motor, ammunition carrier drive motor, and pylon actuators). The low-level switch also closes, sending a signal to the emergency hydraulic shut-off valve. When a low-level fluid condition is sensed:

(1) The pilot's OIL LOW UTIL HYD caution light illuminates.

(2) The emergency hydraulic shut-off valve on the tail boom closes.

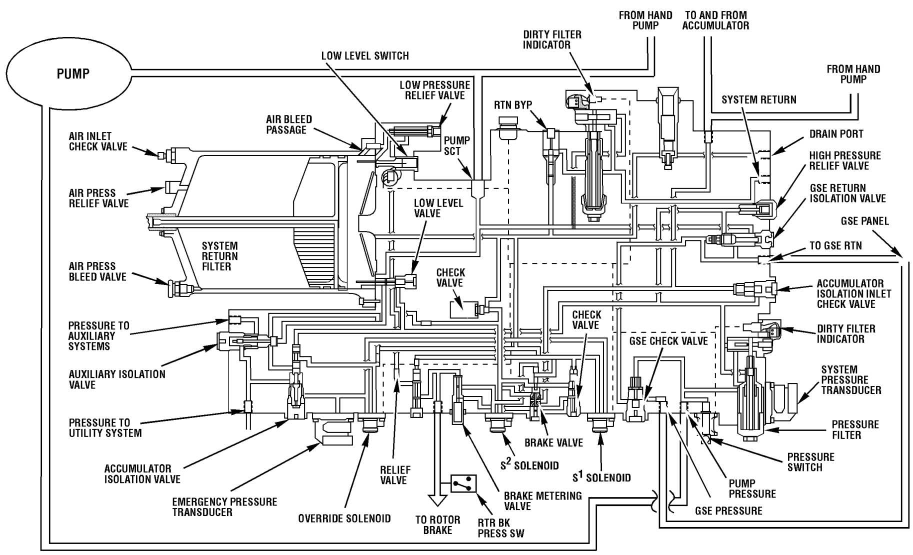
e) Accumulator isolation valve. This is the second valve that isolates accumulator pressure in the accumulator and manifold. Pressure opens the valve.

11) After going through the accumulator isolation inlet check valve, fluid pressure is routed to:

a) The accumulator, where fluid is replenished after an APU start and pressurized to 3000 psi.

b) The rotor brake S1 solenoid. This solenoid is energized open when the pilot's RTR BRK switch is in the BRAKE position, permitting 3000 psi fluid into the brake circuit. This switching causes the solenoid S2 to de-energize (closed). Metering of the fluid by the brake metering valve permits 337 " 25 psi pressure to be routed to the rotor brake actuator. A pressure switch in this line actuates a throttle interlock solenoid, preventing the power levers from being advanced past the IDLE position, and sends a signal to illuminate the pilot's RTR BRK caution light.

UTILITY HYDRAULIC MANIFOLD OPERATION



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c) The override solenoid is opened by the pilot's instrument panel EMER HYD and the CPG's EMER HYD PWR switches. When energized open, the solenoid routes accumulator pressure to open the accumulator isolation valve, permitting use of emergency power to the utility side of the flight control servoactuators.

d) The EMER HYD or EMER HYD PWR switches are used to energize the override solenoid to deplete emergency hydraulic (accumulator) pressure before starting maintenance on the utility system. The only exception is when removing and replacing manifold or servoactuator filters.

e) The emergency pressure transducer uses 28 VDC, converting it to a 1.37 VDC per 1000 psi output, to actuate the pilot's instrument panel UTIL ACC pressure gauge.

12) Pressurized fluid from the pump goes through the accumulator isolation valve before going to the flight controls and through the auxiliary isolation valve before being routed to the auxiliary functions.

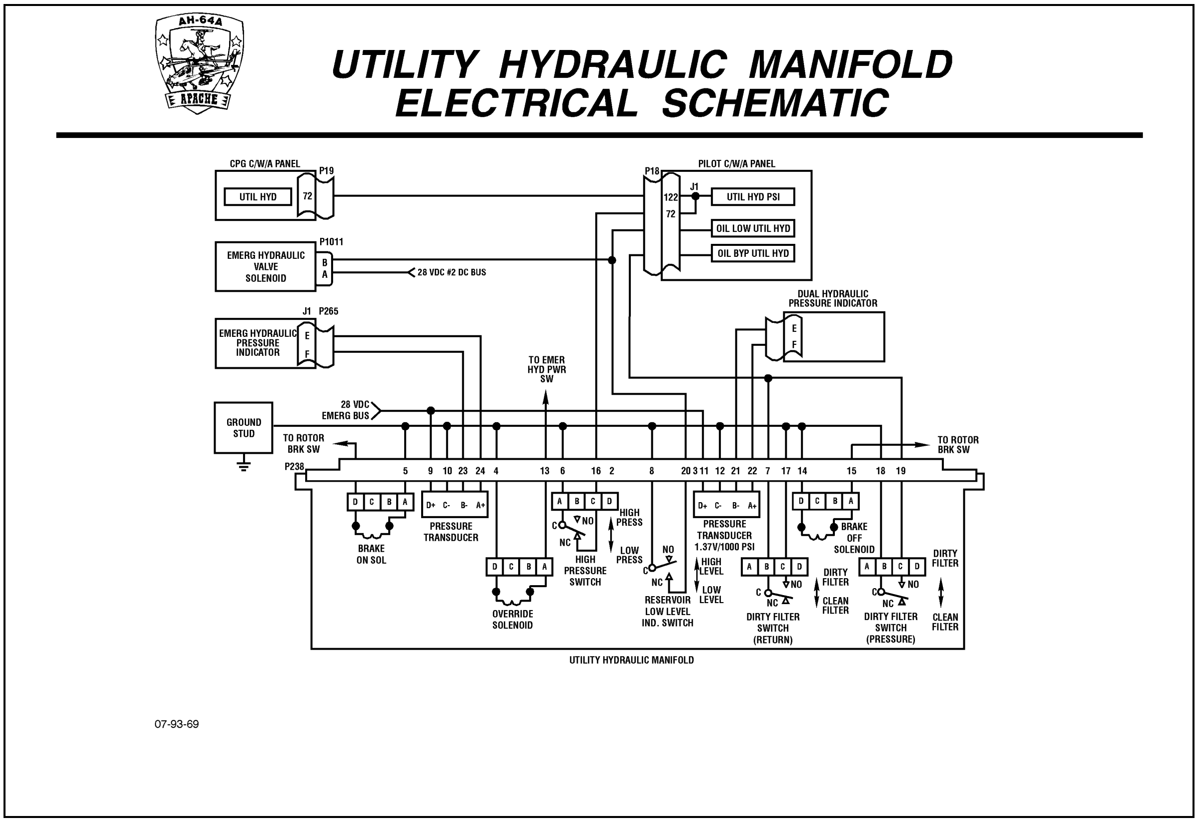
13) Fluid returning to the manifold from the components and heat exchanger (if installed) is filtered before being sent back to the pump. If the filter senses a 70 " 10 psid condition across the filter, a dirty filter indicator pops up and actuates a microswitch to illuminate the OIL BYP UTIL HYD caution light on the pilot's C/W/A panel. When 100 " 15 psid is

sensed, a bypass return valve opens permitting unfiltered fluid to bypass the filter and return to the manifold.

14) After filtering, fluid returns to the pump or the reservoir, depending upon system demands.

15) The APU return port routes return fluid from the APU starter motor straight back into the reservoir, passing through a 25- micron return filter screen.

NOTES



j. Utility hydraulic manifold electrical description and operation

1) The utility hydraulic manifold electrical components are powered by 28 VDC from the emergency bus.

2) The pressure switch is a normally closed switch that opens when the hydraulic pressure reaches 2050 psi, increasing, and will closes when pressure decreases to 1250 psi. The switch provides a ground when closed to illuminate the UTIL HYD PSI caution light on the pilot's C/W/A panel and the UTIL HYD caution light on the CPG's C/W/A panel.

3) The pressure transducer supplies a signal to the dual hydraulic pressure indicator proportional to hydraulic pressure in the utility hydraulic system. Output is 1.37 VDC per 1000 psi.

4) The low-level indicator switch is a normally open switch that closes when the fluid level in the reservoir decreases to 7.0 fluid ounces. When closed, the low-level indicator switch, provides a ground to illuminate the OIL LOW UTIL HYD caution light on the pilot's C/W/A panel and a 28 VDC signal to close the emergency hydraulic shut-off valve solenoid.

5) The pressure dirty filter and the return dirty filter indicators are identical and interchangeable. The indicators contain normally open switches that close at 70 " 10 psid. The switches are wired in parallel. When either switch closes, it provides a ground to illuminate the OIL BYP UTIL HYD caution light on the pilot's C/W/A panel.

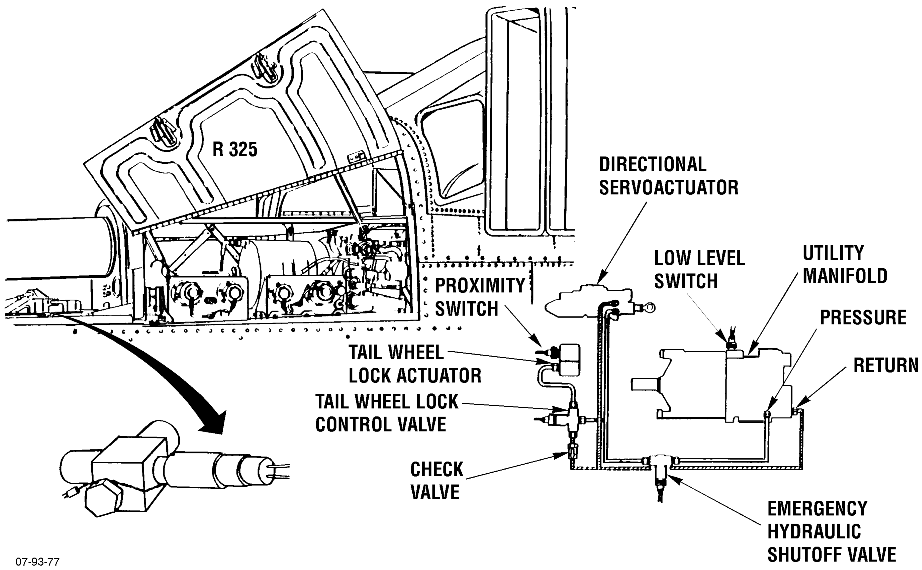
6) A pressure transducer supplies a signal to the utility hydraulic accumulator pressure gauge that is proportional to the pressure in the utility accumulator. Output is 1.37 VDC per 1000 psi.

7) The override solenoid is energized when either crewmember activates the respective EMER HYD PWR switch. When energized, it allows accumulator hydraulic fluid to enter the manifold for emergency flight control operations.

8) The brake on solenoid is energized when the engine power levers are in IDLE or below, and the rotor brake switch is placed in the BRAKE or LOCK position.

9) The brake off solenoid is energized when the rotor brake switch is placed in the OFF position.

EMERGENCY HYDRAULIC SHUTOFF VALVE



2. Emergency hydraulic shut-off valve

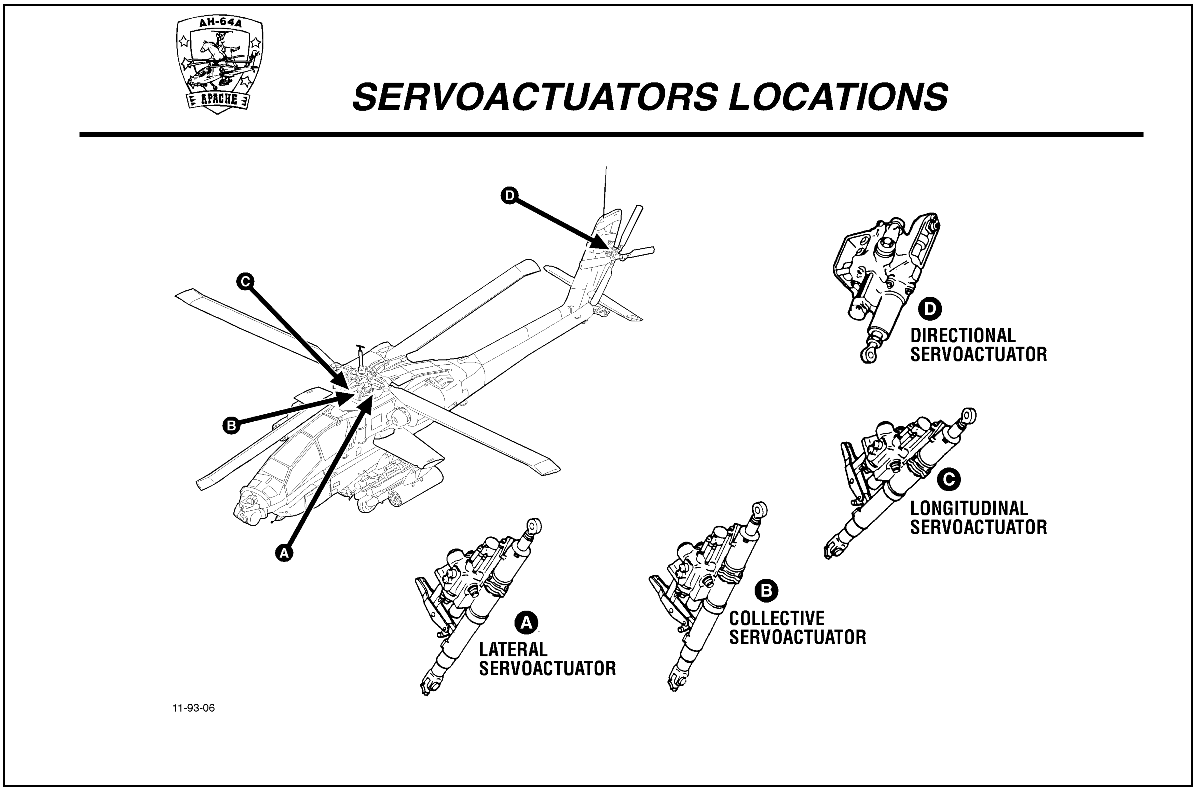
   a. Shuts off utility hydraulic fluid flow to the directional servoactuator and the tail wheel lock control valve when the fluid level in the utility reservoir drops low enough to actuate the low-level switch.

   b. Located in the forward top portion of the tail boom, just aft of the GSE panels.

   c. A solenoid-operated, two-position, two-way valve that operates in temperatures between -54E C and +135E C (-65E F and +275E F).

   d. During normal utility system operation, the emergency hydraulic shut-off valve is open, allowing fluid to flow from the utility manifold to power the directional servoactuator and tail wheel lock control valve.

