

SUBJECT: HYDRAULICS

LESSON-1:PUMPS

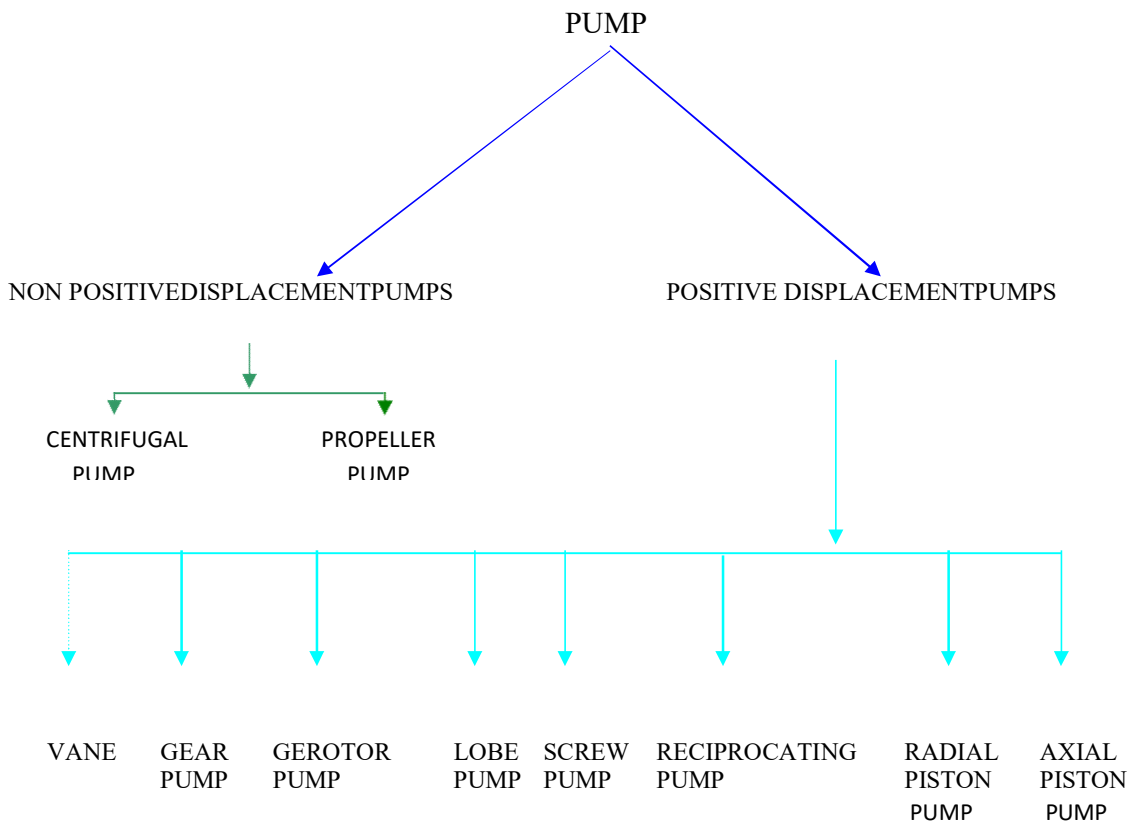
DEFINITION:

Pump is a device which converts mechanical energy into hydraulic energy. Basically pump creates flow from hydraulic tank to system.

FUNCTION:

The hydraulic pump in a hydraulic system converts mechanical energy in a drive unit into hydraulic energy (pressure energy). The pump draws-in hydraulic fluid due to partial vacuum and drives it out into a system of lines. The resistances encountered by the flowing hydraulic fluid cause a pressure to build up in the hydraulic system. Thus the fluid pressure in a hyd. system is not predetermined by the pump. It builds up in accordance with the resistances in extreme cases until a component is damaged. In practice it is prevented by installing a pressure relief valve directly after the pump or in the pump housing at which the max operating pressure recommended for the pump is set.

CLASSIFICATION:

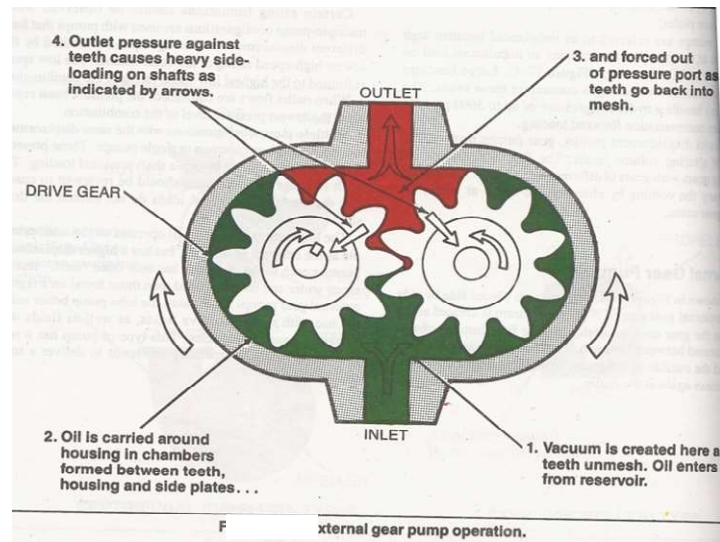


Displacement:

The flow capacity of a pump can be expressed as displacement per revolution or output in GPM. Displacement is the volume of liquid transferred in one revolution. It is equal to the volume of one pumping chamber multiplied by the number of chambers that pass the outlet per revolution. It is expressed in cubic inches per revolutions.

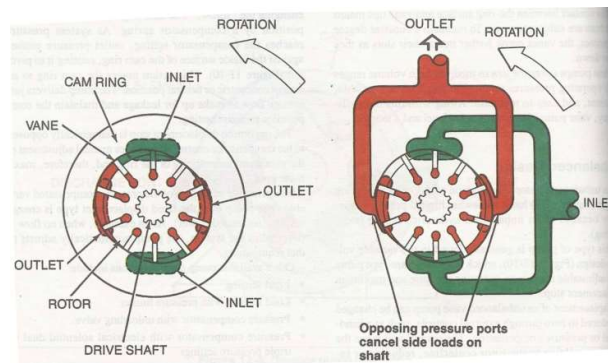
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EXTERNAL GEAR PUMP:-



The pump consists of drive gear and a driven gear and closed in closely fitted housing. The gears rotate in opposite direction and mesh at a point in housing between inlet and outlet ports as the teeth of gear separate, fluid is drawn into the inlet chamber, due to partial vacuum the fluid is trapped between the gear teeth and housing and carried through two separate paths around the outlet chamber. As the teeth re-mesh, fluid is forced through the outlet port. Close fit of the gear teeth within the housing is required to provide a seal between inlet and outlet ports, minimizing internal leakage. High pressure at pump outlet imposes an unbalanced load on the gears and bearing supporting them. Most gear pump are fixed displacement pump. Internal leakage increases with wear. However the units are fairly durable and more dirt tolerant than othertype.

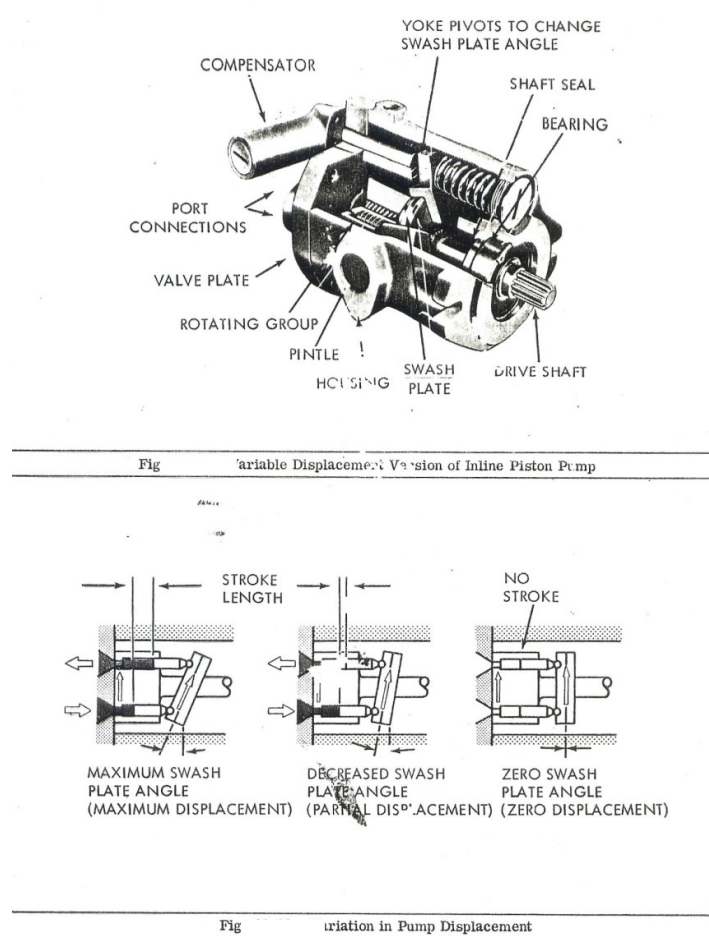
VANE PUMP:



Basically this pump consists of a cam ring and a splined drive shaft carrying a slotted rotor. In each slot of rotor vane is fitted which is free to slide. Thus following the ring profile as the rotor rotates. The vanes are held against the ring contour by a combination of centrifugal force and system pressure. Since system pressure is not usually present until the pump develops flow, centrifugal force is necessary to eject the vanes when the unit is started. Once the pump is in operation fluid at system pressure is directed to each rotor slot to hold the vanes against the ring contour. The vanes divide the area between the rotor and cam ring into a series of varying size of chambers. The pump inlet is situated in that part of pump where the chambers are expanding in size and the vanes are moving outward from rotor. Fluid is drawn into the pump by the partial vacuum, caused by this expansion. At the pump outlet the chambers are contracting in size the pressure increasing and the fluid being forced out.

