PHASE 3

BASIC HYDRAULICS

AND

EXPEDITOR AIRCRAFT HYDRAULIC BRAKES

HYDRAULICS GENERALLY

Introduction to Hydraulics

Before the study of modern aircraft hydraulic systems can be attempted, an elementary knowledge of the characteristics, properties and behaviour of fluids must be understood, as well as the basic principles of hydraulics. Those which are pertinent are summarized below.

Definition

Hydraulics is the study of liquids at rest or in motion.

Fluids

A mass which offers small resistance to deformation and easily takes the shape of the body with which it is in contact. The two classes of fluids are:-

(a) Gases - fluids that can be compressed.
(b) Liquids - fluids that are relatively incompressible.

NB Liquids are compressible to a slight degree under tremendous pressure but as the pressures in aircraft hydraulic systems are comparatively low, for practical purposes they are considered incompressible.

Properties of Fluids

(a) Density - mass per unit volume
(b) Viscosity - the tendency of adjacent "layers" to adhere together or to a surface they contact.

(c) Inertia - Newtons three laws of motion apply to fluids:-

(i) Every body persists in a state of rest or of uniform motion in a straight line unless compelled by external force to change that state.
(ii) The rate of change of speed or direction of a body is proportional to the force causing it.
(iii) For every action (or force) there is an equal and opposite reaction.

Fluids are considered to be perfectly elastic.

Pascal's Principle

Pressure exerted anywhere on a confined liquid is transmitted instantly and undiminished to every portion of the interior of the containing vessel and at right angles to all surfaces that the liquid contacts.

Difference between force and pressure. Force is the total "push" or "pull" per unit area (square inch). Practical application of Pascal's principle to gain mechanical advantage - by applying a force to a small piston, pressure being transmitted to a larger piston creates a greater force on the larger piston.

Flow of Fluid

There are two main types of fluid flow, there being an abrupt transition between the two.

(a) Lamina flow - at slow speeds the particles move in parallel layers and the shearing action is equal between the adjacent layers. The speed increase uniformly toward the centre of the stream.

(b) Turbulent flow - beyond a certain critical speed, mixing turbulence takes place in the stream, the particles no longer move in parallel layers but back and forth across the containing pipe line. The result is a more nearly uniform speed across the stream.

Resistance to flow - the factors that create resistance to a fluid flowing through a pipe line are:-

(a) Viscosity - resistance to shear both within the liquid and between the liquid and the walls of the containing pipe line.

(b) Inertia - resistance to changes in speed and direction.

With turbulent flow there is a greater shearing velocity between the liquid and the walls of the pipe line than with lamin flow, constantly and increase in resistance. Resistance increases with velocity.

Thus in an aircraft hydraulic system, roughness within the pipe lines and units, sharp bends in pipe lines and sudden changes in section should be decreased to a minimum.

Bernoulli's Principle

If the velocity of a fluid is increased, the pressure is decreased proportionately and vice versa.

Henceforth, when the word "fluid" is used it will mean "liquid" as the liquids used in hydraulic systems are commonly known as Hydraulic Fluids.

Hydraulic Fluids in common use are light oils which are divided into two classes:-

(a) Those having a vegetable oil base, 34A/169 (usually castor oil to which some type of alcohol is added to decrease the viscosity). This type is to be used in systems containing natural vulcanized rubber glands and flexible connections.

(b) Those having mineral oil base, 34A/100 (distillate of Petroleum). This type is to be used in systems containing synthetic rubber glands and flexible connections.

These two types can be differentiated by colour, tests and smell. The correct fluid to be used in any hydraulic system is specific in the appropriate aircraft publication.

DIFFERENT FLUIDS MUST NOT BE MIXED UNDER ANY CIRCUMSTANCE as a harmful sludge will result and damage to the flexible parts will occur. Neither must the wrong type of fluid be used as damage to the flexible parts will be the result.

The colour, specifications and reference numbers may be amended at any time, but current information is always contained in EO45 - 15A series.

Requirements for all fluids used in aircraft hydraulic system:-

(a) Low expansion and contraction rate.
(b) Lubricant for moving parts
(c) Non-injurious to materials in the system.
(d) High boiling point and low freezing point.

Hydraulically operated components:-

(a) Retractable undercarriages and tail wheels.
(b) Landing flaps.
(c) Bomb-bay doors and retractable bomb carriers
(d) Gun turrets.
(e) Cowling gills and radiator shutters.
(f) Wheel brakes.
(g) Landing lamps.
(h) Latch pins of aircraft with folding wings, etc.

Advantages of hydraulic operation:-

(a) Many services can be operated from a common power source.
(b) Base of operation by the operator.
(c) Immediate action (if the system is free of air).
(d) Frictional loss within the system is negligible.
(e) Low inertia of parts within the system.

Glands

There are two types of hydraulic glands; they are natural and synthetic rubber. Vegetable oil is used when glands are made of natural rubber; mineral oil is used when glands are made of synthetic rubber. Glands come in various shapes. The shapes commonly used are as follows:

(a) O (round ring)
(b) V (chevron)
(c) U (cup-shaped)
(d) (square-shaped)

REMEMBER

In using hydraulic fluids E.O.'s must be adhered to at all times. Natural rubber glands must not be used in systems using mineral oil.

Simple Hydraulic System

A brief description of a simple hydraulic system follows. A minimum number of components are included merely to demonstrate how fluid can be used to transmit energy and do useful work.

(a) Header Tank (Reservoir, supply tank, storage tank, etc)

Fluid is not consumed during the operation of the system. A tank is fitted for the following reasons:-

(i) Provides storage space for the fluctuation of fluid level due to excess fluid during the retraction of the jacks.
(ii) Accommodate thermal expansion of the fluid in the system.
(iii) It provides a convenient means of filling the system.

(b) Hand Pump

A mechanism to supply pressure to the system when manually operated.

(c) Hydraulic Jack (actuating cylinder)

This unit converts the hydraulic force exerted by the pump mechanical work. The component to be operated may be attached either directly to the jack ram-rod, or indirectly through a suitable link.

(d) Control Valve (selector valve, four-way valve, distributor valve)

This provides a means whereby fluid under pressure from the pump may be directed to either end of the jack to give the desired movement. Simultaneously the opposite end of the jack is communicated to a line returning to the header tank, which provides a free passage for the fluid being expelled.

(e) Pipe Lines

Feed Line - between the header tank and the pump
Power line - between the pump and the control valve
Return line - between the control valve and the header tank
Up and Down lines - between the control valve and the jack

NB: The up line is the line between the control valve and jack which is under pressure when the component is being raised and similarly for the down line when the component is being lowered. The mechanical linkage between the jack and component is the deciding factor.

Systems similar to the simple one just described may be used on smaller aircraft but on larger aircraft it is more practicable to operate more than one service. To operate such services by the hand pump would place a severe strain on the pilot or other operator (crewman). To overcome this a supplementary source of power is provided usually in the form of an engine driven pump. The addition of this pump introducing problems not present in the simple system. These problems will be discussed in the following section, e.g. the basic system.

Basic Hydraulic System

A basic hydraulic system is shown in Fig. 4. Comparison with the simple system will show the additions. This system is not intended to be proof against all contingencies, but will include all the necessary fundamental components for the correct operation of a modern hydraulic system.

Brief Description of the paths of fluid in the system

The engine driven pump draws fluid from the reservoir and forces it into a line. Resultant pressure in this power line is determined by the least resistance offered to flow, since fluid invariably flows the part of least resistance.

When work is required to be done, the control valve will direct fluid to the desired end of the jack and at the same time communicate the flow from the opposite end with the return line leading to the reservoir. The jack, suitably linked to the component, converts hydraulic energy to mechanical work by moving the component.

Upon completion of component travel, further flow of liquid into the jack is impossible, (liquid being incompressible), consequently an alternate route is provided through the pressure relief valve (main relief valve). This valve limits the pressure that the pump can produce within the system.

A continuous flow through this valve would result in excessive wear on the E.D.P., as well as in useless consumption of horsepower. To obviate these conditions, a power valve is installed, which, when opened, allows a flow from the pump back to the supply tank against little resistance.

To prevent undesired movement of components (the result of escape of fluid from the jacks to the return line), a non-return valve is fitted to trap the fluid in the jack. A hydraulic lock is thus obtained.

Fluid, like most substances, will expand if subject to increased temperatures. Such an increase in volume would result in dangerous pressure in the lines, therefore thermal relief valves are incorporated. These relieve to the return line to circumvent such a possibility.

Components - Functions and Facts

(a) Header Tank

This differs from that in the simple system only in the presence of a reserve supply of fluid for the hand pump, in the event of fluid escaping from the E.D.P. or the lines connected to it. This is accomplished by:

(i) Stacked pipes.
(ii) Baffle plate.
(iii) Disposition of pipe lines at the side of the tank.

Methods of ensuring continued atmospheric pressure within the tank are:-

(a) Vent pipe
(b) Breather valve.

NB: On some high altitude aircraft, air is pumped into the tank from an external source, and is relieved or exhausted to atmosphere through a relief valve with a fairly low setting - two to twenty psi - thus ensuring a supply tank pressure slightly above atmospheric pressure.

A filter is usually fitted to the filler neck to ensure cleanliness of the liquid during filling. Frequently too, the returning liquid is compelled through a filter.

(b) Engine Driven Pump

On almost all aircraft the power pump is driven directly by the engine, consequently, a continuous flow is maintained within the system while the engine is running. Blockage of this flow for even an instant will result in immediate damage to the system. THIS FACT CAN NOT BE OVEREMPHASIZED and must be firmly grasped.

Types of pumps in use are:-

(i) Gear
(ii) Multicylinder (plunger)
(iii) Rotary Annular Displacement

Requirements of a good EDP are:

(i) Must provide a steady, even, flow of liquid.
(ii) Must sufficiently cater to the needs of the system at low engine speeds.

NB: These ensure that the components will operate smoothly and not in a series of jerks, and that when the aircraft is approaching for a landing, the reduced delivery from the pump will operate the components with reasonable speed.

(c) Hydraulic Jack

A mechanism for converting hydraulic energy to mechanical movement. Fitted either directly or otherwise to the components.

(d) Control Valve (Selector valve, four-way valve, distributor valve, etc)

Communicates:

(i) Power line with the desired end of the jack.
(ii) Simultaneously, the opposite end of jack to the return.

Types of control units in use.

(a) Rotary
(b) Plunger
(c) Poppet (or combination thereof).

To obtain independent movement of components, a separate control valve is fitted for each service operated. However, these valves may all be embodied in one casting.

The operating levers are located close to the person responsible for a particular operation (pilot, flight engineer), and are usually instructive in operation. N.B. The U/C CONTROL LEVER has a SAFETY LOCK to ensure that no UP SELECTION is made without first releasing the safety device.

A component (e.g. flaps) may be stopped in an intermediate position by placing the control valve in neutral when the desired position is reached. This action usually forms a hydraulic lock.

(e) Pressure Relief Valve

This valve is incorporated to limit pump pressure. It is a heavily spring-loaded valve found in a communication between the power line and one which leads directly to the tank, usually the main return line.

Its spring loading is:

(i) Greater than the highest expected working pressure.
(ii) Less than a damaging pressure.

NB: This valve determines the greatest pressure that can be exerted in the system BY THE PUMP(S).

(f) Power Valve

A mechanism found in communication between the power line and the main return line. The function is, when open, to create an IDLE CIRCUIT, and when closed, a POWER CIRCUIT.

By creating an idling circuit when work has been completed by enabling the pump to drive liquid back to the tank against little resistance instead of the resistance of the pressure relief valve, the power valve thus:

(i) Prevents excessive wear of the EDP.
(ii) Conserves horsepower.