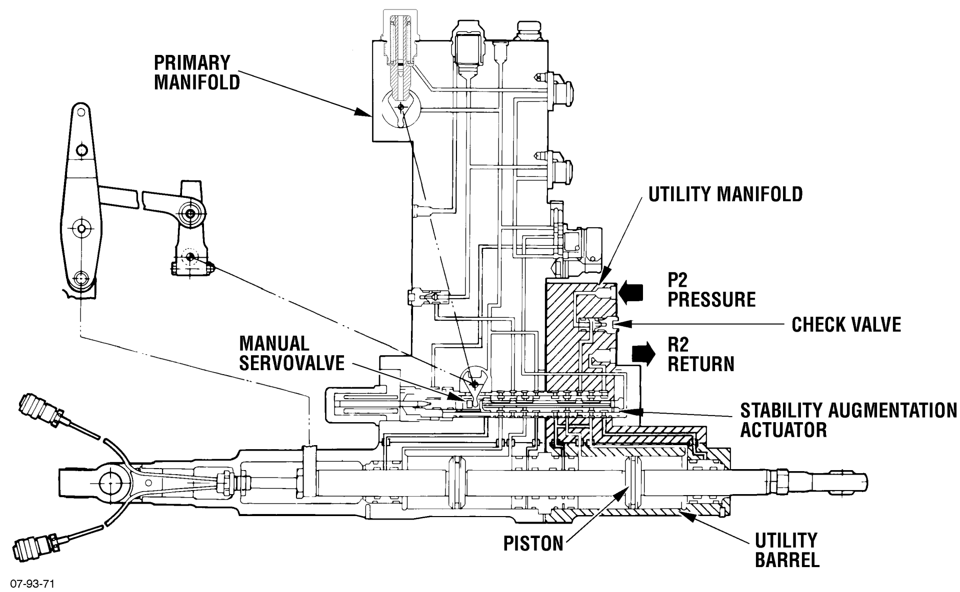
   e. If leakage somewhere in the utility system causes the utility manifold's low-level switch to be actuated, a 28 VDC electrical signal closes the emergency hydraulic shut-off valve. This conserves the remaining fluid for use by the main rotor flight control servoactuators.



3. Longitudinal, lateral, collective, and directional servoactuators

   a. Transform energy in the form of fluid pressure into mechanical outputs which are sent to the main and tail rotor flight controls.

SERVOACTUATOR OPERATION



b. Servoactuator operation

1) Pressurized fluid from the utility manifold enters the servoactuator through the P2 port (utility pressure).

2) The fluid is routed internally through a one-way check valve to prevent pressurized fluid from being forced back through the pressure port.

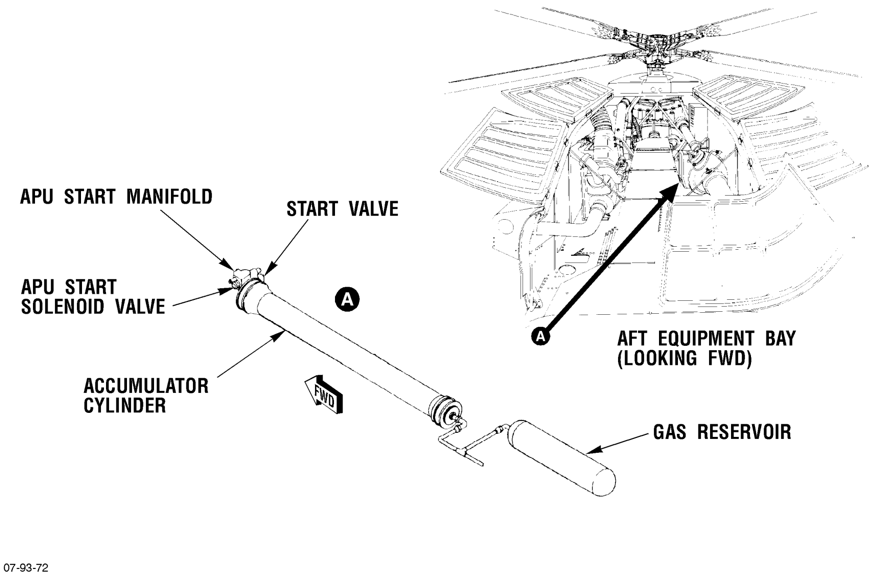
3) The position of the manual servovalve and SAS actuator determine if pressure and return fluid are held, or routed to one side of the piston or the other.

4) When one side of the piston is pressurized, the other side's fluid is routed to the return port.

5) The manual servovalve and SAS actuator control both primary and utility system fluids in the servoactuator.

6) The SAS actuator filter is not replaceable at AVUM or AVIM maintenance levels.

UTILITY HYDRAULIC ACCUMULATOR ASSEMBLY



4. Utility hydraulic accumulator assembly

   a. Stores hydraulic fluid under high pressure for APU starting, rotor brake operation, and emergency operation of the flight control servoactuators.

   b. Located on the right side of the aft equipment bay deck under the APU.

   c. The accumulator cylinder, APU start manifold, APU start solenoid valve, and start valve are combined into one assembly. The major components of the utility hydraulic accumulator assembly and respective descriptions are given below.

      1) Accumulator cylinder

         a) Houses the piston and fluid stored under nitrogen pressure.

         b) Made of aluminum alloy and wrapped with kevlar.

         c) Piston

            (1) Separates hydraulic fluid and nitrogen gas inside the cylinder. The piston moves back and forth within the cylinder, depending on accumulator volume.

            (2) Made of aluminum alloy.

      2) APU start manifold

a) Directs fluid flow to and from the accumulator cylinder.

b) Houses the start valve and provides mounting points for accumulator assembly components.

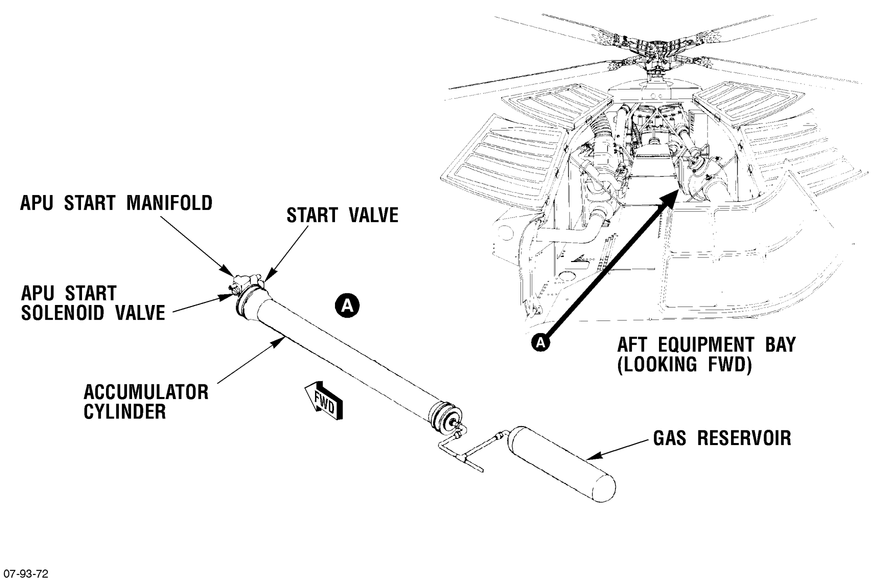
c) Made of aluminum alloy.

3) APU start solenoid valve

a) Provides on/off control of the start valve. It is a normally closed valve, installed on the APU start manifold.

b) Controlled by the APU START/RUN switch in the pilot's crewstation.

UTILITY HYDRAULIC ACCUMULATOR ASSEMBLY



4) Start valve

a) Provides on/off control of fluid flow going to the APU start motor.

b) Mechanically positioned by fluid pressure from the APU start solenoid valve during APU starts.

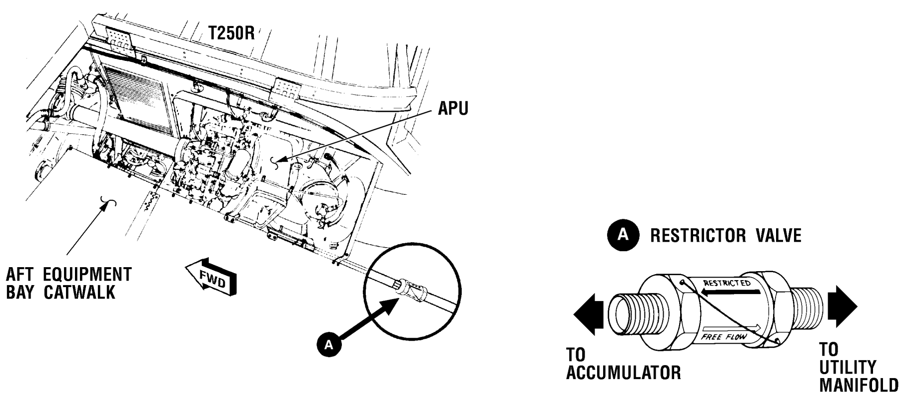
5) Gas reservoir

a) Stores pressurized nitrogen gas (approximately 1650 psi) to pressurize accumulator hydraulic fluid.

b) Made of aluminum alloy wrapped in kevlar.

6) Utility accumulator restrictor valve

UTILITY ACCUMULATOR RESTRICTOR VALVE LOCATION



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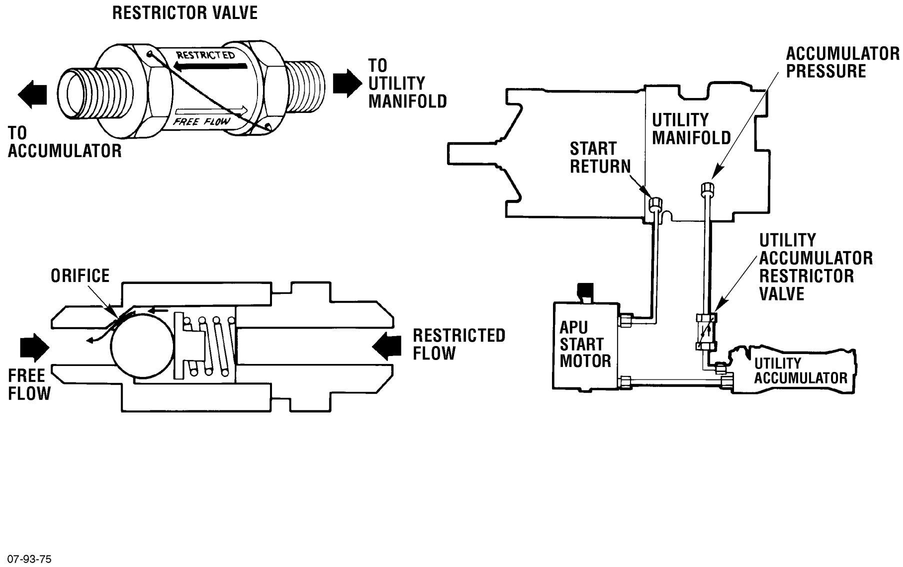
a) Located in the accumulator pressure line along the aft inboard side of the accumulator.

UTILITY ACCUMULATOR RESTRICTOR VALVE OPERATION

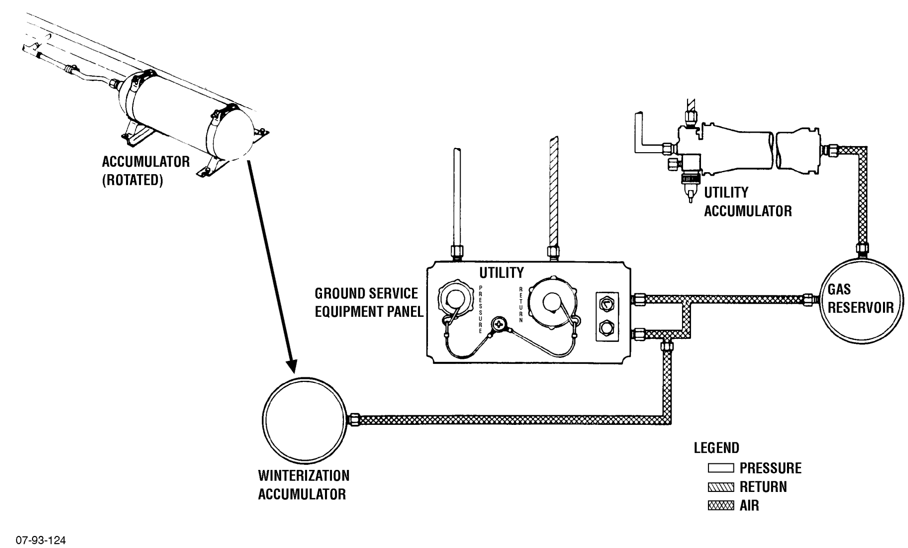


b) Limits the rate of hydraulic fluid that can flow into the accumulator from the utility hydraulic manifold during APU start.

c) Restricts fluid flow to the accumulator during recharging after the APU start. Hydraulic fluid cannot flow from the utility hydraulic manifold through the restrictor valve to the accumulator at a rate higher than 1.2 gpm.

d) During emergency flight control operations, the restrictor valve allows an unrestricted reverse flow of 4.0 gpm from the accumulator to the utility hydraulic manifold.

WINTERIZATION ACCUMULATOR



7) A winterization accumulator (gas reservoir) is available for cold weather operations.

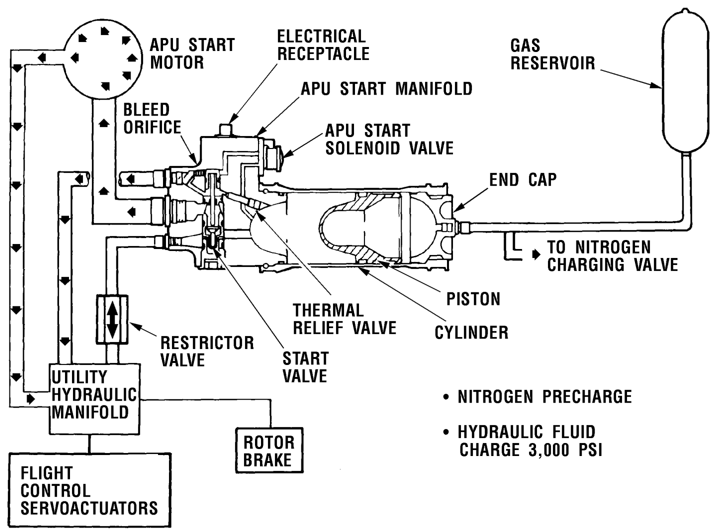
a) The winterization accumulator and gas reservoir use the same nitorgen fill-bleed valve and pressure gauge on the UTILITY ground service equipment panel.

b) The winterization accumulator and gas reservoir are charged to the requirements outlined in TM 55-1520-238-23.

c) Hydraulic fluid capacity does not change.

d) The utility accumulator is hand pumped to 3000 psi as required.