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AXIAL PISTON PUMP:-



The circular arrangement of a piston is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinder barrel which is firmly attached to the drive shaft by means of a key. The piston ends are of ball and socket design and run on slipper pads. These are held on a swiveling swash plate by means of holding discs. On the fixed displacement model the swash plate forms a part of the housing and therefore has a fixed swash angle. On the variable displacement model the swash plate is built into the housing and can be swashed to an angle of $\pm 15^\circ$ from centre. The piston travels a stroke relative to the swash angle which determines the pump displacement. When the swash plate is in centre position i.e. vertical to the drive shaft, the piston stroke and thus the pump displacement are zero. Swashing the pump over center changes the direction of flow without changing the direction of rotation. Control of the axial piston pump is via inlets in a port plate. At any one time four of these moving pistons are connected via these inlet ports with the tank side. Further four pistons are connected with the pressure side and displace fluid. A charge pump is mounted on the same shaft of the axial piston pump. This pump draws oil in from the hyd. tank and supplies it to the hydrostatic loop to keep it charged. The charge pump relief valve is set at 30 bar. The inlet ports of the axial piston pumps are known as low pressure port and high pressure port and denoted by a letter 'A' & 'B'. In either side a pressure relief valve is provided which is set at a certain pressure to suit that hydraulic circuit. Such relief valves are called cross relief valves.

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PRECAUTIONS FOR INSTALLING HYDRAULIC PUMPS:

- 1) Clean entire oil from tank, remove scaling paint, dirt etc. flush it with fresh oil.
- 2) Clean the filter (choked filter may cause cavitation.)
- 3) Check suction and return lines for air Leakages, loose connection and loose connection in delivery will cause fluid leakage.
- 4) Sealant tape and shellac with pump should be used while providing fittings on the pump.
- 5) While assembling direction of rotation should be checked carefully.
- 6) Suction and delivery ports to be kept in desired directions.
- 7) All the bolts, O-rings should be properly fitted at proper torque.
- 8) All blades should be properly fitted. Keeping attention on their direction.
- 9) All bolts should be properly tightened at a uniform pressure.
- 10) Oil seal and bearing should be properly fitted.
- 11) Driving shaft should not be eccentric to the pump shaft.
- 12) All joints and pipe connection should be preferably applied with hard grease.
- 13) There should be no seepage from the pipes and pump premises should remain dry.
- 14) Start the pump at low r.p.m. preferably not more than 1000 r.p.m.
- 15) Run the pump at this rpm for about 20 min..and then apply pressure to it.
- 16) observe the sound if it is taking air the sound is unpleasant and abnormal, at this stage stop the pump and check for air leakage.
- 17) If suction pipe is getting squeezed it means suction is choked, stop the pump and check filter and suction pipe.
- 18) After applying pressure if there is no sound, see heating effect on the pump this should be normal.
- 19) Now the pump is ready for working.
- 20) Do not start pump immediately after filling the tank a period of at least 12 hrs. so that entrapped air may escape from the oil. Normal recoument of oil should also be done after working hours.
- 21) During severe winter the pump must run idle before putting load, for 15-30 min., so that cavitation effect due to high viscosity at lower temperatures is avoided.
- 22) Max. running temperature of hydraulic fluid for day of working must not cross 80°C.

AERATION:

Aeration occurs on account of presence of air in dissolved and free form in the hydraulic oil and renders the oil spongy. Air is always present in small quantity in the oil say up to 10% but this increased inclusion of air in oil reduces its lubricating properties and ultimately reduces the life of the pump.

CAUSES:

The following are the reasons of air inclusion in the oil.

1. Low oil level in the reservoir causes whirl pool at the intake and air is sucked by the pump along with the oil.
2. Restrictions in inlet pipe cause pressure to drop, which helps suction of air into pump.
3. If the return pipe opens above the hydraulic oil level in the reservoir it accompanies foaming in the tank and air inclusion.
4. Turbulent flow (intake and return) also causes air inclusion.
5. If the filter cartridge joint is not perfectly sealed or there is any void in the suction line, the pump sucks air through the same.
6. Leaking pump shaft seal, cylinder rod seals or other leaking unnumbered connections in the intake line cause aeration.

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EFFECTS OF AERATION:

Aeration causes lack of lubrication, erodes the end plates of pump and vane tips are also worn out earlier. The vanes bounce and cause irregular ripples on the inner side of the cam ring. Wearing of these fast moving parts create excessive clearance between the end plates and rotor as well as between vanes/blades and cam ring and ultimately the pressure drops. The pump stops functioning properly and can not build up pressure thus the pump reaches a premature death.

CAVITATION:

It is a sort of vacuum created in the hydraulic oil which breaks the fluid into layers or cavities and the fluid does not fill the line perfectly. It can occur equally in pump, motor or cylinder etc.

CAUSES:

The following are the probable causes of cavitations in the pump and other hydraulic equipments:-

1. Filter is clogged.
2. Sharp bend in the suction line.
3. Obstruction in suction line.
4. High viscosity hydraulic oil used in machine.
5. Pump inlet is too high above the oil level in the tank.
6. Tank, if not ventilated properly-oil shrinks in volume as it cools.
7. The load is more than the delivery of the pump.

EFFECTS OF CAVITATION:

The effects in case of cavitations are similar to those occurring in aeration i.e.

- i. Erosion of end plates.
- ii. Rippled cam ring.
- iii. Worn-out vane tips and loose in slots.
- iv. Pitting in the cam ring near inlet port.

TROUBLE SHOOTING :

PROBLEM	CAUSES	REMEDIES
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1. Pump not delivering oil.	<ol style="list-style-type: none">1. Pump driven in wrong direction.2. Intake filter or pipe choked.3. Oil level too low in the tank.4. Pump shaft or rotor broken.5. Air traps in suction line.	<ol style="list-style-type: none">1. We can check the pump rotation by hand priming, pour the oil in intake port and rotate the shaft and see if the oil is coming from outlet or not. If not change the direction by repositioning the cam ring turned by 90^0.2. Clean or replace the faulty one.3. Fill the tank with hydraulic oil.4. Replace the pump shaft or rotor broken.5. Check the suction line and replace
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<p>2). Pump making noise.</p>	<p>1). Oil level too low.</p> <p>2). Restricted or partially clogged intake filter or line.</p> <p>3). Tank is not vented properly.</p> <p>4). Viscosity of oil too high.</p> <p>5). Air leak at pump intake pipe joints.</p>	<p>1). Fill the tank with hydraulic level that more air influence is prevented.</p> <p>2). Clean or replace the intake filter or line. Suction filter should be changed in time.</p> <p>3). Air breather screening element should be cleaned regularly, so that atmospheric pressure exert effectively on the oil surface in tank and good suction may take place</p> <p>4). Use proper grade oil. In winter Season oil becomes thick so no free flow takes place, warm up the oil by starting pump for few minutes.</p> <p>5). Check for any loose connection or joint and tighten them.</p>
<p>3). Bearing failure.</p>	<p>1). Chips or other contaminants.</p> <p>2). Inadequate lubrication.</p> <p>3). Pump running too fast.</p> <p>4). Excessive or shock loads.</p>	<p>1). Replace bearing and check source of contaminants.</p> <p>2). Excessive heating of oil should be avoided.</p> <p>3). Adjust the R.P.M of prime mover</p> <p>4). Excessive load due to operating pressure may damage bearing so reduce operating pressure.</p>

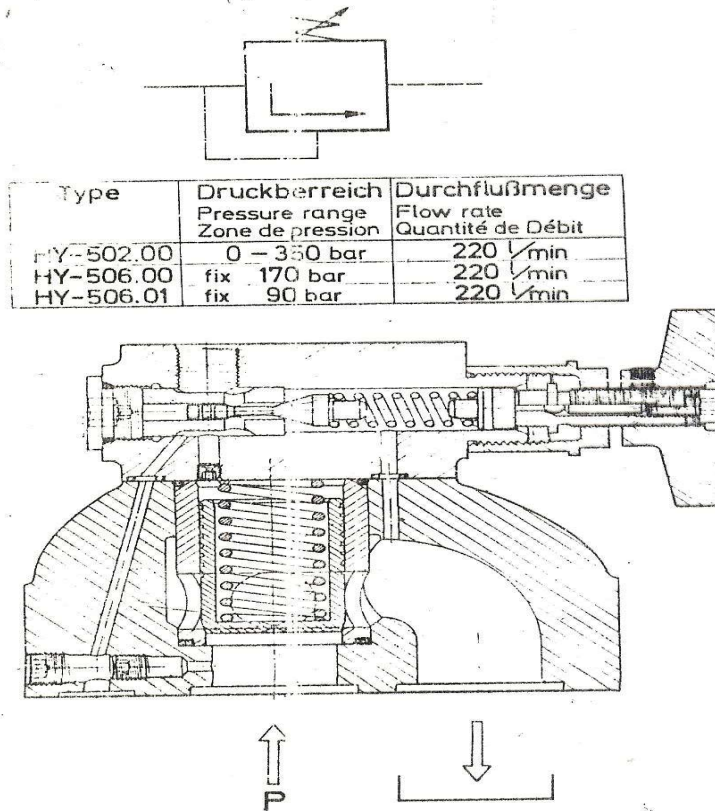
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LESSON-2: HYDRAULIC VALVES:

In hydraulic systems, energy is transferred between the pump and the consuming device along appropriate lines. In order to attain the required values – force or torque, velocity or rpm – and to maintain the prescribed operating conditions for the system, valves are installed in the lines as energy control component. These valves control or regulate the pressure and the flow rate. In addition each valve represents a resistance.

RELIEF VALVE:

RELIEF VALVE VALVE DE SURPRESSION



It is found in virtually every hydraulic system. It is a normally closed valve connected between the pressure line and the tank. Its purpose is to limit pressure in the system to a preset maximum by diverting some or all of the pump's output to tank when the pressure setting is reached.