The power valve may be operated in one of three ways:

(i) Manually
(ii) Automatically
(iii) Semi-automatically

(Most modern power valves are completely automatic).

NB: WORK CAN NOT BE DONE WHILE THE POWER VALVE IS OPEN.

(g) Non-Return Valve

The mechanism usually responsible for this condition is a NON-RETURN VALVE, though the job could be done just as easily, but not quite as efficiently, by a plunger or similar blocking arrangement.

(h) Thermal Relief Valves

Relieves excessive pressures resulting from expansion of the liquid in a locked line due to increased temperature. These valves relieve from the line that is locked to a line that can not possibly be locked, e.g. the main return line.

(i) Head Pump

These pumps are almost invariably double action pumps, with low output requiring a minimum of physical effort from the operator.

Its functions are:-

(i) To provide an emergency means of operation in the event of EDP failure.
(ii) To facilitate ground maintenance without running a/c engine(s).

(j) EDP Power Line Non-Return Valve

This valve always exists in the power line to prevent back pressure from the head pump. It ensures the use of the hand pump power line. They are usually found at the junction of the two power lines.

(k) By-Pass Valve

To prevent damage to component structure due to excessive wind (airflow) loads. The components likely to be affected are landing flap and bomb-bay doors. The valve permits escape of liquid from the down or open side of the jack into either the up or return lines, thus allowing the component to move up when subject to excessive air pressure.

(l) Restrictor Valves

These valves restrict the pipe orifice, thus retarding liquid flow. There are two types:

(i) One-way restrictor.
(ii) Two-way restrictor.

They are fitted for three chief reasons:

(i) To prevent a heavy component falling too rapidly under influence of gravity, in which case the restrictor valve would be fitted to the up-line. (A side-ways retracting undercarriage is a typical example).
(ii) To prevent the rapid movement of a component operated by a small jack when large jacks are used for the other units (landing lights may be cited as an example). Only part of the total pump delivery is allowed into the jack; the rest must return to the tank through a by-pass or relief valve.
(iii) To prevent damage to a pressure gauge which would result from sudden pressure surges. A great restriction is used for this purpose.

(m) Filter

Frequently a filter is installed in the system, usually in the main return line, the fluid, being compelled through the unit, is thus filtered, any foreign matter being extracted, and falling to the bottom of the unit for easy removal.

(n) Pressure Gauge

This is fitted to the power line and is usually mounted on the pilot's instrument panel. The function is to inform the responsible person (pilot, crewman) of the existing pressure in the power line.

Summary - General

All the above may be found in separate units, but is usual to find several embodied in one mechanism. No uniformity of type exists, the mechanisms are as varied as the aircraft on which they are found. The unit responsible for the performance of each function in a hydraulic system must be understood before it can be claimed that the system is known.

TYPICAL HYDRAULIC SYSTEM

1 A typical hydraulic system is obtained by the addition of components and services to the basic hydraulic system. The diagram illustrates the various components and services added.

2 Services added are:

(a) Flap service.
(b) Undercarriage service.
(c) Brake service.

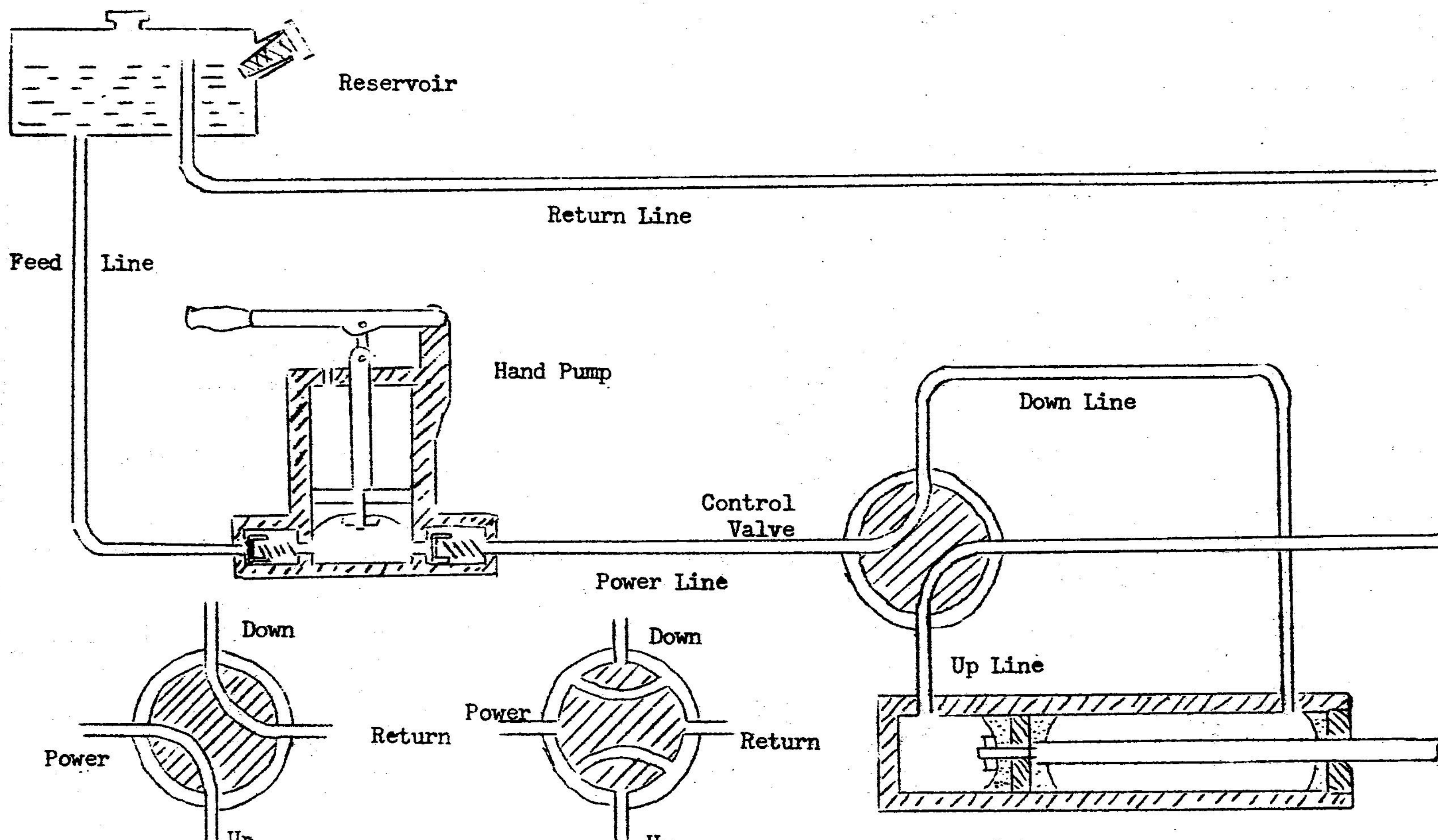
3 Automatic Power Valve

(a) Purpose:

(i) to give a power and idling circuit automatically.

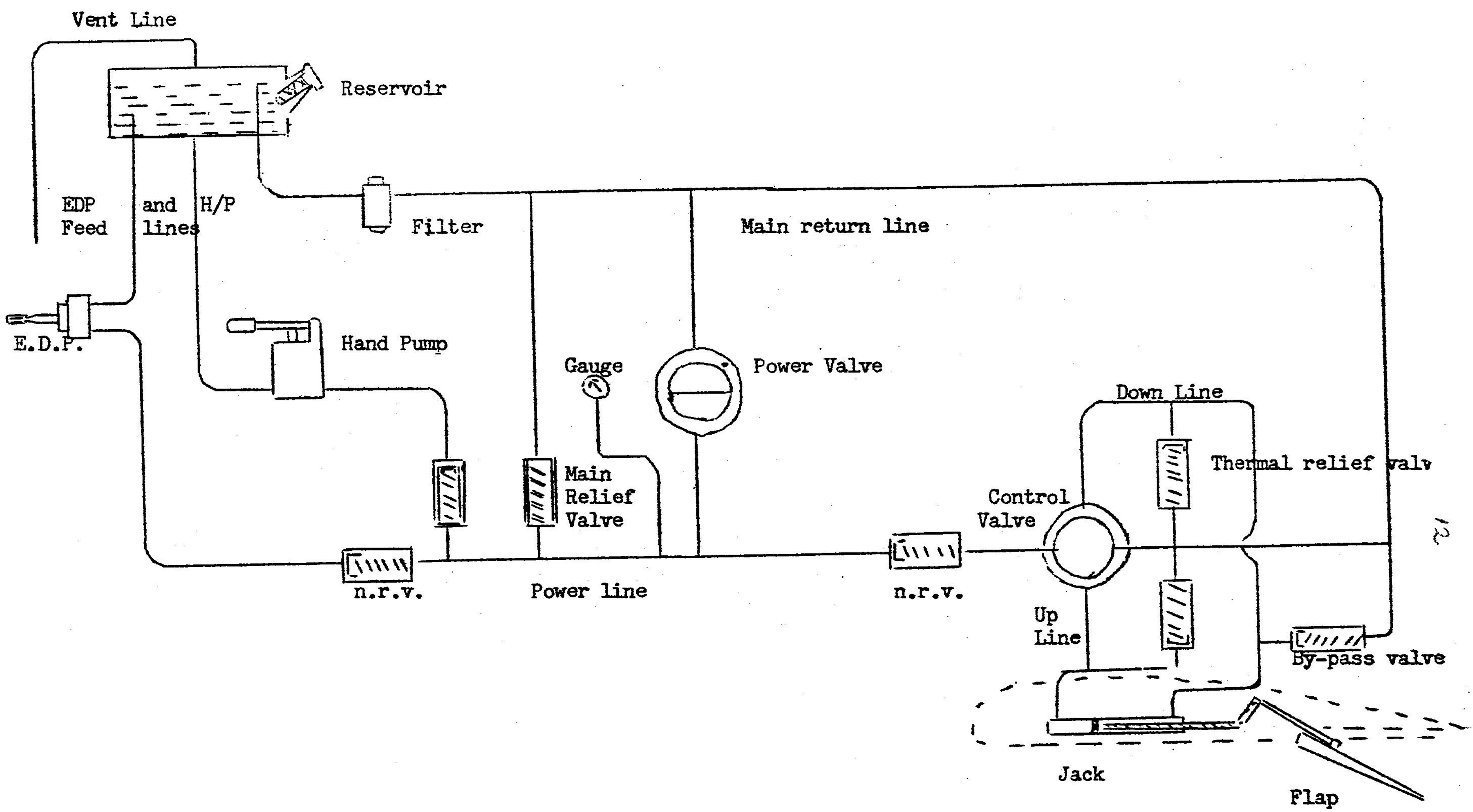
(b) Description:

(i) Three port housing, pressure inlet, pressure outlet and return port.
(ii) Housing contains drilled internal passage for fluid.
(iii) Within the housing is a spring loaded piston and plunger assembly.
(iv) Upper portion of the housing contains a spring loaded by-pass valve assembly and check valve.
(v) By-pass valve has an adjustable rod.



Control Valve in UP selection

Control valve in neutral


Vent Line
Reservoir
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and lines
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Main return line
E.D.P.
Hand Pump
Gauge
Power Valve
Down Line
Main Relief Valve
Thermal relief valv
Control Valve
n.r.v.
Power line
n.r.v.
Up Line
By-pass valve
Jack
Flap
12

(c) Operation:

(i) Automatic power valves are designed to cut in and cut out a power circuit automatically at pre-determined pressure. (For the purpose of describing the operation of this valve we will use random pressures of 700 psi for cut-in and 1000 psi for cut-out).

(ii) The automatic power valve in the illustration is in a power circuit with fluid entering the pressure inlet, passing around the by-pass valve and out the pressure outlet to the system services.

