Basic Hydraulics

Hydraulics is the science of forces and movements transmitted by means of liquids.

FLUID TECHNOLOGY

Fluid transport systems

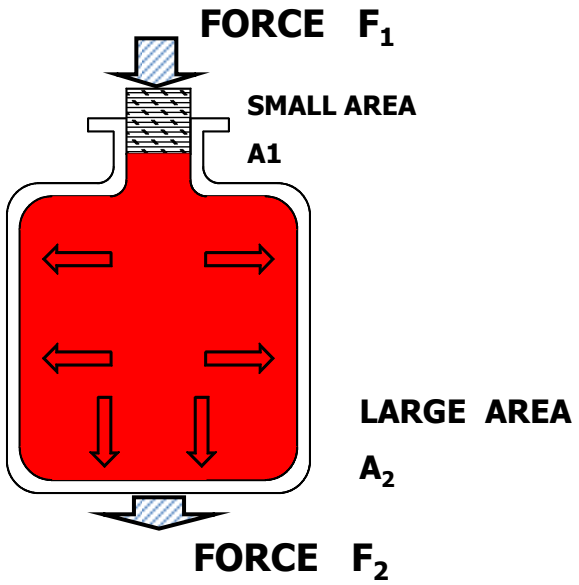
Fluid power systems

In The Beginning…

In the 17th century Pascal developed the law of confined fluids.

Pascal's Law

"Pressure applied on a confined fluid is transmitted undiminished in all directions, and acts with equal force on equal areas, and at right angles to them".



$$P = \frac{F_1}{A_1}$$

$$F_2 = P \times A_2$$

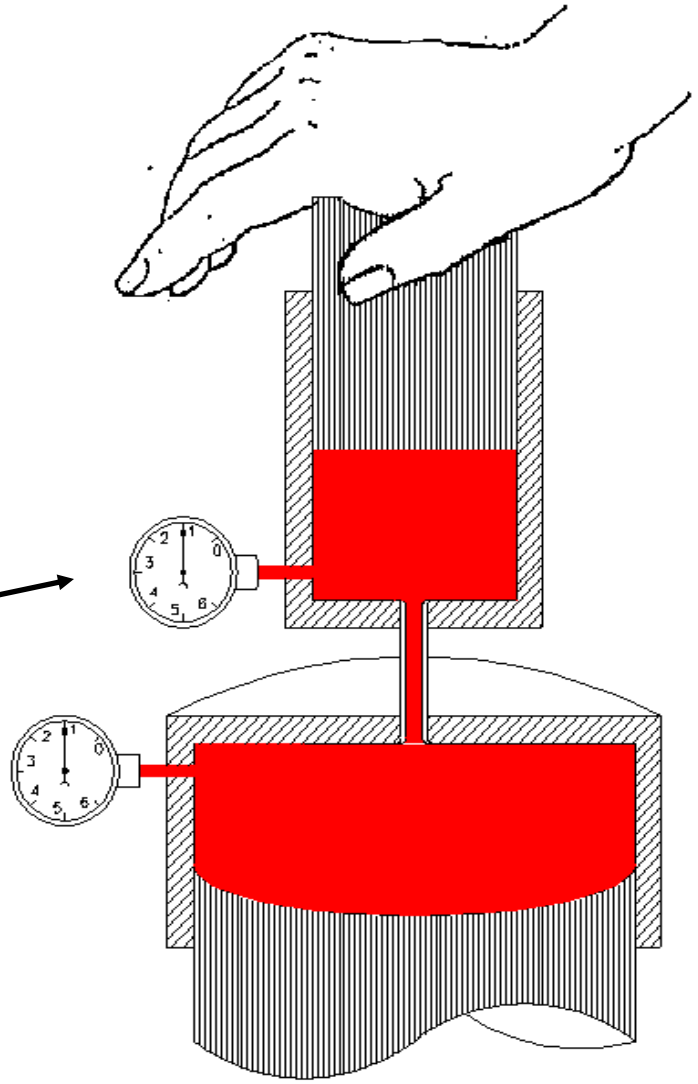
HYDROSTATICS

$F_1 = 1\ Kg$

$A_1 = 1\ Cm^2$

$P = \frac{F_1}{A_1} = \frac{1\ Kg}{1\ Cm^2}$

$= 1\ Kg / Cm^2$



(Same Pressure P)

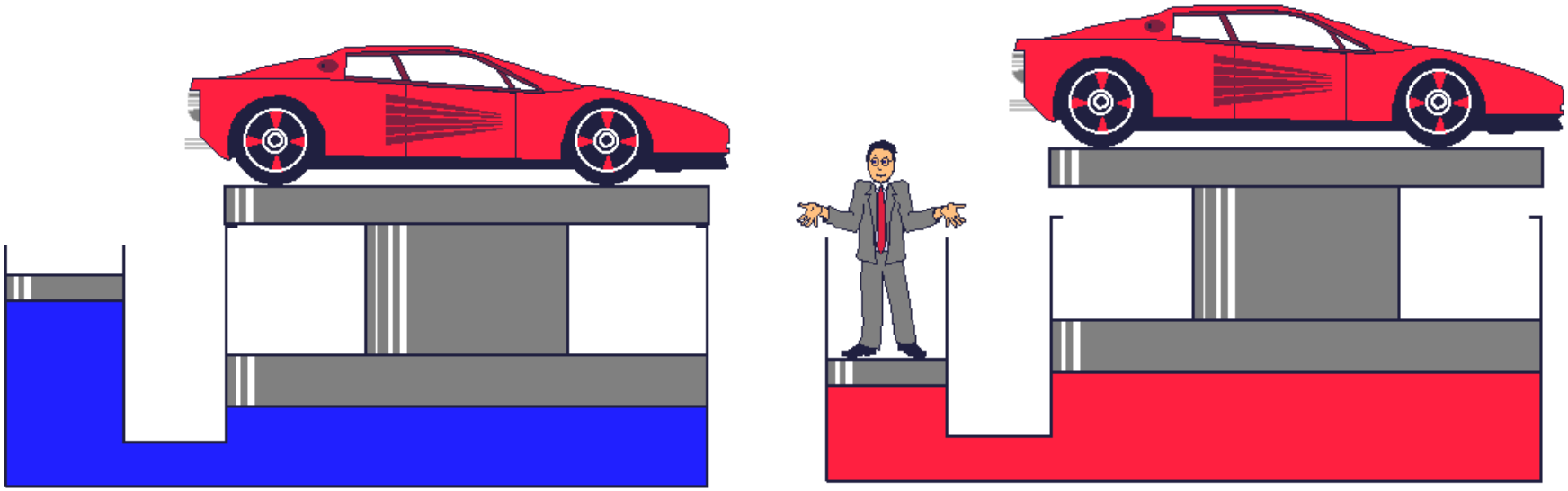
$A_2 = 10\ Cm^2$

$F_2 = P \times A_2$

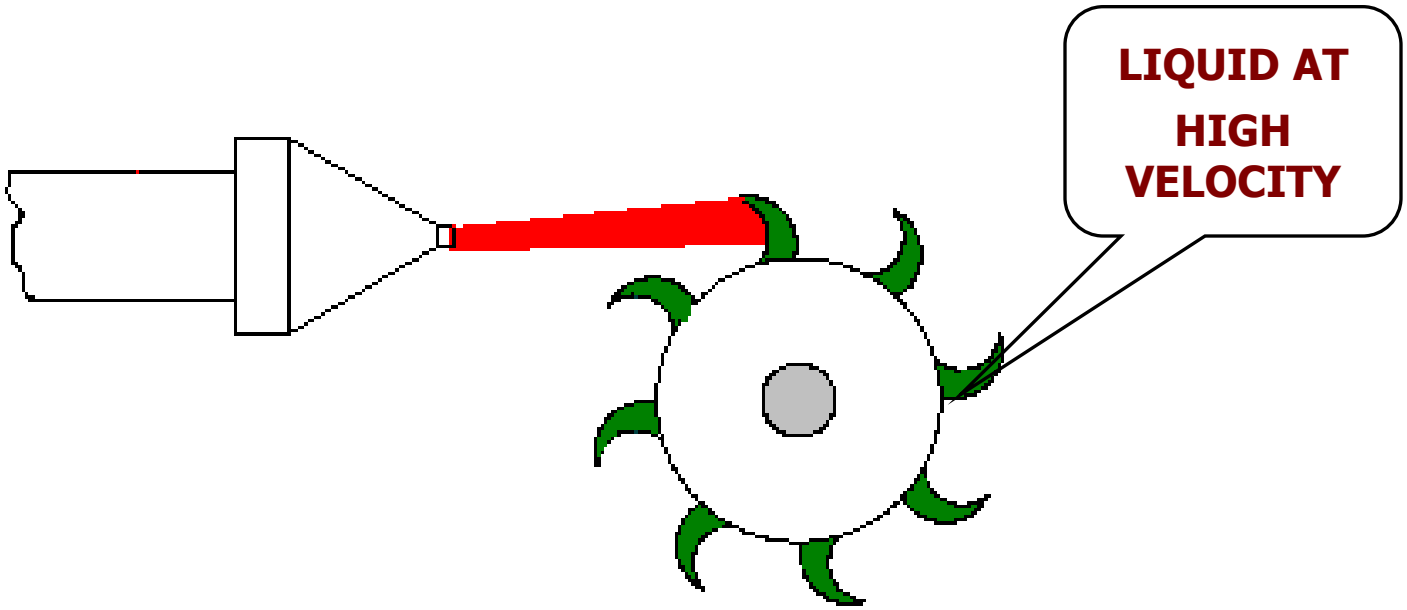
$= 1 \times 10$

$= 10\ Kg$

PASCAL'S Law



HYDRODYNAMICS



Hydraulic System Applications

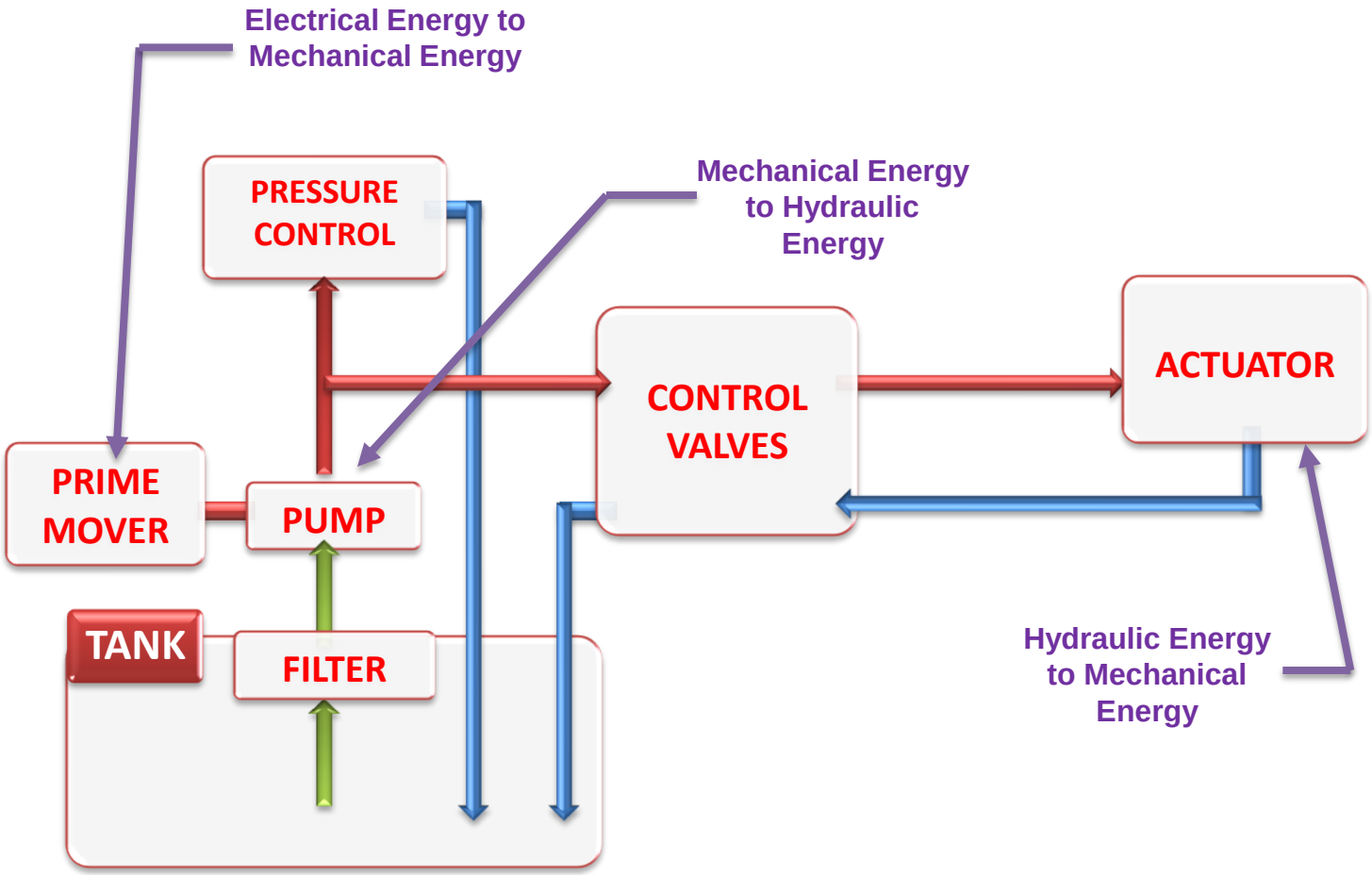
Fig: Hydraulic press

Fig: Hydraulic disc brakes

Fig: Hydraulic lift table

Fig: Excavator

Hydraulic System



Hydraulic System Components

1. **Power pack**

a) Tank / reservoir

b) Oil

c) Filters

d) Strainers

e) Prime movers

f) Pumps

g) Oil level and Temperature indicators

h) Heat exchangers

2. **Control valves**

a) Direction

b) Pressure

c) Flow

3. **Actuators**

a) Cylinders

b) Motors

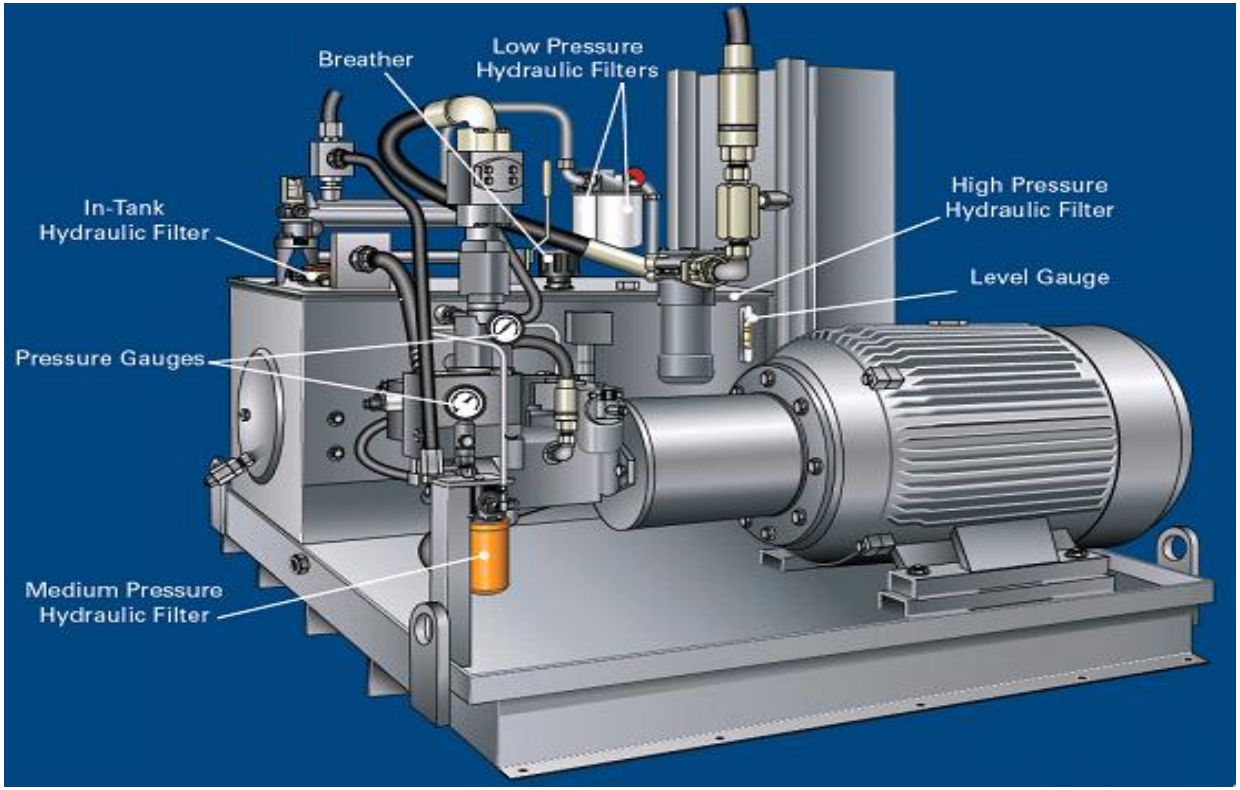
4. **Accessories**

a) Accumulators

b) Pressure gauges

c) Temperature gauges

• POWER PACK



Technical data

Capacities - litres
Type of pump (Fixed / Variable displacement)
Displacement $V_{g\,max}$ cm³
Operating pressure p_{max} bar
El. motor power *P* kW

Elements

- ❑ Tank
- ❑ Oil
- ❑ Filters & Strainers
- ❑ Breathers
- ❑ Pump
- ❑ Electrical Motor
- ❑ Heat Exchangers
- ❑ Oil level indicators
- ❑ Pressure and Temperature gauges

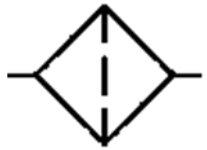
Tank / reservoir

Symbol

Hydraulic Oil

- Temperature range: -54° C to 135° C
- NAS class, ISO class
- Viscosity, Viscosity Index
- Compressibility
- Foaming

Hydraulic Filters



Symbol

Beta ratio (β) = Upstream particle count / Downstream particle count.