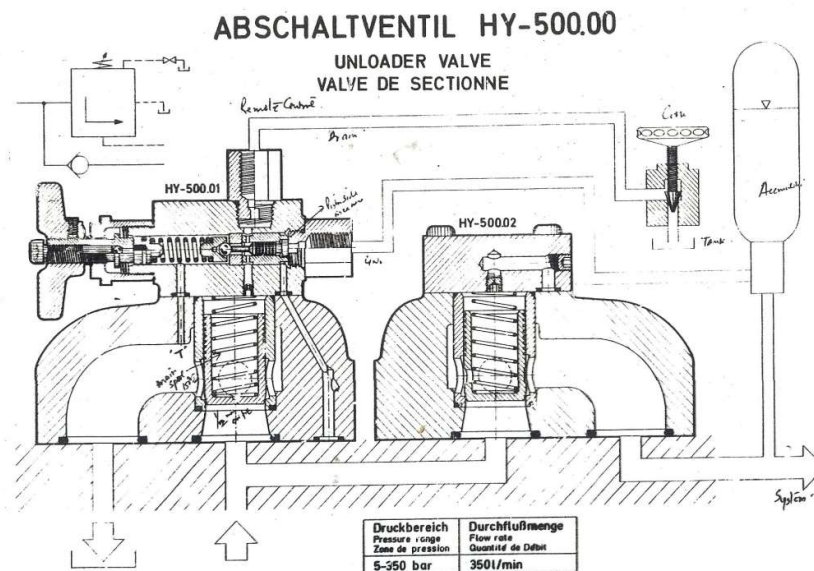
Relief valve consists in two sections (1). Cover section which includes poppet, spring, and adjusting screw & vent connection. (2). Body section which contains the piston, spring & seat. The valve pressure setting is determined by the adjusting screw position which varies the heavy spring compression. The balanced piston is normally held against the seat by the light spring. System pressure is present in lower chamber of piston and also passes to the upper chamber through a pilot line. With system pressure less than the valve setting the pilot poppet is held against its seat by spring force. Pressure in both chambers equalizes and the piston is hydraulically in balance and held against its seat by the light spring.

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When system pressure exceeds the heavy spring setting and forces the poppet away from its seat. Fluid then flows through poppet seat to tank port. The pressure in upper chamber is limited by the setting of the heavy spring. When pressure in lower chamber exceeds upper chamber sufficiently, pressure unbalance overcomes the force of the light spring and lifts the piston. Excess fluid then flows past the bottom of the piston to tank. When system pressure drops below the valve setting, the poppet reseats. Control flow through pilot line stops and pressures in both chambers are again effectively equalized. The light spring then forces the piston towards the seat when the balanced piston is closed against its seat, the unloading stops. The pump delivery now goes to the system.

Venting: Relief valves can be vented to unload pump delivery to tank in the manner – connect a shutoff valve to the vent port of the main relief valve. This removes pressure at the top of the balanced piston. Pressure in the lower chamber overcomes the light spring, unseats the balanced piston and diverts all the delivery of pump to tank.

UNLOADER VALVE:



An unloader valve is used in accumulator charging circuit to (i) limit max. pressure and. (ii) unload the pump when the desired accumulator pressure is reached. In construction, it contains a compound, balance piston relief valve, a check valve to prevent reverse flow from the accumulator & a pressure operated plunger which vents the valve at the selected pressure.

Normally, the relief valve piston is in balance and is held seated by its light spring. Flow is through the check valve to the accumulator/system. When preset pressure has been reached, the relief valve poppet has unseated limiting pressure above piston and on the poppet side of the plunger. Further increase in system pressure acting on the opposite end of the plunger has caused it to force the poppet completely off its seat, in effect, venting the relief valve and unloading the pump. The check valve has closed permitting the accumulator to maintain pressure in the system.

Because of the difference in area between the plunger & poppet seat (approx. 15%), when pressure drops to about 85% of the valve setting, the poppet & piston reseat & the cycle is repeated.

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TROUBLE SHOOTING IN UNLOADER VALVE:

Sl.No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1. Defective pump	Check the pump and replace if required
		2. Leakage in the system	Check the leakage and rectify the fault
2	Pump O.K. no leakage in the system, still no pressure	1. Choked orifice of main spool	Clean the orifice.
		2. Secondary stage vent open to tank	Close the vent
		3. Safety valve at zero setting	Set safety valve as per value written in the circuit.
3	Pressure does not rise to required value even after completely tightening the control knob	1. Worn out pump is not able to push the fluid against set resistance.	Replace the pump.
		2. Leakage in the system	Check the leakage and rectify the fault.
		3. Leakage at seat of ball in control head	Check the seat and ball. If defective replace it.
		4. Safety valve setting lower than unloader valve setting	Set safety valve 10-15 % higher than unloader setting.
4	Unloader does not unload	1. Nil or low nitrogen pressure in the accumulator	Check pressure accumulator
		2. Punctured bladder	Change the bladder.
		3. Leakage in the system	Locate fault and rectify the leakage.
		4. Less delivery from pump than demand of the circuit.	Replace the pump
		5. Partial leakage at ball seat in control head	Replace the ball and seat.
		6. Wrong connection of control head spool from the system.	Correct the connection.
		7. Vent line of unloader connected to return line.	Connect line to drain line.

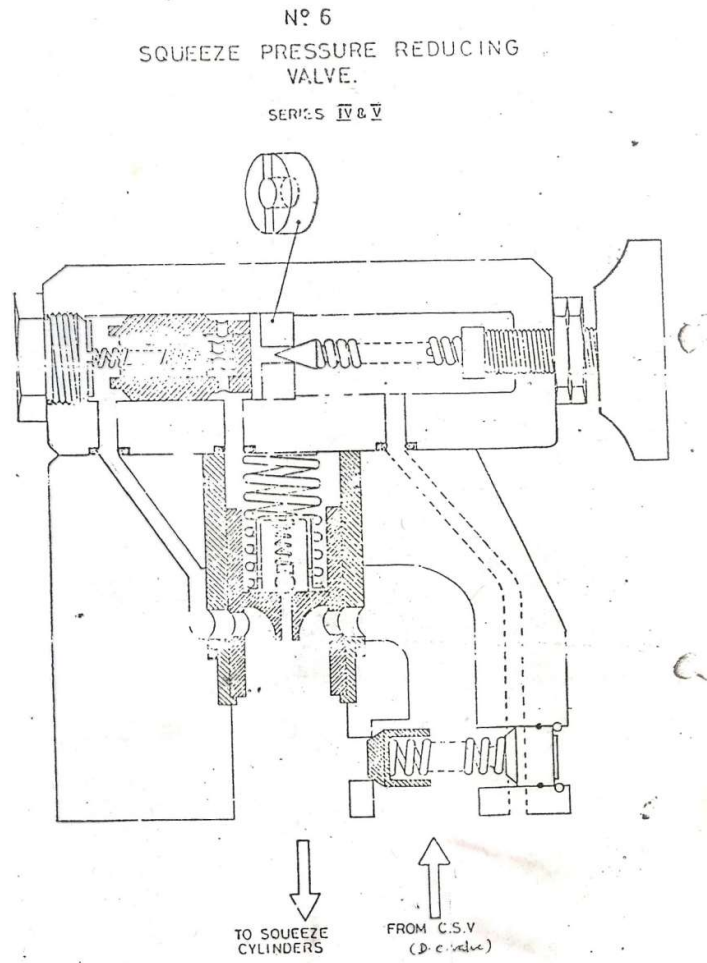
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TROUBLESHOOTING IN RELIEF VALVE

Sl. No.	FAULT	REASON	REMEDIES
1	No pressure in the circuit	1. Defective pump flow 2. Leakage in the system	Check flow with the Meter and replace pump if Required. Arrest the leakage.
2.	Pump OK & no leakage in sys. still no pressure.	1. Choked up orifice of main spool 2. Secondary stage vent open to tank	Take out the spool and clear the orifice. Close the vent
3.	Pressure does not rise to required value even after complete tightening the control knob.	1. Excessive clearance in pump matching parts due to wear 2. Leakage in the system 3. Leakage at poppet seat 4. Under size valve in relation to flow of pump.	Replace the pump. Check the leakage & rectify the fault. Check the seat and poppet, if defective Replace it. Provide proper size valve.
4.	Valve sticks	1. Valve stressed. 2. Oil temperature too low. 3. Piping stressed. 4. Drain line under pressure.	Loosen bolts and tighten uniformly. Warm up system by starting hydraulic system. Providing proper bends in piping. Install line or separate from return line.

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PRESSURE REDUCING VALVE:



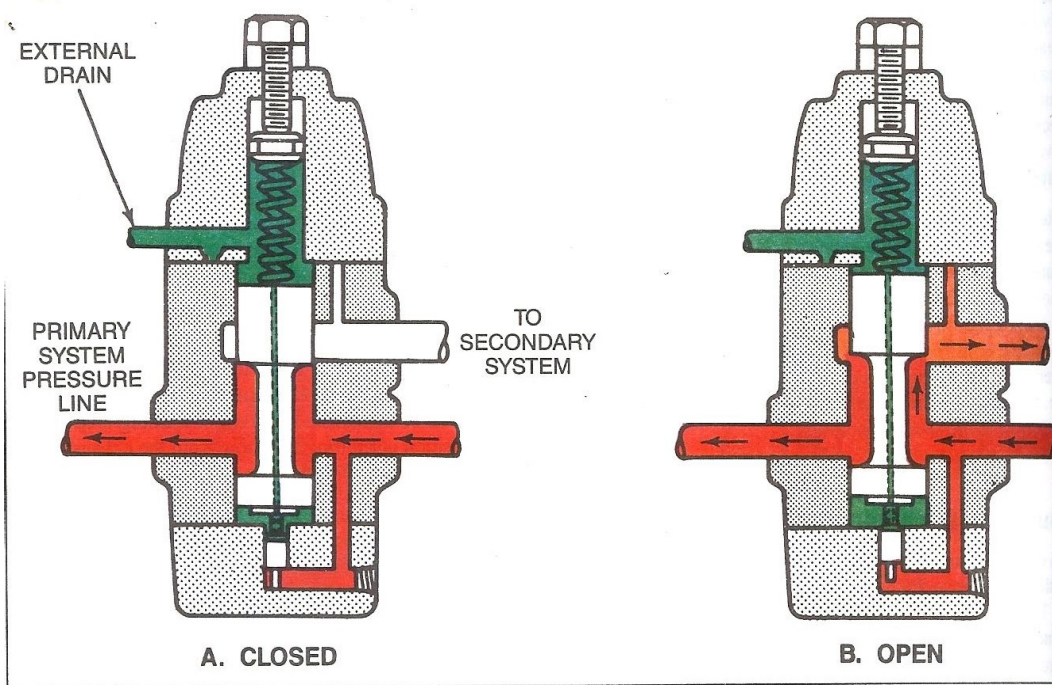
Pressure reducing valves are normally open pressure controls used to maintain reduced pressure in certain portions of the system. They are actuated by pressure sensed in the branch circuit & tend to close as it reaches the valve setting thus preventing further build-up.