UTILITY HYDRAULIC ACCUMULATOR ASSEMBLY FUNCTIONAL DIAGRAM



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d. Utility hydraulic accumulator assembly operation

1) The accumulator and gas reservoir are pre-charged with approximately 1650 psi of nitrogen gas prior to servicing with hydraulic fluid.

2) The pre-charge of nitrogen causes the accumulator piston to move to the manifold end of the accumulator.

3) Fluid servicing is done using the hand pump, or automatically, through the accumulator isolation inlet check valve in the utility manifold when the system hydraulic pump is operating.

4) The fluid enters the accumulator through the pressure line and start valve.

5) Fluid entering the accumulator moves the piston back, compressing the nitrogen gas until a fluid pre-charge of 3000 psi is obtained.

6) The compressed nitrogen gas acts as a spring against the piston.

7) Fluid pressure is allowed to pass freely through the lower portion of the start valve, applying pressure to the utility hydraulic manifold for rotor brake and emergency flight control operations.

8) A thermal relief valve protects the accumulator from high pressures caused by thermal expansion of fluid. The valve opens at 3500 psi and

reseats at 3300 psi, venting excessive high pressure fluid to the utility hydraulic manifold.

9) APU start mode

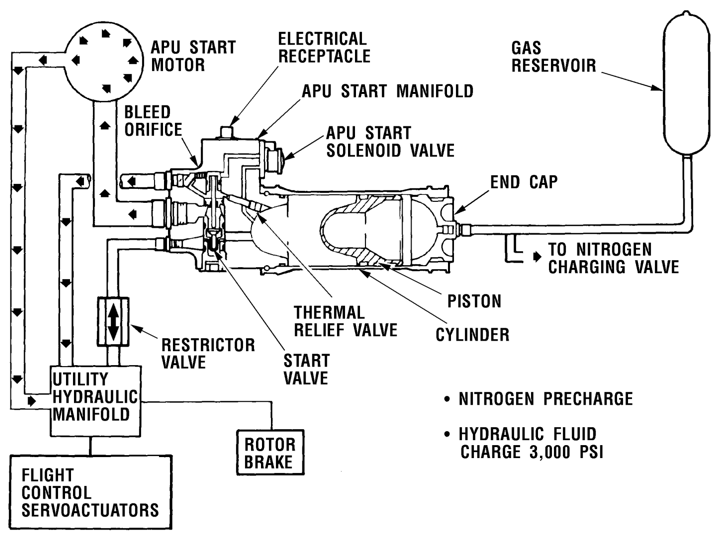
a) Placing the pilot's APU switch to the START position energizes the APU start solenoid valve to the open position.

b) The start solenoid valve directs (pilot) pressure to open the start valve.

c) Opening the start valve allows pressurized fluid to flow from the oil chamber of the hydraulic accumulator to the APU start motor.

d) After starter cutout, the start solenoid valve is de-energized and returns to its normally closed position.

UTILITY HYDRAULIC ACCUMULATOR ASSEMBLY FUNCTIONAL DIAGRAM



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e) The (pilot) pressure holding the start valve open returns to the utility hydraulic manifold through a 0.010 inch diameter, pressure bleed orifice.

f) This closes the start valve, shutting off accumulator flow to the APU start motor.

10) Emergency hydraulic mode

a) Pressurized fluid stored in the accumulator assembly can serve as a limited power source for the flight control servoactuators.

b) Placing the pilot's EMERG HYD switch or the CPGs EMER HYD PWR switch into the ON position energizes the override solenoid on the utility manifold.

c) This allows accumulator hydraulic pressure to reach the servoactuators through the utility hydraulic manifold.

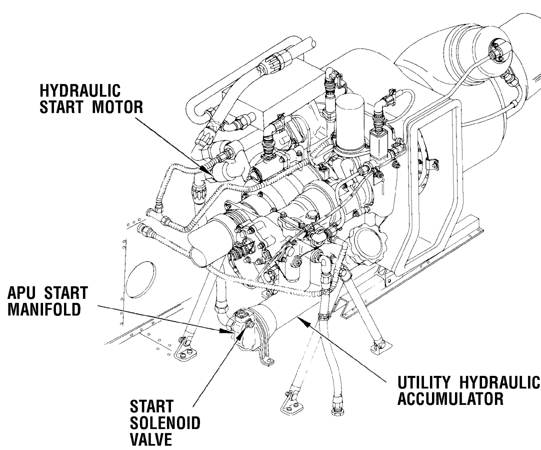
d) The amount of pressure available from the accumulator is displayed on the pilot's UTIL ACC gauge.

11) Static pressure mode

a) The accumulator assembly holds high pressure fluid, even when the rest of the utility hydraulic system is not operating.

b) This pressure can be used to power the rotor brake even without utility hydraulic pump operation.

APU START SYSTEM COMPONENTS



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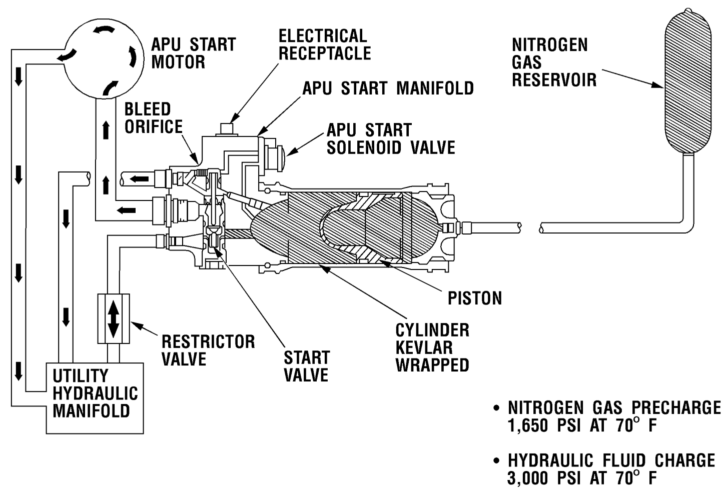
5. APU start system components

a. Provide the initial rotational starting speed for the APU.

b. The system components include the utility hydraulic accumulator, APU start manifold with start solenoid valve, hydraulic starter motor, and sprag clutch.

UTILITY HYDRAULIC ACCUMULATOR/APU START MANIFOLD WITH START SOLENOID VALVE



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c. Utility hydraulic accumulator

1) Stores hydraulic pressure for APU starting.

2) Mounted on the aft fuselage deck below the APU.

3) Is a cylinder wrapped with kevlar for ballistic protection.

d. APU start manifold and solenoid valve

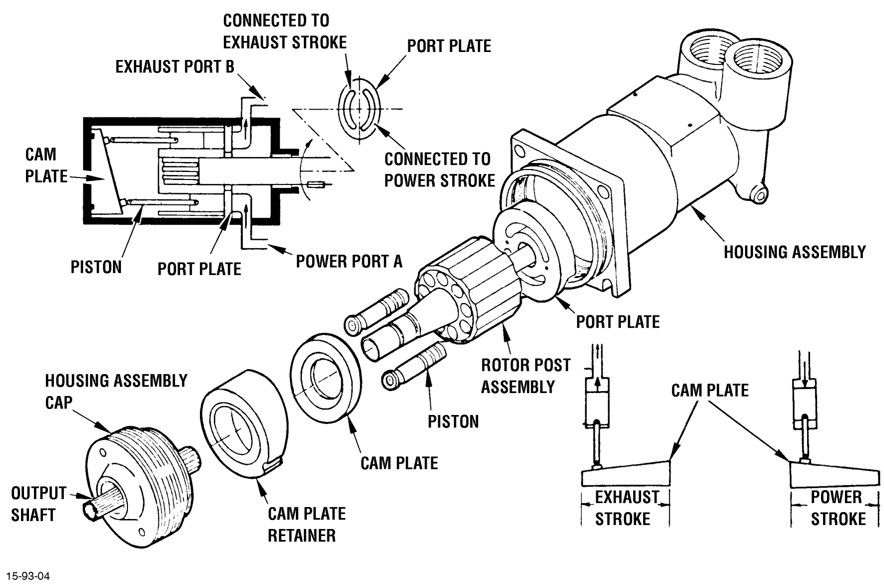
1) Directs hydraulic pressure to the APU hydraulic start motor during APU start.

2) The start manifold is attached to the forward end of the utility hydraulic accumulator and provides a mounting point for the start solenoid valve.

3) The APU start manifold is a series of chambers encased in an aluminum manifold with an internally mounted start valve.

4) The start solenoid valve is normally held closed, and is energized open by the APU controller during APU start. After the APU speed reaches 60 percent , the APU controller de-energizes the start solenoid valve, closed, and allows the spent, pressurized hydraulic fluid to be replenished.

APU HYDRAULIC START MOTOR



e. APU hydraulic start motor

1) Rotates the APU starting components to a speed where combustion can take place and the APU can become self-sustaining.

2) A lightweight (3.5 lbs. dry), high speed (100 percent speed equivalent to approximately 32,000 rpm) LRU attached to the APU accessory gearbox section, upper right side.

3) Contains a power port (inlet from the accumulator) and an exhaust port (return to the utility manifold). The nine-piston axial motor generates rotary force when supplied with high pressure hydraulic fluid from the accumulator.

4) Operation

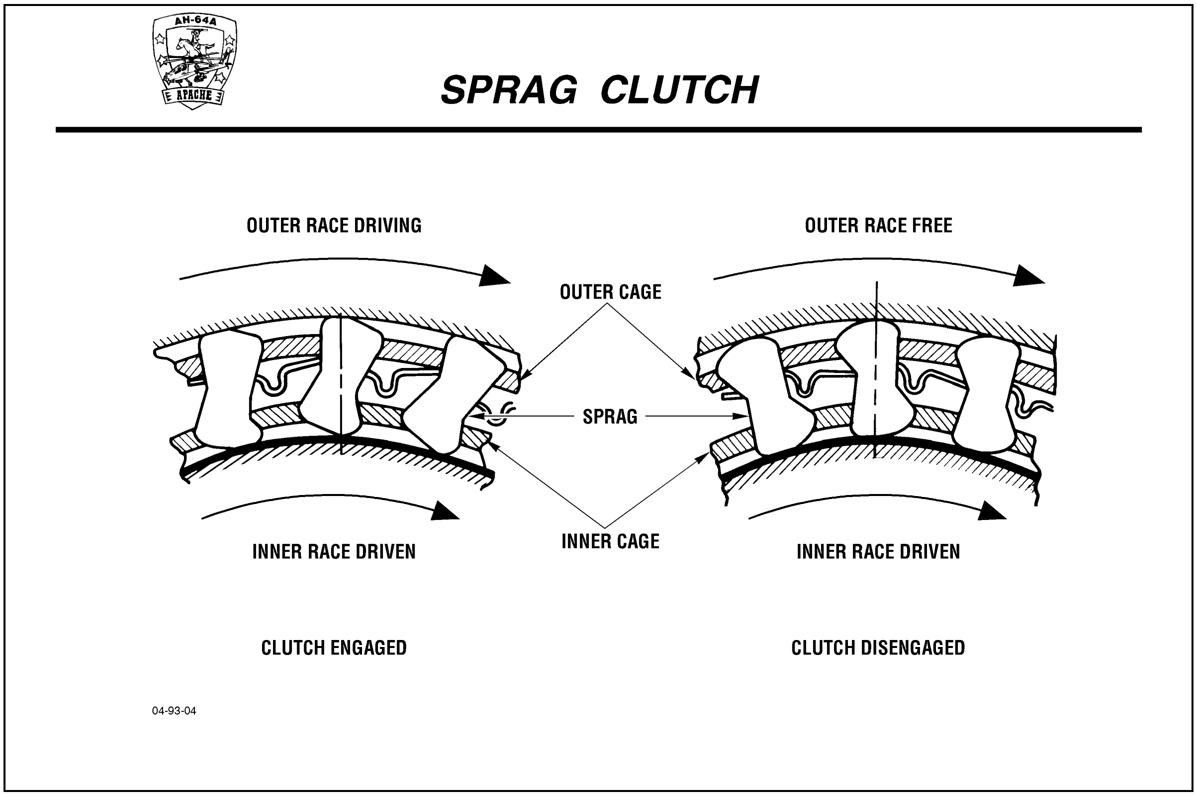
a) Fluid entering port A from the accumulator passes through one side of the kidney-shaped holes in the port plate.

b) The fluid pushes against the piston and causes it to seek the lower side of the sloping face of the cam plate.

c) As the slope of the cam plate decreases, the piston moves outward in relation to the rotating rotor post assembly. Each sequential piston imparts a tangential force to the rotor post assembly, causing it to rotate and turn the output shaft.

d) When the piston reaches the second half of the revolution, the cam pushes the piston back into the motor post assembly, exhausting fluid through port B of the kidney-shaped holes in the port plate.

e) Each sequential piston reacts with the cam plate in the same manner.



f. Sprag clutch

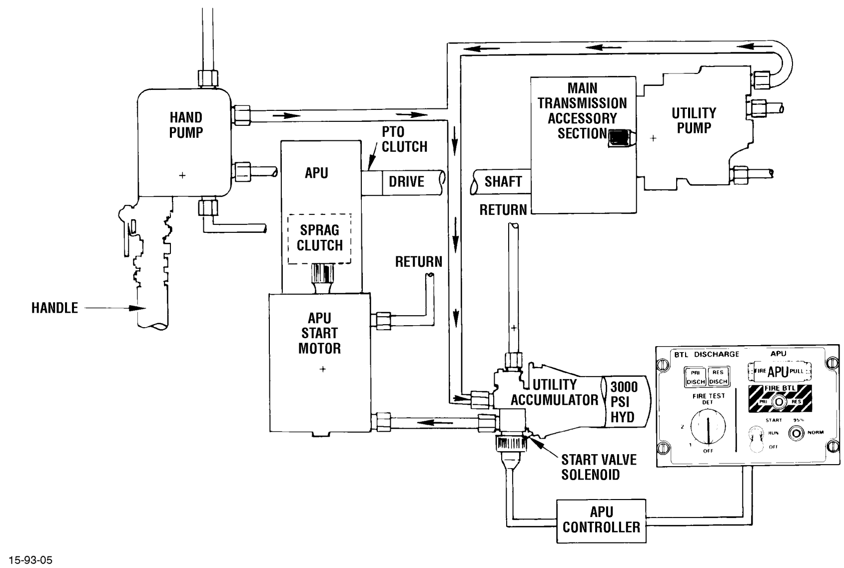
1) An overrunning-type clutch with several sprag assemblies allows the starter to couple with the gear train rotating group in order to drive the unit to a self sustaining speed. It decouples the starter when the APU speed is self-sustaining.