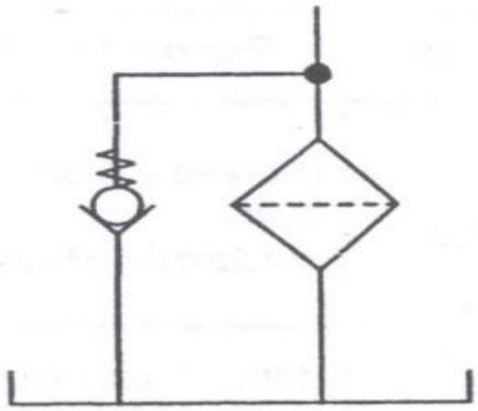
Breathers and Strainers

1. **Air Filtration**
2. **Dehumidification**

Symbol

Types of Filters

Suction Filter

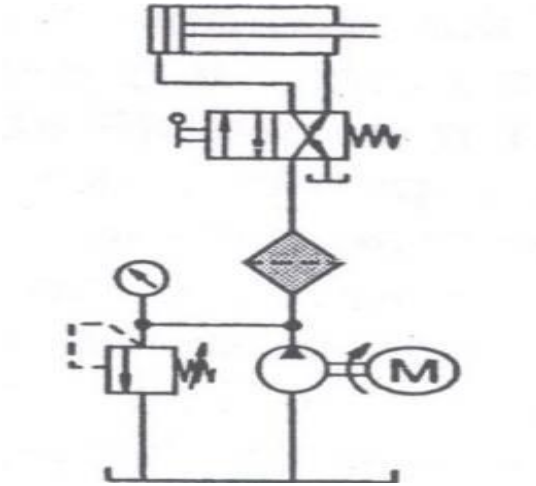


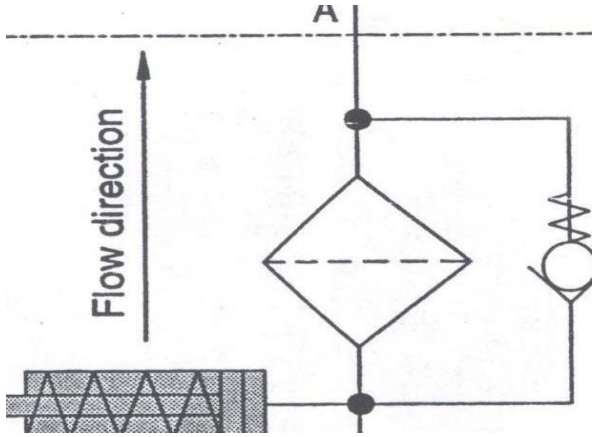
- Located in the suction line of the pump
- Only filtered oil entered the system
- Grade of filtration is 60 µm – 100 µm
- Purely to protect the pump from contamination
- That is why suction filters are equipped with by-pas valves
- Can also be used ahead of the pump as a coarse filter

Types of Filters

Pressure Filter

- Installed in the pressure line of the hydraulic system ahead of the device which are sensitive to dirt e.g. at the pressure port of the pump ahead of valves or flow control valves
- Since this filter is subjected to maximum pressure, it must be of robust design
- Should not have a by-pass but have a contamination indicator
- Operating pressure up to 420 bar
- Grade of filtration 3 µm– 5 µm
- Requires a pressure tight housing and contamination indicator
- The effectiveness of the filter is checked be the contamination indicator





Types of Filters

Return Filter

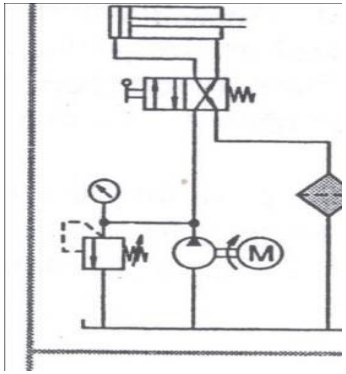
- Installed in the return line
- Cheaper than the high pressure filter
- Operating pressure up to max. 30 bar
- Grade of filtration 10 µm – 25 µm

Main stream Filtering

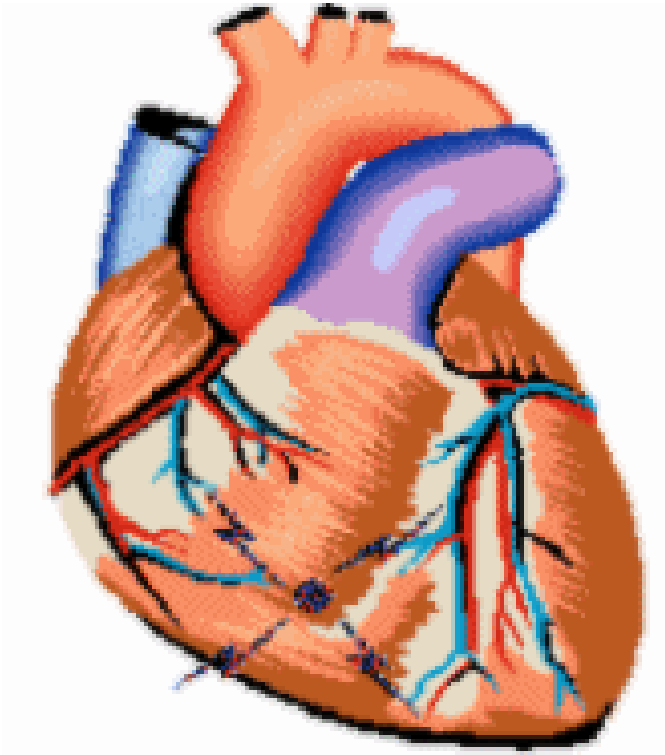
Suction filter : Pr. Difference = 0.05 to 0.1 bar at operating temperature

Pressure filter : Pr. Difference = 1 to 1.5 bar at operating temperature

Return filter: Pr. Difference = 0.5 bar at operating temperature



Principle – What is Pump ?



- **Pump is a Source of Power**
- **Primary Function is to develop**

flow not pressure

Hydraulic Pumps

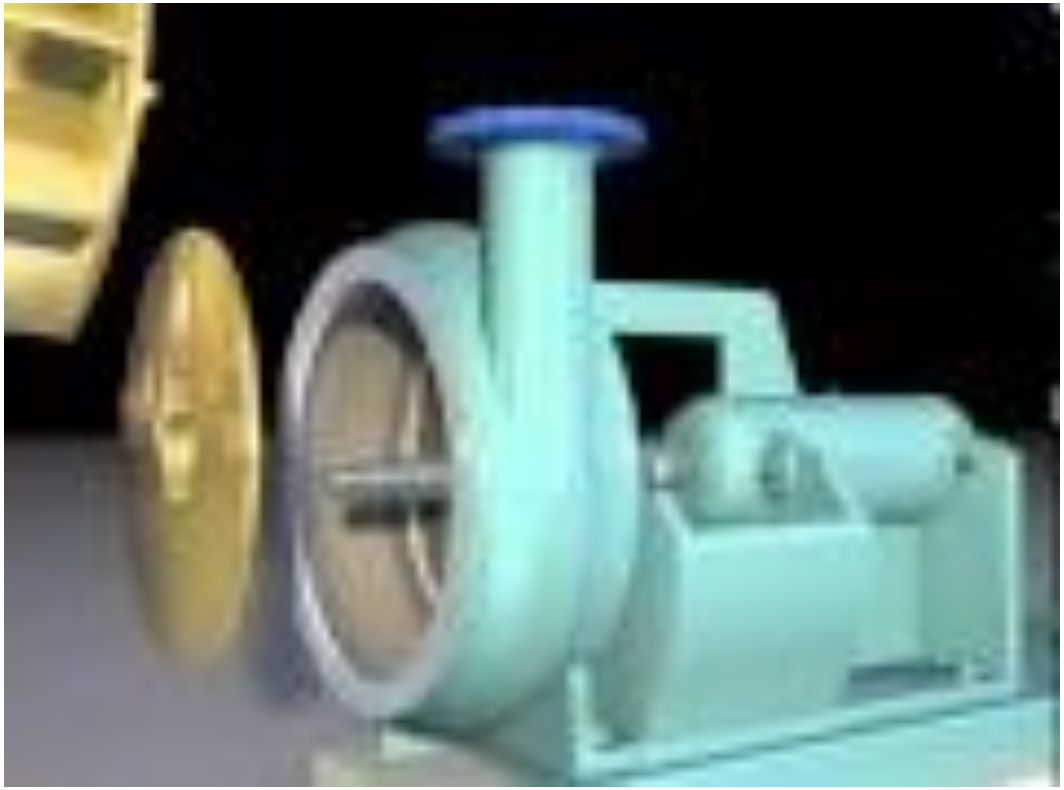
(i) Non-positive displacement or Hydrodynamic pumps

- **Low pressure high flow applications**

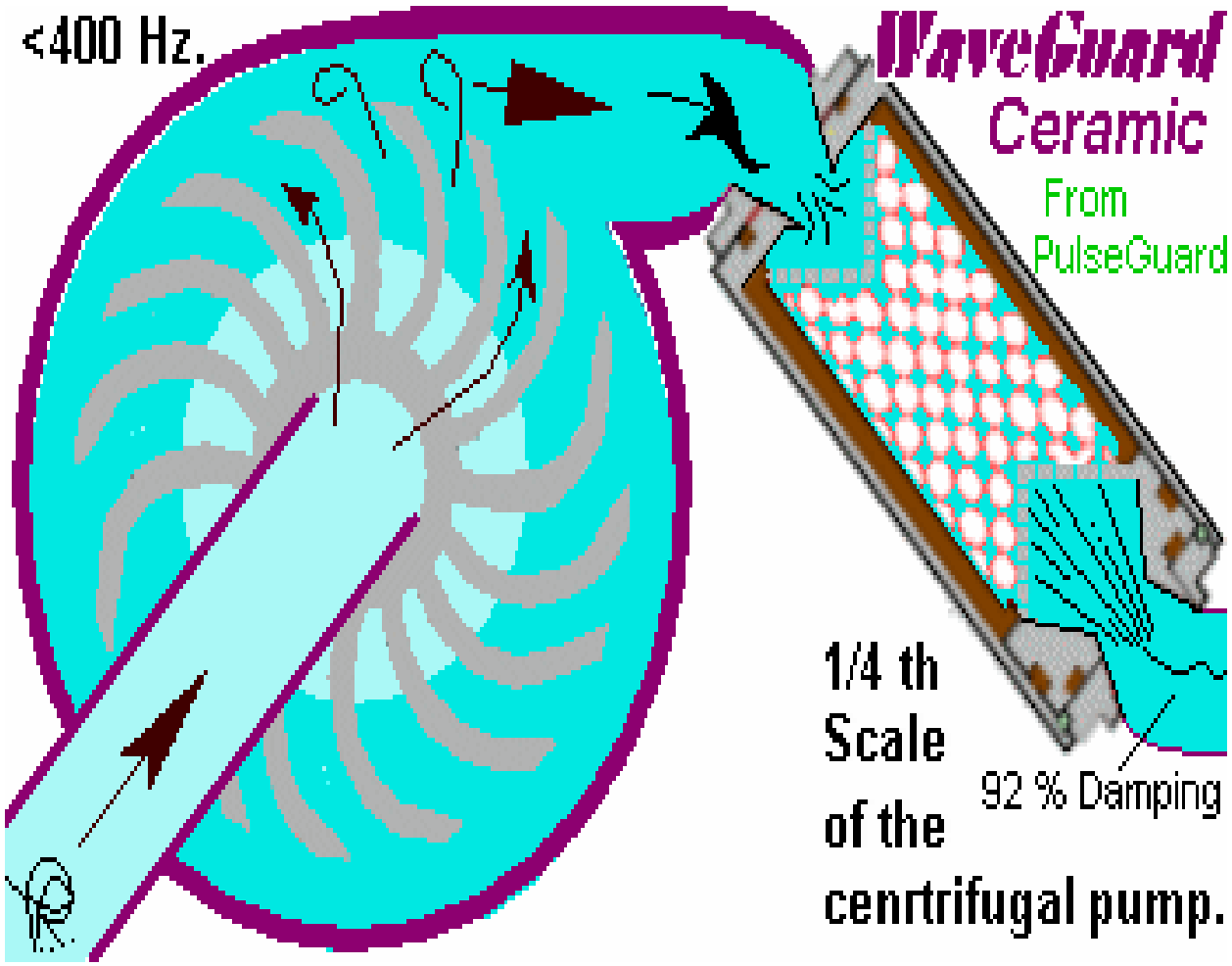
(ii) Positive displacement or Hydrostatic pumps

- **High pressure low flow applications**

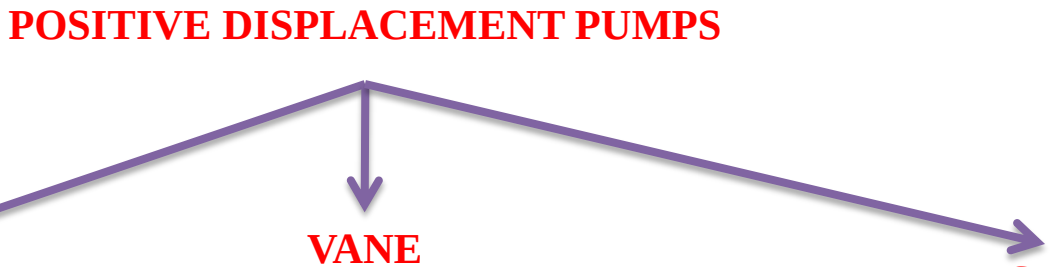
Centrifugal Pump



Non- Positive Displacement Pump


<400 Hz.
WaveGuard
Ceramic
From
PulseGuard
1/4 th
Scale
of the
cenrtrifugal pump.
92 % Damping

Classification of Positive Displacement Pumps



GEAR

1. External Gear
2. Internal Gear
3. Gerotor
4. Lobe
5. Screw

VANE

1. Unbalanced
   a) Fixed Displacement
   b) Variable Displacement
2. Balanced (Fixed)

PISTON

1. Axial Design
   a) Bent axis type (F/V)
   b) Swash plate type (F/V)
2. Radial Design

Volumetric efficiency

1. Gear pumps – 80% to 90%
2. Vane pumps - 82% to 92%
3. Piston pumps - 90% to 98%

Gear Pumps

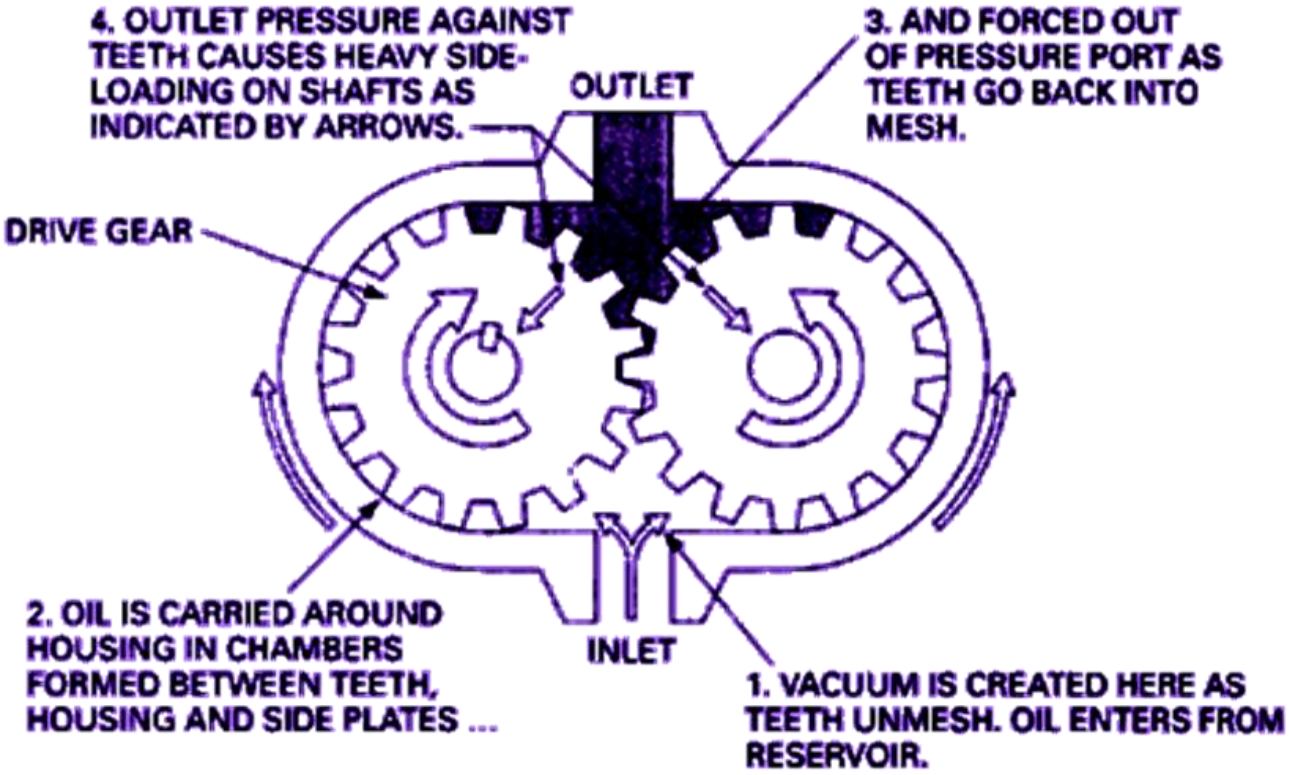
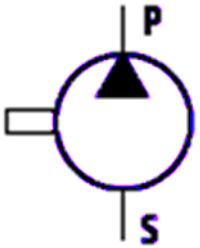


