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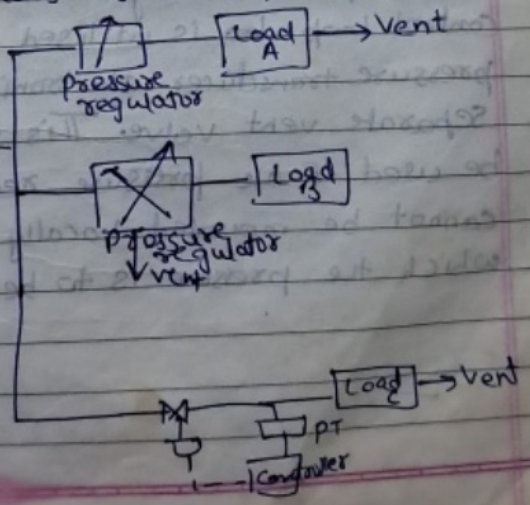
Pressure limiting valves are utilised on the upstream side of the compressor to ensure the receiver pressure is limited for safety and that the supply pressure to the system is set to the correct pressure.

Pressure Regulation:-
Flow velocities in pneumatic systems can be quite high, which can lead to significant flow dependent pressure drops bet" the air receiver and the load.
Air pressure in the receiver is set higher than the reqd load pressure and pressure regulation is performed local to loads to keep pressure const regardless of flow.

3 methods of local pressure control.



Load A vents continuously to atmosphere. Air pressure is controlled by a pressure regulator which simply restricts air flow to the load. This type of regulator requires some min flow to operate. Such regulators in which air must pass through the load are called non relieving regulators.

Load B is dead end load and uses a pressure regulator which vents air to atmosphere to reduce pressure. This type of regulator is called a 3 port (3 connection) or relieving regulator.

Load C is a large capacity load whose air volume requirement are beyond capacity of a simple in-line regulator. Here a pressure control loop is utilised, consisting of pressure transducer, electronic controller and separate vent valve. This technique can also be used if the pressure regulating valve cannot be mounted locally to the point at which the pressure is to be controlled.

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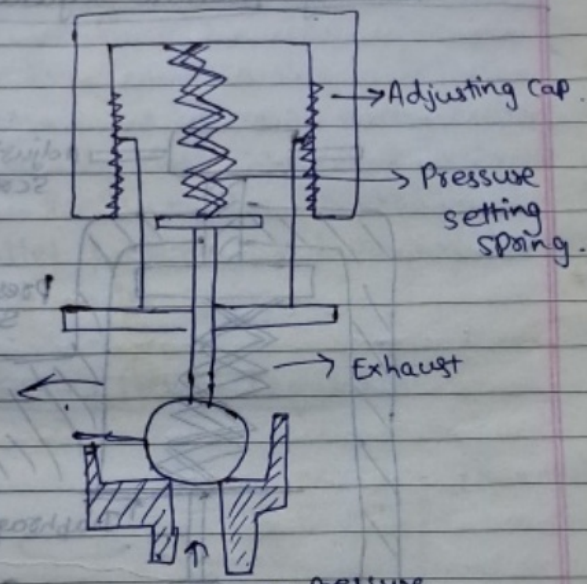
Relief Valves:

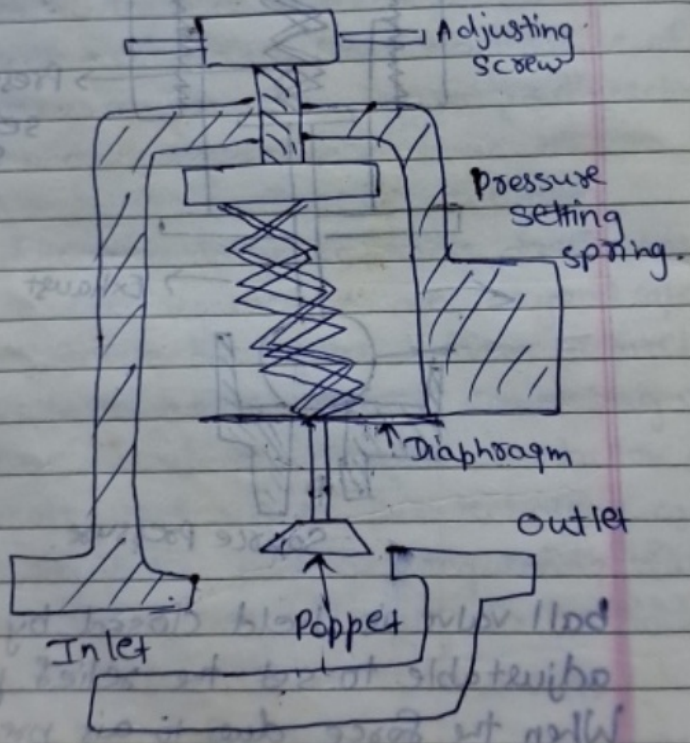
- Simplest pressure regulating device.
- not normally used to control pressure but is employed as a back up device should the main pressure control device fail.
- commonly fitted to air receivers.