(iii) When the service is in operation, pressure is felt back through the automatic cut-out and down through the transfer drilling to bottom of the piston.

(iv) The piston begins to move upwards under the influence of hydraulic pressure.

(v) When the piston is started upwards the effective pressure area is increased, therefore the force is increased on the piston.

(vi) Main spring compresses until the plunger reaches the bypass valve adjustment screw.

(vii) The piston spring and the plunger spring continue to compress under the influence of hydraulic pressure until they overcome fluid pressure on top of the by-pass valve. Fluid pressure now is 1000 PSI.

(viii) By-pass valve opens.

(ix) Fluid pressure escapes past the by-pass valve to the return port.

(x) The check valve closes, trapping fluids between the bottom of the piston and the system services at a pressure of 1000 PSI holding the piston up.

(xi) The plunger will hold the by-pass valve open until the pressure in the system drops to 700 PSI, because of the absence of fluid pressure on top of the by-pass valve.

(xii) As the system pressure drops, the piston moves down, the plunger spring reseats the by-pass valve. This action occurs at a pressure of 700 PSI in the system.

(xiii) The by-pass valve closes and fluid opens the check valve allowing pressure to go to the system. Cycle repeats as pressure rises and falls.

(d) **Pressure Adjustments:**

(i) Remove the by-pass valve cover.

(ii) Screw the pressure adjusting screw out to increase the pressure and in to decrease the pressure.

(iii) Replace the by-pass valve cover

4 Accumulators

(a) Definition:

(i) An accumulator may be defined as a storage tank for fluid under pressure.

(b) Description:

(i) Consists of steel tanks of various shapes divided into chambers by diaphragms, floating pistons or other devices.

(c) Operation:

(i) One chamber within the tank supported to the main pressure line of hydraulic system (fluid chamber)

(ii) The other chamber contains a compressible element, such as air or springs.

(iii) When fluid enters the fluid chamber it exerts pressure on the diaphragm or piston, forcing it towards the opposite end.

(iv) As the volume of fluid in the fluid chamber increases it gradually compresses the air or spring, thereby gradually increasing the pressure.

(v) Pressure is thus effectively stored. (The springs are compressed, exert pressure on diaphragm or piston, which is in turn felt on the hydraulic system).

(d) Uses:

(i) Stores a supply of fluid for the system under pressure, thereby supplementing the hydraulix pump.

(ii) Supplies a limited amount of fluid under pressure of emergency use.

(iii) Damps pressure surges and absorbs fluid shocks by allowing the pressure to increase and decrease gradually.

(iv) Prevents too frequent cut-in and cut-out of pressure regulator, thereby saving wear on the pump.

(v) Caters to thermal expansion by absorbing the increases in volume of fluid due to thermal expansion.

5 Floating Piston Type Accumulator

(a) Description

(i) Outer cylinder
-Seamless steel

(ii) End Caps
- Forged steel
- Threaded into each end of cylinder
- Sealing washers to prevent leakage around end caps
- Port in the lower end cap is connected to main pressure line.

(iii) Piston

- a floating piston divides the cylinder into two compartments.
- necessary glands to prevent the intermiting of air and oil.

(iv) Air Valve Assembly.

(b) Operation

(i) Accumulator is charged with compressed air (to specified pressure).

(ii) When hydraulic pressure builds up, fluid enters the lower compartment of the accumulator, moving the piston upwards compressing the air further. When hydraulic pressure decreases the air pressure will force the piston downwards, displacing fluid.. The air pressure will be felt on system until all hydraulic fluid is displaced from accumulator.

6 Pressure Gauge

(a) Purpose

(i) To indicate pressure in the system.

(b) Operation:

(i) Pressure from system or the air pressure from the accumulator is directed to a bourdon tube (a spring tube of semi-circular shape). As the outer area of the tube is greater than the inner area, the force will be greater on the area, thus the tube will move (straighten out). The amount of pressure applied will govern the movement of the tube.

(ii) This movement of the bourdon tube moves a link and sector which is geared to a small rotating shaft.

(iii) A pointer is attached to the rotating shaft and will indicate, on the dial, the pressure in the tube.

(iv) A small hair spring returns needle as pressure drops.

7 Snubber Valve

(a) Purpose:

(i) To even out pressure surges to a gauge.

(ii) Prevent unnecessary oscillation of the gauge indicating needle.

(b) Description:

(i) Two port housing, pressure inlet and pressure outlet.

(ii) Inside the unit are two floating pins free to move up or down a small amount.

(c) Operation:

(i) Pressure enters the snubber valve and travels up the vertical drilling (A), tending to raise the floating pin (A), in diagram.

(ii) Gravity, however, is acting downwards on pin A so that sudden surges are slowed down.

(iii) Pressure now travels down drilling (B) where pin (B)in diagram, particularly restricts its flow further, smoothing out the surge of pressure.

(iv) Surges of fluid in the opposite direction are slowed down in the same manner.

(v) This action prevents damage to delicate gauges and prevents oscillation (rapid back and forward movement) of gauge indicating needle.

8 Flap Service

(a) Check Valve

(i) To isolate the flap service from the rest of the system.

(ii) Permits a flow in one direction only.

(b) One Way Restrictor

(i) Restricts flow in one direction, and permits free flow in opposite direction.

(ii) The restrictor valve installed between the MRV and the control valve restricts the flow of fluid for both up and down lines, as the fluid is restricted before going to either selection. The fluid flow is through the MRV to the control valve, to be considered a free flow.

(c) Control Valve

(i) Hand operated

(ii) Three positions:
- up
- down
- neutral

(iii) Neutral position permits pilot to stop the flaps at any degree desired.

(d) Thermal Relief Valves

(i) Permits flow of fluid from up and down lines to return line when thermal expansion occurs, thereby relieving pressure.

(ii) Spring loaded valves set to open at pressure higher than normal operation pressure of the hydraulic system. (highest spring loading in the system).

(e) By-Pass Valve

(i) Located between down and up line.

(ii) Spring loaded valve which allows the flaps to move up if, in a down selection, excessive air pressures are encountered. Thus preventing damage to flaps and linkage.

(f) Flap Service Actuator

(i) To raise or lower the flaps.

(ii) Single piston, double ram rod, two port jack. Used where it is necessary to have two separate components which are in line with each other, operate in unision from one actuating jack.

(iii) Cylinder housing.
-With one port at each end of the cylinder (up and down ports). One port allows pressure in for operation of piston, the other allows return fluid to go to the return. The cylinder housing is attached to the aircraft structure.

(iv) Double Ram Rod
- Passes completely through the cylinder housing, and each end is attached to push-pull rods and universal joints, which move the component to the desired position, according to the selection made. Installed around the ram rod at either end is the packing ring (seal or gland) to prevent leakage of the hydraulic fluid as the ram rod moves through the cylinder.

(v) Piston
- The piston attached to the centre of the ram rod in the cylinder housing, moves the ram rod as pressure is directed to either side of it. Glands or seals are attached to the piston, to prevent the fluid from leaking past, thus maintaining pressure and efficient operation of the jack.

(vi) Operation
- The direction in which the jack moves (i.e. port or stbd) is controlled by the selector valve, which directs the fluid under pressure through the ports to one side of the piston or the other. At the same time the displaced fluid from the opposite side of the piston is directed through the ports back to the reservoir through the selector valve.

- A component may be raised or lowered by the movement of the ram rod to the port or starboard. Mechanical linkage, which consists of pushpull rods, universal joints, link rods and swivals, transmit this movement to the component.

9 Undercarriage Service

(a) Check Valve

(i) To isolate the landing gear service from the main system.

(ii) Permits fluid flow in one direction only.

(b) Control Valve

(i) Directs fluid under pressure to desired end of jack and connects opposite end to return.

(ii) Does not usually have a neutral position.

(c) Thermal Relief Valves.

(i) Relieve pressure due to thermal expansion.

(ii) When pressure in hydraulically locked lines becomes excessive due to thermal expansion, spring loading of valves is overcome and fluid flows to return line.

(d) One-Way Restrictor

(i) Situated on up line on landing gear service.

(ii) Restricts return flow in down selection, thereby slowing down landing gear extension.

(iii) Helps reduce cavitation caused by too rapid extension of jack in down end of actuating cylinder.

(e) Actuating Cylinder

(i) Single piston, single ram rod, two ports.

(ii) One or two for each landing gear, depending on size of undercarriage.

(f) Line to Gravity Feed.

(i) Produces a ready supply of fluid gravity fed from reservoir to prevent cavitation in down end of jack, when landing gear lowers rapidly.

(ii) Incorporates a check valve.

(g) Cross Flow Valve (not used on typical system)

(i) To prevent cavitation in down end of jack on rapid lowering of undercarriage.

(ii) Eliminates the need for gravity feed line for undercarriage down line.

(iii) On some aircraft it is attached to and forms part of the actuating cylinder.

(iv) Operation
- Work is in conjunction with actuators which retract to lower landing gear.
Up selection - fluid enters port "B", moves restrictor to the left and free flows out port "A".
Down selection - fluid from up end of cylinder is forced out port "A", moves piston and restrictor to the right, as fluid is demanded by the down side of the cylinder. The check valve unseats and fluid flow is from port "A" to port "C". When the pressure in the down line reaches its maximum pressure, the check valve is seated and the remainder of the returning fluid flows through the restrictor out port "B".

10 Brake Service

(a) Check Valve

(i) To isolate brake service from main power system.

(ii) Permits flow, one way only.

(b) Accumulator

(i) To store fluid under pressure for brake operation.

(ii) It incorporates a gauge to indicate accumulator pressure and an air charging valve.

(iii) Initial air charge (the accumulator is charged with air to be specific air pressure with no hydraulic pressure in the system.

(c) Snubber Valve and Gauge

(i) Purpose:

Meters a controlled amount of pressure from the main hydraulic system, or accumulator, to the brake units.

(ii) Description:

The brake valve may be a compound unit containing two control valves in the same housing and having a common pressure and a common return line, or it may have a separate control valve unit for each wheel.

(iii) Brakes - Off Operation

System pressure entering inlet port is stopped at pressure valve which is held in closed position by spring acting on sliding valve. Return valve is open, allowing fluid pressure from brake assembly to port to return.

(iv) Brakes - On Operation

As load is applied to the brake pedals, it is transferred to the operating plunger.

The plunger moves, impressing the return spring and the balance spring.

The balance spring moves the sliding valve, opening the pressure valve, allowing fluid pressure to the brakes.

The fluid pressure to the brakes is felt through the drilling to the ball type return valve. When fluid pressure exceeds the tension of the balance spring, fluid is ported to return through return valve until pressure equals tension of spring.

PURPOSE AND REQUIREMENTS OF BRAKES

1 Purpose:

(a) Shorten landing and take off run.
(b) Taxiing.
(c) Parking of aircraft.

2 Requirements

(a) Progressive Braking

(i) Off position to fully on gradually.

(b) Differential Braking

(i) Ability to apply either left or right brake individually.

(c) Parking Brakes

(i) Leaving brakes in the applied position to hold aircraft while running up or parked on the line.

(d) Equal Brakes

(i) Must have equal braking power on all wheels to prevent ground loops, etc.

3 Methods of Application

(a) Mechanical:

(i) Used on light aircraft
(ii) Consist of a set of brake control cables that connect the brake toe pedals with the actuating units of the wheel brake shoes.

(b) Hydraulic:

(i) Use on most modern day aircraft.
(ii) Use the principal of hydraulics to connect the brake toe pedals with the actuating units of the brake shoes, expander tube on disc type brake.

(c) Pneumatic

(i) Use the principal of compressed air to connect brake pedals to the expander tube of the brake unit.

4 Brake Materials. Braking action is brought about by using two dissimilar materials so they will not fuse together from heat generated by braking action.