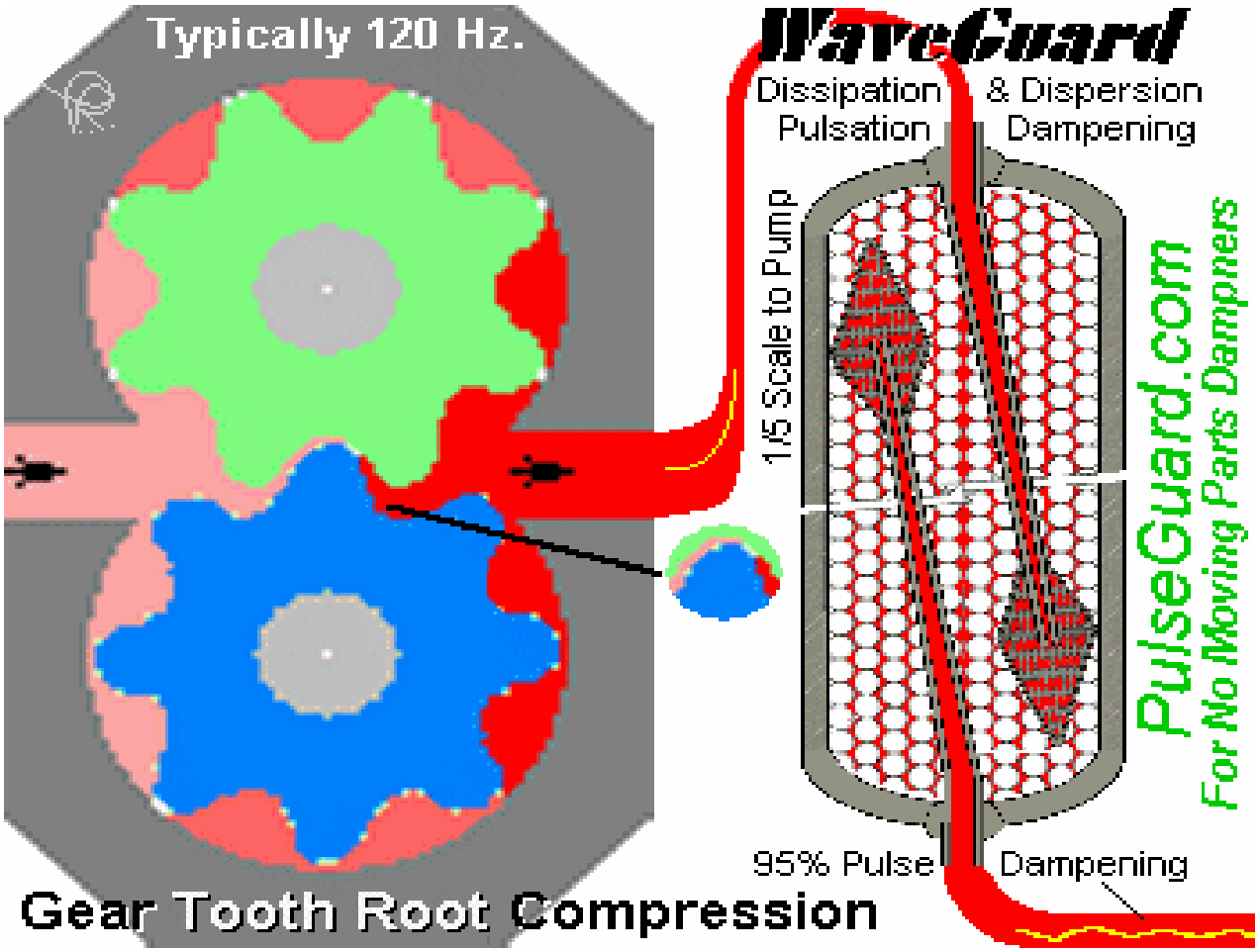
Fig: External gear pumps

Symbol

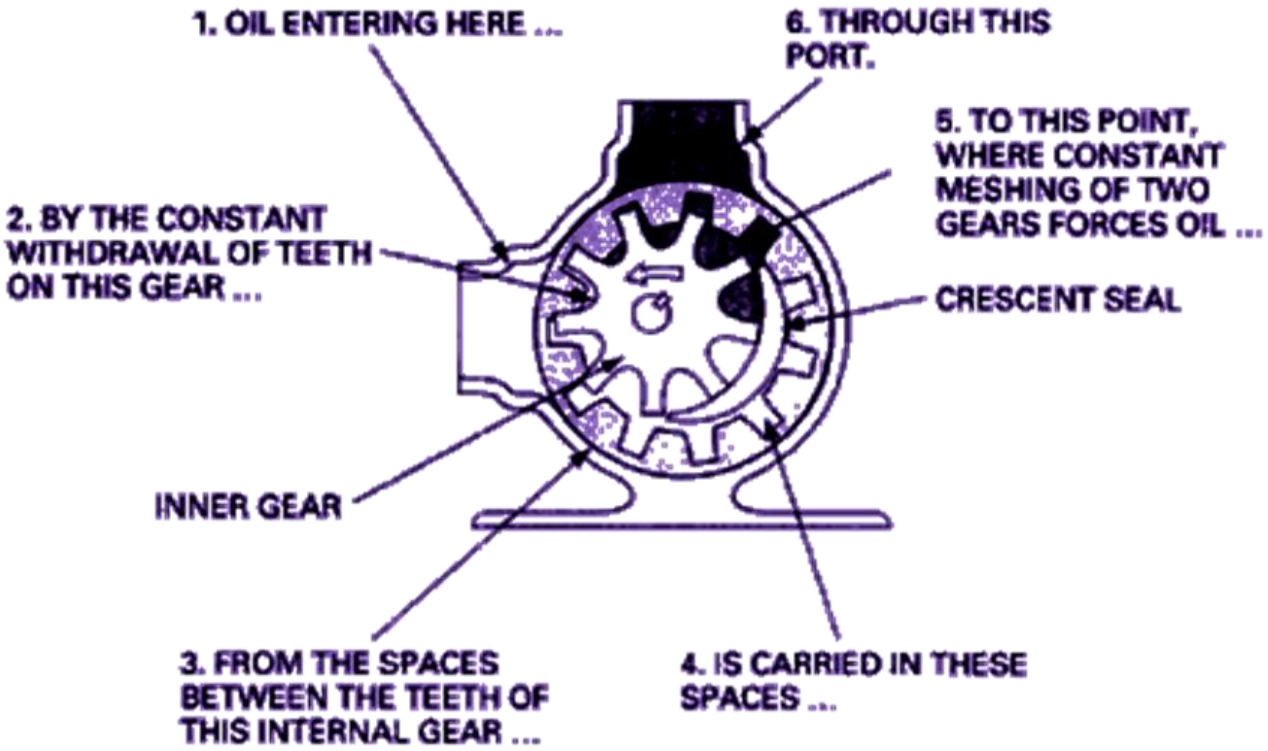


Important Parameters

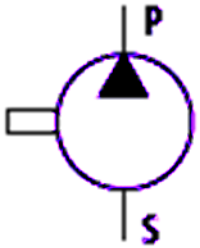
1. **Displacement Volume – 0.2 to 200 cc**
2. **Maximum pressure – up to 300 bar**
3. **Speed range – 500 to 6000 rpm**


Typically 120 Hz.
WaveGuard
Dissipation & Dispersion
Pulsation Dampening
1/5 Scale to Pump
PulseGuard.com
For No Moving Parts Dampners
95% Pulse
Dampening
Gear Tooth Root Compression

Internal gear pumps



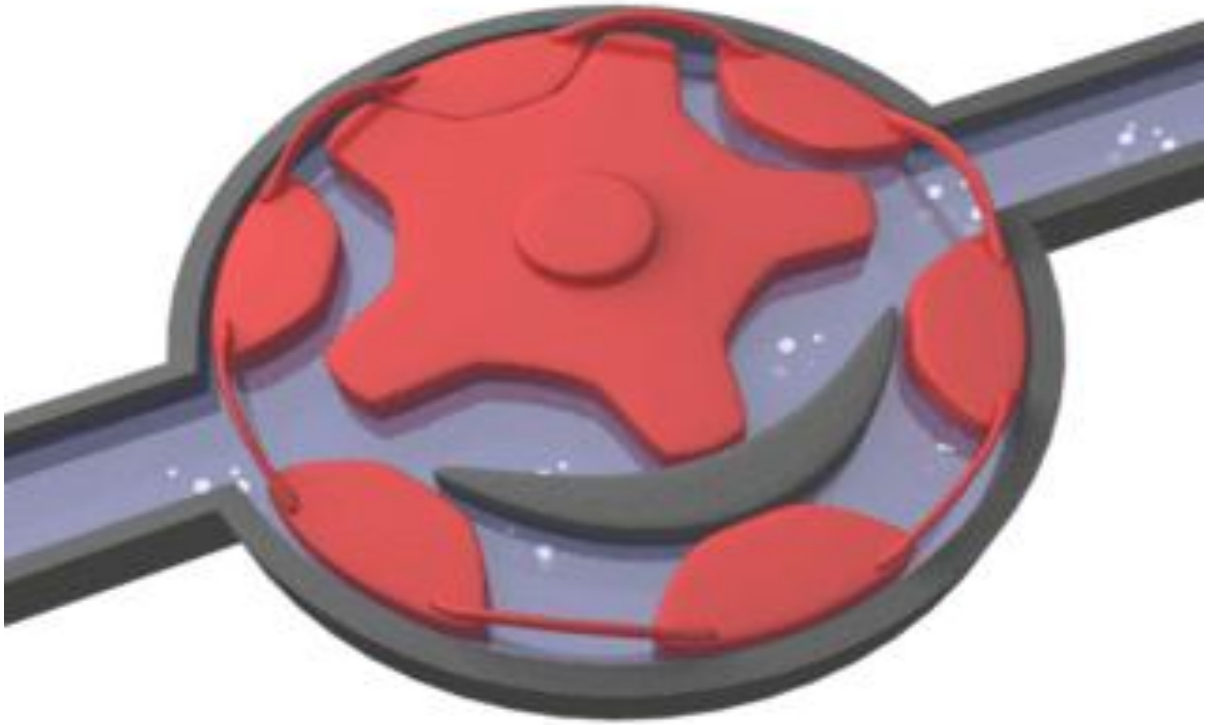
Symbol



Important Parameters

1. **Displacement Volume – 0.2 to 200 cc**
2. **Maximum pressure – up to 300 bar**
3. **Speed range – 500 to 6000 rpm**