Ball valve is held closed by spring tension adjustable to set the relief pressure.
When the force due to air pressure exceeds the spring tension, the valve opens releasing air and reducing the pressure.
Relief valve is specified by operating

pressure range, span of pressure betn opening and full flow and full flow rate It has a flow/pressure relationship and self seals itself once the pressure falls below the cracking pressure

Non relieving pressure regulators



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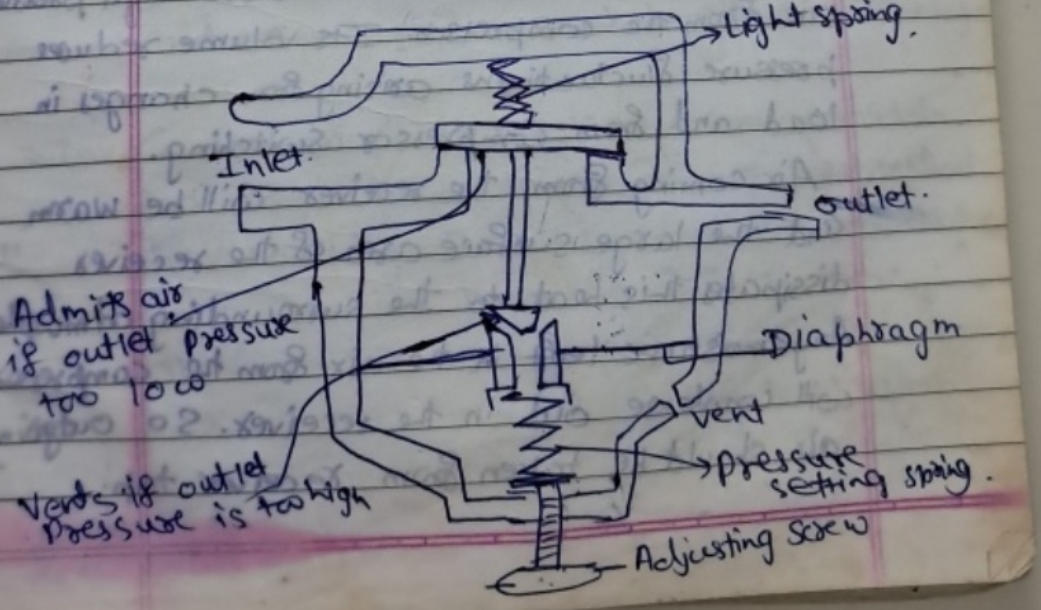
Outlet pressure is sensed by a diaphragm which is preloaded by a pressure setting spring. If outlet pressure is too low, the spring forces the diaphragm and poppet down opening the valve to admit more air and raise outlet pressure.

If the outlet pressure is too high, air pressure force the diaphragm up reducing air flow and causing a reduction in air pressure as air vents away through the load. In steady state valve will balance with the force on the diaphragm from the outlet pressure just balancing the preset force on the spring.

Relieving Pressure Regulators



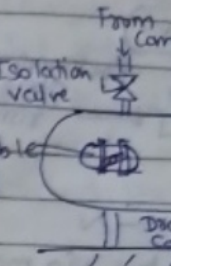
Outlet pressure is sensed by a diaphragm preloaded with an adjustable pressure setting spring. The diaphragm rises if the outlet pressure is too high and falls if the pressure is too low.

If the outlet pressure falls the inlet poppet valve is pushed open admitting more air to raise pressure. If the outlet pressure rises, the diaphragm moves down closing the inlet valve and opening the central vent valve to allow excess air to escape from the load thereby reducing pressure.

Air Receivers and Compressor control

An air receiver is used to store high pressure air from the compressor. Its volume reduces pressure fluctuations arising from changes in load and from compressor switching.

Air coming from the receiver will be warm and the large surface area of the receiver dissipate this heat to the surrounding atmosphere. Any moisture left in the air from the compressor will condense out in the receiver. So outgoing air should be taken from receiver top.