2) Mounted in the accessory gearbox section and is accessible by removing the hydraulic starter.

3) When starter torque is applied to the inner race, the sprags move with a rolling cam action and, being larger than the space between the races, are wedged between them (the clutch engages).

4) When the starter is de-energized, the outer race overruns the inner race and the sprags roll out of engagement. As the outer race continues to increase in speed, centrifugal force moves the sprags away from the inner race.

APU START SYSTEM



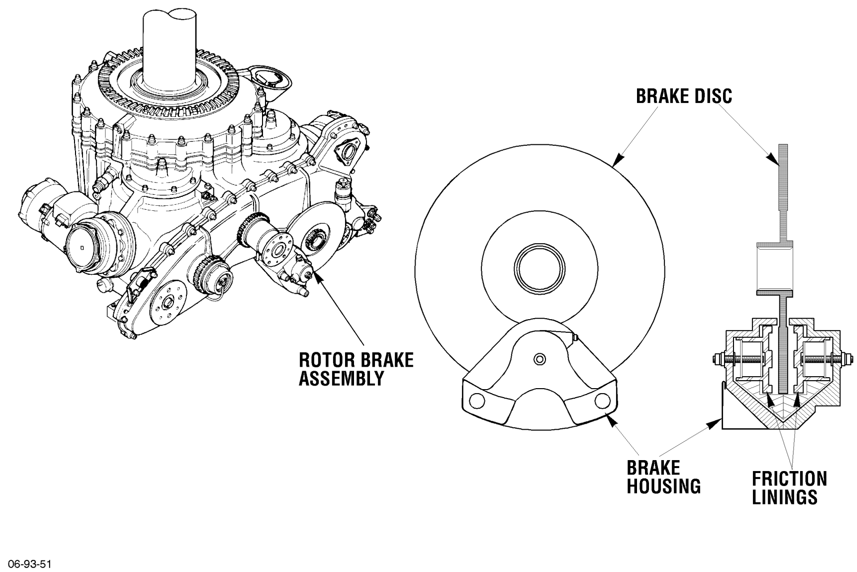
g. APU start system

1) When the APU OFF/RUN/START switch is moved, momentarily, to the START position, an electrical signal is provided by the APU controller to energize the hydraulic start valve solenoid. This directs pressurized hydraulic fluid from the utility accumulator to the APU hydraulic start motor.

2) The APU hydraulic start motor is coupled to the APU by means of the sprag clutch and disengages at approximately 60 percent APU speed.

3) The utility hydraulic pump recharges the utility accumulator with 3000 psi hydraulic pressure.

ROTOR BRAKE ASSEMBLY



6. Rotor brake actuator

   a. Retards or prevents rotation of the rotor assemblies.

   b. Installed on the center section of the main transmission accessory gear case.

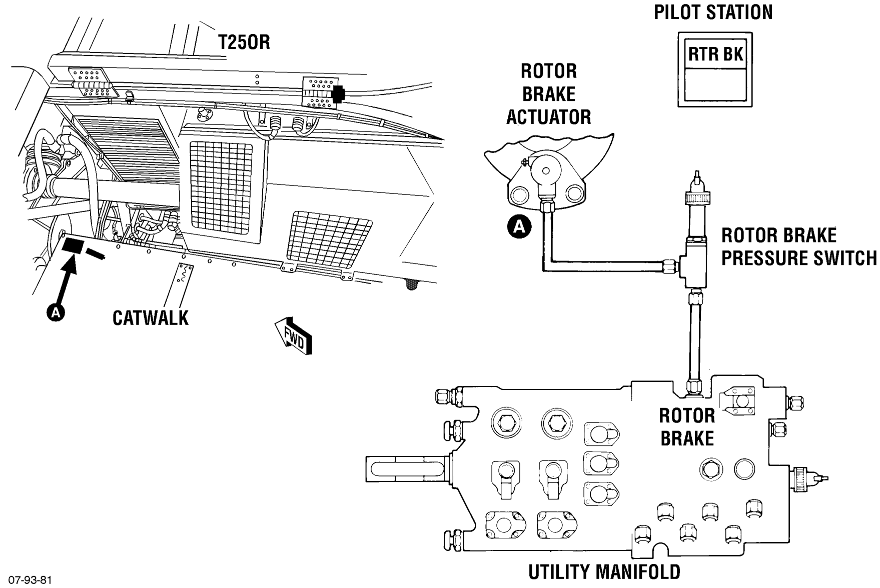
   c. Rotor brake components

      1) A steel disk driven by the rotor brake drive gear.

      2) A magnesium brake housing, incorporating two friction linings. Newer friction linings are made from an organic material.

   d. For an operational description of the rotor brake, refer to the utility hydraulic manifold portion of this lesson.

ROTOR BRAKE PRESSURE SWITCH



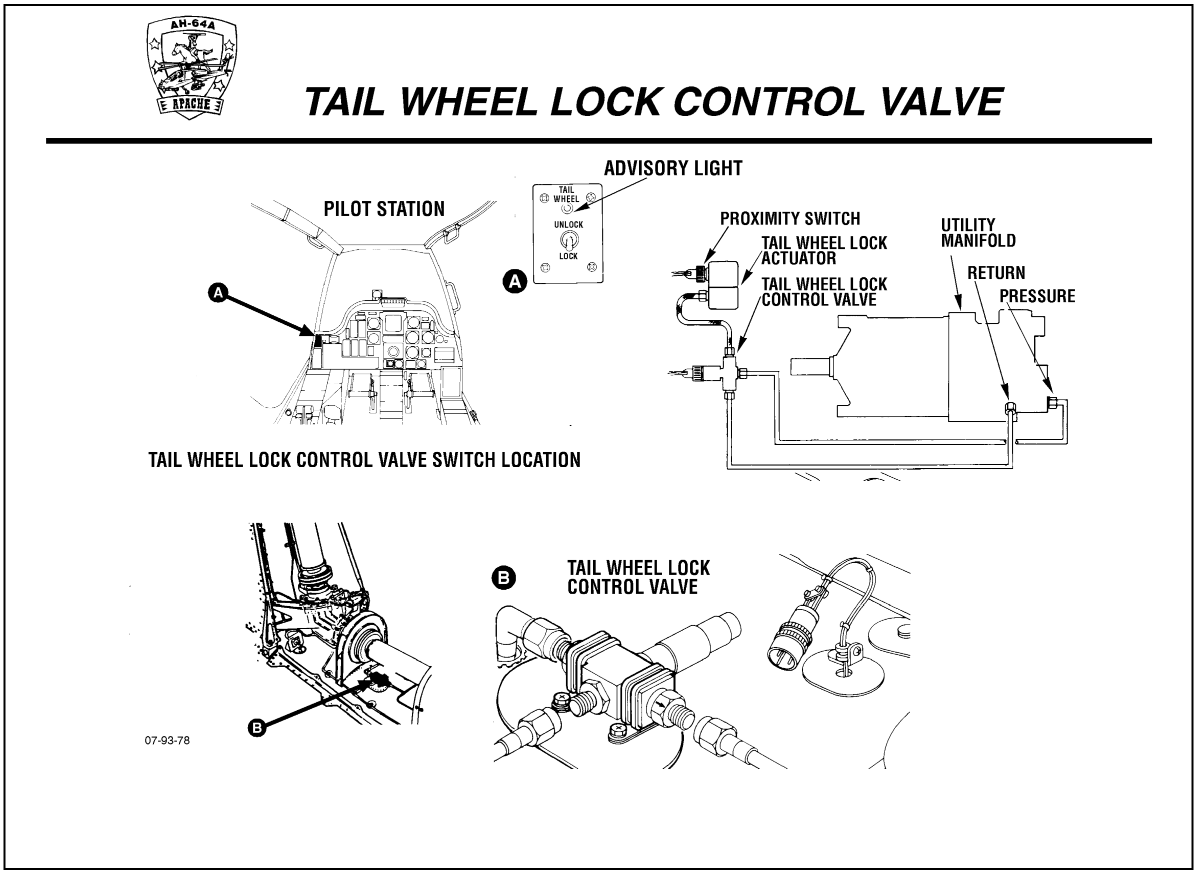
7. Rotor brake pressure switch

   a. Provides a visual indication of pressure applied to the rotor brake actuator by illuminating the RTR BK caution light on the pilot's C/W/A panel.

   b. Installed on the aft equipment bay deck under the forward portion of the catwalk.

   c. Sends a signal to the power lever locking solenoid in the pilot's power lever quadrant, preventing the power levers from being advanced past the idle position.

   d. Actuated closed at 200 " 50 psig, increasing, and illuminates the RTR BK caution light on the pilot's C/W/A panel. The switch opens at 100 psig, decreasing.



8. Tail wheel lock control valve

   a. Controls hydraulic pressure to the tail wheel lock actuator.

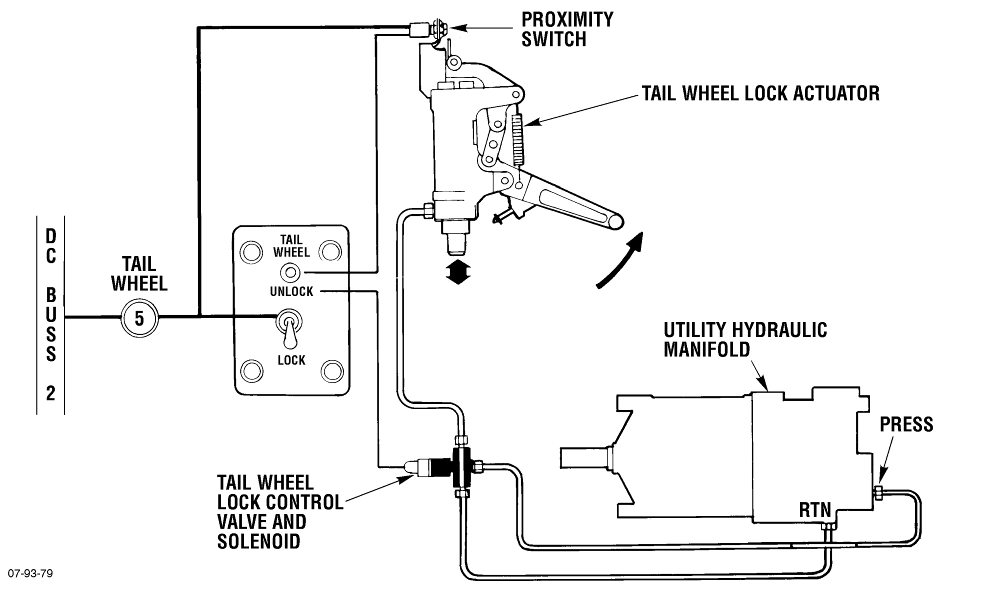
   b. Located on top of the tail boom, slightly forward of the intermediate gearbox.

   c. An aluminum alloy, two-position, three-way, solenoid-operated, hydraulic valve. It is 33 inches long, 1 inch wide, and : inch high.

   d. The valve pressure, return, and cylinder ports are clearly marked for ease of installation.

   e. The tail wheel LOCK/UNLOCK switch is located on the upper left corner of the pilot's instrument panel. The TAIL WHEEL unlock light is located above the switch.

TAIL WHEEL LOCK CONTROL VALVE OPERATION



f. Tail wheel lock control valve operation

1) DC BUS 2 supplies 28 VDC to the TAIL WHEEL lock control panel through the TL WHL LK circuit breaker. The two- position toggle switch on the panel controls operation of the tail wheel lock control valve.

2) When the tail wheel switch is placed in the LOCK position, the control valve solenoid is de-energized.

a) This shuts off the hydraulic pressure to the lock actuator and opens the return line to the utility hydraulic manifold reservoir.

b) Spring tension overcomes hydraulic pressure in the lock actuator, locking the tail wheel.

3) When the tail wheel switch is placed in the UNLOCK position, the control valve solenoid is energized.

a) This closes the return line to the lock actuator and opens the pressure line to the lock actuator.

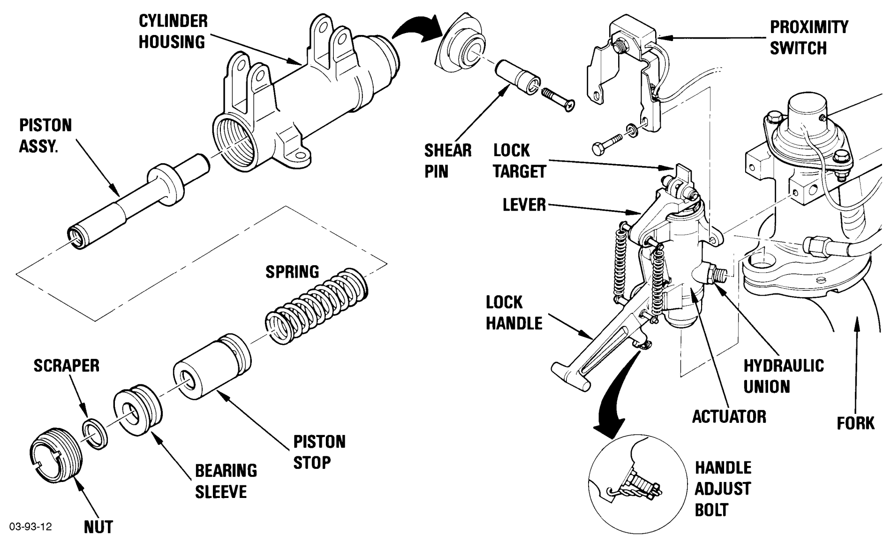
b) Hydraulic pressure overcomes spring tension in the lock actuator, unlocking the tail wheel.

c) A proximity switch at the tail wheel lock actuator is closed, completing an electrical circuit, to illuminate the green advisory light on the TAIL WHEEL lock panel in the pilot's crewstation.