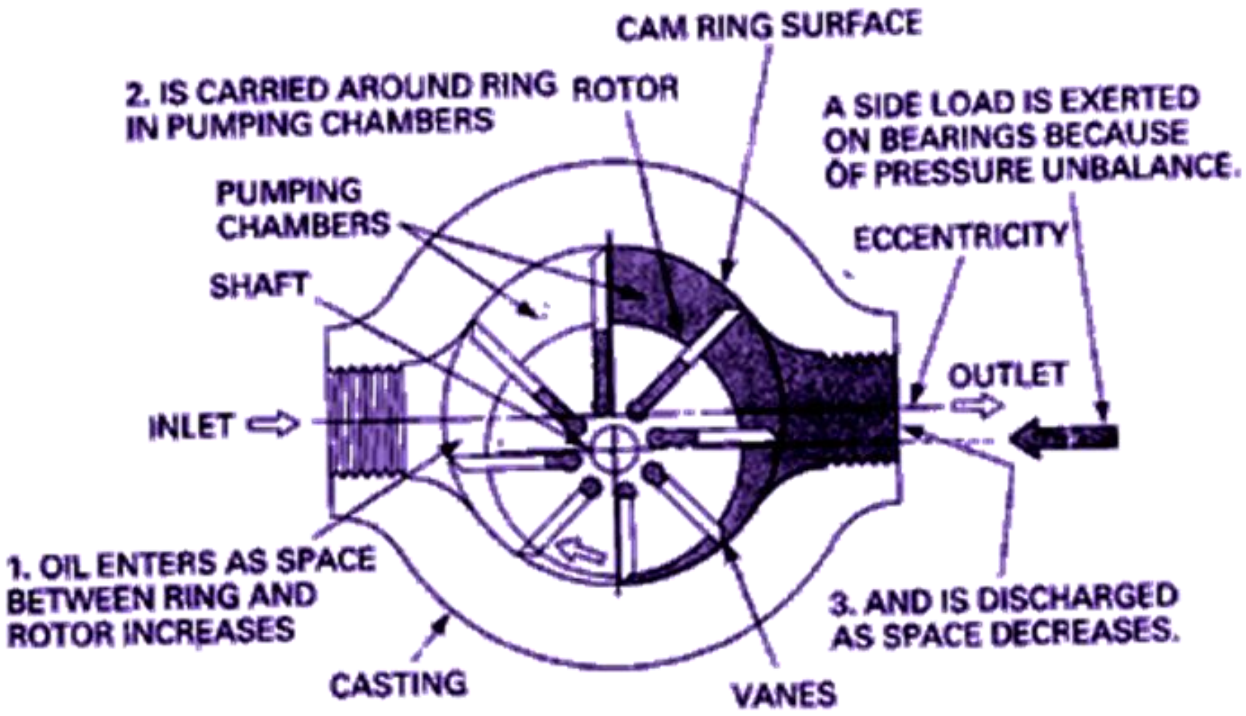
Internal Gear Pump



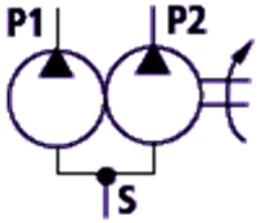
Vane Pumps

Unbalanced vane pumps

Fixed displacement pumps



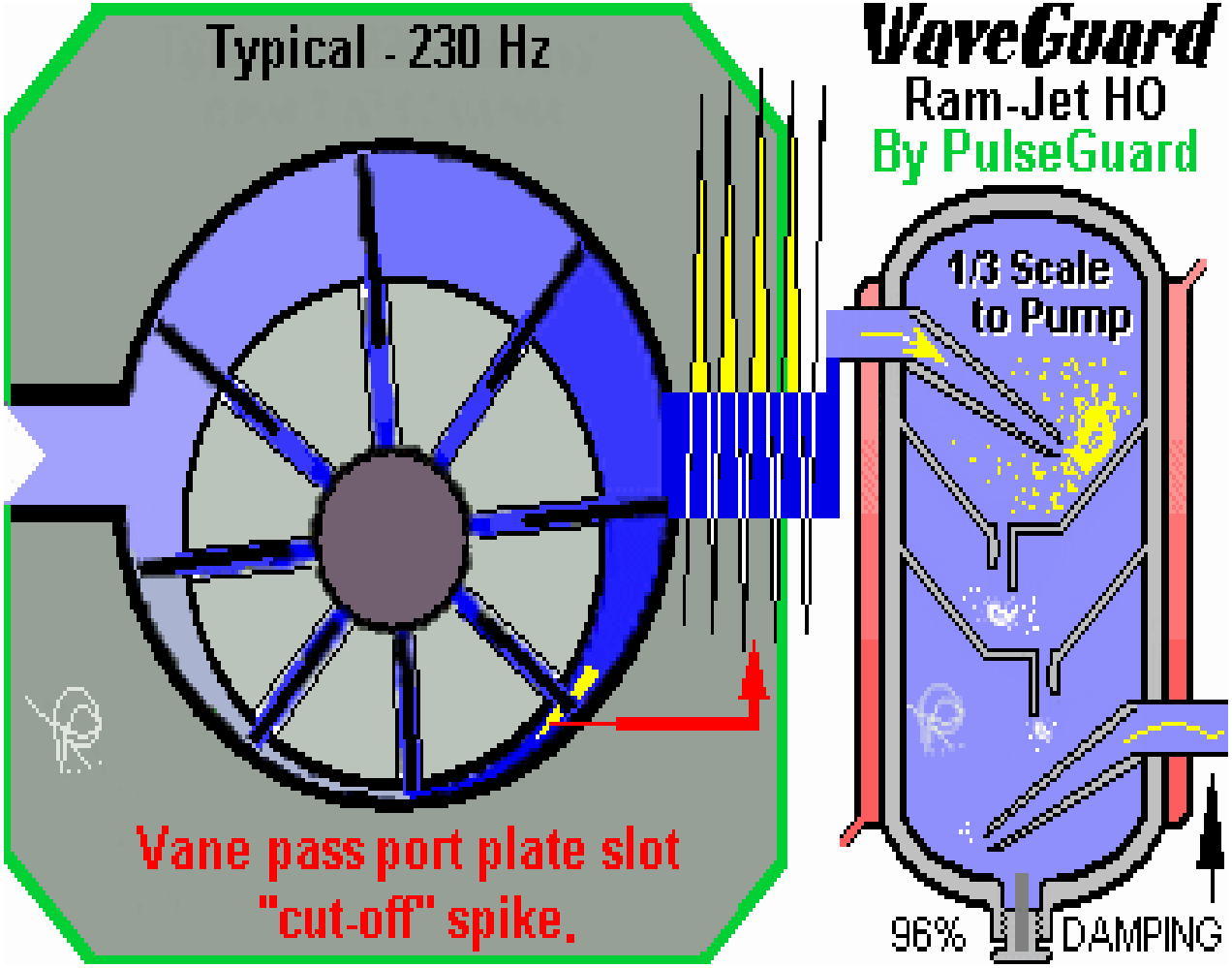
Single pump



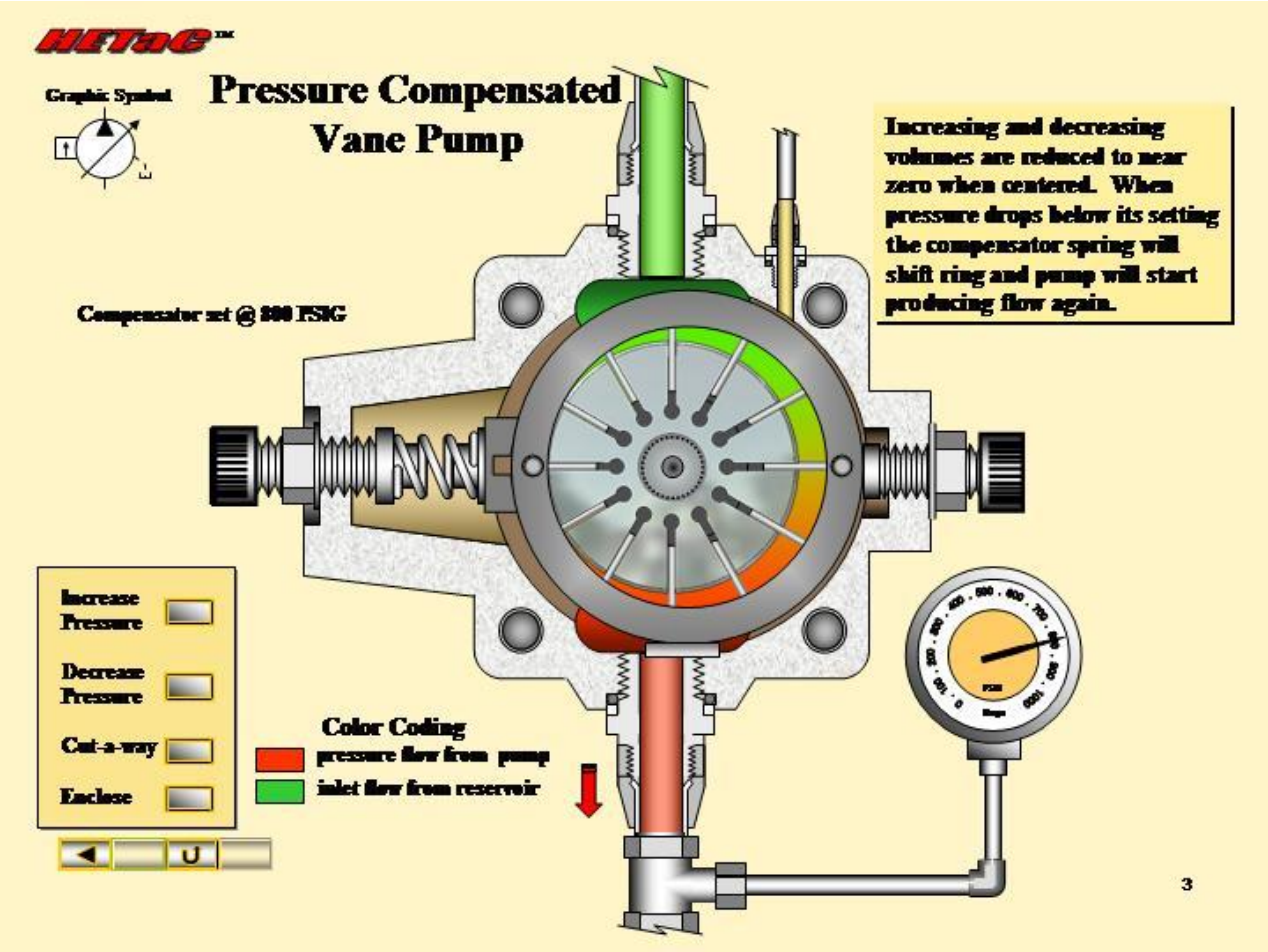
Double pump

Important Parameters

1. **Displacement Volume – 18 to 195 cc**
2. **Maximum pressure – up to 210 bar**
3. **Speed range – 600 to 2700 rpm**

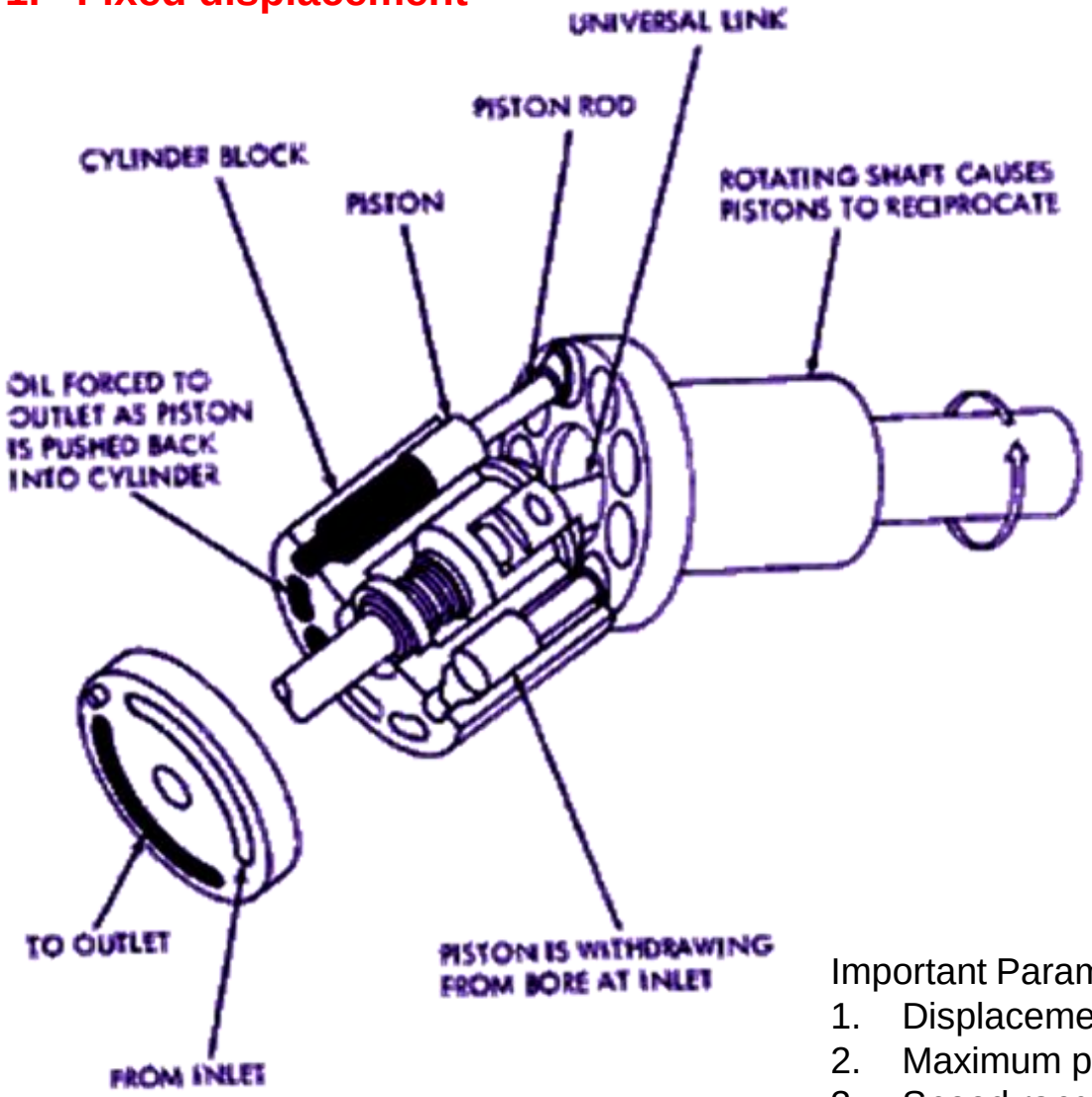

Typical - 230 Hz
WaveGuard
Ram-Jet HO
By PulseGuard
1/3 Scale
to Pump
Vane pass port plate slot
"cut-off" spike.
96%
DAMPING