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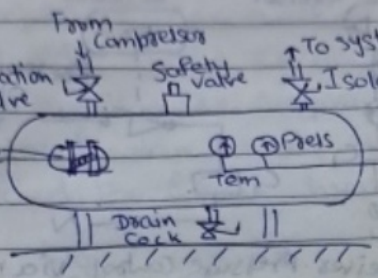
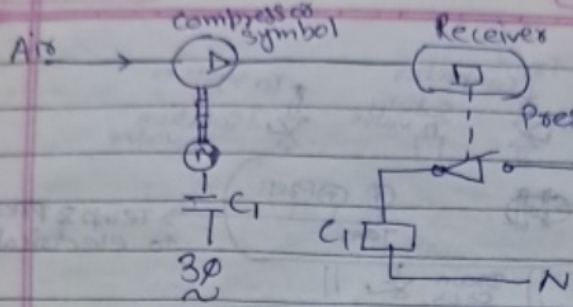


Fig shows essential features of a receiver. They are usually of cylindrical construction for strength and have a safety relief valve to guard against high pressures arising from failure of the pressure control scheme. Press. indicators and usually temp indicators are provided with press switches for control of pressure and high temp switches for remote alarms.
A drain cock allows removal of condensed water and access via a manhole allows cleaning.

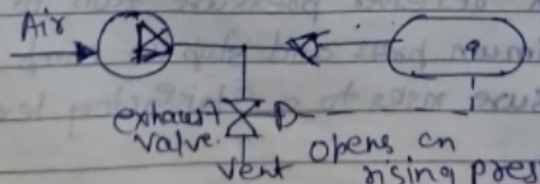
Control of compressor is necessary to maintain pressure in the receiver. The simplest method of achieving this is to start the compressor when receiver pressure falls to some minimum press and stop the comp when pressure rises to a satisfactory level again.



Receiver Pressure control via motor start/stop

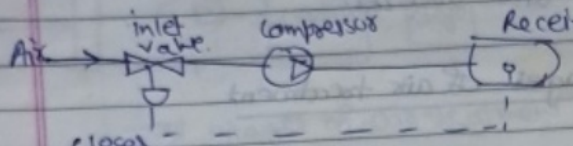
2 press switches are reqd (with the motor start pressure lower than the motor stop pressure) but in practice internal hysteresis in a typical switch allows one pressure switch to be used. The pressure in the receiver cycles between the start and stop pressure settings.

Another method of pressure control is where the compressor runs continuously and an exhaust valve is fitted to the compressor outlet. This valve opens when the reqd pressure is reached. A non-return valve prevents air returning from the receiver. This technique is known as exhaust regul



RPC using compressor outlet valve

Compressors can also be controlled on the inlet side. In the eg an inlet valve is held open to allow the compressor to operate and is closed when the air receiver has reached the desired pressure.



inlet valve and exhaust valve can be electrically operated solenoid valve controlled by pressure switches or can be pneumatic valves controlled directly by receiver pressure.

The control method is largely determined by flow rates from receiver to the loads and the capacity of the compressor. If the compressor has significant spare capacity then start/stop control is commonly used.

Air receiver size is determined by load requirements, compressor capacity and allowable pressure deviations in the receiver

When a compressed gas expands suddenly there is a fall of temp. If the compressed air has high water content, a rapid expansion at exhaust ports can be accompanied by the formation of ice as the water condenses out and freezes.

Stages of air treatment

Air in a pneumatic system must be clean and dry to reduce wear and extend maintenance periods. Atmospheric air contains many harmful impurities (smoke, dust, water vapour) and needs treatment before it can be used.

In general this treatment falls into 2 distinct stages.

1st inlet filtering removes the particles which can damage the air compressor. Next there is the need to dry the air to reduce humidity and lower the dew point. normally performed betn the compressor and the receiver and is termed as primary air treatment.