9. Tail wheel lock actuator assembly

a. Provides a means for locking the tail wheel in the center position, either mechanically or hydraulically.

TAIL WHEEL LOCK ACTUATOR ASSEMBLY



b. Mounted to the trailing arm housing.

c. The major components of the tail wheel lock actuator assembly are the actuator, lock handle, and proximity switch.

d. Tail wheel lock actuator assembly components and descriptions

1) Actuator

a) Consists of the cylinder housing, piston assembly, spring, piston stop, bearing sleeve, scraper, nut, and shear pin (fuse pin).

b) A packing and seal is installed into the bearing sleeve and two retainers and a packing are installed on the bearing. Another seal and packing is installed at the shear pin-end of the cylinder housing.

c) The actuator is spring loaded in the locked position. The shear pin is the actual locking device and is installed into the piston assembly via a self-locking screw.

2) Lock handle

a) Provides manual operation of the lock actuator.

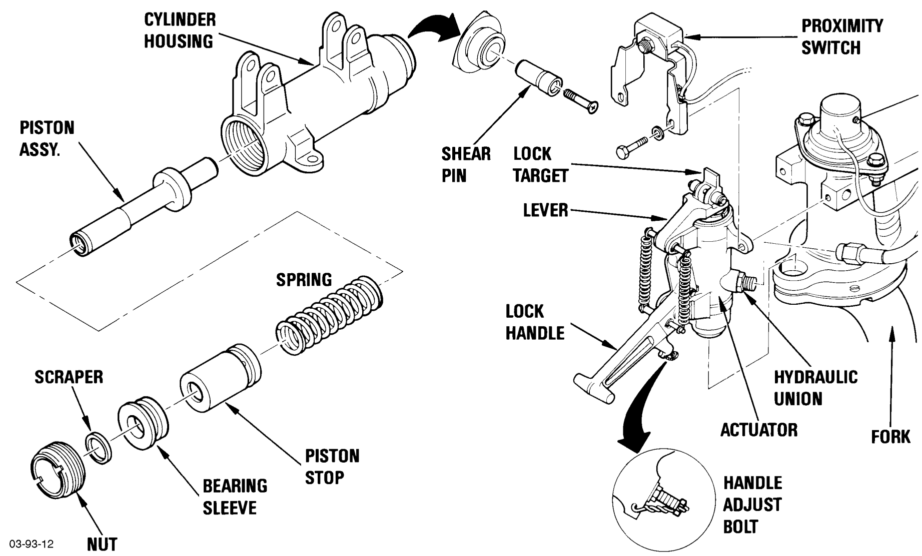
b) Mounted to a set of lugs on the lower portion of the actuator and connected to the lock target via a swing lever attached to the upper set of lugs.

c) Held in the locked position by an over-center mechanism and two springs. The underside of the lock handle contains an adjustable bolt assembly used to adjust the handle over-center mechanism travel so that it does not automatically return to the full up (locked) position.

3) Proximity switch

a) An electrically controlled, magnetically operated, switch installed on a bracket mounted to the upper portion of the lock actuator.

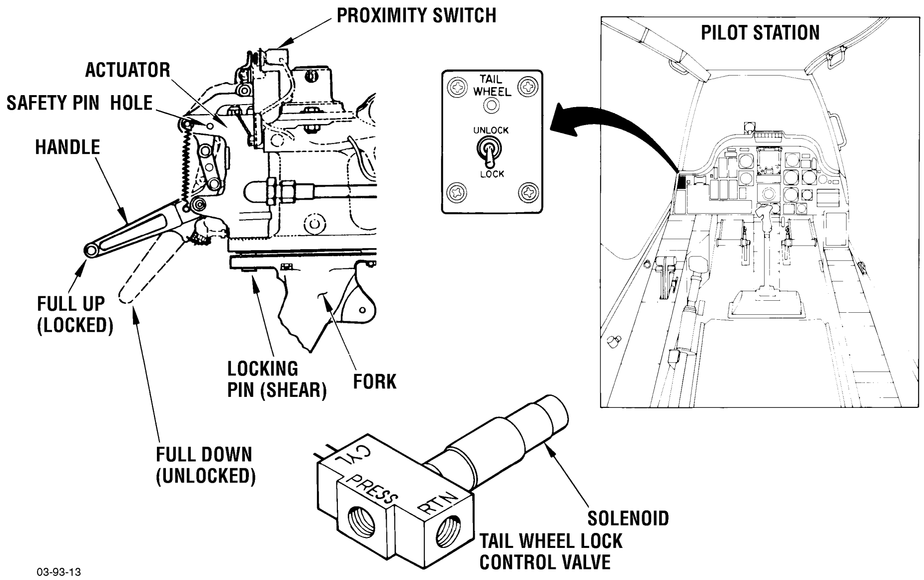
TAIL WHEEL LOCK ACTUATOR ASSEMBLY



b) Operates in conjunction with the lock target installed in the upper end of the actuator.

c) When replacing the switch, a vertical alinement and gap adjustment are required between the proximity switch face and the target.

TAIL WHEEL LOCK ACTUATOR OPERATION



e. Tail wheel lock actuator operation

1) Controlled by the tail wheel LOCK/UNLOCK switch through the tail wheel lock control valve, or manually at the tail landing gear.

2) When the actuator is in the locked position, it:

a) Absorbs rotor torque reaction during rotor brake operations.

b) Prevents tail wheel shimmy during rolling takeoffs or landings.

c) Prevents swivel during ground operations in high winds.

d) Prevents swivel during operations on slopes.

3) The shear pin shears under high side load conditions (approximately 6800 pounds) to prevent damage to the fork, trailing arms, or tail boom.

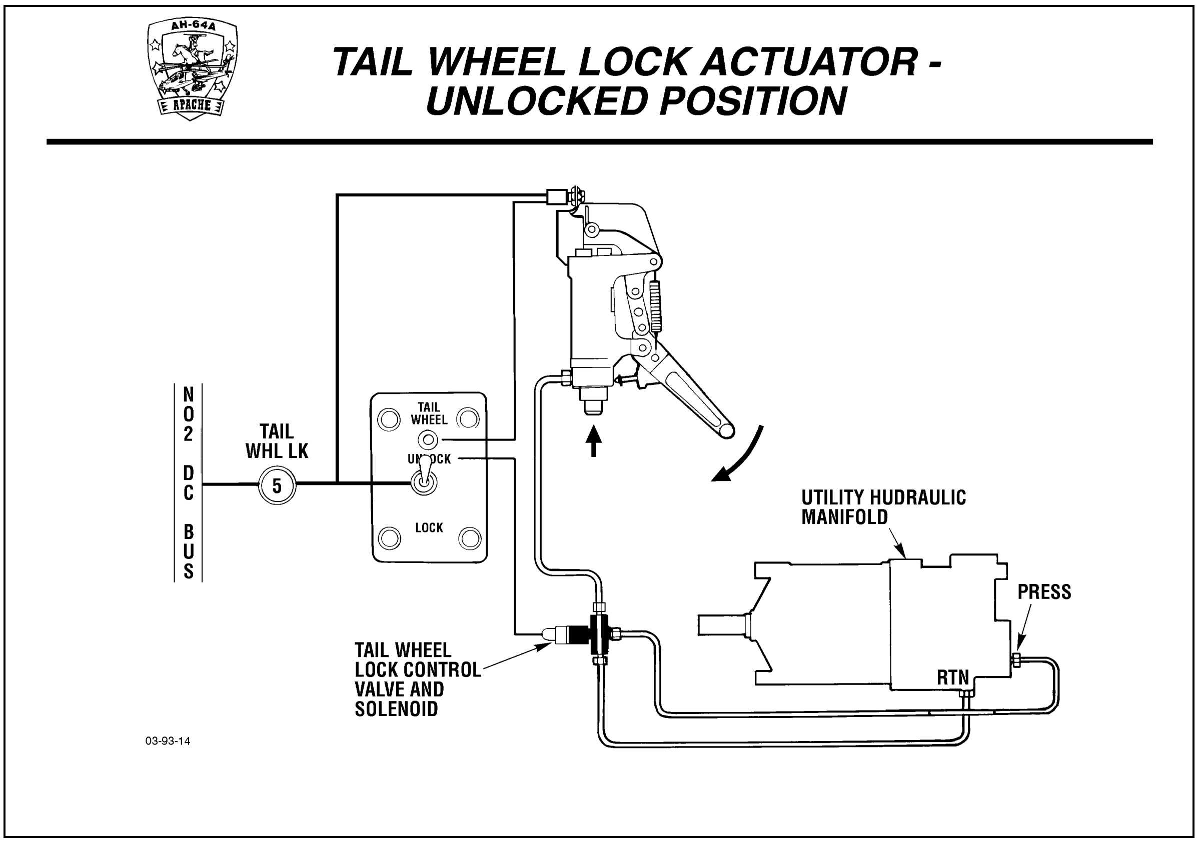
4) Manual control

a) The handle attached to the actuator is used to manually unlock and lock the tail wheel.

b) A quick-release safety pin with an attached warning flag is used to hold the actuator in the unlocked position during ground handling. This prevents accidental locking of the tail wheel.

c) When the handle is placed in the full up position, it seats the shear pin to secure the fork in the center position.

d) Placing the handle in the full down position unseats the shear pin, allowing the fork freedom of movement.



5) Pilot control - unlocked position

a) When the TAIL WHEEL switch is placed in the UNLOCK position, it energizes the tail wheel lock control valve solenoid.

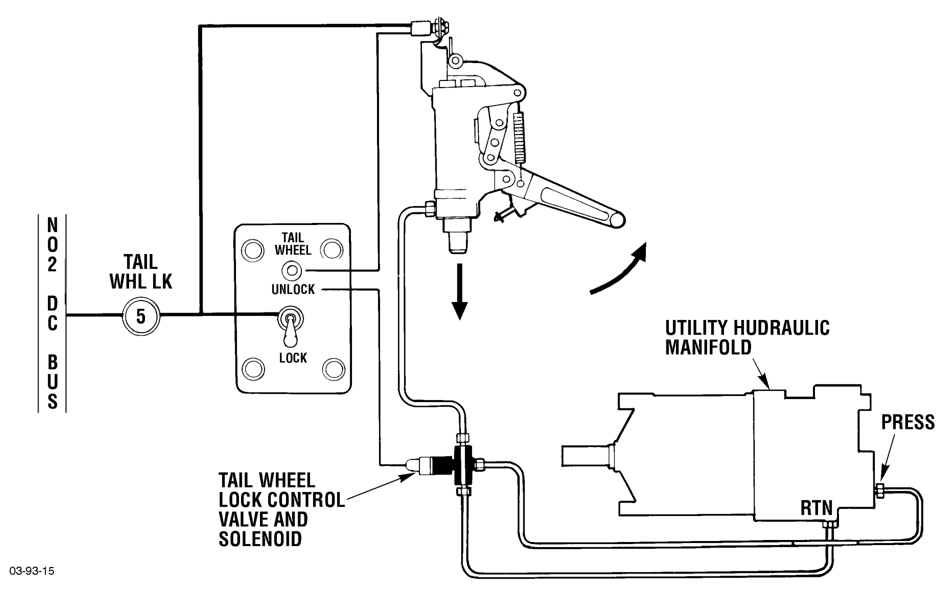
b) This closes the return line to the utility manifold and opens the pressure line from the manifold, through the control valve, to the actuator.

c) Hydraulic pressure overcomes the actuator spring tension, lifting the shear pin out of the fork assembly. The tail wheel is then free to swivel.

d) When the actuator moves to the unlocked position, a target, located at the top of the actuator, is moved upward closing the proximity switch.

e) When the proximity switch closes, the green advisory light on the pilot's TAIL WHEEL switch panel illuminates, indicating that the tail wheel is unlocked.

TAIL WHEEL LOCK ACTUATOR - LOCKED POSITION



10. Pilot control - locked position

a) Placing the TAIL WHEEL switch in the LOCK position removes power to the tail wheel lock control valve.

b) The control valve solenoid is de-energized, shutting off hydraulic pressure from, and opening the return line to, the utility manifold.

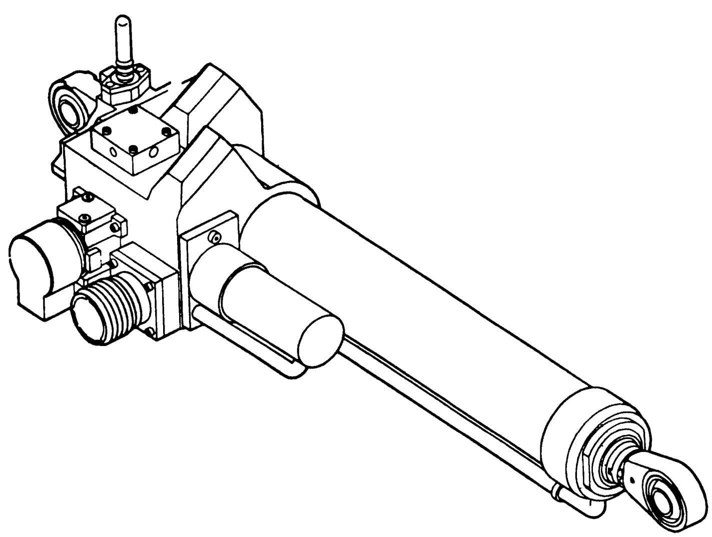
c) Hydraulic pressure vents from the actuator through the control valve's return port. This allows the actuator internal spring tension and external spring tension to override the lock handle's over-center mechanism, forcing the shear pin down into the fork assembly, locking the tail wheel.

d) The movement of the lock target opens the proximity switch, turning off the green light at the pilot's TAIL WHEEL switch panel, indicating the tail wheel is locked.

e) The tail wheel lock is fail safe to the locked position.