Variable Displacement Pump

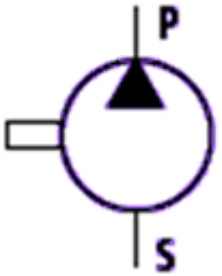


Axial Piston Pump – Bent Axis Design

1. Fixed displacement

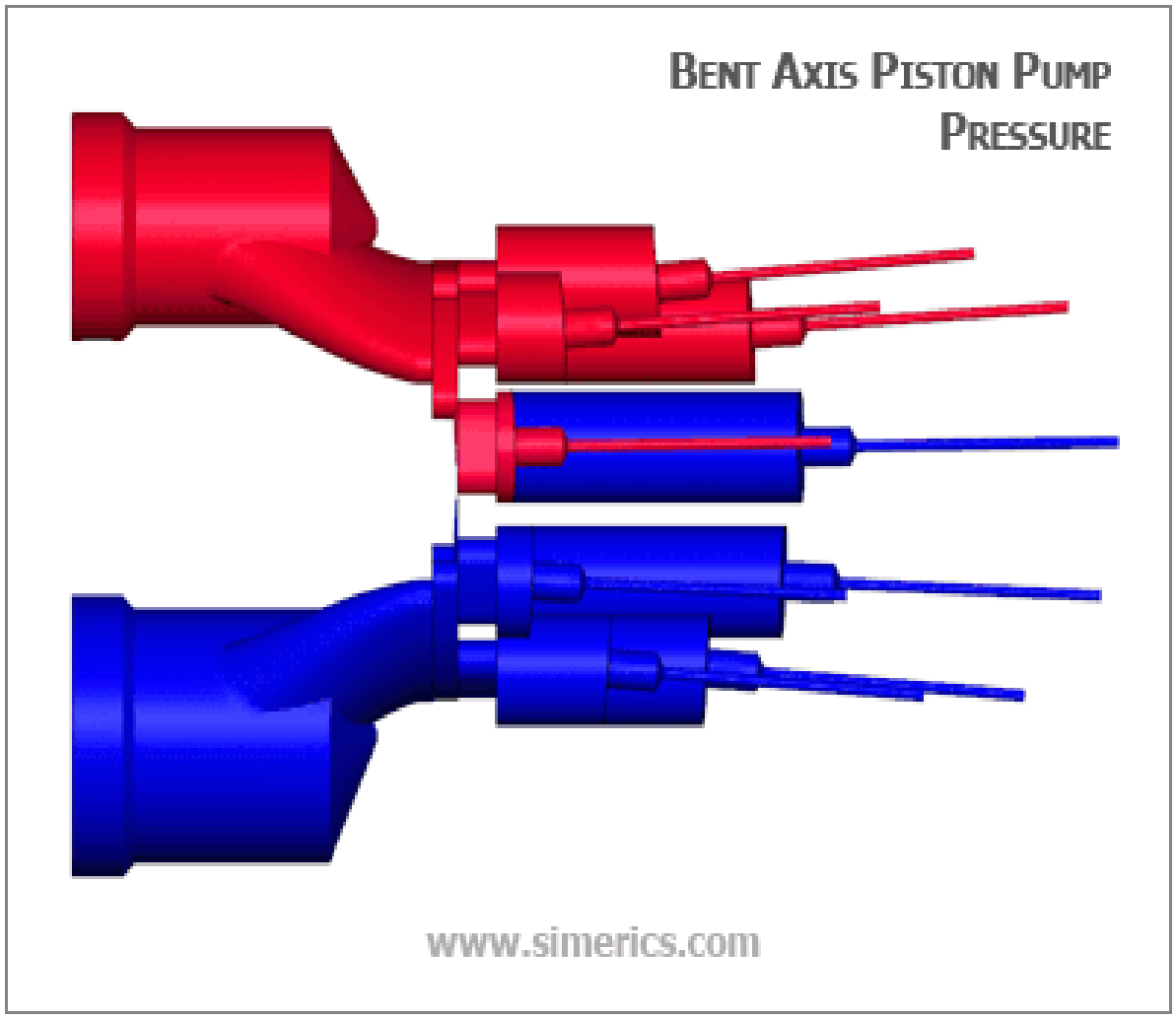


Symbol

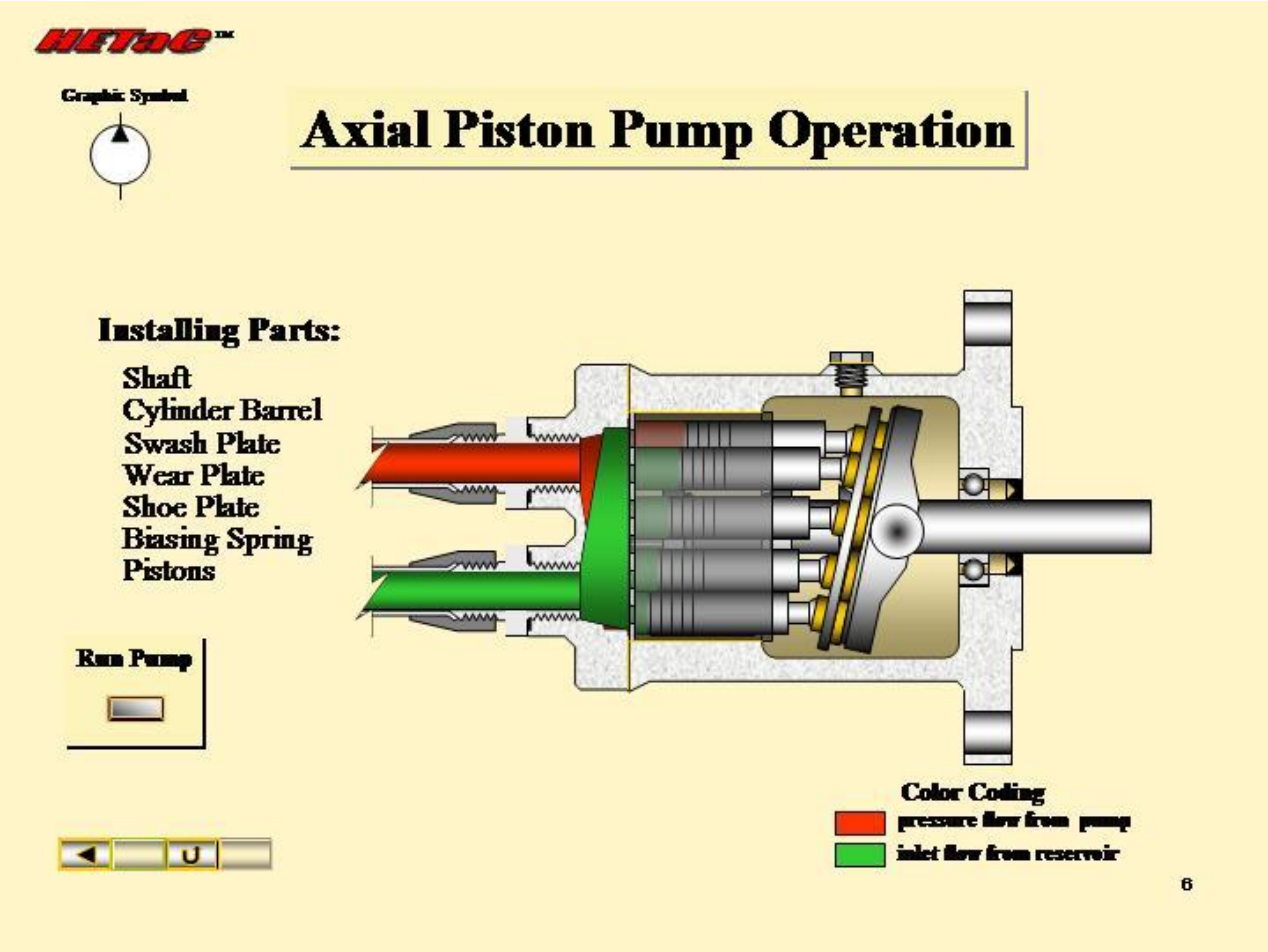


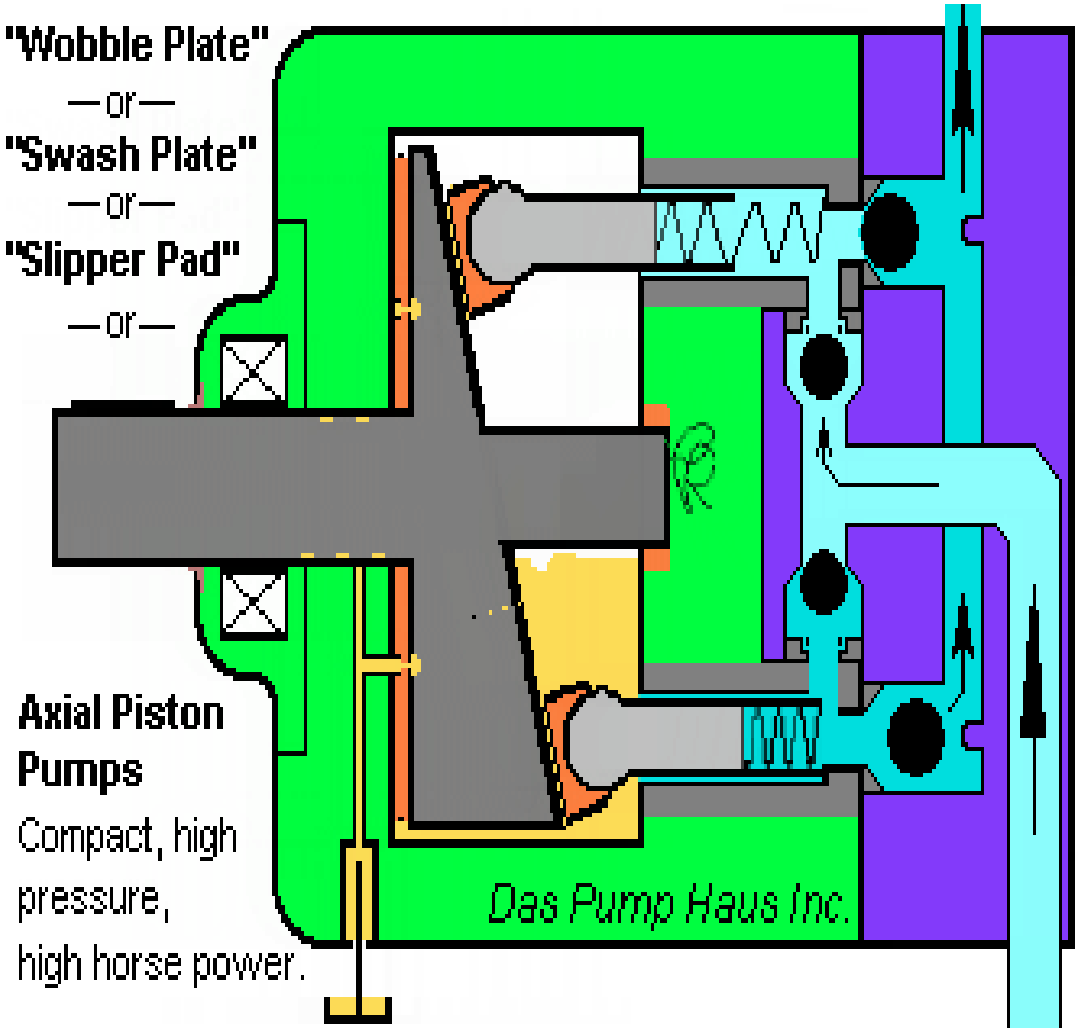
Important Parameters

1. Displacement Volume – 18 to 1000 cc
2. Maximum pressure – up to 400 bar
3. Speed range – 600 to 6000 rpm

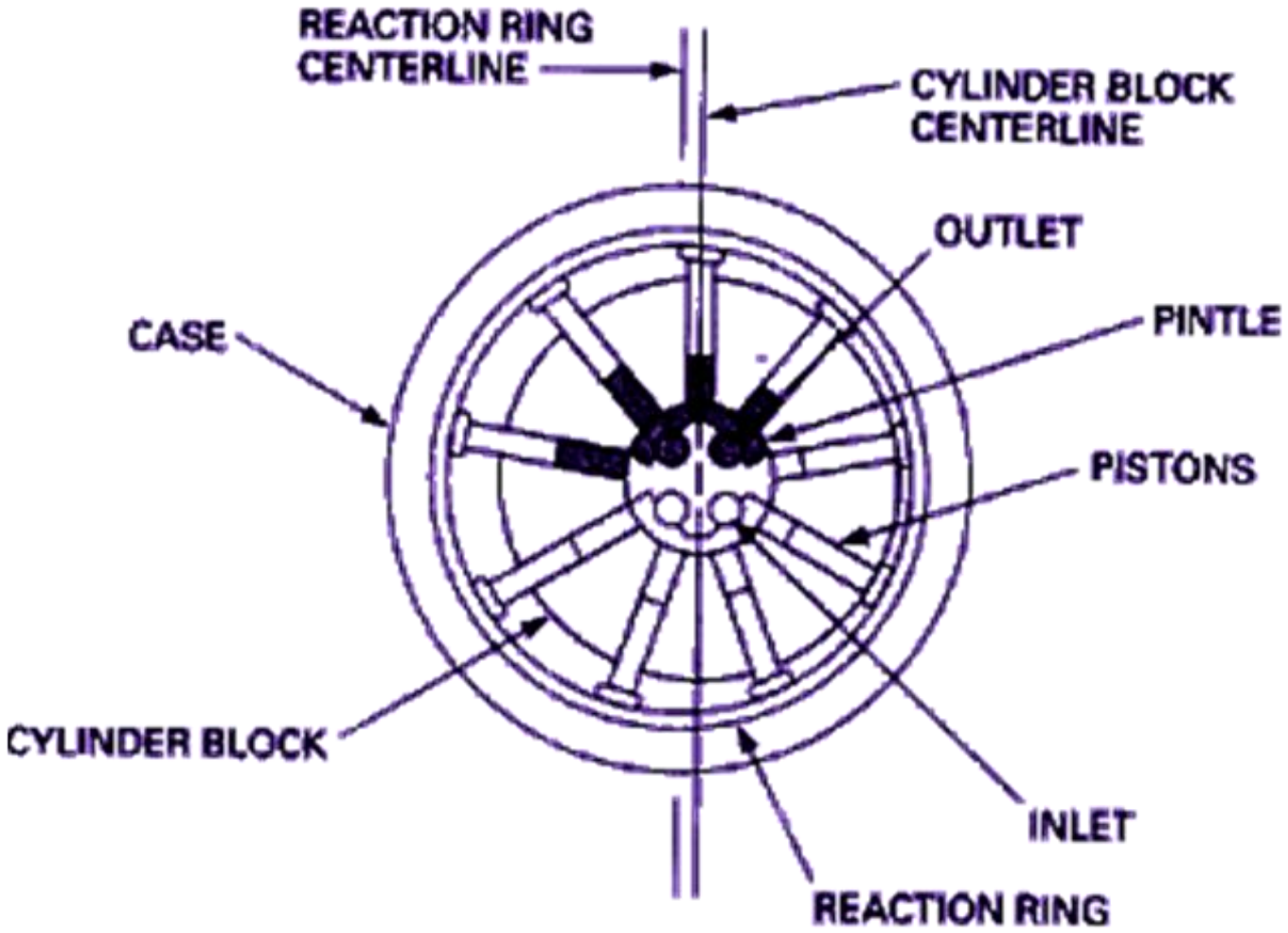

BENT AXIS PISTON PUMP
PRESSURE
www.simerics.com

Axial Piston Pump – Swash Plate Design

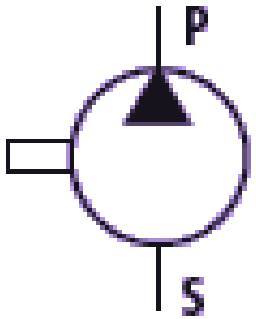



"Wobble Plate"
—or—
"Swash Plate"
—or—
"Slipper Pad"
—or—
Axial Piston Pumps
Compact, high pressure, high horse power.
Das Pump Haus Inc.

Radial Piston Pump

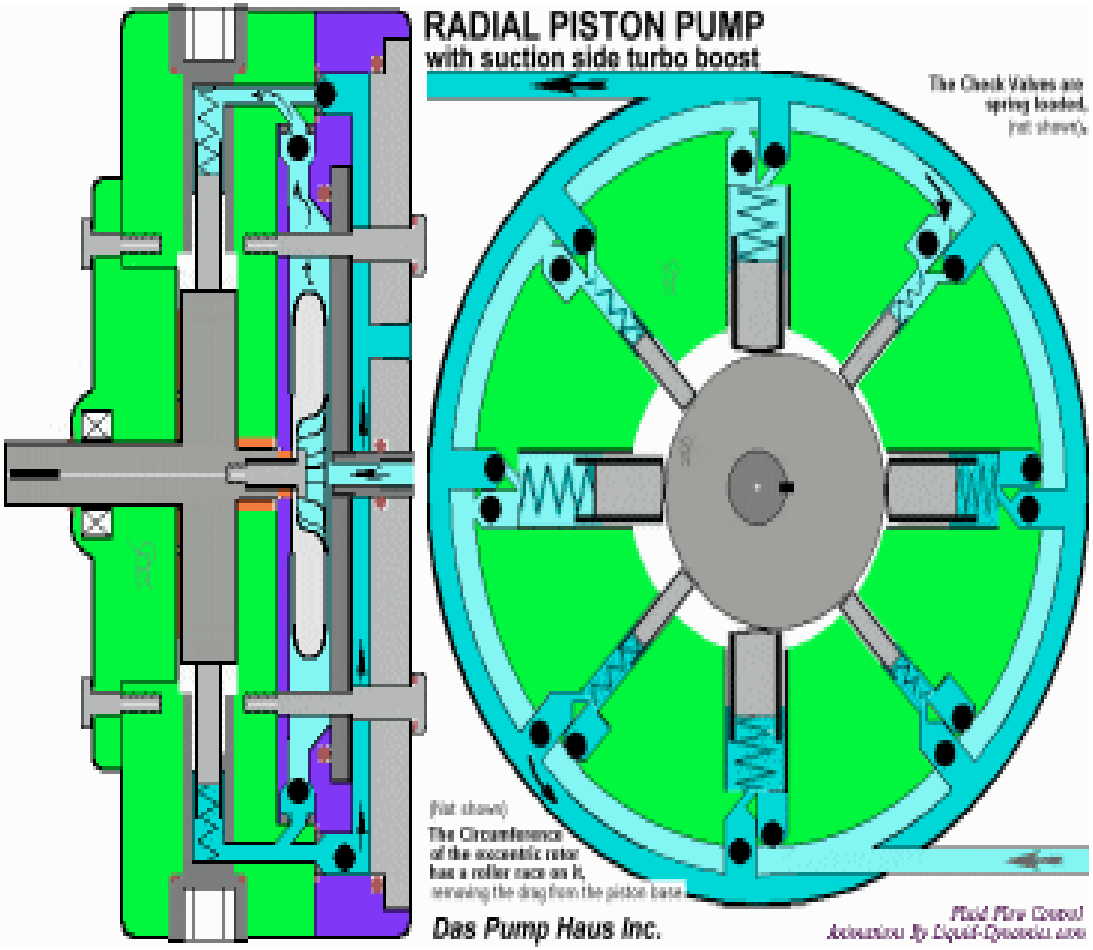


Symbol



Important Parameters

1. Displacement Volume – 500 cc
2. Maximum pressure – up to 700 bar
3. Speed range – 1000 to 3400 rpm

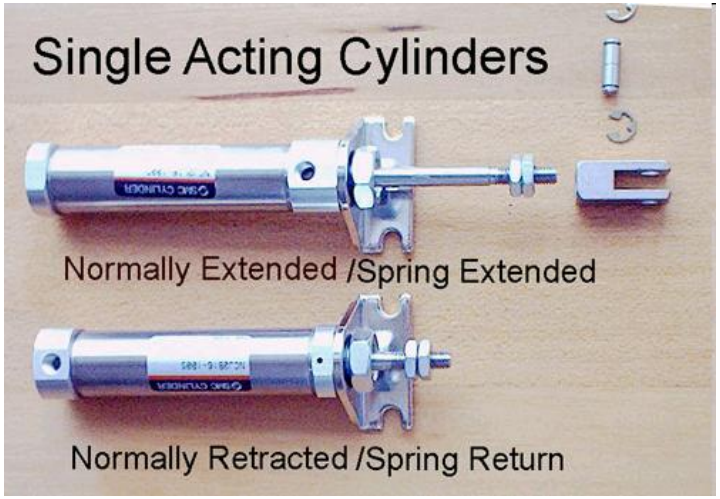

RADIAL PISTON PUMP
with suction side turbo boost
The Check Valves are spring loaded,
(not shown).
(Not shown)
The Circumference of the eccentric rotor has a roller race on it, removing the drag from the piston base.
Das Pump Haus Inc.
Fluid Flow Control
Animation By Liquid-Dynamics.com

Control Valves

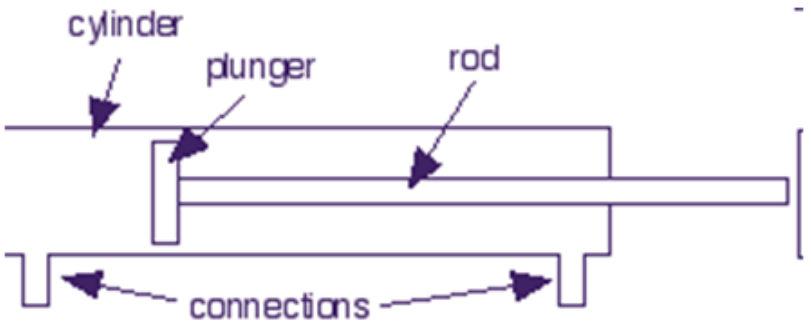
1. Non-return Valve (NCV)
2. Flow control valve (FCV)
3. Pressure control valves (PCV)
4. Direction control valves (DCV)

Actuators

1. Single acting



2. Double acting

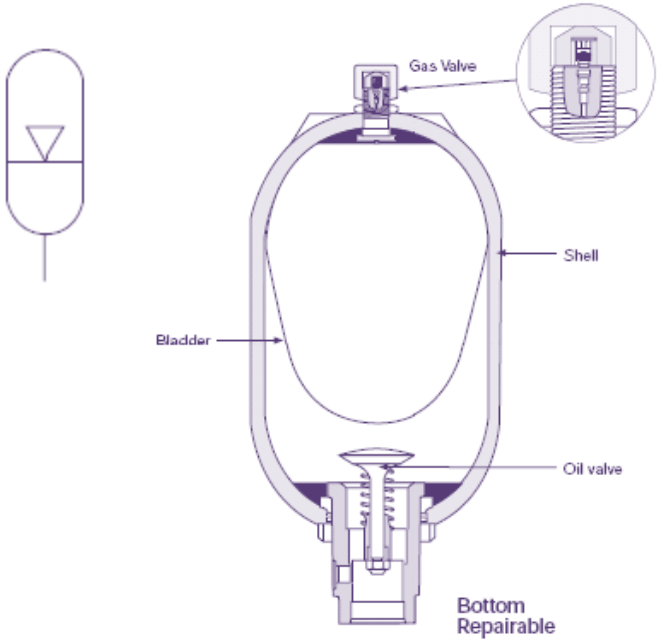


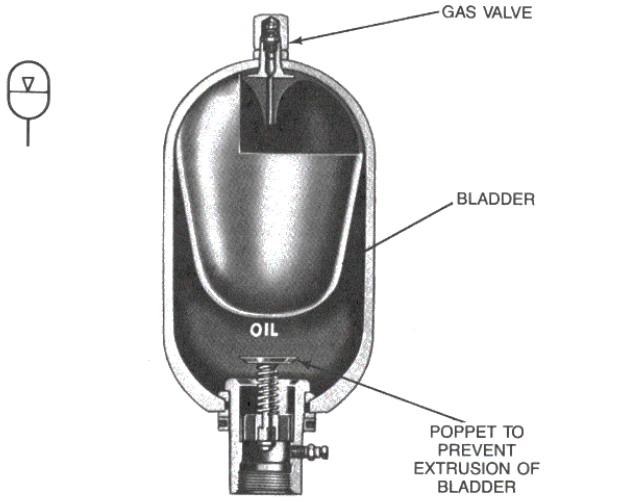
Accumulator

It is the Energy storage device which is used when

- ❑ **The pump cannot meet the extremes of fluid demand in the circuit**
- ❑ **Supply circuit needs to respond more quickly to any temporary demand**

Bladder type



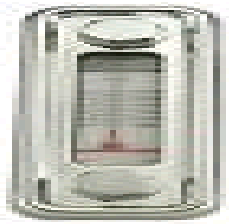


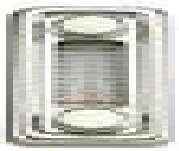
Bladder-type accumulator uses rubber separator between gas and liquid.

Heat Exchanger

Oil Temperature Indicators

Oil Level Indicators





Simple open-loop open-center circuit

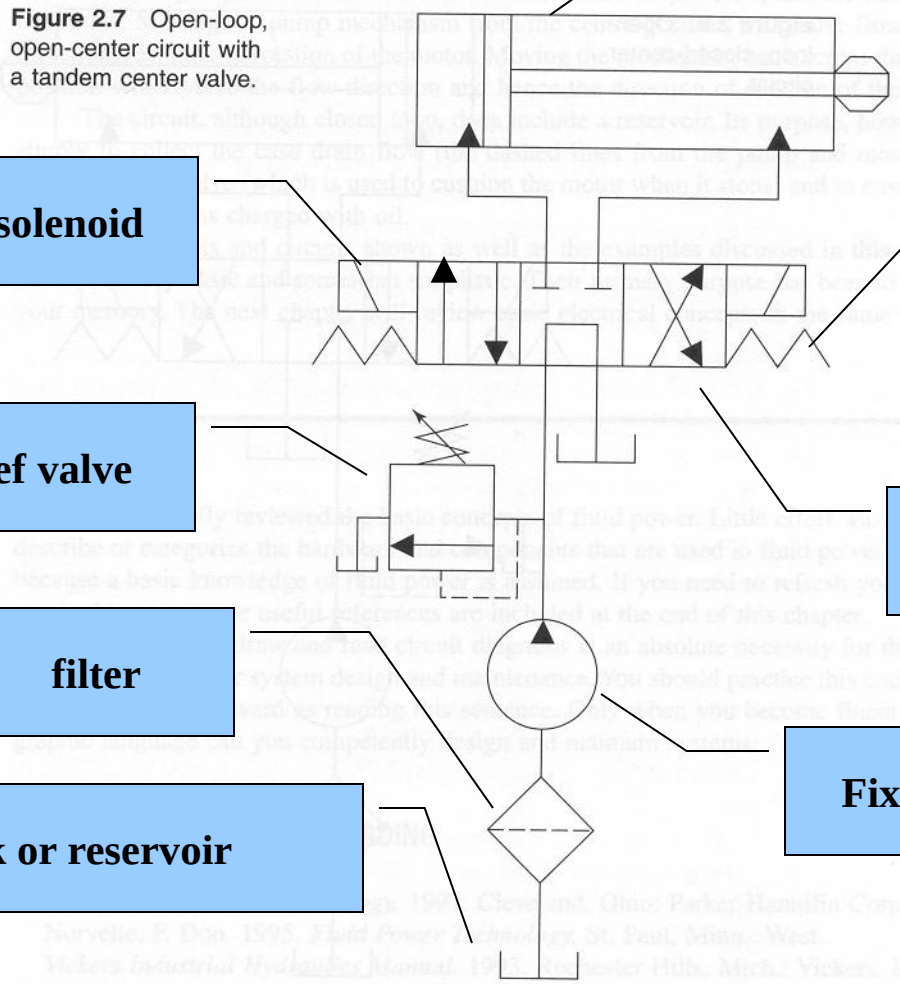


Figure 2.7 Open-loop, open-center circuit with a tandem center valve.