(a) Steel and its alloys:

(i) Used for brake drums

(b) Asbestos Composition

(i) Used for brake shoes and blocks

(c) Resin Impregnated Fibre

(i) Used for brake shoes and block

5 Types of Wheel Units

(a) Internal Expanding Shoe Brake.

(i) The One-Way or Single serve
- Single piston, single shoe.
- Operated either mechanically or hydraulically.

(ii) Two Way or Duo Serve.
- Double piston single shoe
- Double piston double shoe
- Operated either mechanically or hydraulically.

(b) Expander Tube or Block Brake

(i) Consists of four main parts
- Brake frame
- Expander tube
- Return springs
- Brake Block

(ii) Operated either hydraulically or pneumatically.

(c) Multi Disc Brakes

(i) Consists of alternate discs with brake linings riveted to both sides and steel discs or rings that are sandwiched in a metal casing. One set rotates with wheel while remaining hold stationary by brake unit.

6 Serve Action

Serve action when applied to brakes refers to the use of the rotary motion of the brake drum to apply the shoes more effectively.

(a) Single Serve Brakes:

(i) Serve action is effective for one direction of wheel rotator.

(b) Duo Serve Brakes:

(i) Operates and may be adjusted to give serve action in either direction.

HYDRAULIC BRAKES - EXPEDITOR AIRCRAFT

Wheel Brake Assembly.

The single disc brake assembly, on each main landing gear wheel, consists of two parts, the housing assembly attached to the axle and the disc driven by the wheel. The housing assembly contains three pressure cylinders, each equipped with a piston assembly and movable circular segment linings. As the brake pedals are depressed the hydraulic fluid pressurizes the cylinders simultaneously, causing the pistons in the cylinders to press the linings against the disc. The disc is forced laterally against the stationary circular segment linings on the opposite side of the housing, causing braking action on the disc.

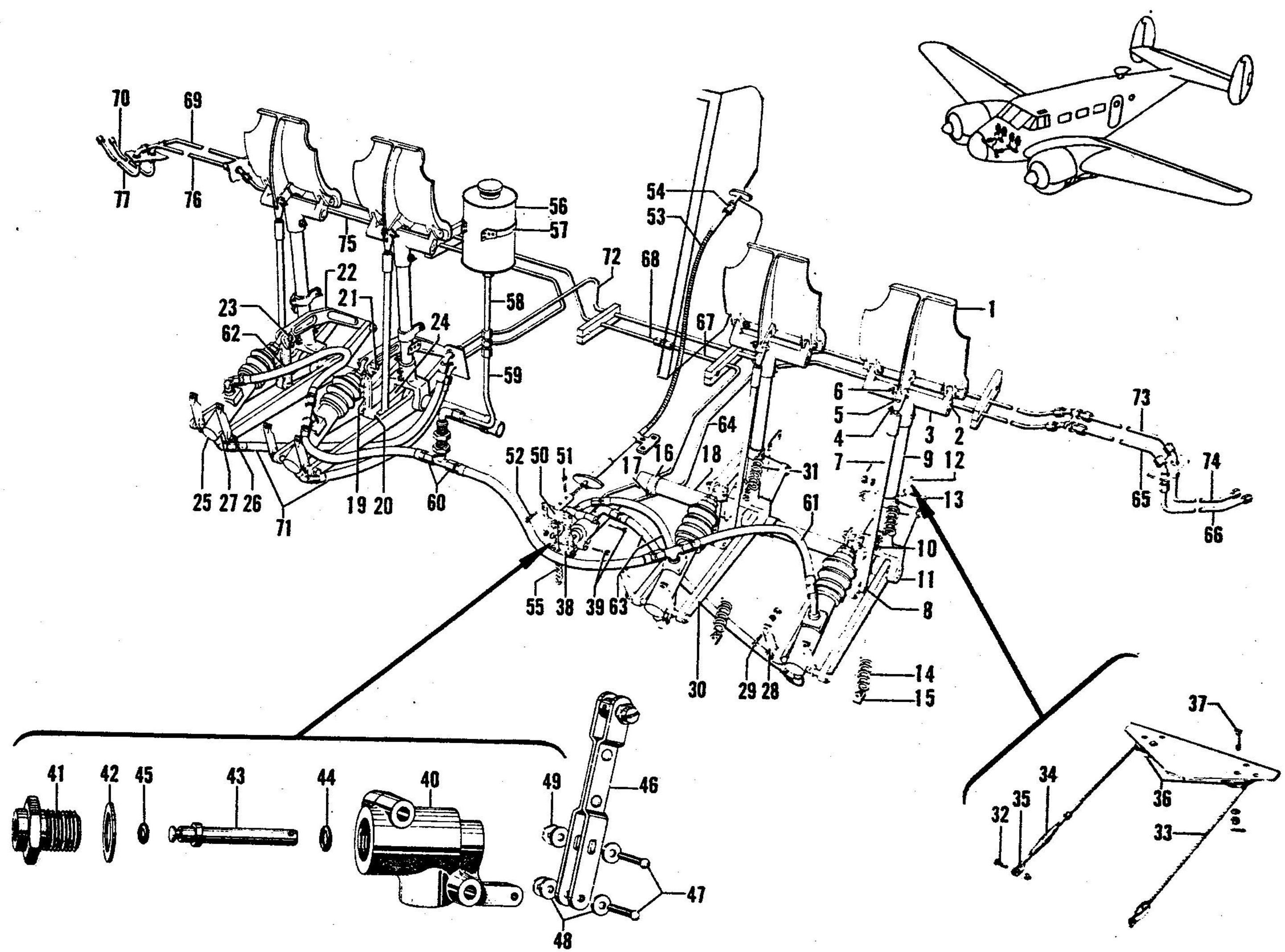
Minor Repairs and Parts Replacement

1 Glazed brake linings slightly worn, are considered serviceable.

2 All seals and rubber O rings should be replaced if damaged, shrunk or leaking.

3 Replace brake linings if excessively worn. The brake lining wear is indicated by the position of the adjusting pin. Excessively worn linings are indicated when the adjusting pin is nearly flush with the adjusting pin packing nut. If 3/8 inch or more clearance exists between the outboard housing and the centre disc of the brake with the brakes applied, the inboard linings are considered unsafe for further service and must be replaced.

4 The steel disc should be replaced if it is warped or dished.



Dual Brake System Installation

1 Pedal - rudder and brake
3 Hanger - rudder pedal
5 Terminal - brake rod upper
7 Rod assembly - brake
9 Support Assembly - rudder pedal LH and RH
11 Yoke Assembly - rudder pedal LH and RH
12 Link - pilots cable extension
14 Spring - pilots pedal balance
15 Clip - pilots pedal balance spring
16 Collar - rudder pedal cross shaft
18 Shaft - pilots rudder pedal cross
19 Link - brake master cylinder actuating
22 Link - brake master cylinder actuating mechanism LH and RH
24 Bellcrank Assembly - master cylinder actuating
25 Cylinder Assembly - brake master
28 Support - pilots brake linkage
30 Support Assembly - brake master cylinder
33 Cable Assembly - brake balance
34 Barrel
35 Fork
36 Pulley
38 Valve Assembly - parking brake
40 Body - parking brake valve
41 Seat - valve
42 Gasket - valve seat
43 Piston - parking brake valve
44 Seal - O ring
45 Seal - O ring
46 Arm Assembly - valve control
50 Link Assembly - parking brake valve control
53 Control Assembly - parking brake
55 Spring
56 Can Assembly
57 Bracket Assembly - fluid supply tank

Adjustments

The single disc brake is self compensating and requires no lining clearance adjustment. An increased volume of fluid between the cylinder head and the piston compensates for lining wear during the life of the brake lining. Brake pedals require no adjustment, but remain constant regardless of lining wear. Brake pedal setting can be changed at the attaching brake rod clevis. If fluid leakage is noted around the adjusting pin, check the torque on the packing nut (300 inch pounds). If leakage continues, replace the packing gasket.

Wheel Brake Assembly (Gear Type)

On Expeditor 3 series aircraft, beginning with serial Ca220 through Ca265 and Ca276 and after except Ca281, the key type brake and wheel assembly is replaced with a more durable brake and wheel assembly incorporating gear type teeth to provide a linkage between the floating brake disc and the wheel assembly. The floating brake disc now utilizes gear type teeth, which are milled around the outer edge of the disc, instead of the slots originally used. Matching teeth on the extended flange of the wheel assembly intermesh with those on the brake disc. The brake cylinder pistons which were formerly held in place by snap rings (tru-arc) now incorporate a threaded cap which screws into the brake cylinder. The internal assembly of the brake cylinder remains basically the same.

Minor Repairs and Replacement

Glazed brake linings, if worn only slightly, are considered serviceable. Seals and O rings, if damaged, shrunk, or leaking should be replaced. Replace brake linings if excessively worn. The brake lining wear is indicated by the position of the adjusting pin. Excesssively worn linings are indicated when the adjusting pins are nearly flush with the adjusting pin packing nut. If 3/8 inch or more clearance exists between the outboard housing and the centre disc of the brake with the brakes applied, the lining segments are excessively worn and must be replaced. Replace the steel disc if it is warped or dished.

Note: The steel used with the gear type brake is not chrome plated. When placed in service the disc will first turn bluish in colour and eventually turn to a straw colour. After turning to a straw colour, the discs have less tendency to rust and will give better service. This discolouration (straw colour) will not effect braking operation.

Adjustments (Gear Type)

Torque piston assembly cap to 75 foot pounds.

Torque packing screw adjusting nut to 15 foot pounds.

The single disc brake is self compensating and requires no lining clearance adjustment. An increased volume of fluid between the cylinder head and the piston compensates for lining wear during the life of the brake lining. Brake pedals require no adjustment and remain constant regardless of the lining wear. Brake pedal setting can be changed at the attaching brake rod clevis. If fluid leakage is noted around the adjusting pin check the torque on the packing nut (15 ft. lbs). If leakage continues, replace the packing gasket.

Brake Fluid Reservoir

The brake fluid reservoir is attached to the centre support on bulkhead 3 forward of the instrument panel. The fluid level should be maintained about 2 inches from the top of the filler neck with hydraulic fluid, 34/100 or specification 5-GP-26A. The fluid reservoir can be drained by removing a bleeder from one of the wheel brakes and pumping the fluid out with the brake pedal.

Master Cylinders

The master cylinders are of the compensating barrel type designed to maintain constant and correct colume of fluid in the system. Small amounts of fluid lost through leakage are automatically replaced. The piston, when actuated, pressurizes the fluid in the chamber, brakes lines and wheel brake cylinders. Seals in the master cylinder insure positive fluid pressure and prevent leakage. A spring in each master cylinder returns the piston. The cylinders are actuated by the toggle action linkage below the pilots compartment floorboards. They receive a direct supply of hydraulic fluid from a reservoir tank located on the aft side of bulkhead 3.

Adjustment

Adjust the linkage to the master cylinder so the piston touches the retaining washer. Piston cap must clear compensating part when in full back position.

WARNING: Never adjust the master cylinder linkage to exceed seven threads showing outside the jam nut.

Adjustment for Toe Brake Pedal

The brake pedal adjustment is located at the attaching point of the brake rod and the toe brake pedal. The toe brake pedal is set at right angles to the floorboards with the rudder pedals in neutral position. 10 3/8" from #3 bulkhead to aft upper face of toe pedal.

Shuttle Valves

The shuttle valves, one mounted on each wheel brake assembly, shuttle the brake operation between the pilots and co-pilots brake system. The small pistons sliding back and forth prevent the flow of fluid to the inoperative brake and master cylinder.

Minor Repairs and Parts Replacement

If evidence of internal leaking is indicated, the valve should be disassembled and the O ring seals replaced.

Drain brake system before disassembling valve.

Moisten O ring seals and barrell with hydraulic fluid, specification 5-GP-26A, before reassembling. Bleed brake after installing valve.