AH-64A APACHE

TURRET ACTUATOR



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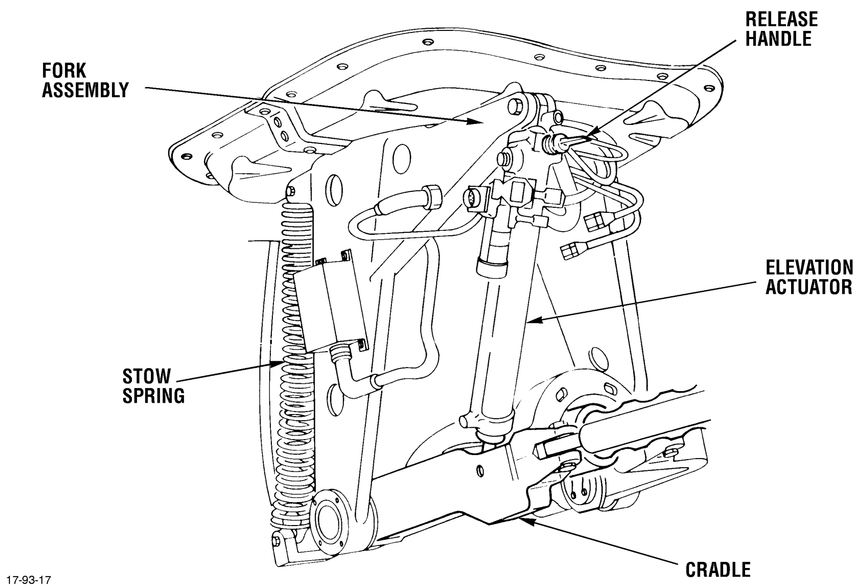
11. AWS elevation actuator

a. Provides the drive force required to position the automatic cannon in elevation. The design and operation of the elevation actuator is similar to that of a typical hydraulic servocylinder.

ELEVATION ACTUATOR ASSEMBLY



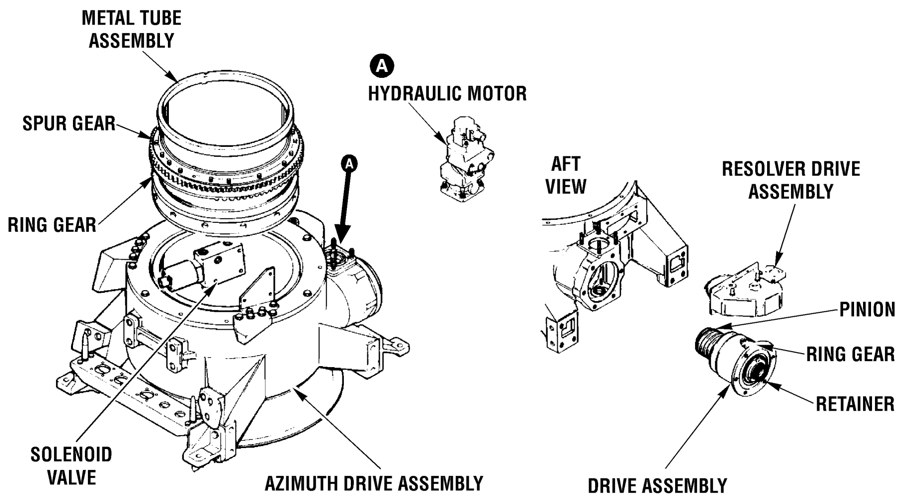
b. Mounted between the turret cradle and fork assemblies.

c. Actuated by 3000 psi hydraulic fluid from the utility hydraulic system. It can be manually unlocked by a release handle on the side of the elevation actuator.

12. AWS azimuth drive motor

a. Provides the rotational drive to move the turret in azimuth. The operation and design of the azimuth drive motor is similar to that of a typical hydraulic motor.

AZIMUTH DRIVE ASSEMBLY COMPONENTS



17-93-18

b. Mounted to the azimuth drive housing, upper aft side.

c. Electrically controlled by the TCB. A hydraulic solenoid provides ON/OFF control of the hydraulic pressure to the turret system.

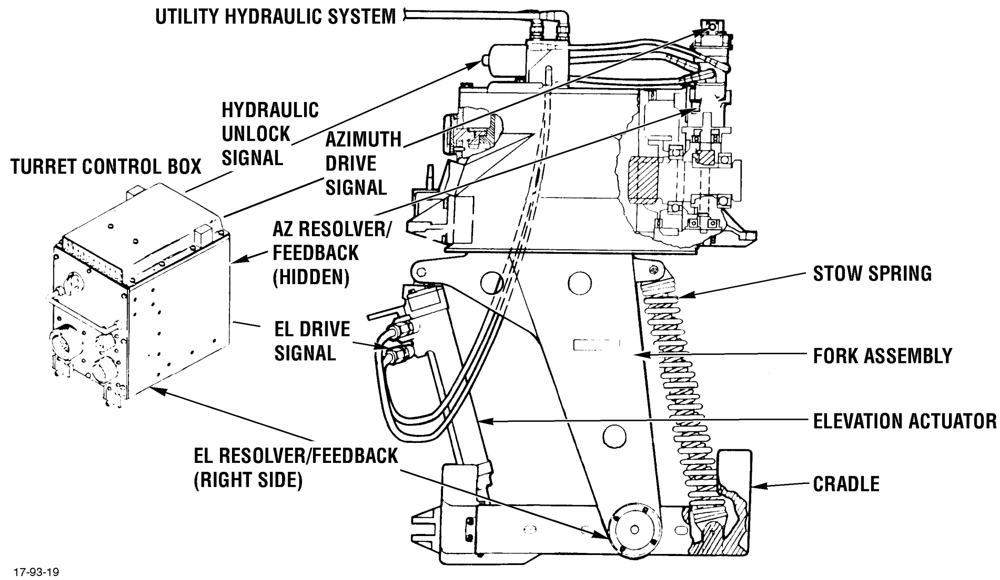
13. Hydraulic solenoid valve

a. Provides the ON/OFF control of pressurized hydraulic fluid to the turret system.

b. Mounted on the top left side of the turret housing assembly.

c. Receives hydraulic unlock signals from the turret control box (TCB).

TURRET OPERATION



14. Turret operation

a. When the fire control computer (FCC) processes all control signals for an azimuth or elevation command, the TCB sends a signal to the hydraulic solenoid valve. When the solenoid valve opens, hydraulic pressure is applied to the azimuth drive motor and elevation actuator.

b. Hydraulic pressure through the hydraulic solenoid valve unlocks the azimuth bypass control and elevation actuator. The hydraulic pressure also overrides the elevation stow spring.

c. A drive signal from the TCB is applied to the azimuth drive motor. Depending upon the polarity of the drive signal, the drive motor turns either clockwise or counterclockwise. The rotating drive motor drives the primary pinion and ring gear which, in turn, drives the secondary pinion and ring gear. As the secondary ring gear turns, the torque tube, fork assembly, and cradle rotate in azimuth. An azimuth resolver sends turret position signals to the TCB.

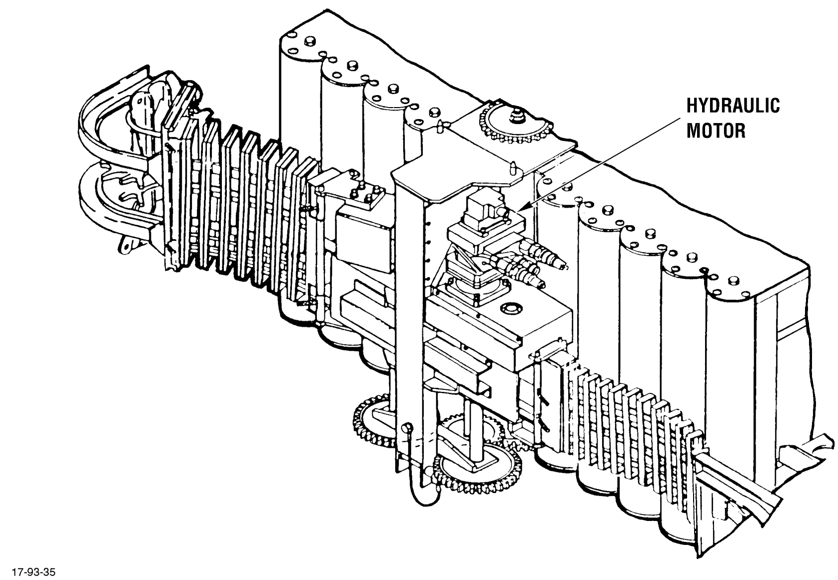
d. Elevation drive signals from the TCB direct the elevation actuator to move in the proper direction. Depending on the polarity of the signal, the actuator extends or retracts. An elevation resolver transmits the position of the cradle to the TCB.

e. If utility hydraulic system pressure is removed from the turret, the turret stows in elevation (stow spring) but not in azimuth.

15. Ammunition carrier hydraulic drive motor assembly

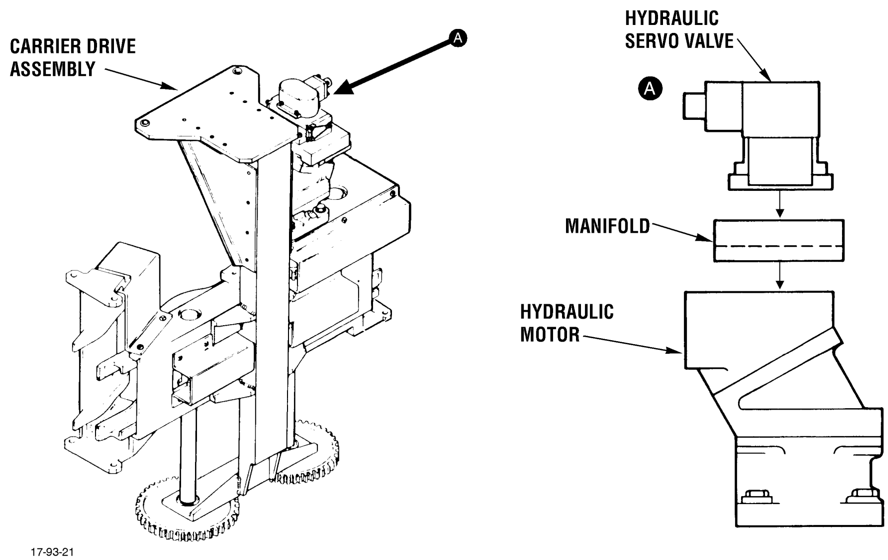
a. Provides rotational drive to the carrier drive assembly shaft.

CARRIER DRIVE HYDRAULIC MOTOR LOCATION



b. Located on the upper left portion of the carrier drive assembly, in forward portion of the ammunition bay.

CARRIER DRIVE HYDRAULIC MOTOR (2)



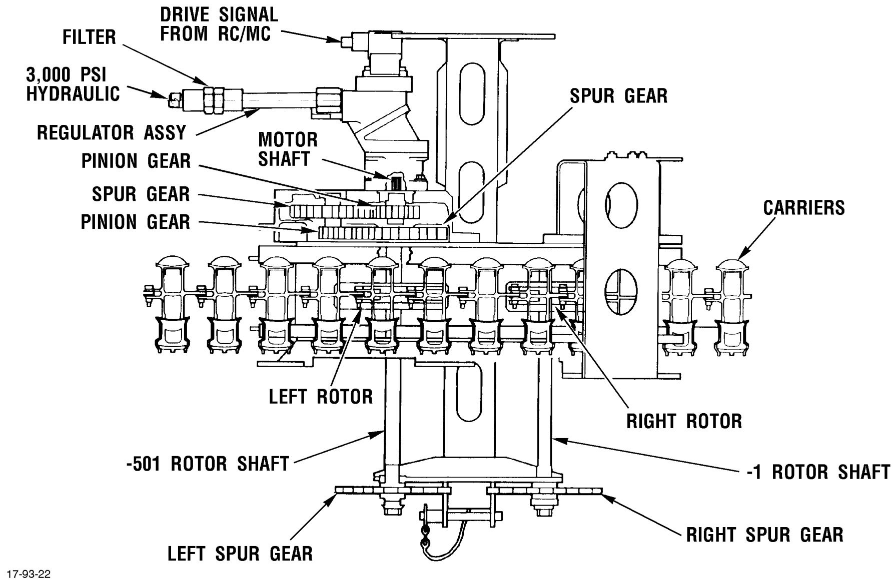
c. Assembly components

d. Hydraulic motor that drives the carrier assembly.

1) Manifold assembly to distribute hydraulic fluid to the motor.

2) Hydraulic servovalve to direct hydraulic fluid through the manifold.

CARRIER DRIVE OPERATION



e. Carrier drive operation

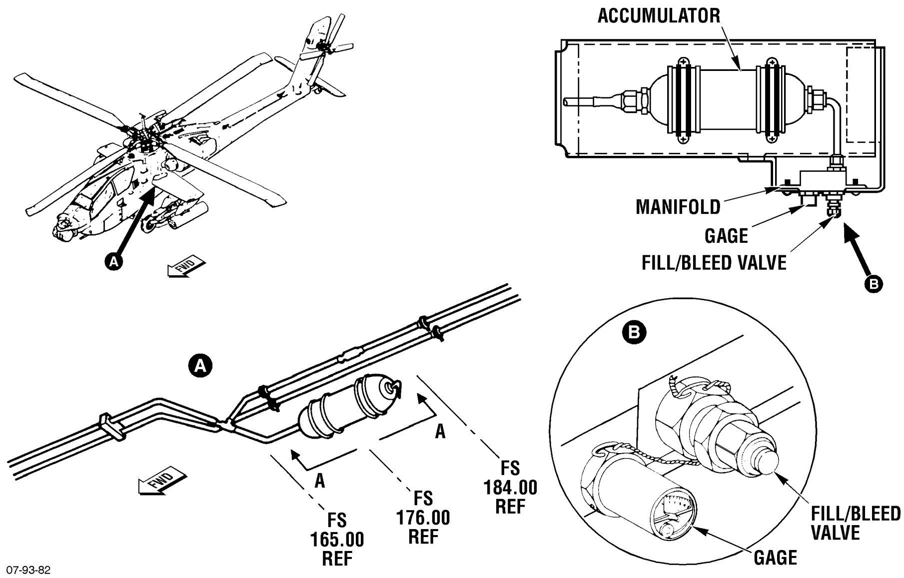
1) The carrier drive motor drives the carrier drive assembly. In conjunction with the gun drive motor, it also drives the ammunition handling system.

2) With 3000 psi hydraulic fluid from the utility hydraulic system applied to the hydraulic motor, the system begins to operate.

3) Because of a built-in bias in the hydraulic motor assembly, it begins to rotate in a forward direction, causing the motor shaft to rotate.

4) The hydraulic operation and design of the carrier drive motor is similar to that of a typical hydraulic motor.