The pilot op. pressure reducing valve has a wider range of adjustment & generally provides more accurate control. The op. pressure is set by an adjustable spring in the pilot stage in the upper body. The spool is hydraulically balanced through an orifice in its centre and the light spring holds it in the wide open position.

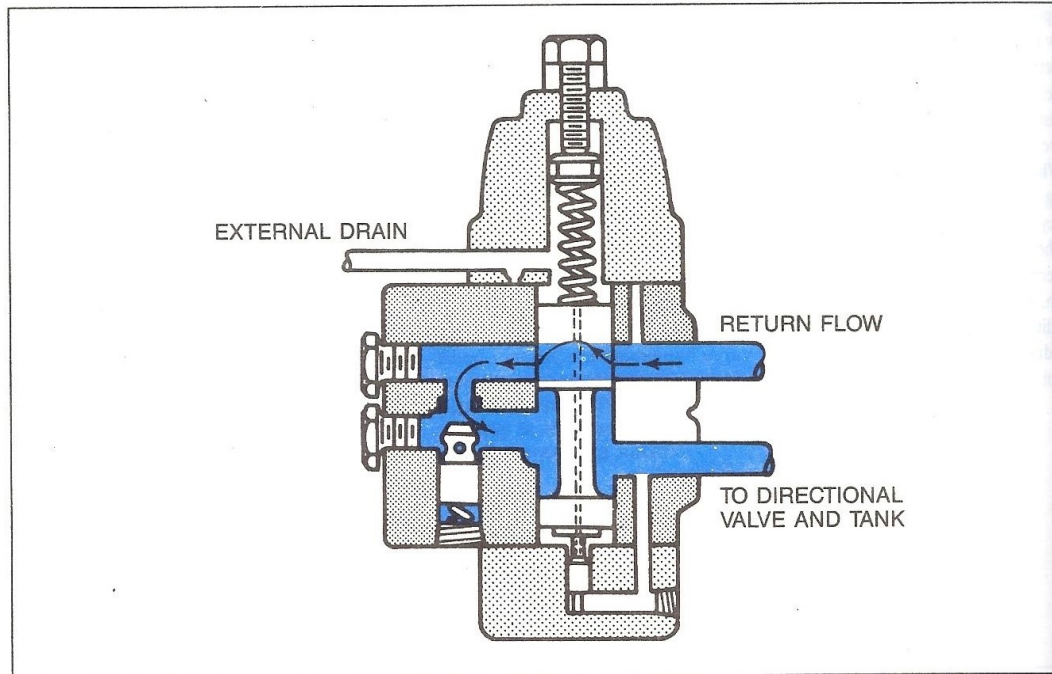
When pressure has reached the valve setting and the pilot valve is diverting flow to the drain passage limiting pressure above the spool. Flow through the orifice in the spool creates a pressure difference that moves the spool up against the spring force. The spool partially closes the outlet port to create a pressure drop from the supply to the branch system.

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SEQUENCE VALVE:



Sequence valve.



Sequence valve with integral check permits reverse free flow.

A sequence valve is used to cause actions to take place in a system in a definite order, and to maintain a predetermined minimum pressure in the primary line while the secondary operation occurs. Fluid flows freely through the primary passage to operate the first phase until the pressure setting is reached. A typical application is clamping from the secondary after the work piece is firmly clamped.

To maintain pressure in the primary system, the valve is internally operated. However, the drain connection must be external, since the secondary port is under pressure when the valve sequences. If this pressure were allowed in the drain passage, it would add force and raise the pressure required to open the valve.

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TROUBLE SHOOTING:

Sl. No.	Problems	Causes	Remedies
1.	Valve flutters	1. Valve seat defective	Exchange parts
		2. Pilot control defective	Repair pilot control
		3. Oil speed too high	Install valve of greater nominal size
		4. Wrong oil grade	Respect oil recommendations
		5. Dirt in system	Flush system if needed pickle and flush out
		6. Damping defective	Repair valve or change spring
2.	Valve sticks	1. Valve stressed	Loosen bolts and tighten uniformly
		2. Oil temperature too low	Warm up system through pump or install heating
		3. Piping stressed	Incorporate balancing bends
		4. Drain line lacking or under pressure	Install line or separate form return
		5. Dirt in system	Flush system or if needed pickle and flush
		6. Wrong oil grade	Respect oil recommendations
		7. Water condensation in system	Check cooler and check system for condenser effect
		8. Oil gumming	Clean spool and if needed change oil
		9. Body parts wrongly fitted	Observe assembly sequence in service instructions
		10. Wrong seals	Replace seals prescribed
3.	Valve does not function	1. Valve spring broken	Change spring
		2. Valve sticks	Establish cause and repair defect
4.	Valve overheats	1. System temperature too high	Observe maximum pressure
		2. Oil speed too high	Install valve of greater nominal size

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D.C. VALVE

FUNCTION:

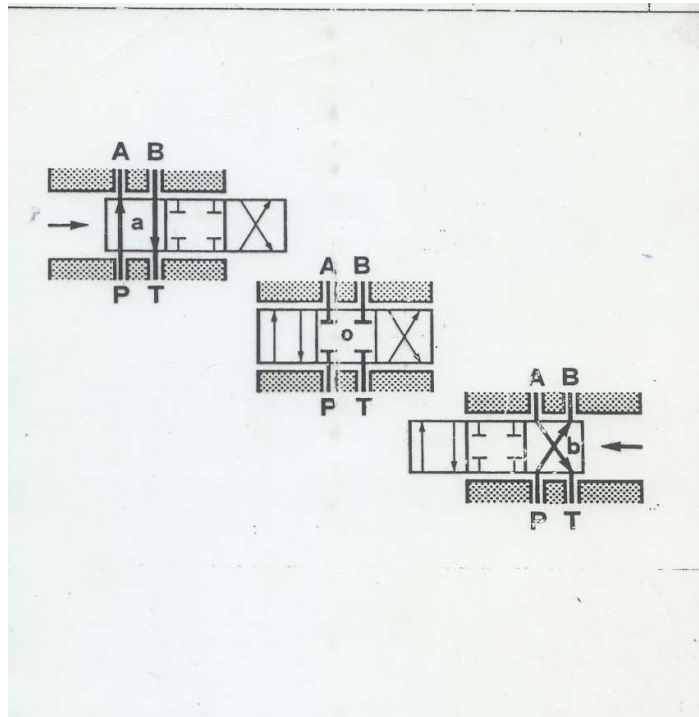
There are several types of valves in hydraulic system. Some are used to limit and regulate the pressure, while other controls the direction of fluid flow. The direction of pressurized fluid is controlled by D.C. valve and thus the direction of movement. They can be simple check valve, more complicated pilot and solenoid operated valves. It can be manually or automatically operated. Valve body has a precision machined bore in which a very close tolerance spool is suspended on a film of hydraulic fluid. Spool lands and body cavities are designed to divide the bore openings into separate chambers. Ports in the body lead into this chambers so that spool positions determine which ports are opened or closed.

TYPES:

There are three types of D.C. valves:-

1. Spring centered valve.
2. Spring offset valve.
3. Pilot operated valve.

Spring centered valve:



This valve is provided with spring and centering washer at each end of spool. The spring and washer centre the spool with in the valve body when solenoids are de-energized where it is necessary to stop or hold an actuator at some mid point in its travel, a 3 position valve is used. The third position is achieved by centering springs. Flow conditions in this centre or neutral position are determined by the work requirement of the system.

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Spring offset valve:

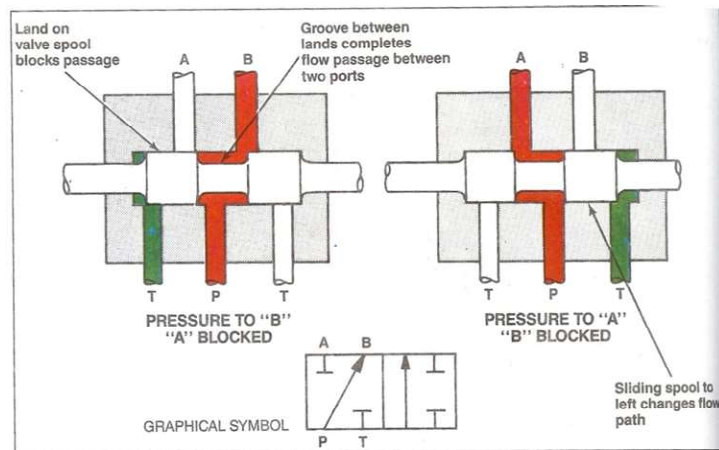


Figure 8-11. Two-way spool valve slides in machined bore.