Parking Brakes

Location - 2 lever type valves, below the pilots floorboards to the right of the pilot master cylinder linkage.

The Expeditor is equipped with parking brakes, which work in conjunction with the pilots toe brakes. To operate the parking brakes, depress the pilots toe brake pedals until sufficient pressure is built up in the pilots brake links, then pull out on the parking brake handle. For releasing brake, depress on the pilots brake pedals. This will automatically disengage the parking brake handle and the brake handle will return to the normal "OFF" position.

CAUTION: Do not push in on the parking brake to release the parking brake.

NOTE: The parking brakes can not be applied by using the co-pilots brake pedals.

The parking brake assembly consists of the parking brake control assembly, two parking brake valves and two pressure hoses that connect the pilots master cylinders to the parking brake valves. The two lever-type valves are located in the belly, just to the right of the pilots master cylinder linkage and directly alongside the elevator brake handle. Closing the valve retains the pressure pumped up in pilots brake line.

Parking Brake Control Arm Adjustment

When a parking brake valve has been replaced, it is of great importance that full travel of the parking valve arm be maintained. The adjustment of the parking brake valve arm travel is accomplished by loosening the phenalic block bolts and repositioning the outer housing of the parking brake control in the phenalic block.

Clearance between the end of the outer housing and parking brake valve arm is 1/8 plus or minus 1/16 inch. In the event that the inner control wire of the parking brake control becomes broken, it is recommended the entire parking brake control be replaced.

When a new parking brake control assembly is to be installed, cut the inner control wire of the new control assembly to the proper length as follows:

(a) Make certain the parking brake control handle is all the way in. This may be accomplished by pushing in on the handle or pulling on the protruding end of the inner wire.

(b) Cut the protruding end of the wire at a point measured 2¾ inches from the third coil of the outer housing to the end of the wire.

(c) Bond 1/16 inch of the protruding inner wire at a 90 degree angle. This 1/16 inch leg hooks into a small hole in the parking brake valve arm assembly as an additional safety measure.

(d) Adjustment of the parking brake valve for correct travel is accomplished as outlined previously.

(e) All sharp bends on links should be avoided in the routining and installations of the control to insure smooth operation.

Brake Pedal Adjustment

Adjust toe brake pedal at the attaching point of the brake push rod and the toe brake pedal. The pedal must be 10 5/8 inches from the bulkhead. The pedals should require equal operating pressure and should be free of all ponginess. The pedal travel necessary to get full braking pressure in the lines may be adjusted at the linkage between the pedal and the master cylinder. Loosen the lock nut on the piston rod terminal and screw rod in to increase the pedal travel. Screw rod out to decrease the pedal travel. Normal setting is five to seven threads showing on the rod.

WARNING: Seven complete thread showing is the maximum setting.

Brake Bleeding

Two men and the following pieces of equipment are needed for bleeding the brake system.

(a) Bladder type pressure pot of 3 or 5 gallon capacity.

(b) Fluid supply hose approximately 10 ft. long.

(c) Flat drain pan, about 1 gallon capacity, for each brake casing.

The pressure pot is filled with hydraulic fluid. Charge pot with air and set pressure regulator to 65 PSI.

Proceed as follows:-

(a) Disconnect brake fluid supply line from brake reservoir. Connect supply line from pressure pot to supply.line for the brake system.

(b) Disconnect all four brake hoses at shuttle valves. A container approximately 1 gallon capacity is recommended to catch fluid at each wheel.

(c) Open bleeder pot valve and allow fluid to flow through the four lines.

(d) Connect brake hoses to shuttle valves, but do not tighten. Allow fluid to flow out around the two brake hose fittings.

(e) Pump pilot brake pedals in slow strokes maintaining as nearly as possible a constant pressure. In operating brake pedals, they should be fully depressed and then allowed to return, to the limit of their travel range. Speed of operation should be such that not more than 12 complete cycles are accomplished per minute. Wiggle brake hoses at shuttle valve fittings during pumping operation.

(f) Allow the fluid to flow until there is no apparent air bubbles. Then tighten pilots brake hose fittings at each shuttle valve.

(g) Set the parking brake.

(h) Depress co-pilots brake pedals and at the same time loosen fittings on pilots brake hose at shuttle valve just enough to allow shuttle valve to move over and close off pilots brake supply lines. Tighten the fittings.

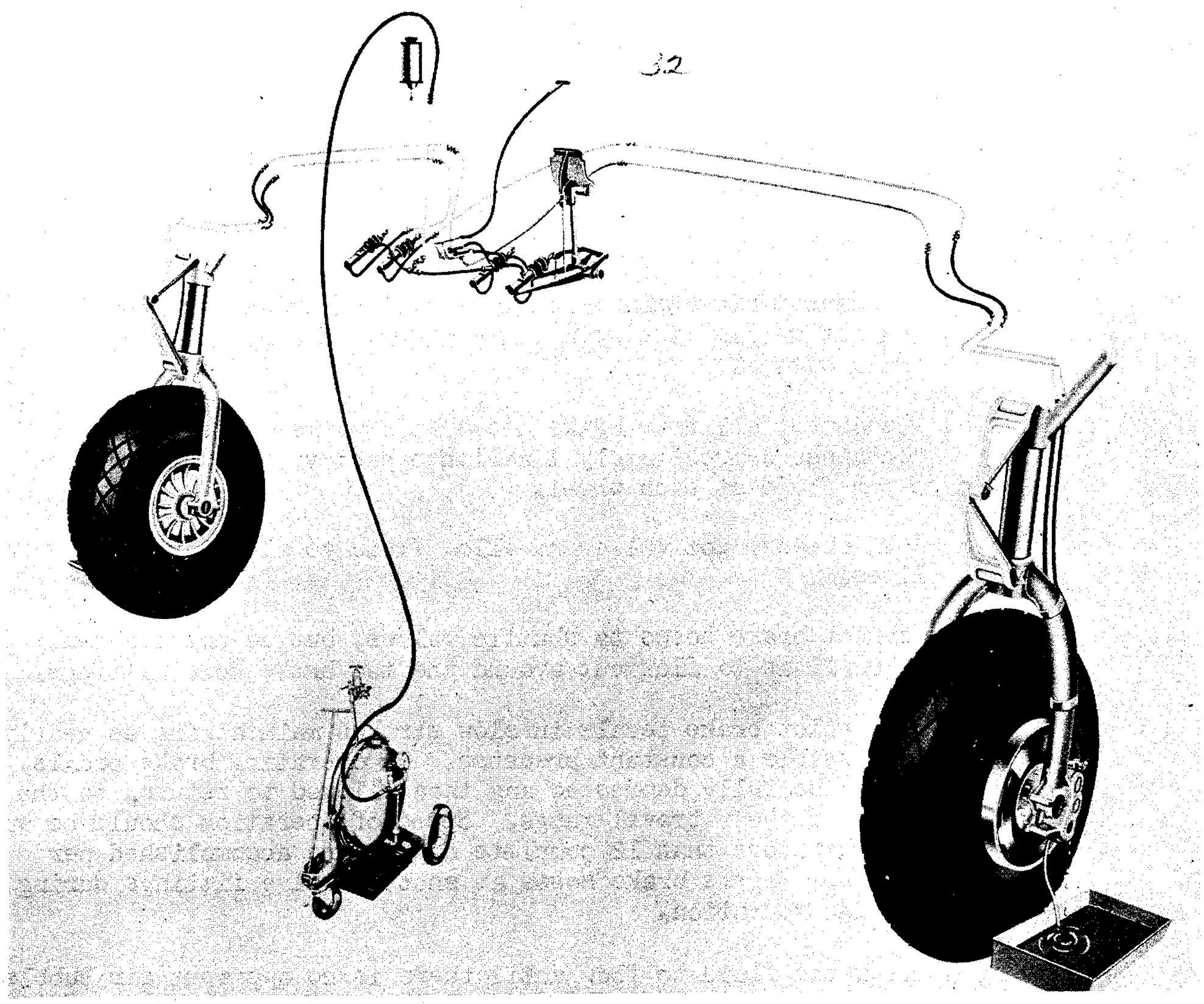
(j) Pump co-pilots brake pedals using the procedureoutlined in (e) and (f).

(k) Allow fluid to flow until there is no apparent air bubbles. Tighten co-pilots brake hose fittings at the shuttle valve.

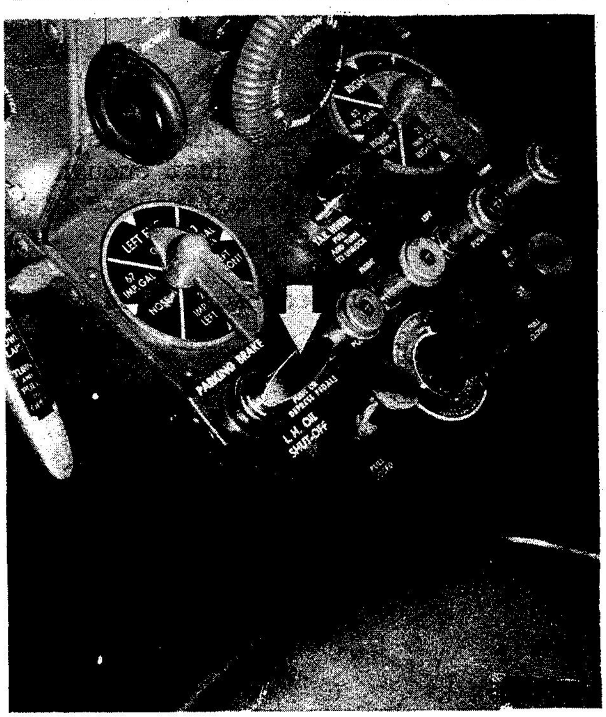
(l) Remove bleeder valve screw at the bottom of each wheel brake casting.

(m) Remove the upper bleeder valve screw in wheel brake casting.

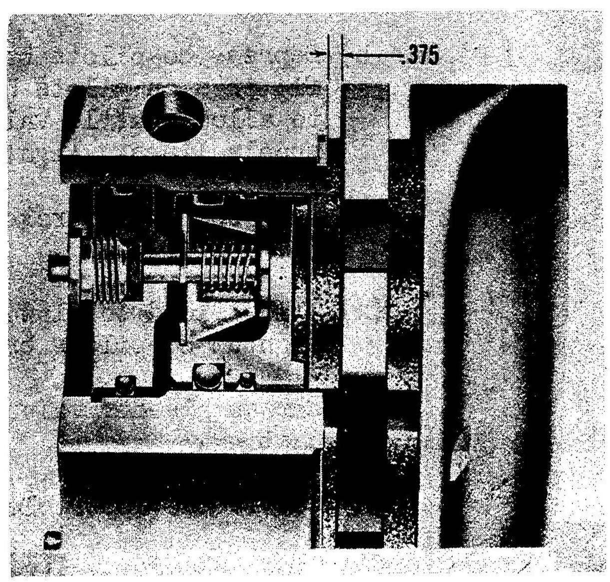
(n) Close bleeder valve.



Brake Bleeding



Parking Brake Handle



Brake Lining Wear Limit

(o) Tap brake casting with a soft mallet while bleeding casting. Use thumb to close off and release the fluid flow during bleeding operation.

(p) Continue bleeding until no air is coming out in the stream of fluid from the open bleeder valve.

(q) Install upper bleeder valve screw and washer.

(r) Again tap on the brake casting with soft mallet

(s) Continue bleeding until no air is noted coming out in the stream of fluid. Close bleeder valve. Use the same procedure for opposite brake assembly.

NOTE: Before starting to bleed the other brake assembly check pressure pot for the amount of fluid it has. If low do not take off bleeder pot filler cap until all air has been released.

(t) Close off fluid supply line from pressure pot.