UTILITY HYDRAULIC RETURN ACCUMULATOR



16. Utility hydraulic return accumulator

a. During normal operation of the AWS, the hydraulic return pressure spikes are approximately 800 to 900 psi. The utility hydraulic return accumulator works as a damper, absorbing the spikes and reducing them to approximately 150 psi.

b. Located in the left forward avionics bay (FAB) at fuselage station 176.00. A FAB access door allows inspection of the accumulator.

c. Approximately 6.7 inches long and about 2.8 inches wide. The total nitrogen gas volume is 10.5 cubic inches, minimum, and oil displacement volume is 9.5 cubic inches (17.14 fluid ounces), minimum.

d. Contains a pressure gauge and a fill/bleed valve.

1) The pressure gauge is a small LRU. The scale ranges from 1 to 5, x 100, in increments of 50. It is not interchangeable with the utility accumulator pressure gauge.

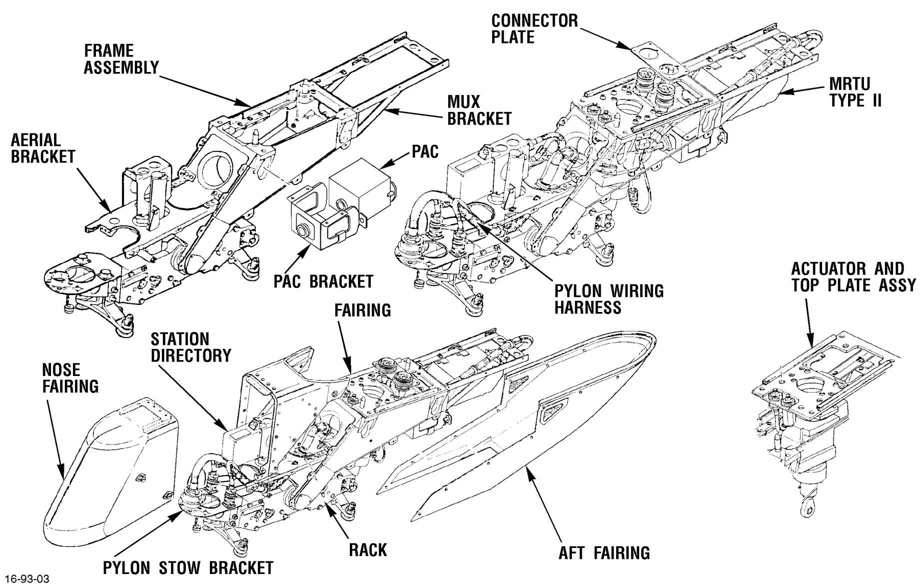
2) The fill/bleed valve is a standard, schrader-type valve which provides a means of charging or bleeding the gas reservoir in the accumulator.

e. When pressure surges from the AWS occur in the utility hydraulic system return lines, the utility hydraulic return accumulator absorbs the pressure surges. Fluid enters the return accumulator, forcing the accumulator piston to compress nitrogen gas, dissipating the fluid's energy. The hydraulic fluid re-enters the return system at a reduced pressure.

17. Pylon actuator and top plate assemblies

a. Provide the means for elevation positioning of the rack assembly, and

PYLON COMPONENTS



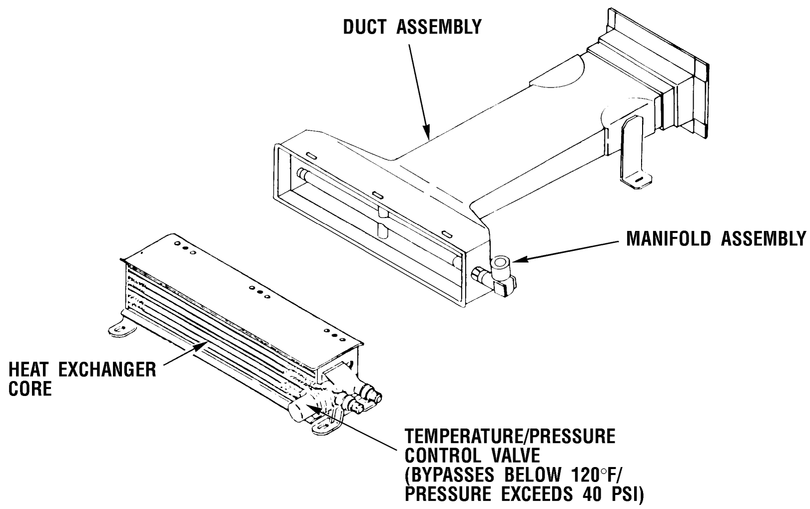
consequently, the external stores. Provide angular position information to the pylon actuator controller.

b. Mounted within each of the four pylon frames with the top plate attached to the upper part of the frame. The actuator is attached to the aft end of the rack.

c. Consists of an electrically- controlled (pylon actuator controller) hydraulic actuator with the top plate providing the hard point mounting and hydraulic quick-disconnects (self-connecting and releasing). The lower portion has a telescoping rod that attaches to the rack assembly.

d. The design and operation of the pylon actuators is similar to that of a typical hydraulic servocylinder.

HEAT EXCHANGER/EDUCTOR ASSEMBLY MAJOR COMPONENTS



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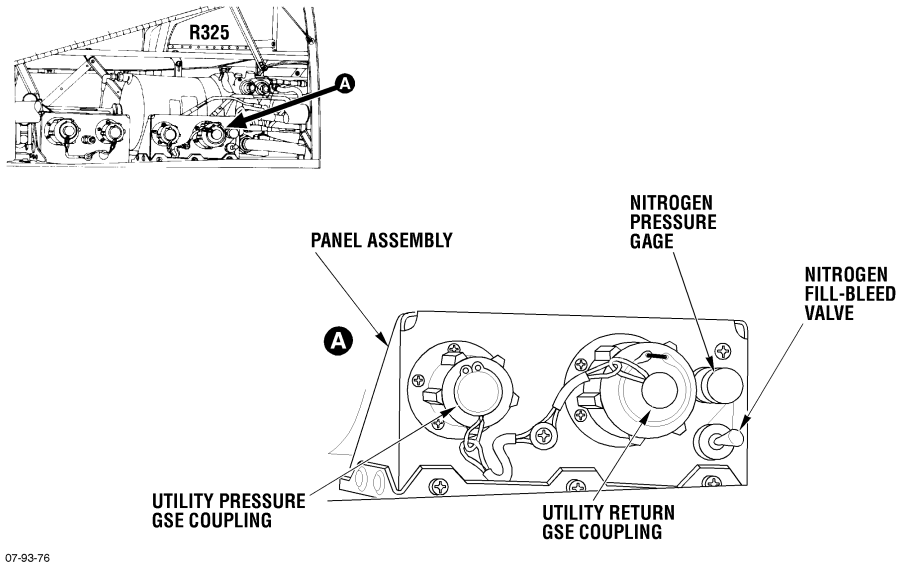
18. Utility heat exchanger

a. Cools utility hydraulic system fluid as it returns the utility reservoir. Description and operation is the same as the primary heat exchanger.

b. Originally installed on helicopters with S/N 82-23355 through 86-9011. If installed, the heat exchanger is located on the aft equipment bay deck, on the right side of the catwalk. MWO 1-1520-238-50-30, dated 27 July 1992, calls for removing of the utility heat exchanger.

UTILITY HYDRAULIC GROUND SERVICE EQUIPMENT PANEL ASSEMBLY LOCATION



19. Utility hydraulic GSE panel assembly

a. Provides connections for external hydraulic power application, and a connection for charging the gas reservoir from a nitrogen source. The panel also incorporates an accumulator pressure gage.

b. Located on the aft equipment bay deck, aft of the APU, and outboard of the utility manifold. It is accessible through panel R325.

c. Utility hydraulic GSE panel assembly components and descriptions

1) Pressure coupling

a) Mates with the AGPU pressure hose coupling.

b) A quick-disconnect type coupling made of aluminum.

2) Return coupling

a) Mates with the AGPU return hose coupling.

b) A quick-disconnect type coupling made of aluminum.

3) Manifold. Provides mounting points for the nitrogen pressure gauge and the nitrogen fill-bleed valve.

4) Nitrogen pressure gauge

a) Indicates pressure in the accumulator. When hydraulic pressure is bled off, the gauge provides an indication of nitrogen pressure.

b) A 0 - 4000 psi gauge, threaded into the manifold.

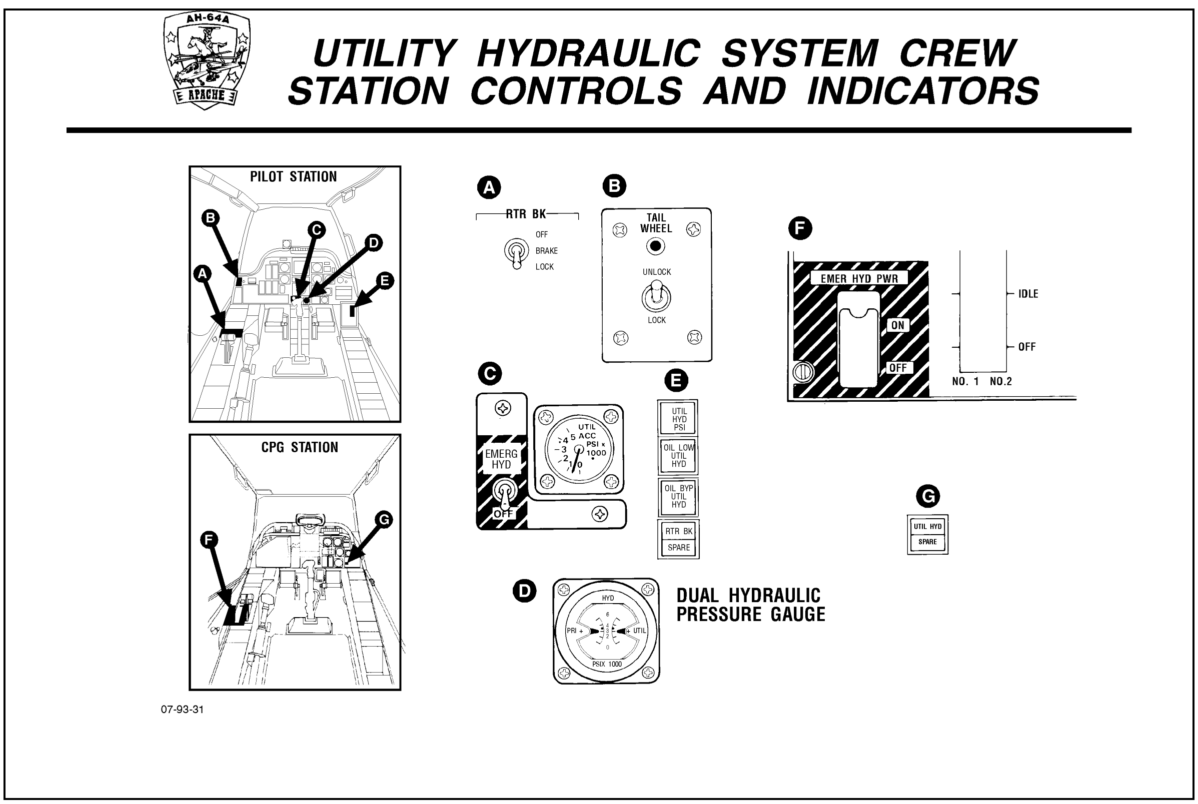
5) Nitrogen fill-bleed valve

a) Provides a means of charging or bleeding the gas reservoir and accumulator nitrogen pressure.

b) A standard schrader-type valve, threaded into the manifold.

d. To operate the utility hydraulic system with ground service equipment hydraulic power, connect the GSE to the panel assembly pressure and return quick-disconnect couplings.

e. Nitrogen servicing of the utility hydraulic accumulator is accomplished by connecting a GSE nitrogen source to the fill-bleed valve.



A. Utility hydraulic system crewstation controls and indicators

1. Rotor brake switch (RTR BK)

a. Allows the pilot to regulate utility accumulator pressure to stop the rotor brake disc, and trap pressure to maintain the disc in the non-rotating position.

b. A three-position switch (OFF, BRAKE, LOCK) located on the pilot's power lever quadrant on the left console.

c. For rotor brake operation, refer to the utility hydraulic manifold section of this lesson plan.

2. Rotor brake (RTR BK) caution light

a. Provides a visual indication of rotor brake, in either the brake or lock position.

b. A half-segment amber light located on the pilot's C/W/A panel on the lower right side of the instrument panel.

3. Tail wheel switch

a. Controls the application of pressurized hydraulic fluid to the tail wheel lock actuator, to lock or unlock the tail wheel.

b. A two position switch (UNLOCK and LOCK), located in the upper left side of the pilot's instrument panel. A green advisory light above the switch illuminates when the tail wheel is unlocked.

c. For tail wheel lock/unlock operation, see the tail wheel lock control valve and tail wheel lock actuator sections of this lesson plan.

4. Utility accumulator pressure indicator

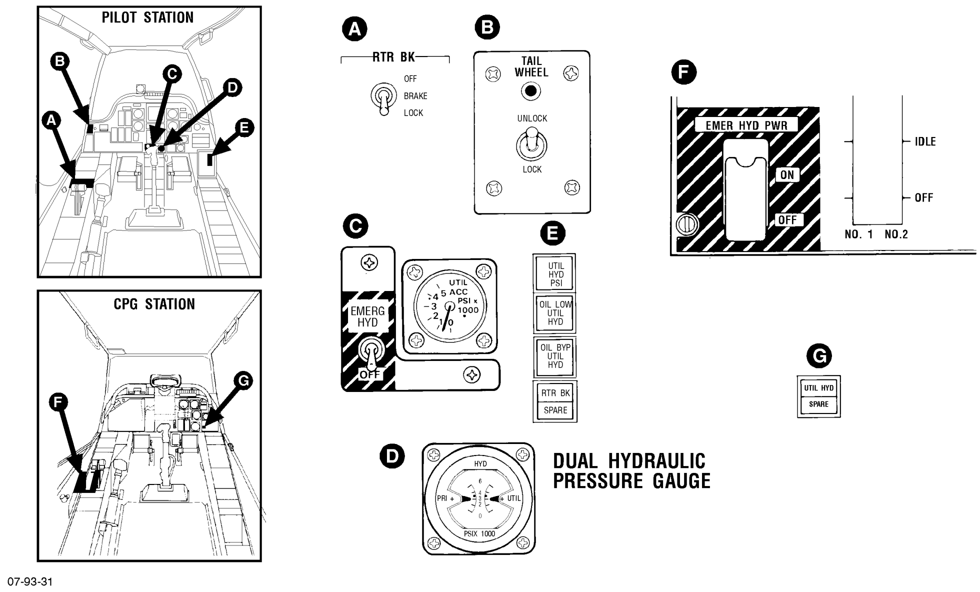
a. Provides a visual indication of the utility accumulator pressure.

b. Located on the center of the pilot's instrument panel, left of the dual hydraulic pressure gage.

c. Consists of a numbered, scaled dial (0 to 4) and a dial pointer. The dial shows pressure in thousand-pound increments.

d. Receives signals from the emergency hydraulic pressure transducer on the utility hydraulic manifold. The signals are proportional to hydraulic system pressure. Output is 1.37 VDC per 1000 psi. The transducer requires 28 VDC from the emergency bus for operation.