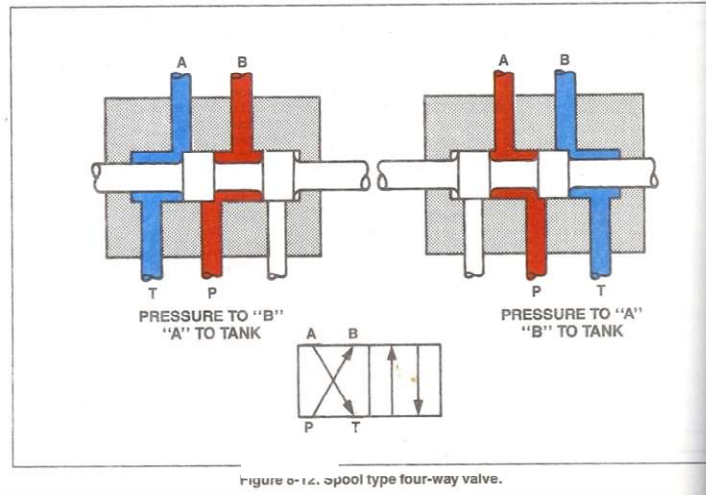
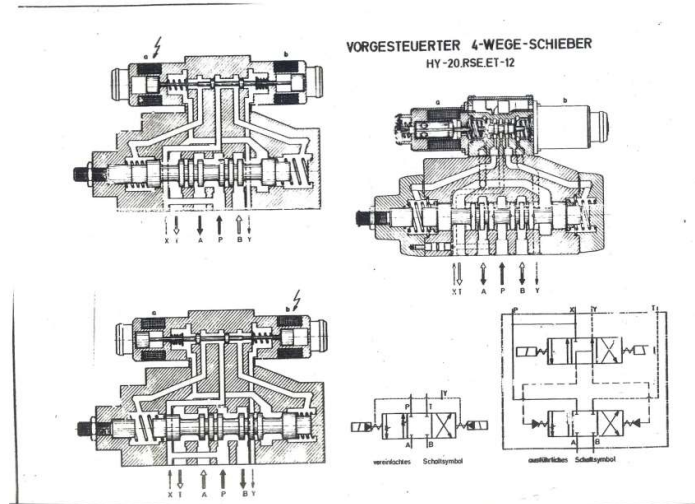


Figure 8-12. Spool type four-way valve.

These valves use one solenoid only. Spring returns the spool to offset position when the solenoid is de-energized.

Pilot operated valve:

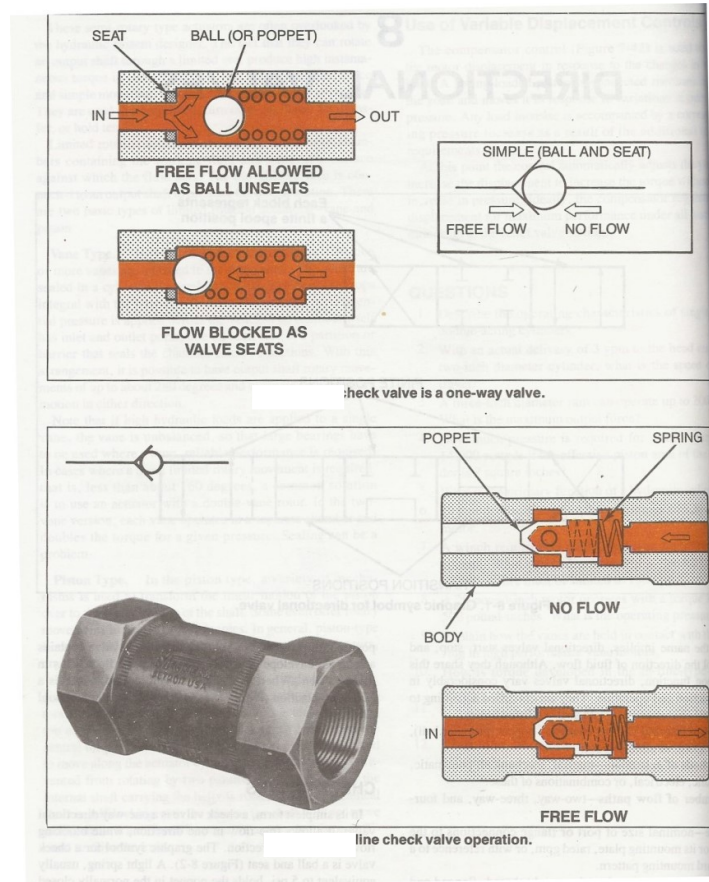


In larger valves much force is required to shift the spool which can not be shifted by 24 V

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which is actuated by solenoids. Thus we may control high flow rates with low solenoid power. Pilot valve or master valve is mounted on top of the larger “slave valve”. The normal position of pilot valve is A – B to T.

NON RETURN VALVE (CHECK VALVE):



Non-return valves block the flow in one direction and permit free flow in the other. As there must be leaks in the closed direction, these valves are always of poppet design and are constructed according to the following basic principle.

The sealing element (generally a ball or cone) is pressed against an appropriately shaped seat. The valve is opened by volumetric flow in the flow direction, the sealing element being lifted from the seat.

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PILOT OPERATED CHECK VALVE:

Pilot operated check valve designed to permit free flow in one direction and to block return flow until opened by a pressure signal. This valve is used to support vertical cylinders which come downwards due to leakage in D.C valve. Normal position of D.C valve is always A – B to tank. It is a variation of directional poppet valve and commonly used in hydraulic system. It works on the principle that in order to allow and additional flow over the valve seat in opposite direction a small cylinder with a piston and piston rod acts on the closing part and lifts it from the seat when pressured the area ratio between control piston and valve seat is the deciding factor for the operation of valve.

LOGIC VALVE (CARTRIDGE VALVE):

Refinements in hydraulic system development have led to greater use of manifold blocks. A manifold block greatly reduces the number of fittings required for the interconnecting lines between components in a system. This eliminates many potential leakage points and reduces fluid waste from leakage. A cartridge valve is inserted into a standardized cavity in a manifold block and held in place with either self-contained screw threads or a cover secured with bolts to complete the cartridge valve design concept.

Cartridge valves are two types: (1) Slip-in cartridge valves and (2) Screw-in cartridge valves.

Advantages of Cartridge valve:

Cartridge valves provide several advantages over conventional line-or subplate-mounted spool-type directional, pressure, and flow control valves. In many applications, the advantages include:-

1. Greater system design flexibility.
2. Lower installed cost.
3. Smaller package size.
4. Better performance and control.
5. Improved reliability.
6. Higher pressure capability.
7. More efficient operation.
8. Elimination of external leakage and reduction of internal leakage.
9. Greater contamination tolerance.
10. Faster cycle times.
11. Lower noise levels.

Operation of Slip-in Cartridge Valves:

These valves are used in hook lifting-lowering circuit of Unimat machine. Most Slip-in cartridge valves are poppet type elements that are normally controlled by another valve to provide a complete hydraulic function. These valves are similar to poppet check valves and consist of an insert assembly that slips into a cavity machined into a manifold block. A control cover bolted to the manifold secures the insert within the cavity. The insert includes a sleeve, a poppet, a spring and seals.

The cartridge valve insert can be viewed as the main stage of a two-stage valve. It has two main flow ports, “A” and “B”. Drilled passages in the manifold connect the “A” and “B” ports to other cartridge or to the operating hydraulic system. Similarly, a drilled pilot passage in the manifold connects the control port “X” as desired.

Notice the orifice in the drilled passage between the “X” port and the spring chamber “AP”. The purpose of this orifice is to reduce the speed at which the valve poppet opens and closes. Various orifice sizes are available to optimize or tune cartridge response in relation to that of the entire hydraulic system. The hydraulic system designer can select the orifice size that provides maximum operating speeds with minimum hydraulic shock.

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PRECAUTIONS DURING MOUNTING D.C. VALVE:

1. On solenoid operated D.C. valve make sure that the electrical ground is connected to the valve that prevents the possibility of shock hazards developing if a coil were to short out to the frame.
2. The number of bends in tubing should be kept to a minimum to prevent excessive turbulence and friction of oil flow. Tubing must not be bent too sharply the recommended radius for bends is three times more than the pipe inside diameter.
3. The selection of valve should be according to the circuit.
4. The normal configuration of valve should be checked. Pour hydraulic oil in P port and check the position of A, B and T port.
5. O – Ring should be checked on the grooves provided between valve and base plate.

TROUBLE SHOOTING

PROBLEM	CAUSE	REMEDIES
1. Valve spool stick.	1). Dirt in the system.	1). Disassemble, clean and re-assemble
	2). Body parts wrongly fitted.	2). Fit properly. Clean
	3). Rusting due to water	3). Clean or replace if required.
	Condensation	
	4). Solenoids not operated 5). Spool is stressed.	4). Check electrical supply and source 5). Check surface, clean, tighten the bolts. Oil film should be available between valve body and spool.
2. Solenoid not functioning	1). Faulty electrical circuit.	1). Check and rectify.
	2). No current.	2). Check the electrical wires and supply.
	3). Coil burnt out.	3). Replace
3. Leakage in valves	1). Connections not sealed	1). Check and rectify.
	2). Wrong seals	2). Replace by proper size.
	3). Defective valves, cracks in body.	3). Repair or replace.
4. Valve overheats	1) System pressure too high	Reduce pressure setting
	2) Wrong oil grade	Use proper grade oil
	3) Dirt in the system	Flush system and clean the valve
	4) Faulty electric circuit	Check electric circuit
	5) Spool defective	Repair spool

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PROPORTIONAL VALVES

FUNCTION:

- Proportional valves control and vary pressure, flow, direction, acceleration and deceleration.
- They are adjusted electrically are actuated by proportional solenoids.
- Output flow is proportional to the input signal.
- By varying the input signal solenoid adjusts the spool movement to vary the flow through the valve.
- To control the speed of the spool a gradually increasing or decreasing signal (a ramp function) is fed to the control amplifier and thus we get a smooth, shock free movement.
- Used for Tamping unit lifting-lowering and satellite drive.
- Maximum voltage 24V DC, current range-250mA to 750mA
- For Tamping Unit Lowering current-650mA
- For Tamping Unit Lifting current-600mA

Working of Proportional Valve:

D.C conventional valves are 'Yes' or 'No' type valve. These valves are completely 'OFF' or 'ON' type that means either the ports will be completely closed or completely opened and these types of valves are known as finite positioning valves. During operation the movement of actuator is not controllable.