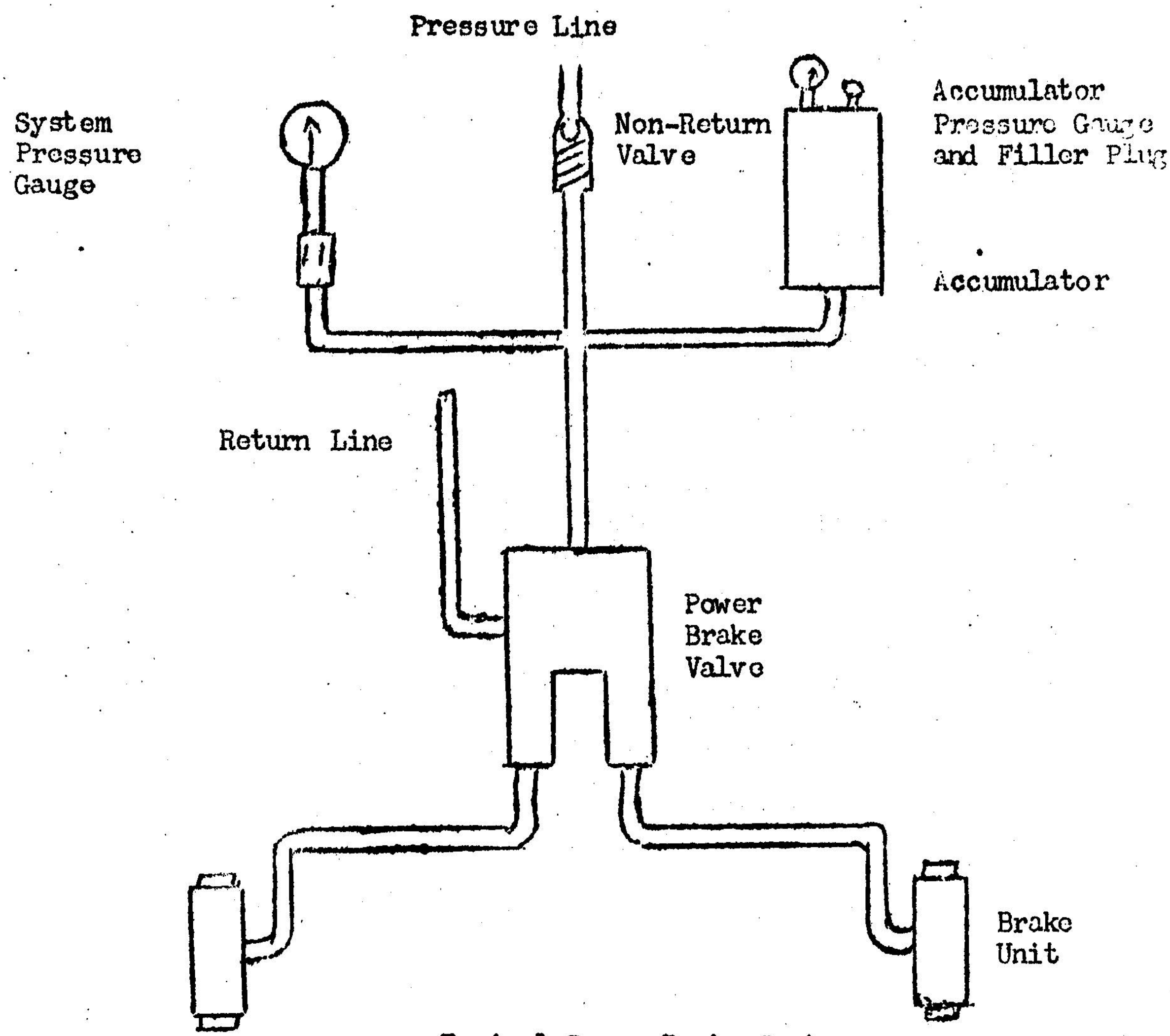
(u) Disconnect pressure pot supply line from brake system supply line to fluid reservoir.

(v) Put approximately one inch of fluid in reservoir.

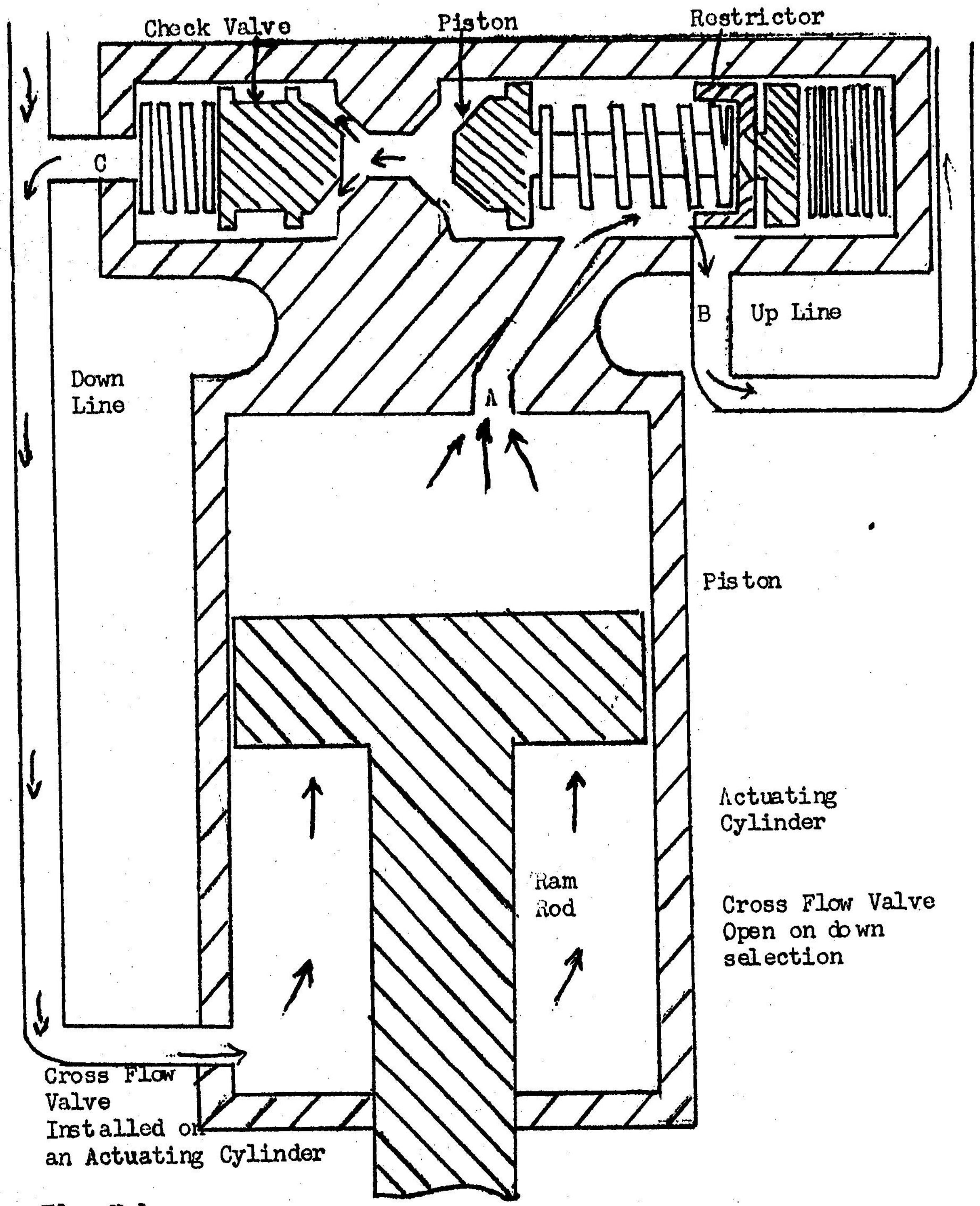
(w) Release parking brake and allow two systems to set twenty or thirty minutes before trying the brakes. This is to allow any air to escape that may have entered the system while connecting the supply line to the reservoir.

(x) Fill the reservoir to the recommended level and test brakes for operation and firmness.

(y) Set parking brakes and check for possible leaks.