UTILITY HYDRAULIC SYSTEM CREW STATION CONTROLS AND INDICATORS



5. Emergency hydraulic (EMER HYD) switch

   a. Allows the pressurized fluid stored in the accumulator to be used for operating the flight control servoactuators.

   b. There are two switches. One is located on the center of the pilot's instrument panel, left of the utility accumulator pressure indicator, and the other is on the CPG's power lever quadrant on the left console.

   c. The EMERG HYD switches are two-position switches: EMERG HYD and OFF. The switch panels are high-lighted with yellow and black stripes.

6. Dual hydraulic pressure gauge

   a. Provides a visual indication of the primary and utility hydraulic system pressures.

   b. Mounted to the lower center portion of the pilot's instrument panel.

   c. The dual hydraulic pressure gauge is a dual-number, scaled dial with a pointer for each scale. Each number equals hydraulic pressure in thousands of pounds.

   d. Receives signals from a pressure transducer located on the utility hydraulic manifold. The signals are proportional to hydraulic system pressure. Output is 1.37 VDC per 1000 psi. The transducer requires 28 VDC from the emergency bus for operation.

7. Pilot's UTIL HYD PSI caution light

a. Indicates that the utility hydraulic system oil pressure is below 1250 psi, (illuminates at 1250 psi, decreasing, and extinguishes at 2050 psi, increasing).

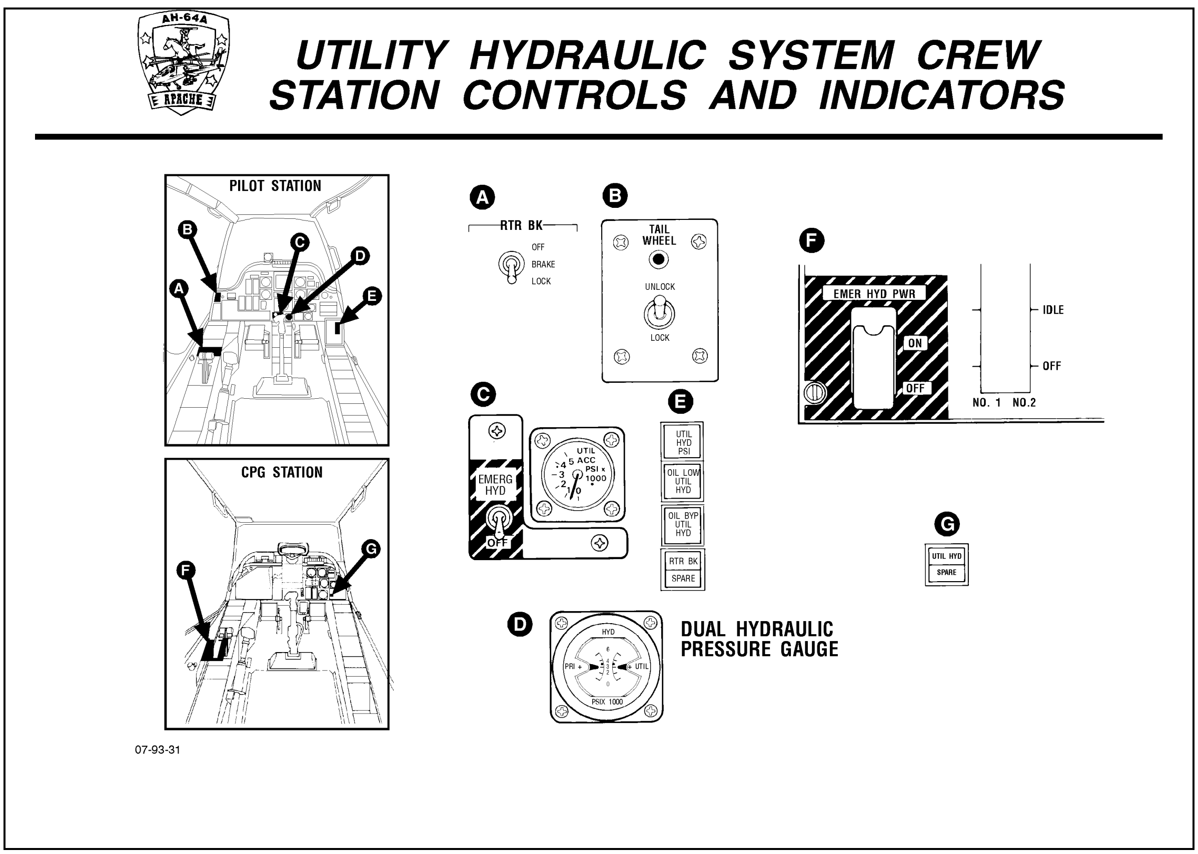
b. A full-segment amber light located on the pilot's C/W/A panel.

c. Illuminates when a pressure switch, located in the utility hydraulic manifold, closes and supplies a ground. Voltage for caution light operation is 28 VDC from the emergency DC bus.

8. Pilot's OIL LOW UTIL HYD caution light

a. Indicates that the utility hydraulic system fluid is at a minimum operating level (fluid level in the reservoir has decreased to 7.0 fluid ounces).

b. A full-segment amber light located on the pilot's C/W/A panel.



c. Illuminates when the low-level indicator switch, located on the utility hydraulic manifold, closes and supplies a ground. Voltage for light operation is 28 VDC from the emergency DC bus.

9. Pilot's OIL BYP UTIL HYD caution light

a. Indicates that a pressure differential of 70 " 10 psid has been detected in either the pressure or return filters of the utility hydraulic system.

b. A full-segment amber light located on the pilot's C/W/A panel.

c. Illuminates when either the pressure or return dirty filter switches (the switches are wired in parallel) on the utility hydraulic manifold, close and supply a ground. Voltage for caution light operation is 28 VDC from the emergency DC bus.

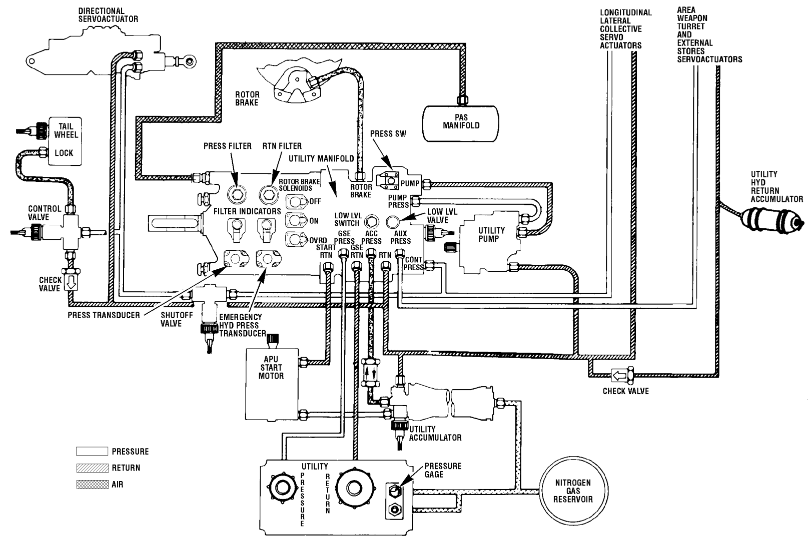
10. CPG's UTIL HYD caution light

a. Indicates that the utility hydraulic system oil pressure is below 1250 psi, (illuminates at 1250 psi, decreasing, and extinguishes at 2050 psi, increasing).

b. A half-segment amber light located on the CPG's C/W/A panel.

c. Illumination of the pilot's UTIL HYD PSI caution light causes the CPG's UTIL HYD caution light to illuminate also. Voltage for caution light operation is 28 VDC from the emergency DC bus.

UTILITY HYDRAULIC SYSTEM FUNCTIONAL DIAGRAM



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A. Utility hydraulic system operation

1. During normal operation, pressurized air (30 psi) from the PAS manifold enters the utility reservoir through a one-way air inlet check valve. The pressurized air acts upon the reservoir piston, creating low-pressure hydraulic fluid and helps prevent pump cavitation.

2. The air relief valve protects the air pressure-side by opening at 105 psi. The low-pressure relief valves open at 215 psi, relieving excess trapped fluid and air. A manual air bleed valve relieves reservoir air pressure during maintenance.

3. Should the reservoir fluid level reach the minimum permissible operating volume (7.0 fluid ounces), the low-level switch closes illuminating the pilot's OIL LOW UTIL HYD caution light, and actuates the emergency hydraulic shut-off valve. The low-level valve actuates causing all auxiliary functions to be turned off hydraulically.

4. The utility hydraulic pump is driven by the transmission accessory gear train at 12,635 rpm. Low-pressure hydraulic fluid is drawn from the reservoir to the utility hydraulic pump, by pump suction, pressurized to 3000 psi, then returned to the utility hydraulic manifold.

5. The high-pressure fluid returning to the manifold is sensed for pressure by the pressure switch and either illuminates or extinguishes the pilot's UTIL HYD PSI and the CPG's UTIL HYD caution lights.

6. The pressurized fluid is then filtered by a 5-micron filter (if MWO 1-1520-238-50-27 has

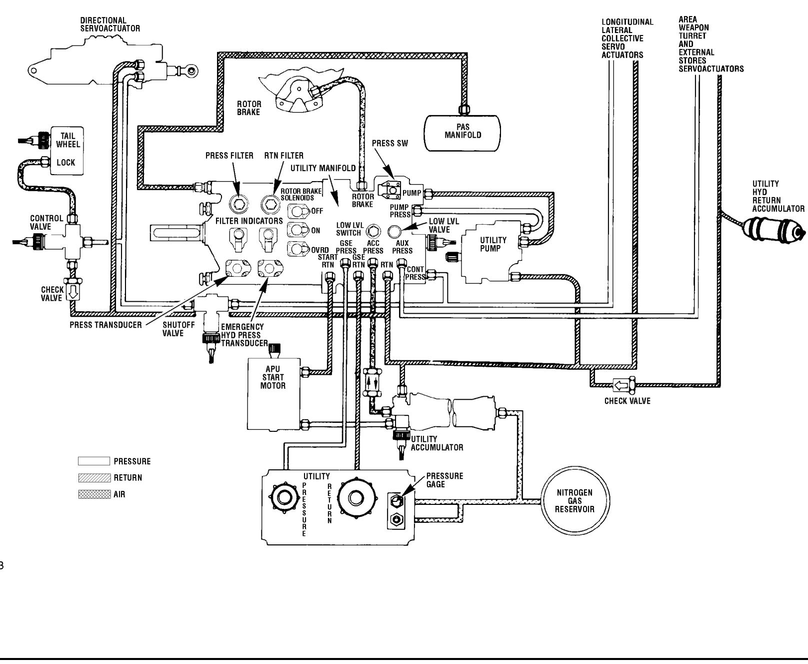
been applied). If the filter is partially clogged, the differential pressure of 70 " 10 psid is sensed by an electrical switch in the dirty filter indicator. The switch closes, causing the OIL BYP UTIL HYD caution light to illuminate on the pilot's C/W/A panel and the pop-up visual indicator on the manifold to extend.

7. Fluid is isolated from the GSE ports during normal operation by the GSE check valve.
8. A high pressure relief valve returns excessive pressure to the return side of the utility hydraulic manifold.

9. Fluid goes through the accumulator isolation inlet valve and replenishes the accumulator to 3000 psi after an APU start.

10. The rotor brake S1 solenoid is energized by placing the RTR BK switch in the BRAKE position. Opening of the solenoid permits 3000 psi into the brake circuit. With solenoid S2 closed, the brake metering valve permits 337 " 25 psi pressure to be routed to the rotor brake actuator. A rotor brake pressure switch actuates a throttle lock relay and illuminates the pilot's RTR BK caution light. The power lock relay also prevents the power levers from being advanced past the IDLE position.

UTILITY HYDRAULIC SYSTEM FUNCTIONAL DIAGRAM



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11. The override solenoid is opened by the pilot and CPG's EMER HYD switches. When open, the solenoid routes accumulator pressure to open the accumulator isolation valve, routing the accumulator's pressurized hydraulic fluid to the utility side of the flight control servoactuators in an emergency. The emergency hydraulic pressure transducer transmits the amount of pressure available to the UTIL ACC indicator. The pilot and CPG's EMER HYD switches are also used to deplete accumulator pressure before performing maintenance on the utility system.

12. Prior to output to the flight control servoactuators, the fluid pressure is monitored by the pressure transducer. The pressure transducer provides signals to the utility side of the pilot's dual hydraulic pressure indicator.

13. The manifold then distributes high-pressure hydraulic fluid to the utility hydraulic system components.

14. Fluid from the servoactuators is cooled by the heat exchanger (if installed) before returning to the utility hydraulic manifold.

15. Returning fluid is filtered by a 5-micron filter (if MWO 1-1520-238-50-27 has been applied). If the filter is partially clogged, the differential pressure of 70 " 10 psid is sensed by an electrical switch in the dirty filter indicator. The switch closes, causing the OIL BYP UTIL HYD caution light to illuminate on the pilot's C/W/A panel and the pop-up visual indicator on the manifold to extend. When a differential pressure of 100 " 15 psid occurs, a bypass valve opens and allows the unfiltered fluid to be routed around the return filter into the utility reservoir. After being filtered, the fluid returns to the pump.

16. The APU return port routes fluid from the APU start motor through a system- return filter screen and into the utility hydraulic reservoir.

17. During GSE operation, an AGPU sends high-pressure hydraulic fluid to the GSE pressure port. A flow-limiting orifice limits the flow rate to a maximum of 8 gpm at 3000 psi.

18. The GSE pressurized fluid is circulated through the manifold pressure filter, through the manifold and its components, and then out to the utility system components.

19. Fluid returning from the utility system components enters the manifold through the return port and is directed through the return filter.

20. The GSE return isolation valve allows the return fluid to travel back to the AGPU through the GSE return port.