To get a controlled and measured amount of actuation, other types of valves known as proportional valves have been introduced and such valves are known as infinite positioning valves. These valves are also known as direction cum flow control valve. To get measured amount of correction or actuation and accordingly the movement of spool of the valve is proportionate to the current. It means whatever amount of correction or actuation we need. That only will be done. Neither this will be less nor will be more.

In this valve how much amount of current flows through coil, proportional amount of fluid will pass through it. It means its operation is proportional to signal it receives i.e. as movement will be such that it corresponds to the controlling signal. Higher the amounts of signal, higher the actuation. Lower the amount of signal, lower the actuation will be. So we need a proportional movement and proportion actuation.

The amount of movement of the spool in either direction is electrical from an electrical i/p signal. This signal is converted via an electrical amplifier to a current signal to the relevant solenoid the force generated moves the main spool against the main spring. The positional transducer then ascertains the actual position of spool and feeds this back as a voltage signal to the amplifier. The input signal and actual values are then compared electrically. From these two values a signal is generated and fed to the solenoid in order to give a defined position to the main spool. The main spool has metering slots cut into it which give a progressive flow characteristic.

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TROUBLESHOOTING OF PROPORTIONAL VALVE:

Sr.No.	Trouble	Causes	Rectification
1.	Spool sticks	a) Spoolstressed b) Dirt in thesystem c) Body parts wronglyfitted d) Wrongseals e) Oil temperature toohigh f) Spooldefective g) Return pipe under high pressure	Loosen union and tighten uniformly. Clean the valve and flush the system. Dismantle valve, observe assembly sequence and reassemble. Replace seals prescribed. Check cooling circuit. Repair or replace. Dismantle the connection and clean. If required lead pipe separately to tank.
2.	Proportional valve does not function.	a) Proportional solenoid defective b) Electric circuitfaulty c) Proportional filter clogged d) No current	Replace. Check circuit & PCB. Replace. Check electrical installation.
3.	Proportional valves overheat.	a) Oil temperature toohigh b) Wrong oilgrade c) Dirt in thesystem d) Faulty electricalcircuit e) Spooldefective	Check cooling circuit, reduce pressure setting. Use recommended oil. Flush system. Check and rectify. Repair or replace.

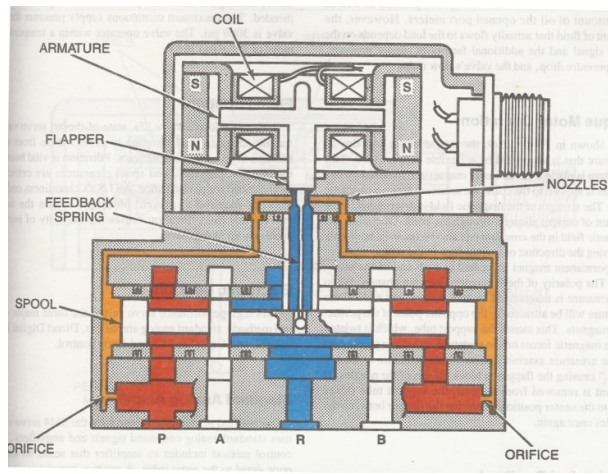
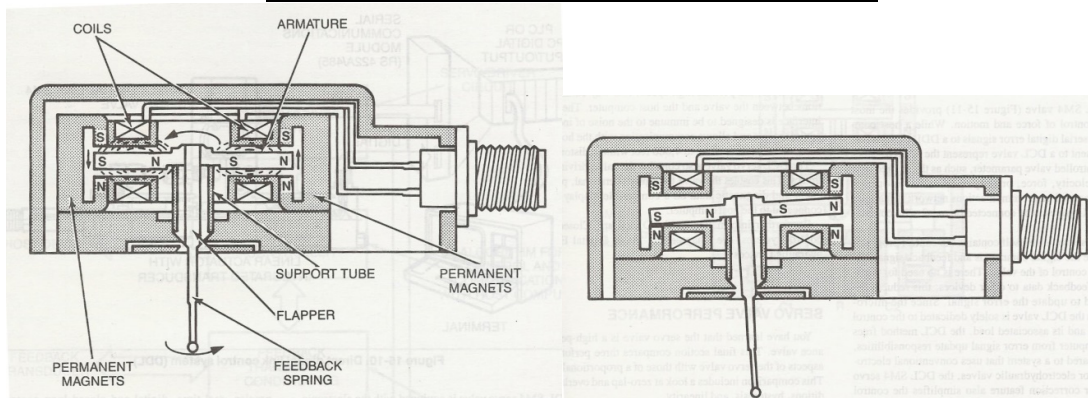
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SERVO VALVE

FUNCTION:

- Servo valve is a directional valve that may be infinitely positioned to control of both the amount and the direction of the flow. A servo valve coupled with the proper feedback sensing devices provides very accurate control of the position, velocity, or acceleration of an actuator.
- Small input signal causes a large output of hyd. Power.
- A low power control signal can produce output of several hundred horse-power.
- In airplanes, jet planes servo valves are used for fast response.
- Used in lifting and lining circuit in 09 CSM, 09-3X, Unimat-3X, new Duomatic.
- For track lifting – 2 nos and for alignment – 1 no servo valve is provided.
- Voltage-3V DC, Current-15mA.
- Contaminated oil is not desirable.
- Maintain the oil cleanliness to NAS-5 class.
- Before installing the servo valves flush the system.
- Filter should be replaced in non-contaminated atmosphere.
- Null should be adjusted properly, if null gets disturbed.

Working of servo valve:



Servo valve consists of an electrical torque motor, nozzle flexure tube, flapper and sliding spool. In the torque motor there are upper and lower pole plates, permanent magnet and an armature. The armature is supported for limited movement by a flexure tube. The flexure tube acts as a seal between the electromagnetic and hydraulic portion of the valve. The coils surround the armature one on each side. The flapper is rigidly attached to centre of armature. The flapper extends down inside and passes between two nozzle tips and flapper. Flapper motion varies the nozzle openings. The pressurized oil is supplied to each nozzle through a

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filter and inlet orifices. Differential pressures caused by flapper movement between the nozzles are applied to the ends of the valve spool. Due to nozzle area difference force develops accordingly more on one side and spool is shifted and 'P' may connect 'A or B' depending upon our requirement. A feed back wire is deflected by spool movement so that feed-back torque is applied to the armature.

Input signal in the torque motor coils causes clockwise or anticlockwise torque on the armature. This torque displaces the flopper between the two nozzles. Thus pressure difference is created due to area difference in nozzle and moves the spool either left or right. The spool displacement causes a force in feed back wire, which opposes the input signal torque. Spool movement continues until the feed-back wire force equals the input signal force. So the spool stops and remains displaced until electrical input changes to a new level. The actual flow from the valve to the load will depend upon the load pressure. In neutral position leakage rate is 0.005cc/sec.

TROUBLESHOOTING IN SERVO VALVE:

Sr. No.	Fault	Causes	Rectification
1.	Servo valve spool sticks.	a) Feed tubedirty b) Fine filterdirty c) Mechanical return sticks d) Valve stressed	Check system for dirt and clean filter. Check system for dirt and clean filter Valve should be dismantled. Loosen unions and tighten uniformly
2.	Servo valve does not function.	a) Electric circuitdefective b) Rotary magnet system defective c) No differentialcurrent d) Nopressure e) Oilgummy f) Oil temperature toohigh g) Servo filterclogged	Check electric circuit. Repair system or replace torque motor. Check electrical installation. Check pump and relief valve. Clean valve, flush system and change oil if needed. Check cooling circuit, check for any line restrictions and reduce pressure setting. Replace filter.
3.	High null basis (High input current required to maintain the hydraulic cylinder stationary)	a) Incorrect Null adjustment b) Partially pluggedinlet orificeassembly c) Partially pluggedfilter element. d) Partially pluggedNozzle	Readjust the null. Clean the inlet. Replace the filters element. Servicing required.
4.	Out flow obtain from one part only	Plugged inlet orifice	Clean inlet orifice.
5.	Low flow gain (Problem in getting high speed)	Plugged button filter	Replace the filter element.
6.	High threshold (jerky, hunting motion)	Sticky spool	Servicing.
7.	Servo valve overheats.	a) Wrongcurrent b) Mechanical return sticks c) System pressure toohigh d) Wrong oilgrade e) Dirt insystem	Check current use servo valve tester. Needs opening valve. Reduce pressure settings. Respect oil recommendations. Flush the system.

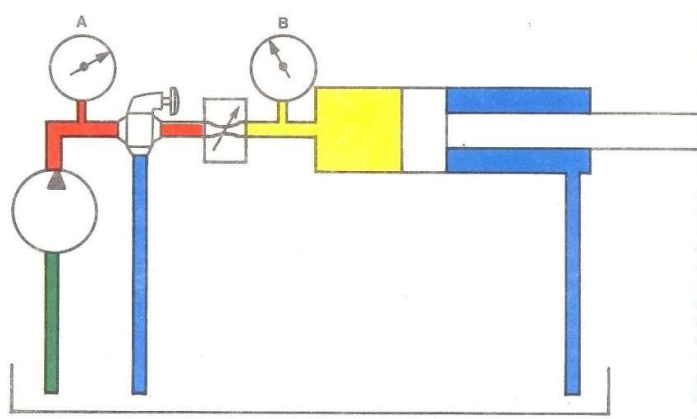
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FLOW CONTROL VALVE

FUNCTION: By controlling the rate of flow in a hydraulic circuit, it's possible to control the speed of hydraulic cylinder or motors. A more typical method is to use a flow control valve. By varying the size of opening, one can vary the amount of oil entering the cylinder and thus control its speed. Three factors affect flow rate: pressure, fluid temperature, and orifice size. If any one of these factors is increased, the flow rate increases.