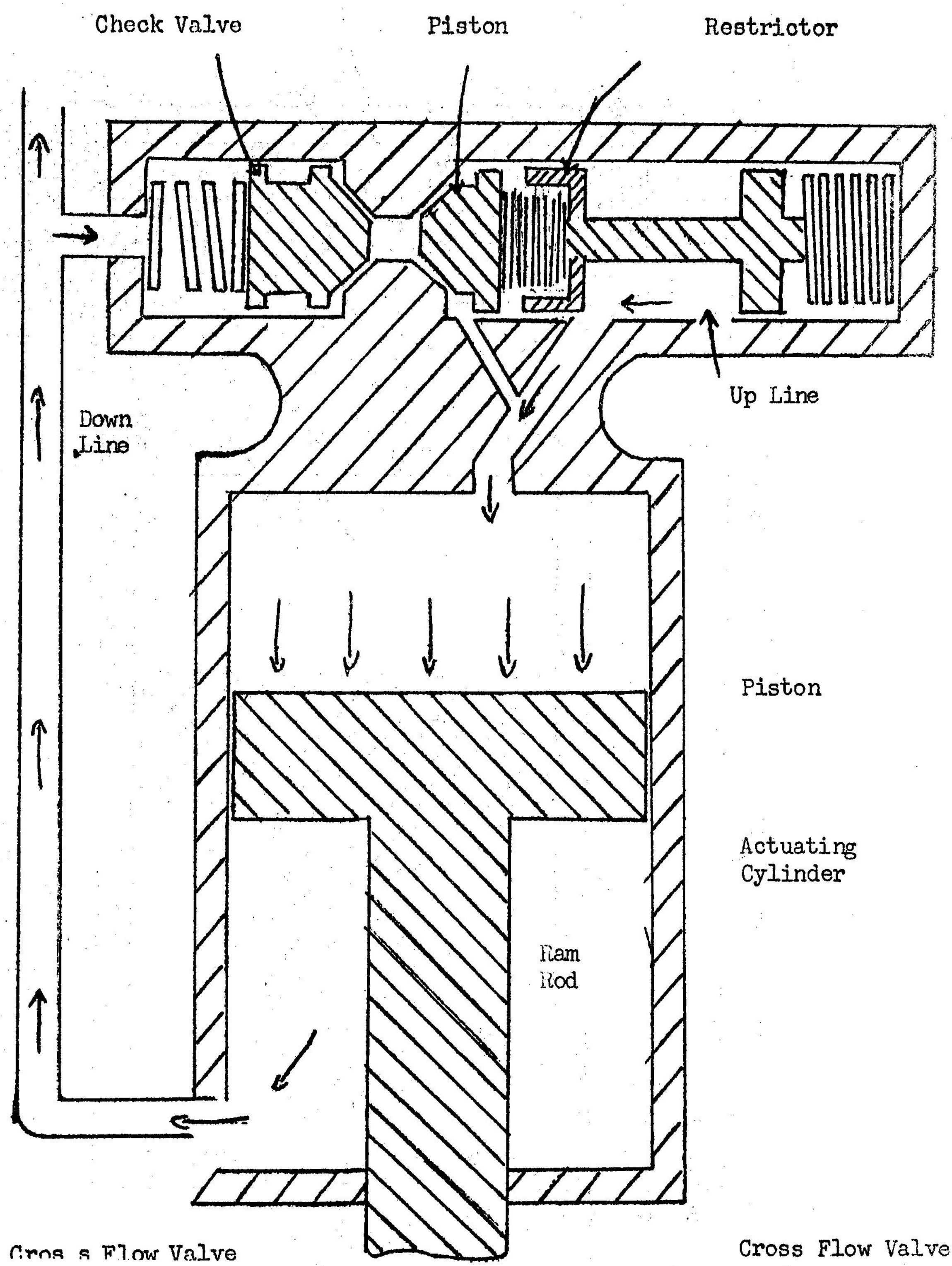


Typical Power Brake System

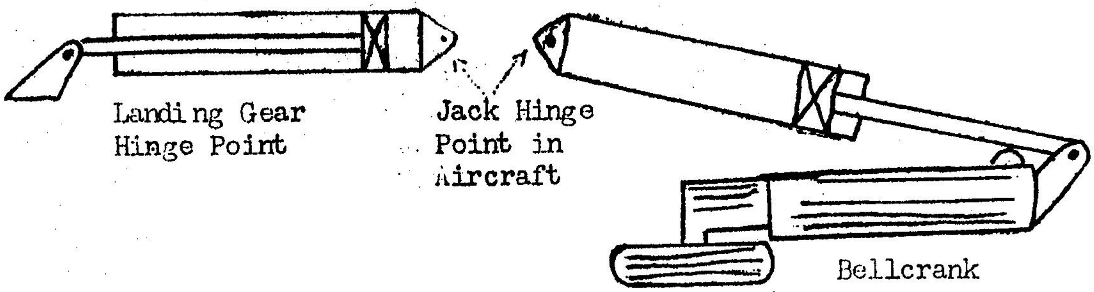


Cross Flow Valve Installed on ann

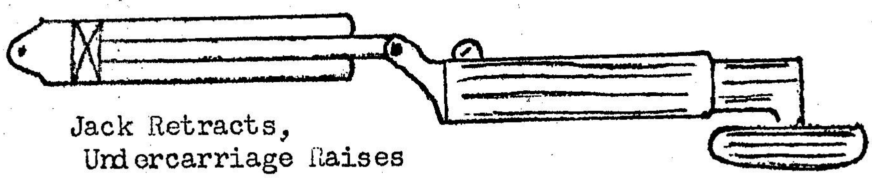
Cross Flow Valve Open



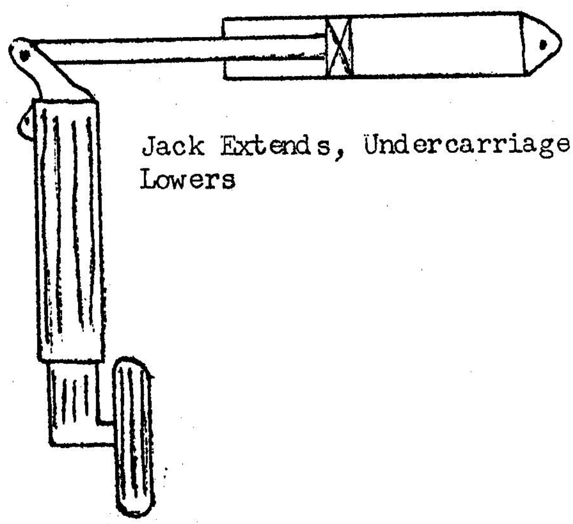
Check Valve
Piston
Restrictor
Up Line
Down Line
Piston
Actuating Cylinder
Ram Rod
Cros s Flow Valve
Cross Flow Valve