cylinder

Actuating solenoid

Spring return

Pressure relief valve

4-way, 3 position valve

filter

Fixed displacement pump

Fluid tank or reservoir

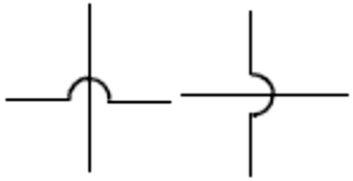
Fluid power symbols

Main Line

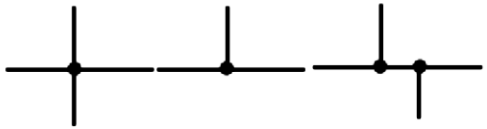
Pilot Line

Drain Line

Lines Crossing



Lines Joining



Variable

Temperature

Pneumatic

Hydraulic

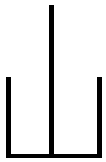
Flexible line

Plugged Port

Vented

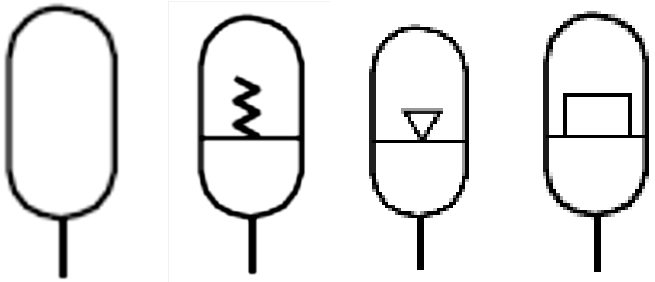
Pressurized

Below fluid level

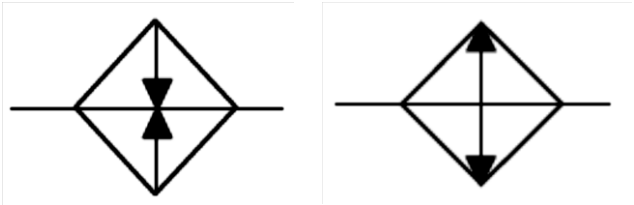


Above fluid level

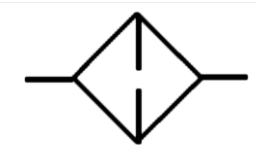
Accumulator



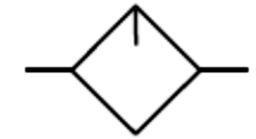
Heat Exchanger



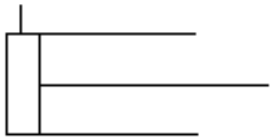
Filter or Strainer



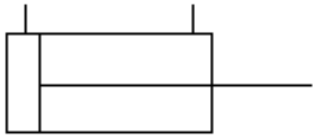
Lubricator



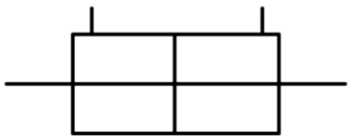
Single Acting Cylinder



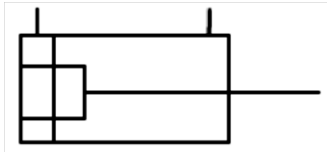
Double Acting Cylinder



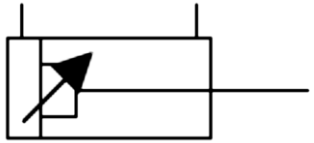
Double Acting Double rod Cylinder



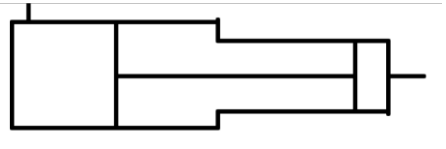
Double Acting Cylinder with Cushion



Double Acting Cylinder with adjustable Cushion

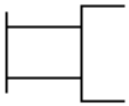


Pressure Intensifier

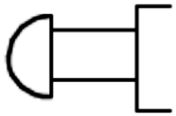


Spring

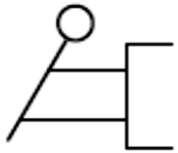
Manual



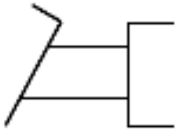
Push Button



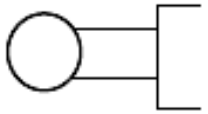
Lever



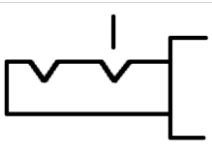
Pedal or Treadle



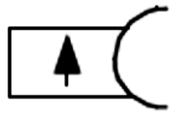
Mechanical



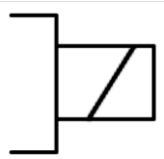
Detent



Pressure Compensated

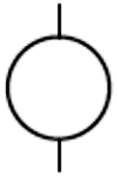


Solenoid



Rotary Devices

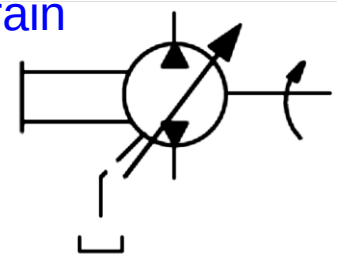
Rotary Device with ports



Hydraulic Pump - Unidirectional

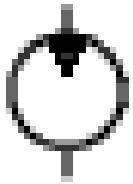
Hydraulic Pump - Bidirectional

Pump with rotating shaft, control, and Drain

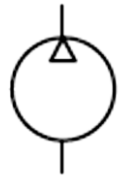


Pressure compensated variable displacement pump

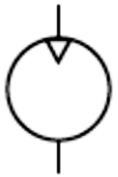
Hydraulic Motor



Air Compressor



Pneumatic Motor



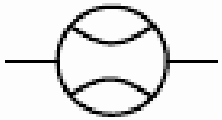
Electric Motor

Internal Combustion Engine

Pressure Indication

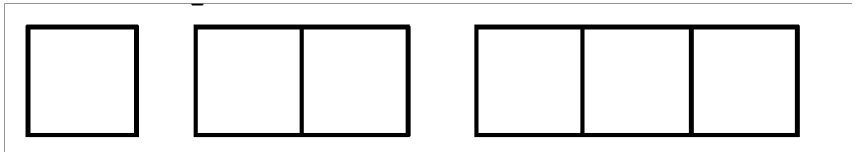
Temperature Indication

Flow Meter



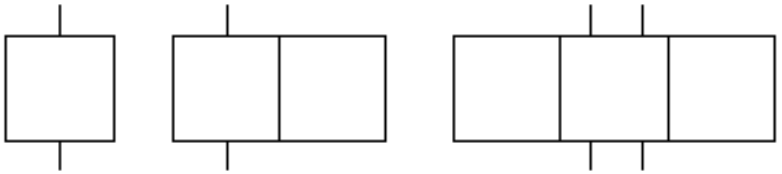
Envelopes or Positions

One Two Three

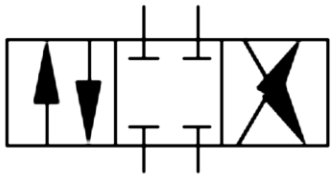


Ports

Two Two Four

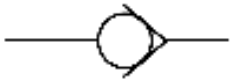


Three Positions, Four Ports (4/3)



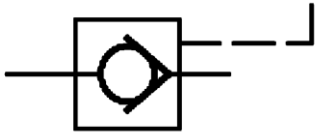
Shut Off

Check Valve

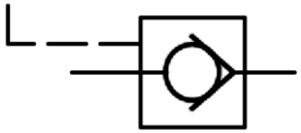


Pilot operated Check Valve

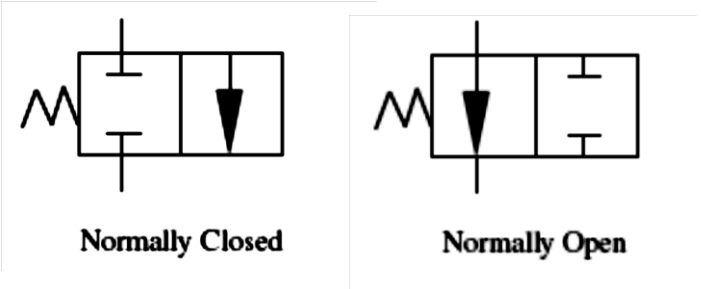
Pilot to open



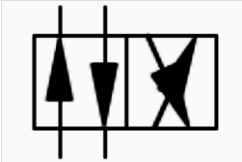
Pilot to close



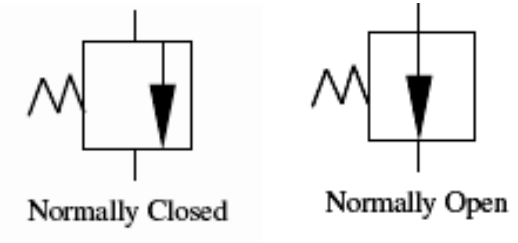
Two position, Two port, (2/2) DCV



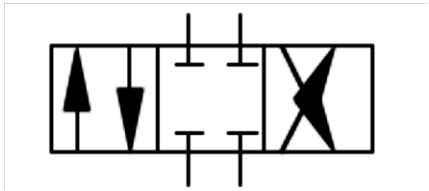
2/2 DCV



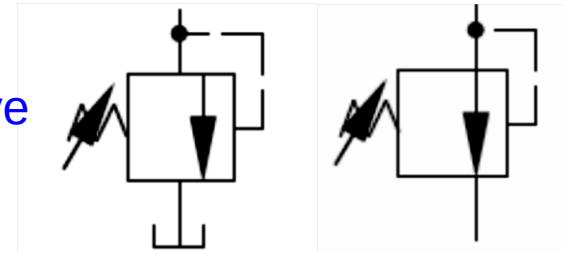
Infinite position



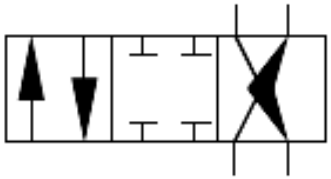
4/3 DCV



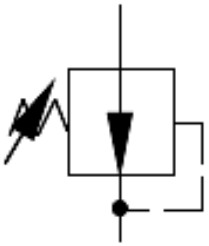
Pressure Relief Valve



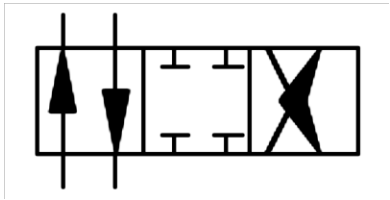
4/3 DCV, Left actuated



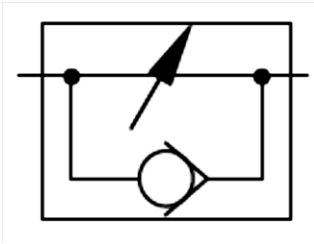
Pressure Reducing Valve



4/3 DCV, Right actuated



Flow Control Valve with bypass check valve



Hydraulic Fluids

The hydraulic fluids used must fulfill the following properties:

- Pressure transfer
- Lubrication of moving parts
- Cooling
- Corrosion protection
- Scuff removal
- Signal transmission

Types of Hydraulic Oils

- Hydraulic Oils are divided according to their characteristic and composition into three classes:

    1. Hydraulic oil HL
    2. Hydraulic oil HLP
    3. Hydraulic oil HV

Within these two groups – hydraulic oils and hydraulic fluids with low inflammability – there are various types of fluid with different characteristics. These characteristics are determined by a basic fluid and small quantities of additives.

Hydraulic oils

In DIN 51524 and 51525 hydraulic oils are divided according to their characteristics and composition into three classes:

- Hydraulic oil HL
- Hydraulic oil HLP
- Hydraulic oil HV.

The designations for these oils are composed of the letter H for hydraulic oil and an additional letter for the additives. The code letter is supplemented by a **viscosity code** defined in DIN 51517 (ISO viscosity classes).

Designation	Special characteristics	Areas of application
HL	Increased corrosion protection and ageing stability	Systems in which high thermal demands are made or corrosion through immersion in water is possible.
HLP	Increased wearing protection	Like HL oil, also for use in systems where variable high friction occurs owing to design or operating factors.
HV	Improved viscosity-temperature characteristics	Like HLP oil, for use in widely fluctuating and low ambient temperatures.

HLP 68	H: hydraulic oil L: with additives to increase corrosion protection and/or ageing stability P: with additives to reduce and/or increase load carrying ability 68: Viscosity code as defined in DIN 51517

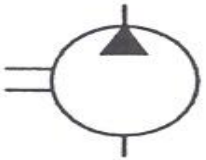
Characteristics of Hydraulic Oil:

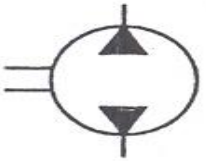
The Hydraulic oil exhibits certain qualities under the relevant operating conditions:

- Low possible density
- Minimal compressibility
- Viscosity not too low – high viscosity results in increased friction leading to excessive pressure losses and heating at the throttling points and too low viscosity creates leakages
- Good viscosity – temperature characteristics
- Low flammability

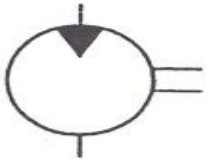
Hydraulic Symbols

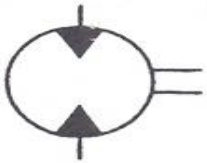
Hydrauli Pump

with one flow direction 

with two flow directions 

Hydraulic motors with fixed displacement

with single direction of rotation 

with two directions of rotation 

▲ Fluids

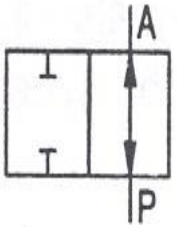
△ Gases

Ports & Positions

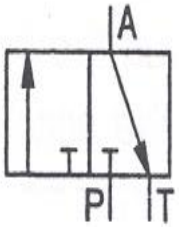
Number of ports

Number of switching positions

2/2 – way valve



3/2 – way valve

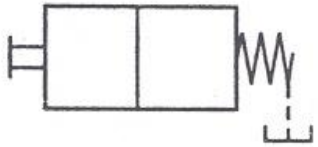


Port designations

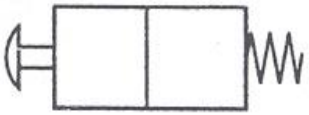
P	pressure port
T	return port
A, B	power ports
L	leakage oil

Method of Actuations

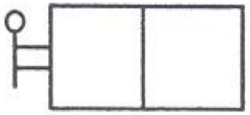
general symbol with spring return and bleed port