TYPES: Control of flow in hydraulic circuits can be accomplished with a meter-in circuit, a meter-out circuit or a bleed-off circuit.

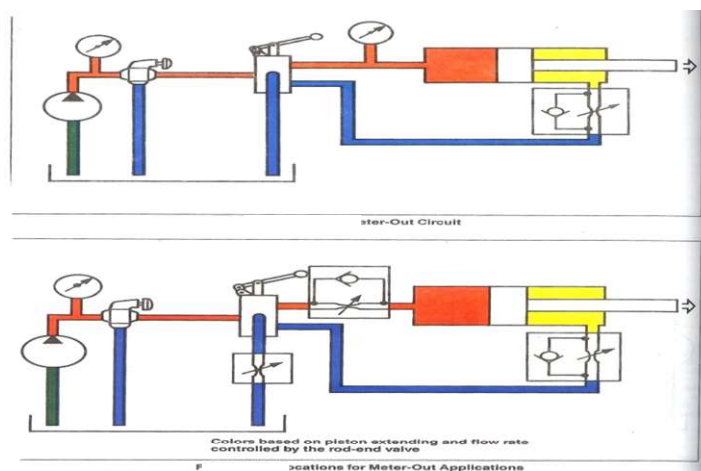
Meter-In circuit:



In meter-in operation, the flow control valve is placed between the pump and actuator. In this way, it controls the amount of fluid going into the actuator. Pump delivery in excess of the metered amount is diverted to tank over the relief valve.

Meter-in circuit can only be used with opposing loads. If the load tends to run away, it would pull the cylinder piston ahead of the oil supply; and since the exhaust flow has a free path back to tank, the meter-in circuit could not prevent the load from running away.

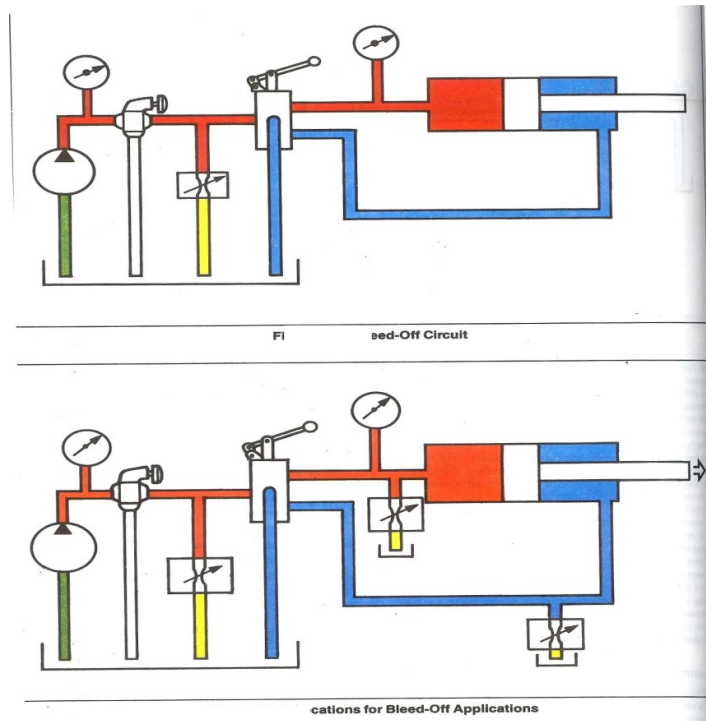
Meter-Out circuit:



The flow control is on the outlet side of the cylinder to control the flow coming out. This is known as a meter-out circuit. If the flow control were closed completely, the oil could not exhaust from the cylinder and it could not move. Regulating the size of the opening controls the flow rate and thus the speed of the cylinder. Although metering into the cylinder

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Bleed-Off circuit:



The flow control is simply bleed off the main line to control cylinder speed. For instance, with the flow control completely closed, the full flow from the pump would go into the cylinder. However, the moment the flow control is opened up, some bleed off of that pump delivery occurs and the cylinder starts to slow down. Adjusting the size of the opening will bleed off any amount necessary to control how fast the cylinder moves. In the case, unlike the meter-in or meter-out circuits, there is no excess flow going over the relief valve and the pump operates at only the pressure that is needed to move the work load on the cylinder, which saves energy. The bleed-off circuit will not prevent a load from running away. As with meter-in circuit, it can be used with opposing load only.

TROUBLESHOOTING IN FLOW CONTROL VALVE:

Sr.No.	Fault	Causes	Rectification
1.	Device does not function	a) Device stressed b) Seat defective c) Throttle valve defective d) Non-return valve sticks e) Fine throttle-valve sticks f) Compensator mechanism defective g) Piston sticks h) Spring broken i) Corrosion on setting mechanism j) Wrong choice of device	Loosen bolt and tighten uniformly. Exchange seat. Exchange cone. Check cone and seat, if needed exchange it. Exchange restrictor Disassemble controller and exchange defective parts. Check system for dirt, exchange piston. Exchange spring. Clean if needed change. Install controller of correct nominal size.

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LESSON-3: HYDRAULIC MOTOR

DEFINITION:

Hydraulic motor converts the movement (Kinetic energy and pressure – potential energy) of a stream of hydraulic fluid in the continuous rotating force or movement. More specifically the kinetic energy of a fluid is converted into the kinetic energy of a fluid is converted into the kinetic energy of a rotating shaft in a hydraulic motor. The output of the shaft is the point where the motor is connected to the machine or device to be operated. The pressure of the fluid admitted to the motor determines its force or output. Motor's rating is represented in torque, GPM, cubic inches/rev A hydraulic motor converts hydraulic energy into mechanical energy. It is a rotary actuator. In construction it is almost some as hydraulic pump. The gear's, rotor are pushed by pressurized fluid and torque is developed i.e. continuous rotating motion is developed hydraulic motor's are externally drained Hydraulic motors are rated according to displacement (size),torque capacity, speed and maximum pressurelimitations.

CLASSIFICATION OF HYDRAULIC MOTORS:

Hydraulic motors can be classified by application into three categories:

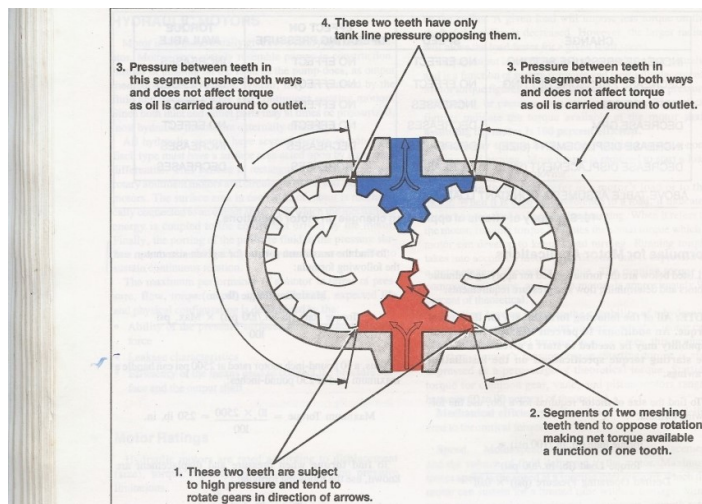
- (1) High Speed, Low Torque Motors (HSLT)-in line piston motor , bent-axis motor vane motor and gearmotor.
- (2) Low speed, High Torque Motors (LSHT)-internal gear motor, vane rolling motor radial piston motor and axial ball pistonmotor.
- (3) Limited Rotation Motors (Torque Actuators)

TYPES OF MOTORS:

1. Gear motors –including external and internal (gerotor and rolator or orbital) motors
2. vane motors—including unbalanced, balanced, fixed, variable and cartridge (high performance) types
3. piston motors-including in-line, bent-axis, and radial motors (fixed, variable and cam type)
4. screwmotors-
5. Torque Generators –including

WORKING:

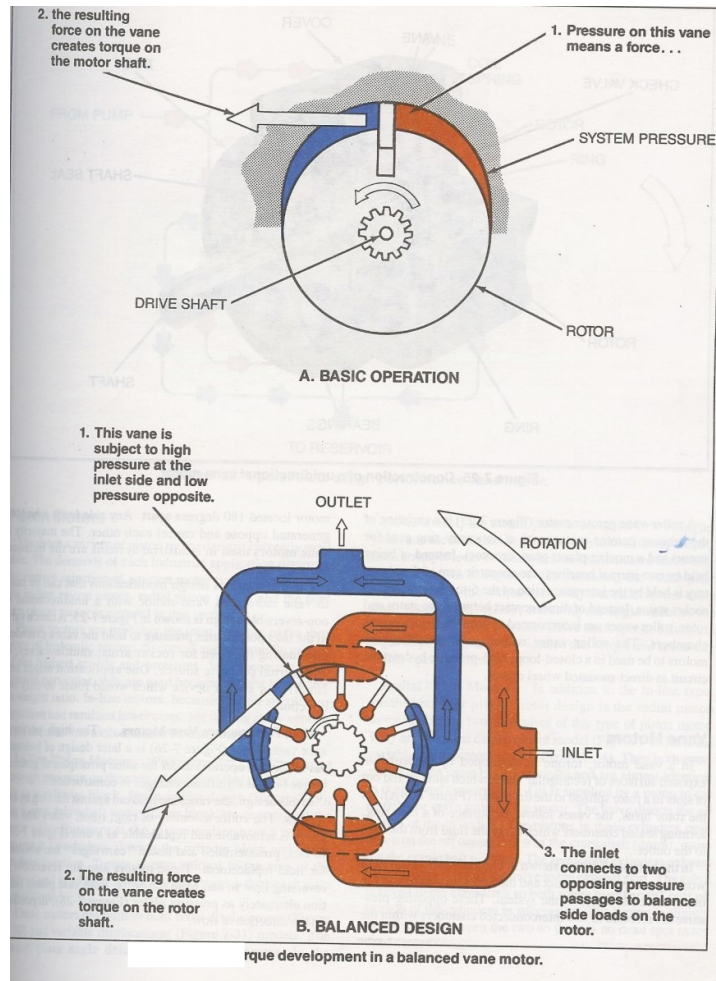
1. Gearmotor:



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A gear motor develops torque through pressure on the surfaces of gear teeth. The two gears mesh and rotate together, one gear coupled to drive shaft. The displacement of a gear motor is fixed and is equal to volume between two teeth multiplied by number of teeth. Generally gear's are not in balance with respect to pressure at the outlet result in high side loads on the shaft and gears as well as the bearings. Gear motor's are simple and more dirttolerant.