Jack Retracts, Undercarriage Lowers

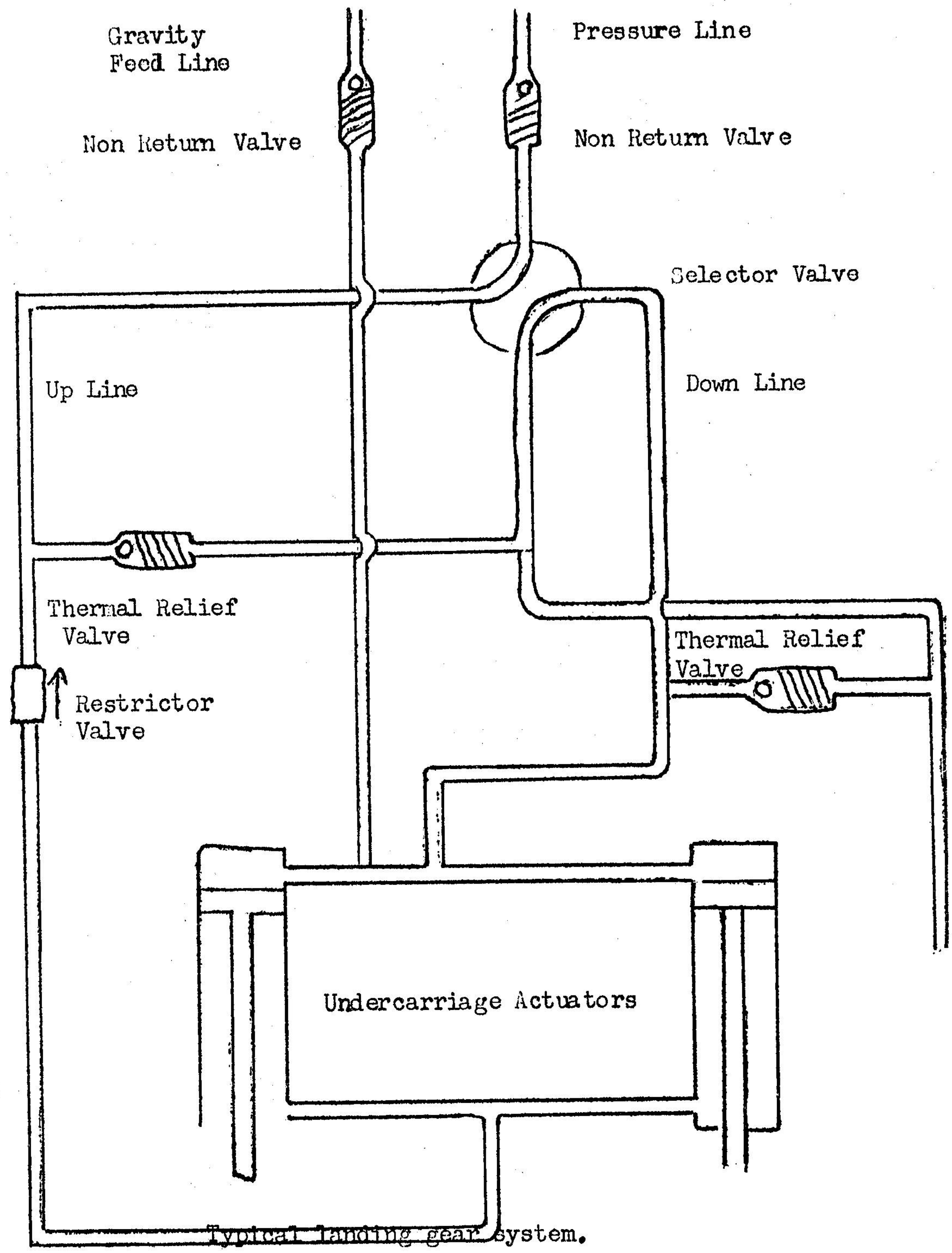


Jack Retracts,
Undercarriage Raises

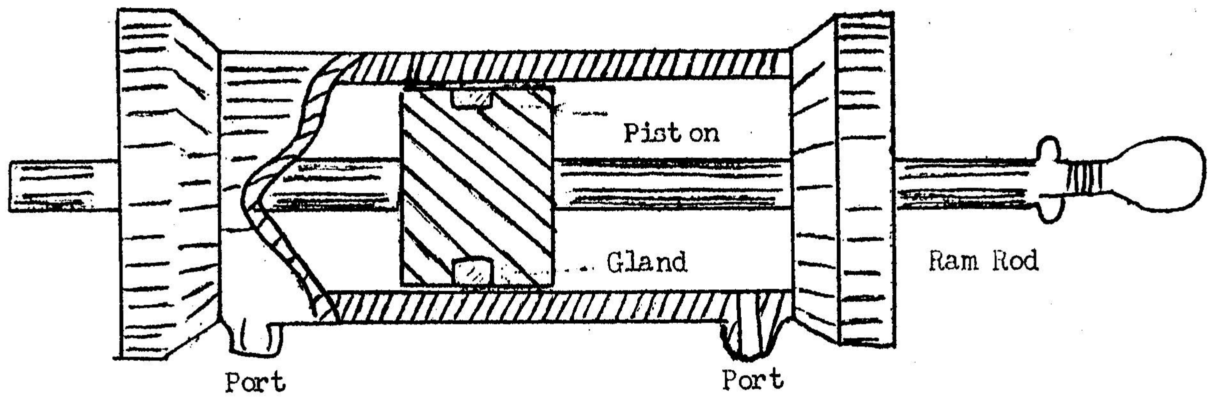


Jack Extends, Undercarriage
Lowers

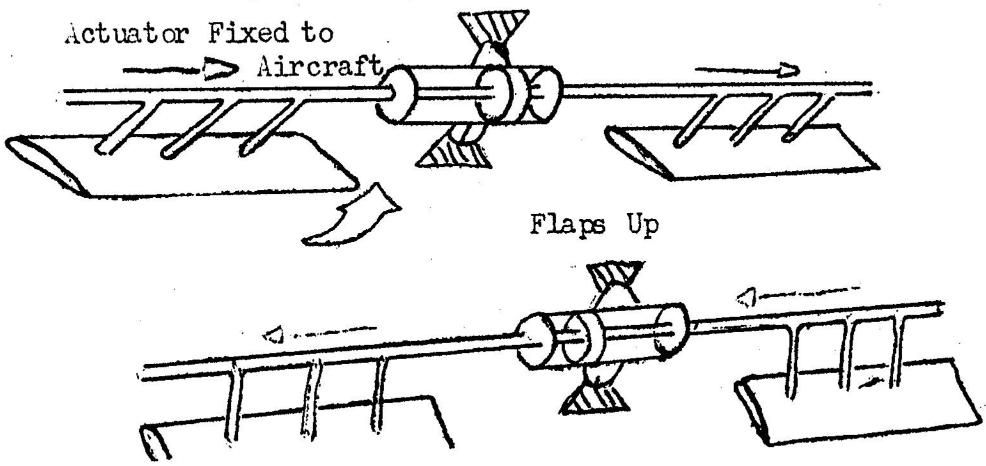
Undercarriage Extension and Retraction

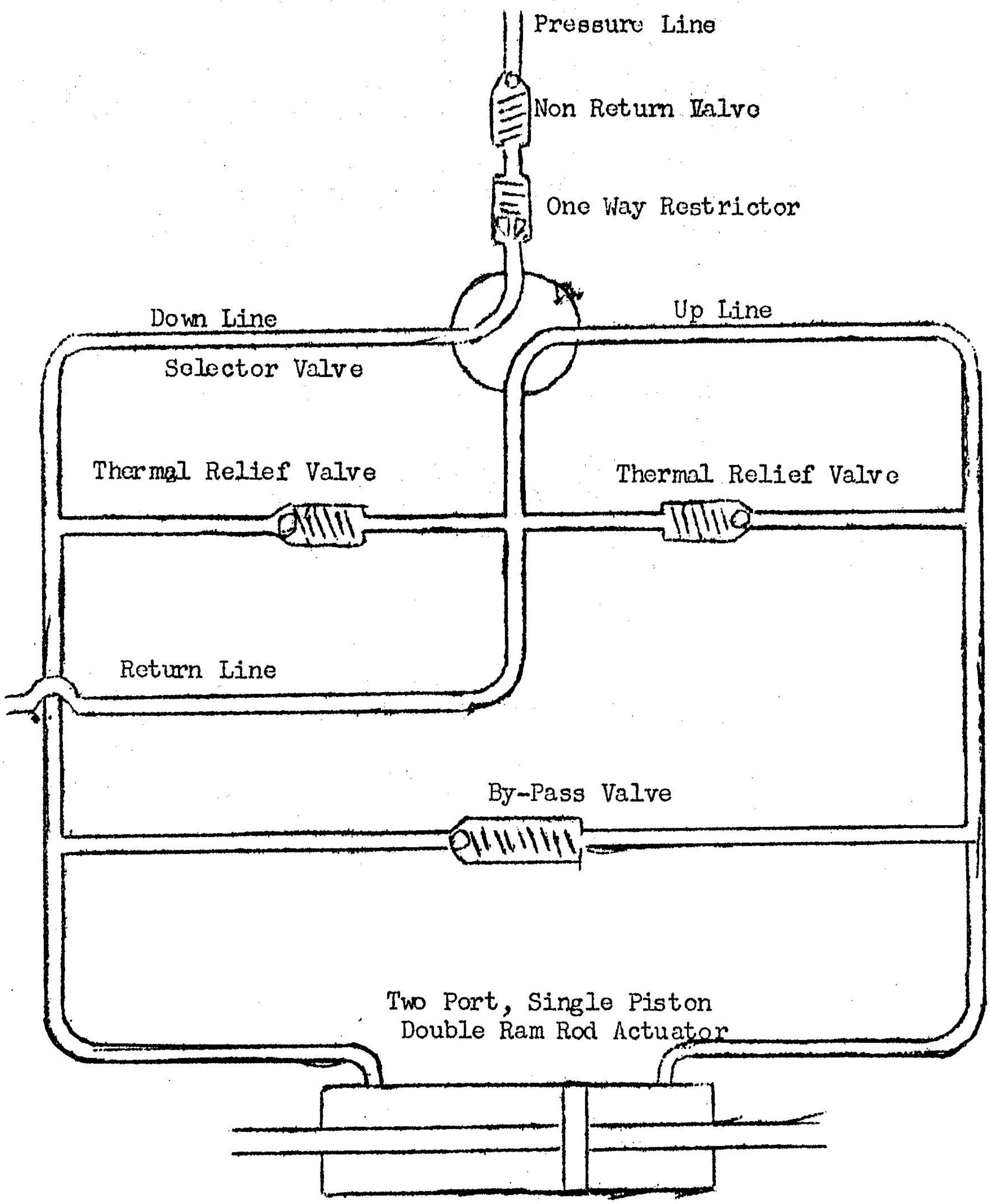


Typical landing gear system.

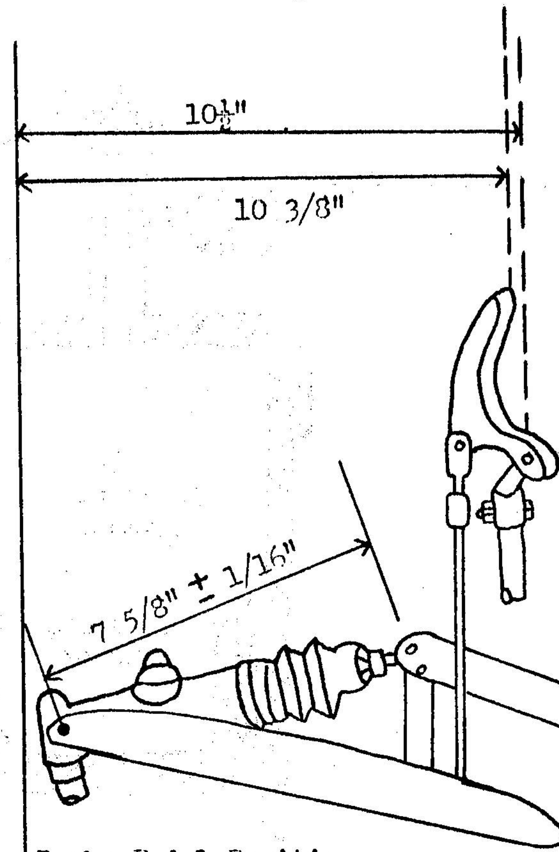


Single Piston, Double RamRod, Two Port Jack

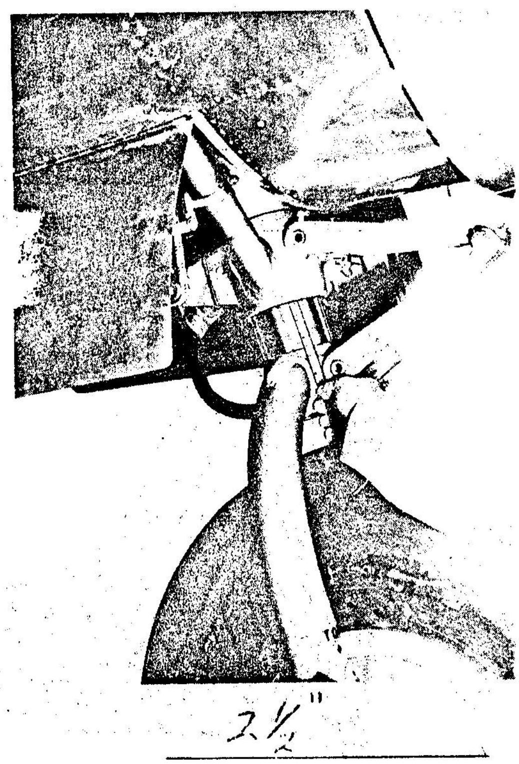




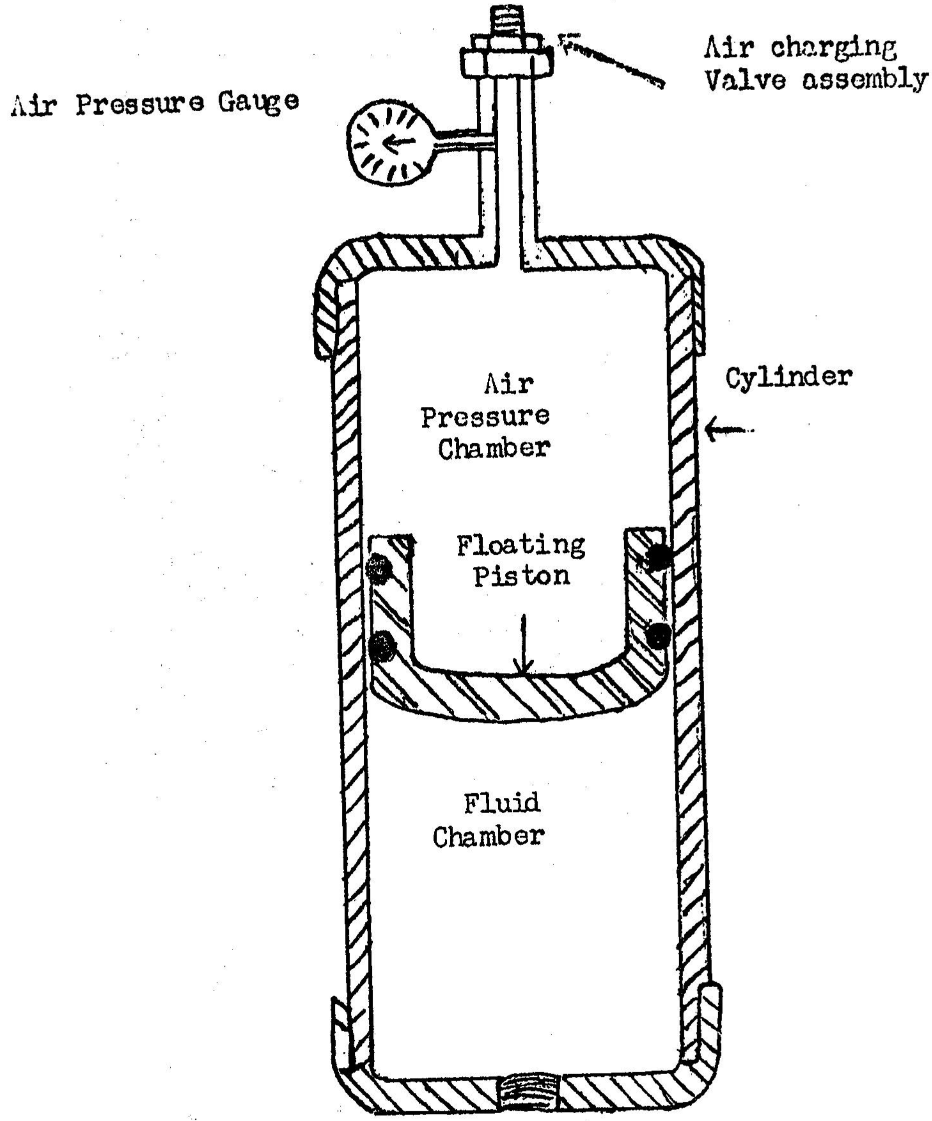
Typical Hydraulic System Flap Service



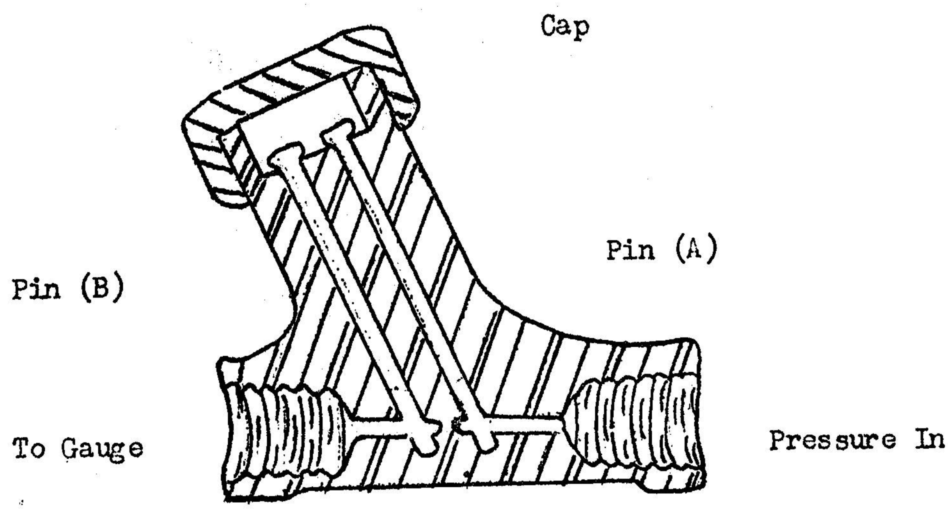
Brake Pedal Position



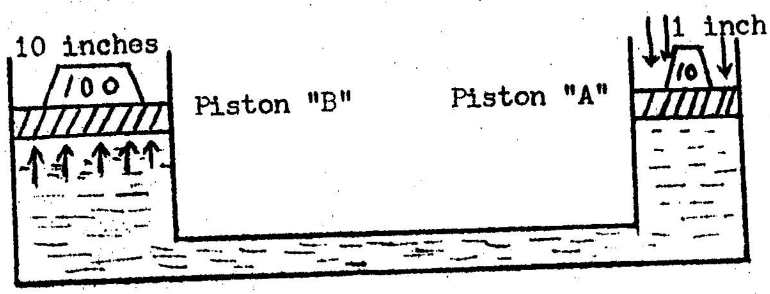
Main Gear Shock Strut Inflation



Floating Piston Type Accu mulator



Snubber Valve



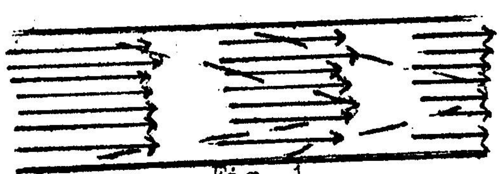


Fig. 1
Lamina flow in a pipe

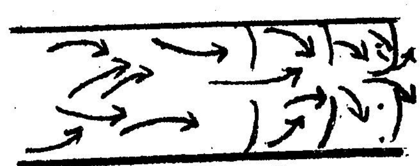


Fig. 2
Turbulent flow in a pipe