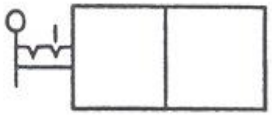
by push button with spring return



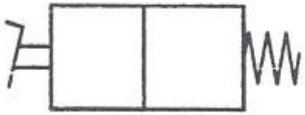
by lever



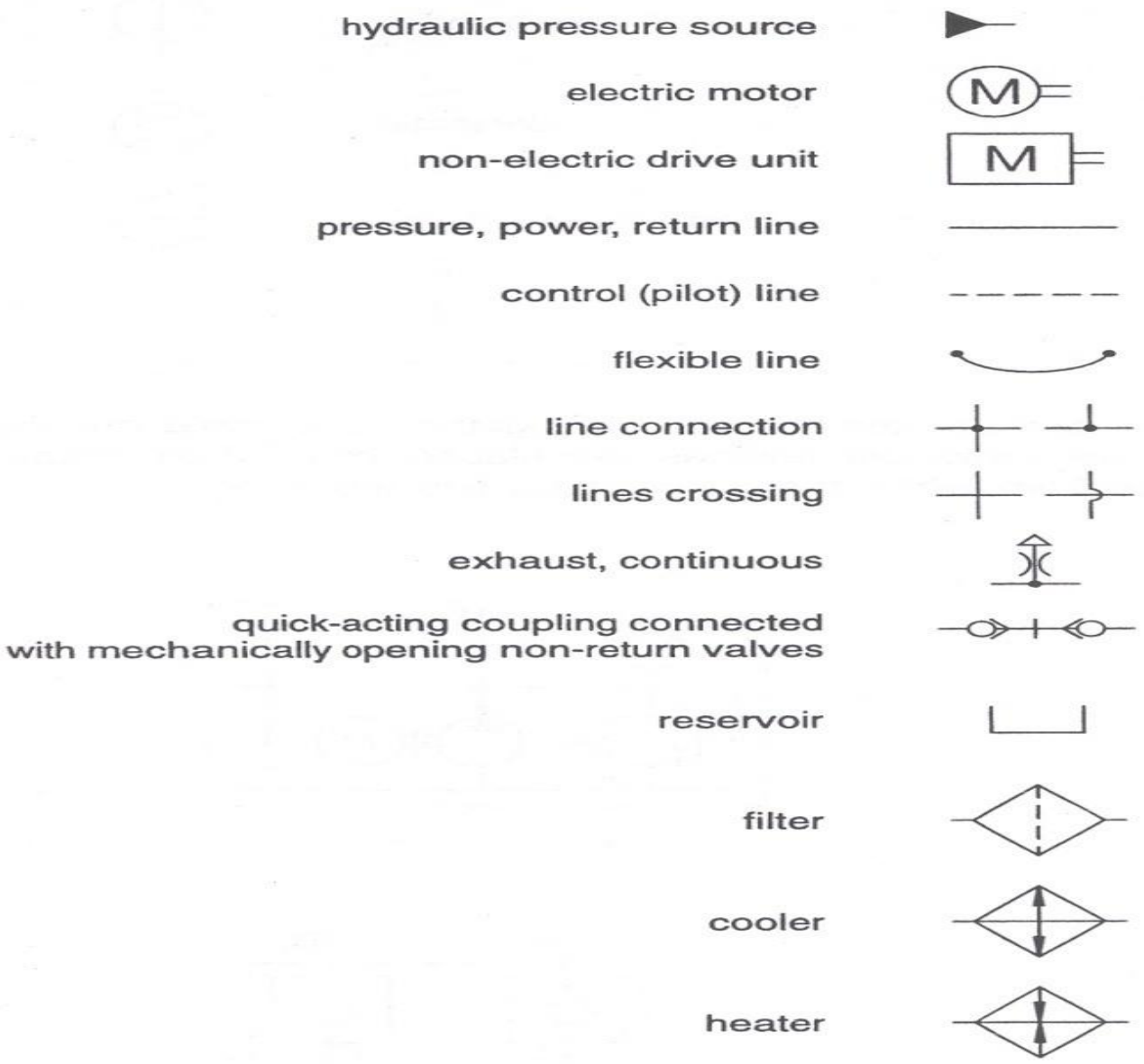
by lever with detent setting



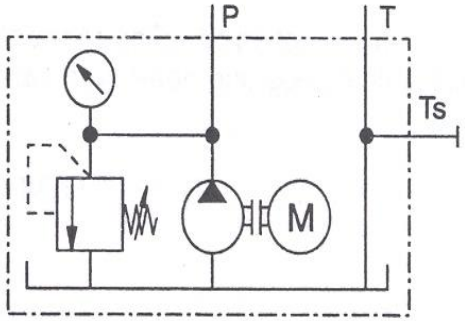
by pedal and spring return

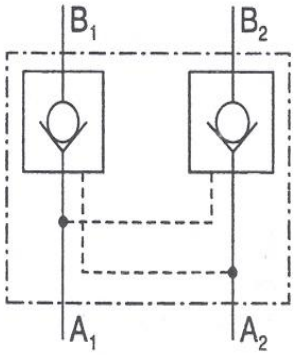


Hydraulic Symbols



Hydraulic power Pack





Measuring devices

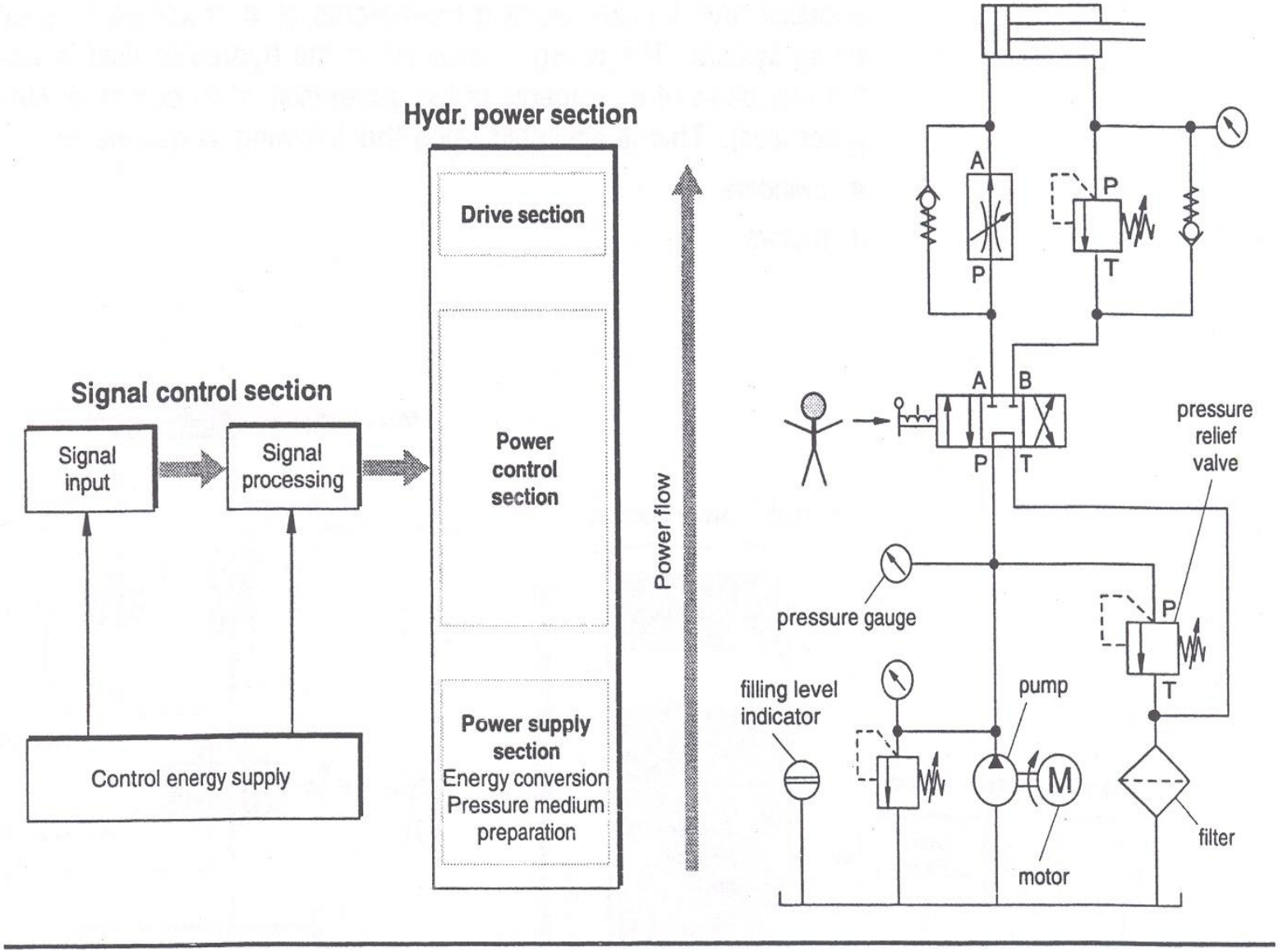
pressure gauge 

thermometer 

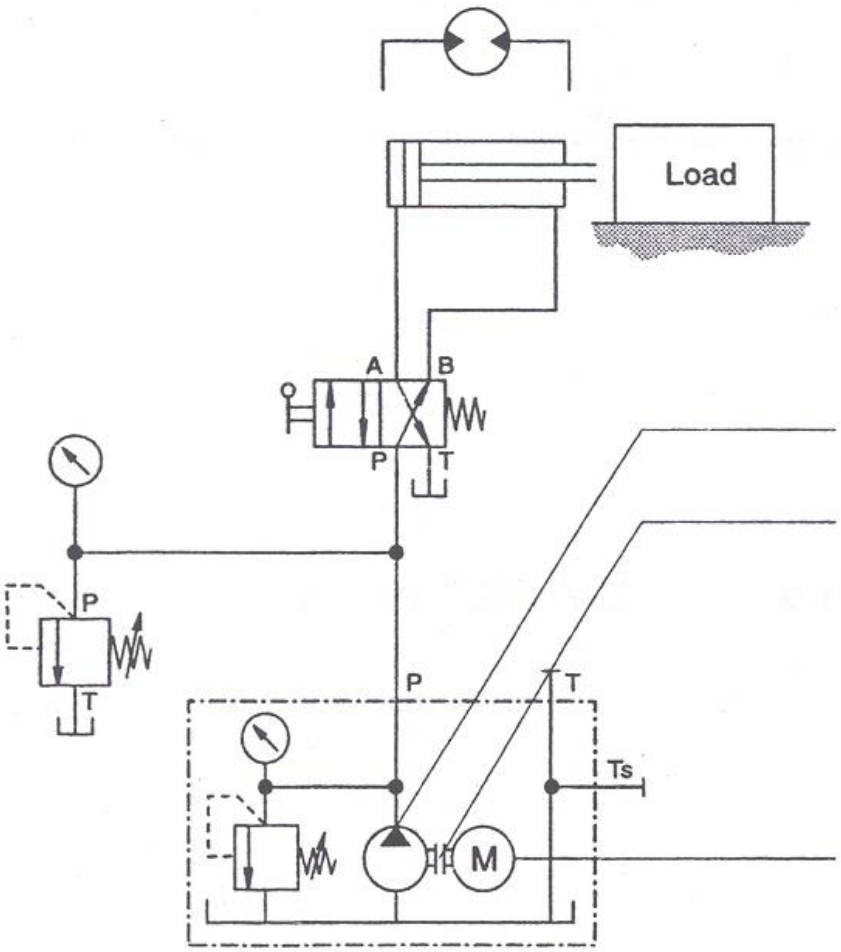
flow meter 

filling level indicator 

Signal flow in Hydraulic System



Hydraulic System



Mechanical power $P = F \cdot v$

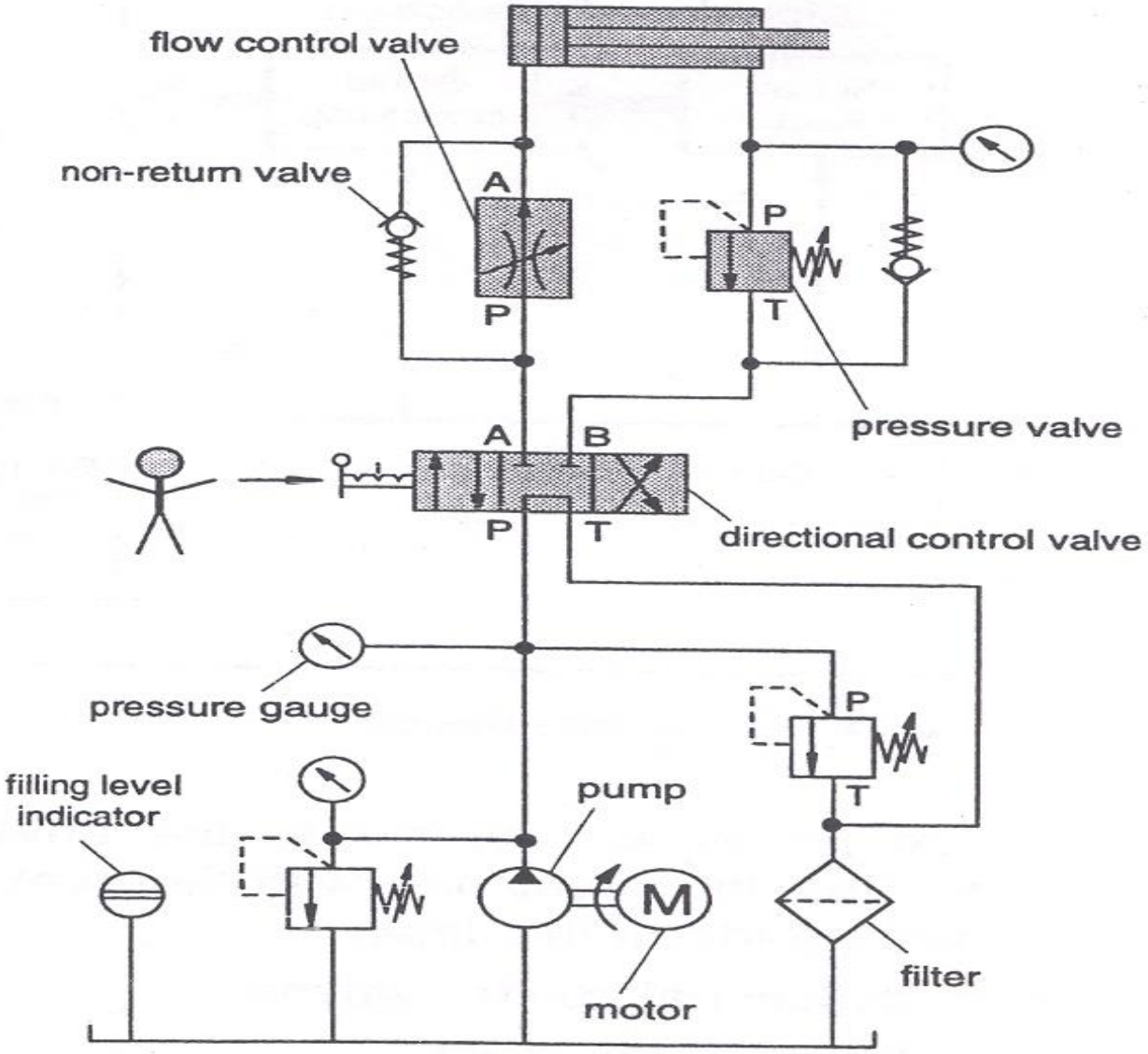
Hydraulic power $P = p \cdot Q$

Mechanical power $P = 2\pi n \cdot M$

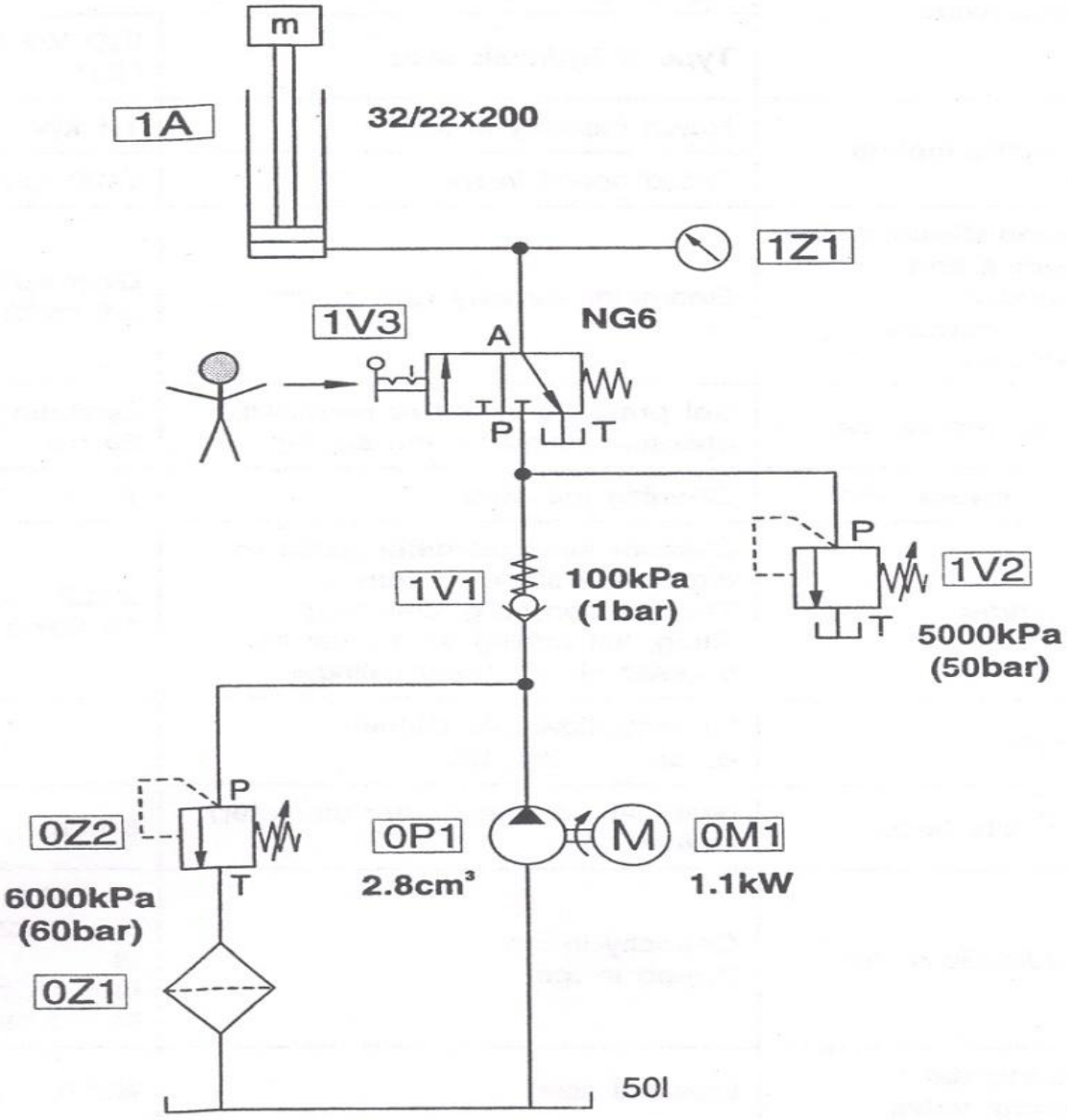
M = Turning moment (Nm)