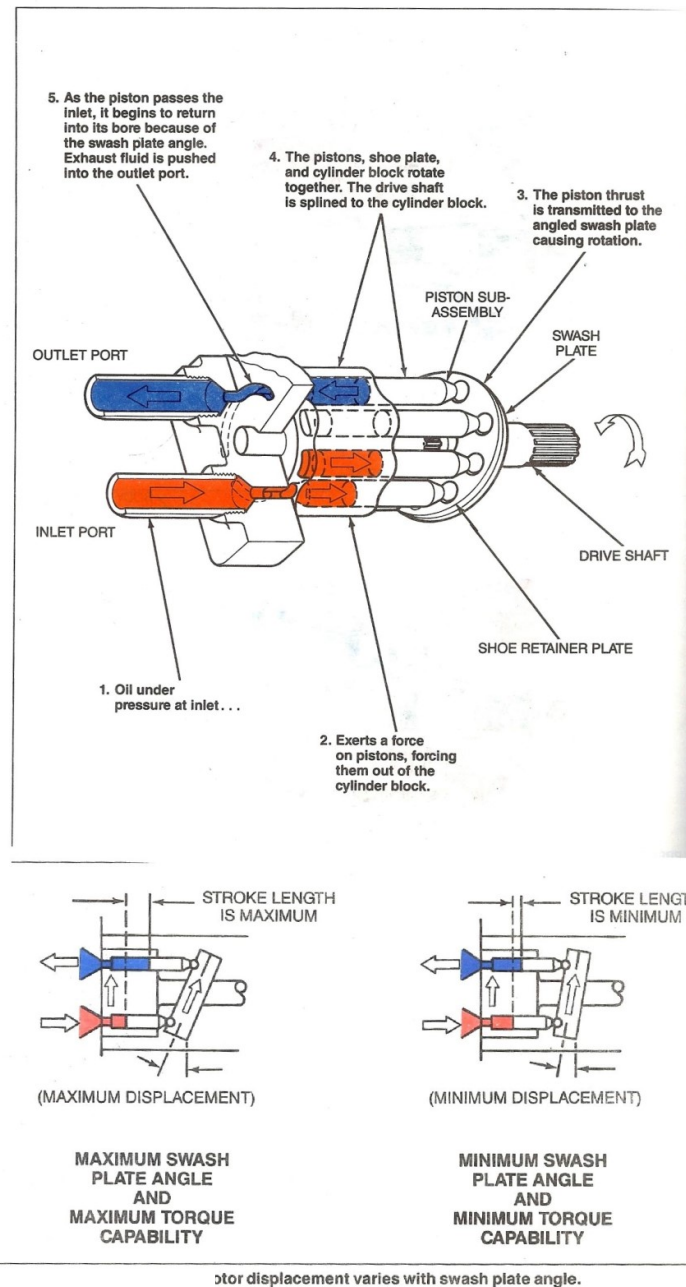
2. Vane motor:



In vane motor torque is developed by pressure on exposed surface of rectangular vanes, which slides in and out of slots in a rotor to drive shaft. As the rotor turns the vanes follow the surface of cam ring, carrying the fluid from inlet to outlet. In operation pressure under the vanes also holds them in contact with cam ring some devices are used to hold the vanes, may be spring clips or small springs beneath each vane pushing it out.

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AXIAL PISTON MOTOR:

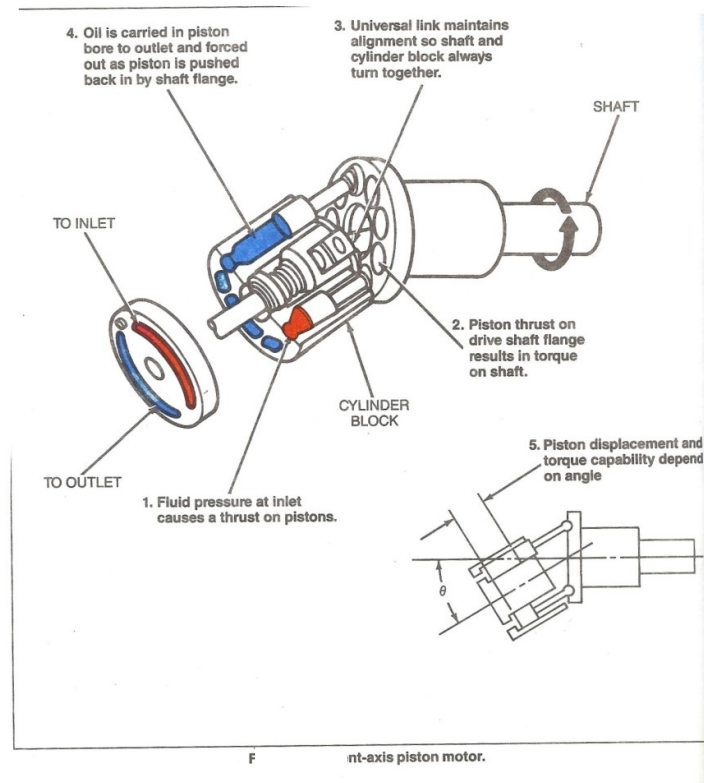


The axial piston motor is an energy converter with an axial piston arrangement in a barrel shaped body in swash plate-design motor circular arrangement of 9 pistons is located parallel to the drive shaft in a fixed housing. The pistons run in a cylinderal barrel which his firmly fixed to the drive shaft by means of a key. The piston ends or of burn and surface design and run on slipper pads. These are held on a swiveling but not rotating swash plate by means of holding discs. On the fixed displacement model the swash plate forms a part of the housing and therefore has a fixed swash angle which determines the pump displacement. The function of hydraulic motor is the reverse of that of the pump. Energy laden fluid is directed to the hydraulic motor while fluid is being directed at atmospheric pressure from a tank to the pump which then receives a specific amount of energy via the drive motor and the fluid is supplied to the system as pressure fluid. By charging the direction of the active components of this

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pressure fluid, hydraulic energy is converted into mechanical energy (as a torque) via the driven shaft (31). The energy- free fluid is now returned from the hydraulic motor to the tank. On this particular design too, 4 pistons are pressurized 4 are connected to the tank, and 1 is in an intermediate position. The bores in the pistons leading to the ball and socket serve to reduce the high surface pressure in the ball and socket and on the sliding disc that is to say – they serve to provide a hydro-static bearing. For special applications these hydraulics motors can also be equipped with any of the control and regulating devices

BENT AXIS DESIGN MOTOR:



The axial piston motor of bent axis design is an energy converter which converts the energy of the input fluid via a rotary movement into a torque on the driven shaft. The output speed is proportional to the displacement on the so called swept volume, and the torque is proportional to the operating pressure for to be more to the pressure drop between the inlet and outlet. As a rule motors with fixed displacement that is with a fixed swivel angle are used. Variable displacement units are, however, used in some applications.

The rotary group takes from of a complete interchangeable unit and consists of the angled barrel type body with output shaft, supported in the housing by robust bearings.

Pressure oil is supplied via the spherical port plate and those pistons not connected, the hydraulic energy being transmitted to the driven shaft by means of the stroke and output force of 3 pistons are converted into a torque. The now energyless fluid is returned to the tank by means of the return stroke of the 3 pressure unloaded pistons. The seventh piston remains in the crossover position. Due to the spherical design of the port plate torque free bearing of the barrel body is always given, even with maximum loading, the resulting forces in the motor housing being fully absorbed.

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MOUNTING PRECAUTION:

1. Motor's rating should be according to the workload.
2. All hydraulic connections must be tight. Loose connections will permit air to be drawn into the system causing noisy and erratic operation or will permit the hydraulic fluid to leakout.
3. Incoming and outgoing ports should be kept in desired direction.
4. All mounting screws should be properly tightened to prevent misalignment of shaft connections.
5. Shaft connecting devices such as keys, collars, etc. must be properly seated to avoid slippage and possible shearing of the shaft.
6. Tubing must not be bent too sharply. The minimum radius for bends is three times the inside diameter of the tube.
7. Sometimes motor is mounted indirectly to work load using pulleys and V-belts or chain or spur gear arrangements. Because of slippage possibilities flat belts must not be used. It is important to check for correct alignment and excessive belt tension. This is necessary to prevent excessive side loads imposed on the drive shaft bearings.

TROUBLE SHOOTING:

PROBLEMS	CAUSES	REMEDIES
1. Motor not running	1. No incoming pressure	1. Check pump and relief valve.
	2. Shaft seizure due to misalignment.	2. Align correctly the shaft with workload.
	3. Shaft seizure due to excessive load.	3. Check load and load capacity of motor.
	4. Too much play in the shaft.	4. Replace bearing.
	5. Oil spill at motor.	5. Check if port plate is in contact.
	6. O-ring on port plate effective.	6. Replace O-ring.
	7. Motor type too small.	7. Replace for larger type.
2. Slow motor operation.	1. Inlet pressure too low.	1. Increase pressure by setting relief valve.
	2. Motor parts defective	2. Replace defective parts.
	3. Oil temperature too high.	3. Check for line restrictions, wrong fluid viscosity and also check cooling circuit.
	4. Outlet pressure too high	4. Check outlet line
	5. Port plate does not make contact.	5. Disassemble motor and repair.