Electrical power in watts

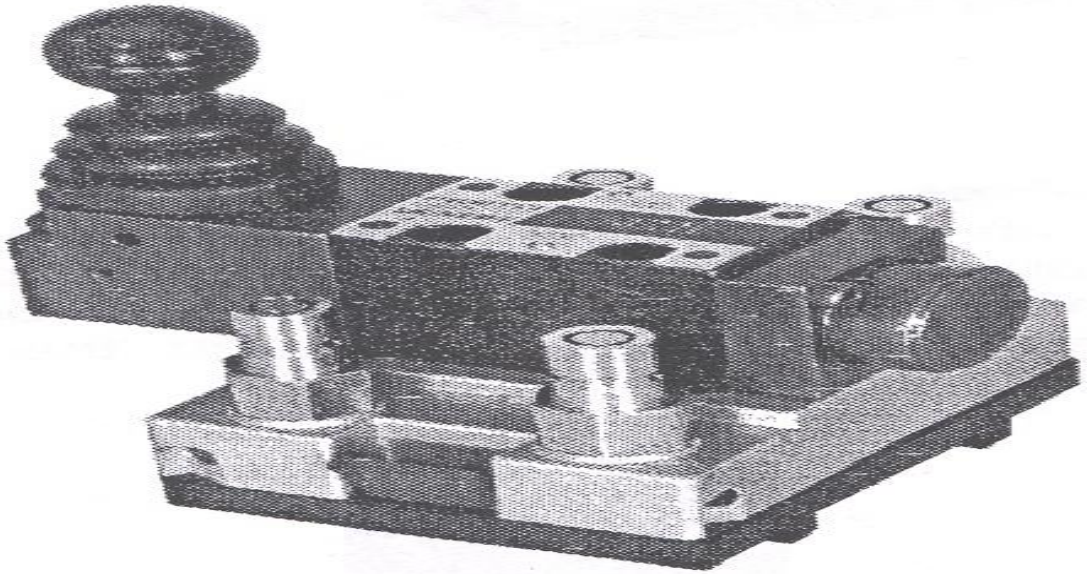
Hydraulic System



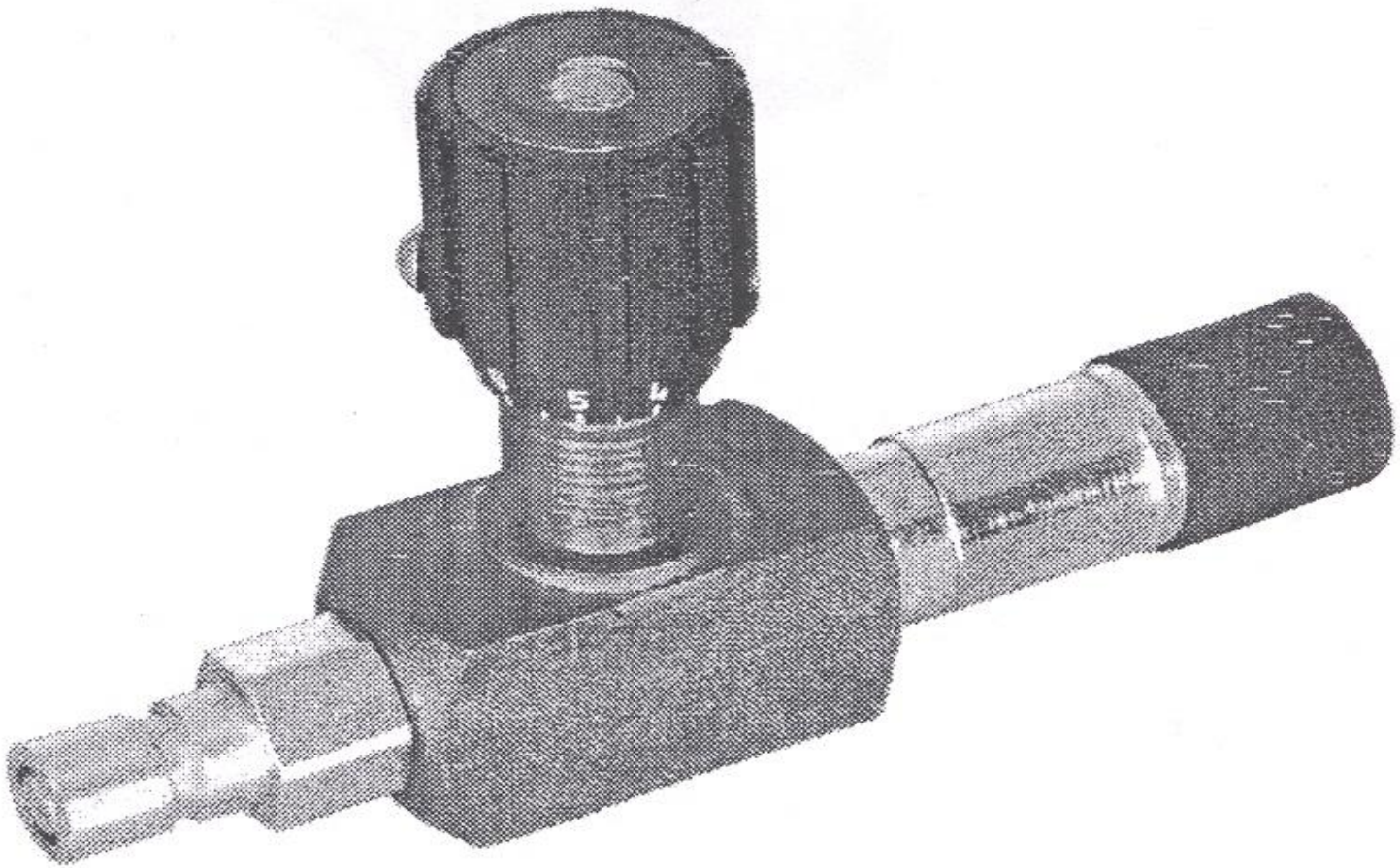
Technical data



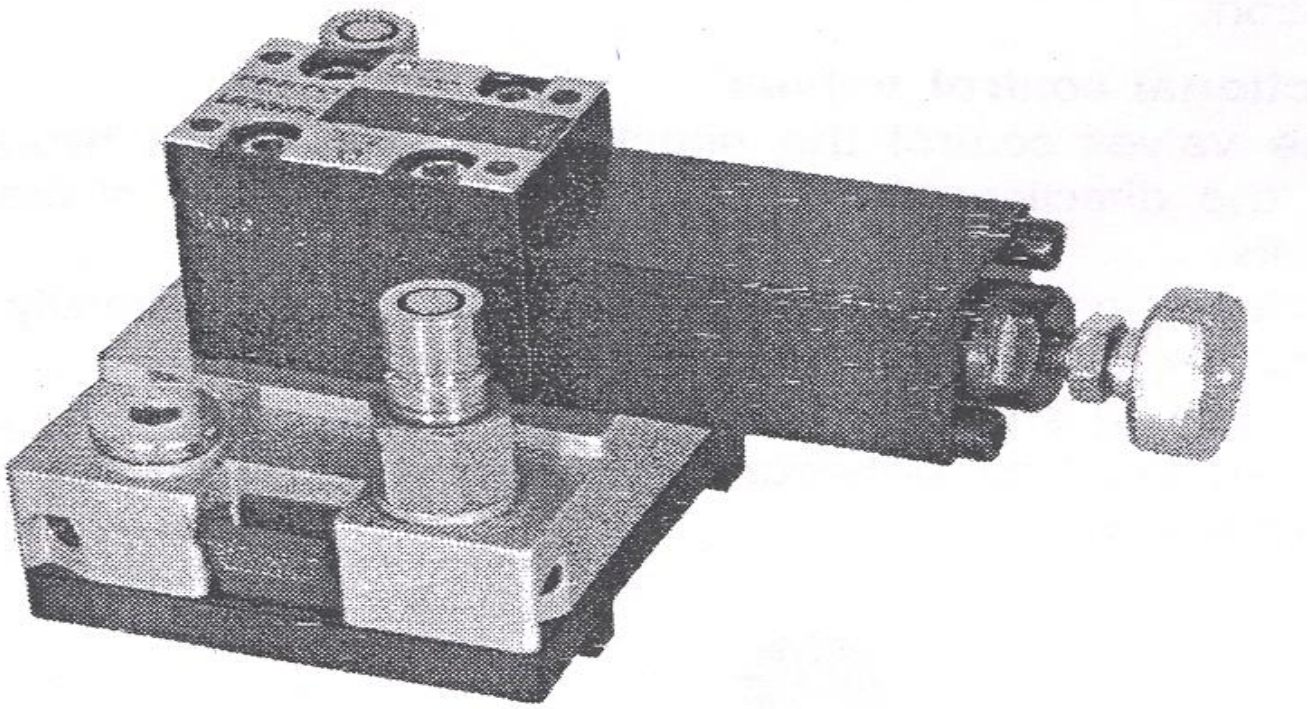
Directional Control Valve



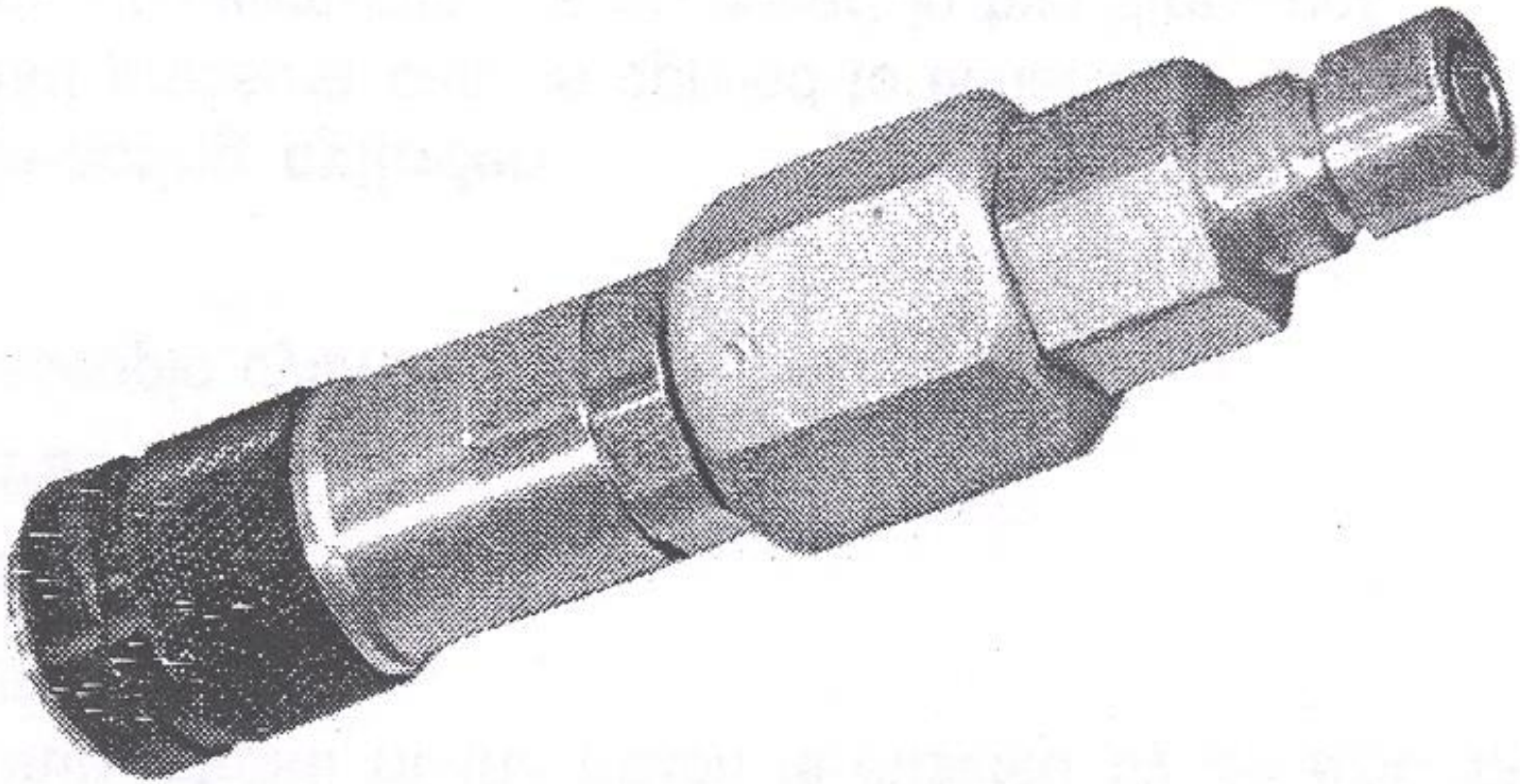
Flow Control valve



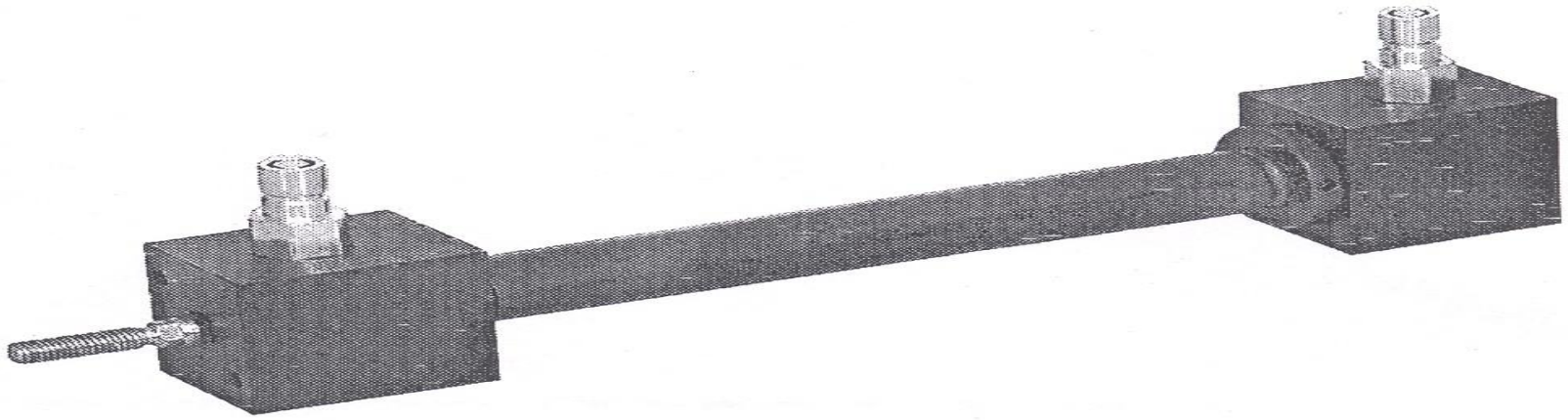
Pressure relief valve



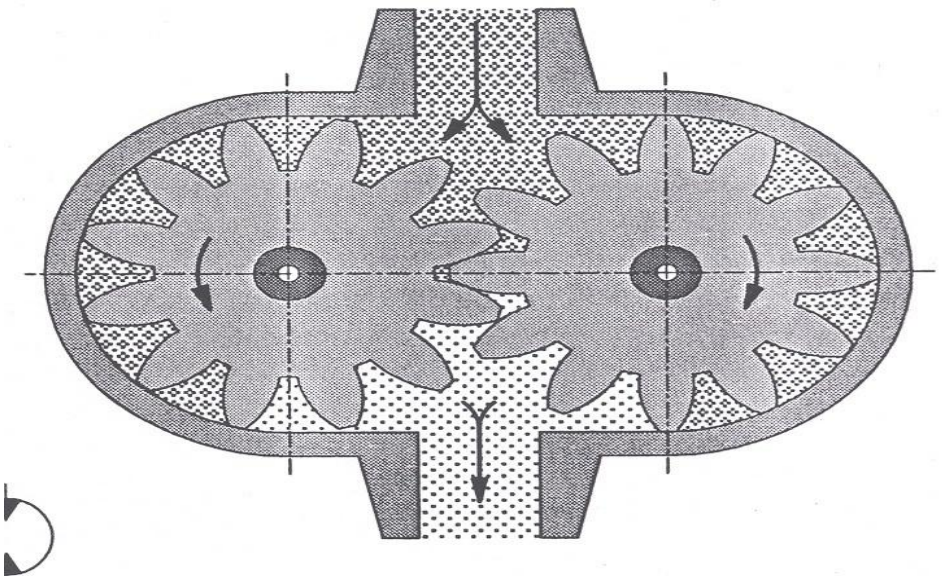
Non return Valve



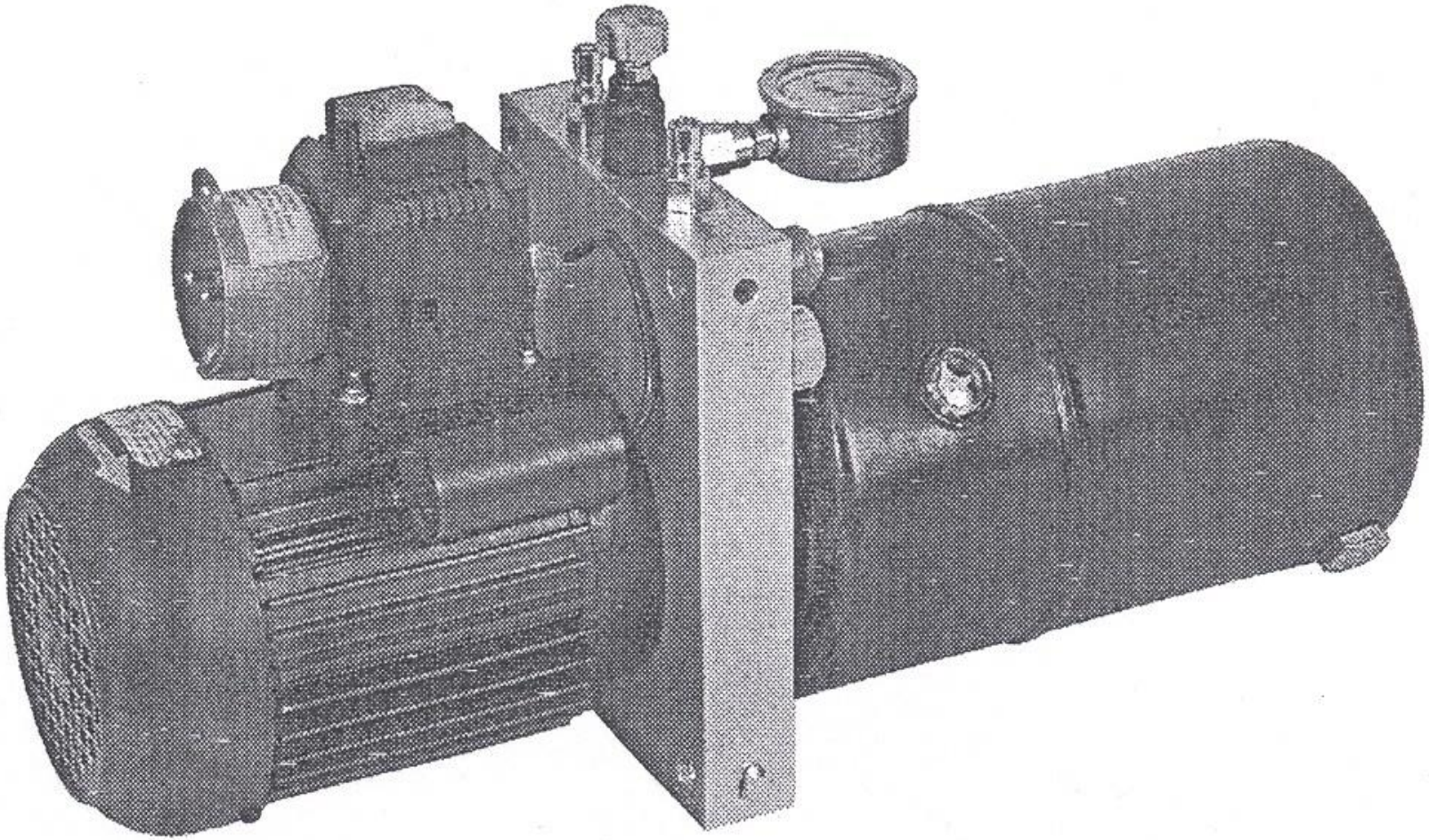
Double Acting Cylinder



Hydraulic Motor(gear motor)



Hydraulic Power Unit



THANK YOU