Final treatment is performed local to the duties to be performed and consists of further steps to remove moisture and

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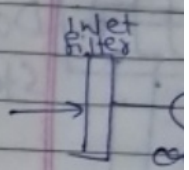

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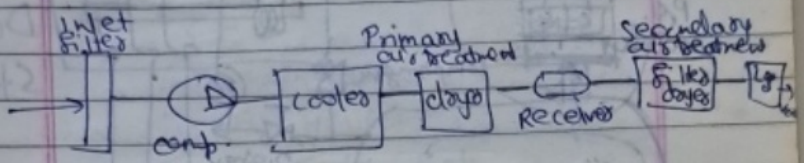
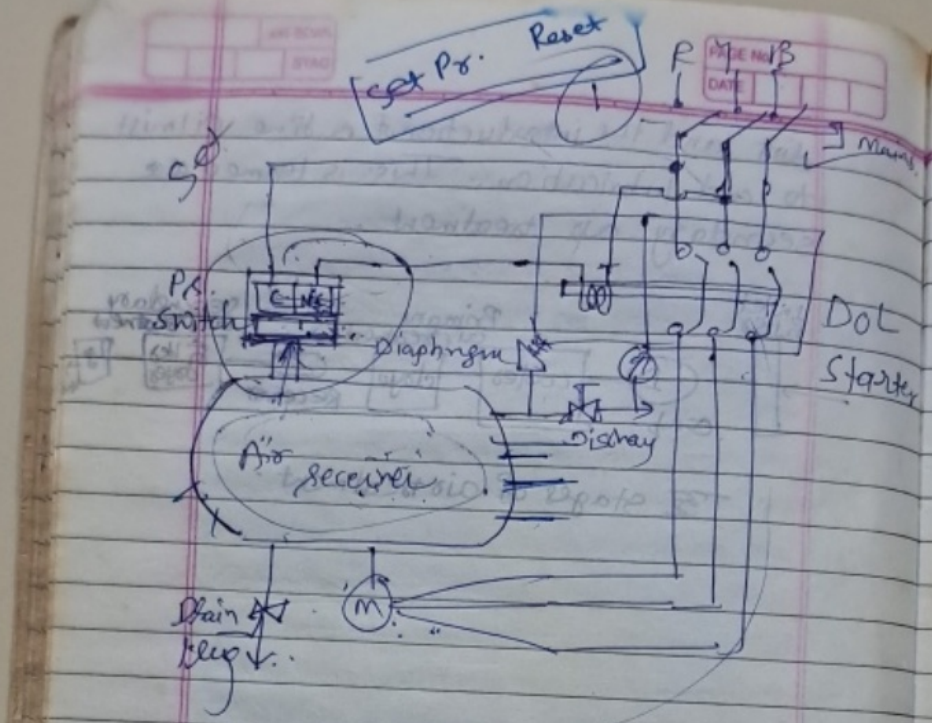
dirt and the introduction of a fine oil mist to aid lubrication. This is termed as 'secondary' air treatment.



3 stages of air treatment.



During Operation

1. start main from MCB.
2. Supply Complete

PS SW & Coil of DOL & DOL starter

POWER ON & Compressor starts.

3. Compressor develops Air into Receiver upto set pressure & Trips due to PS. SW
4. DOL Trip causes Comp. to Trip
5. After which ST can monitor pr. & Record which is set pr

Mains

DOL Starter

& DOL starter

to Receiver

e to Pr. SW

Trip

r pr.

r

6. After releasing Air below Reset settings, via

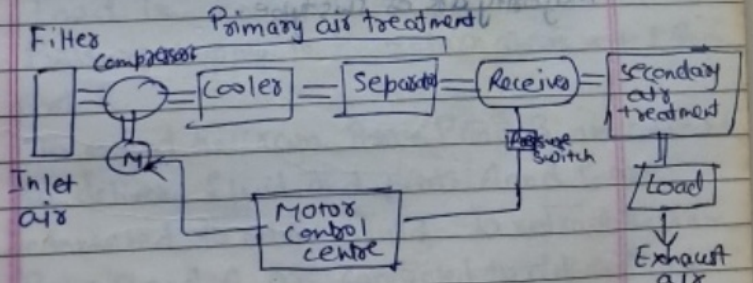
i) Safety
ii) I V
iii) Drain valve
iv) Air Header
v) OR System Inst.

Compressor restarts as DOL Restarts thro Pr. switch.

Pr. SW - specification.

~~Compressor Types~~:

Components parts of a pneumatic system:



Compressor increases air pressure by reducing its volume and there is rise in temperature. To remove this excess heat a separate cooler is employed.

Atmospheric air contains water vapour which may condense out as liquid droplets. These water droplets would cause valves to jam and corrosion to form in pipes. An after cooler must be followed by a separator. Dry cool air is stored in receiver with a pressure switch used to start and stop the compressor motor. The air passes through the secondary air treatment then to load.

Compressor types:

- +ve displacement devices (fixed volume of air is delivered on each rotation of the compressor shaft) majority are of this type.
- dynamic device e.g. centrifugal or axial flow

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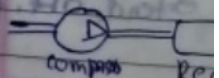

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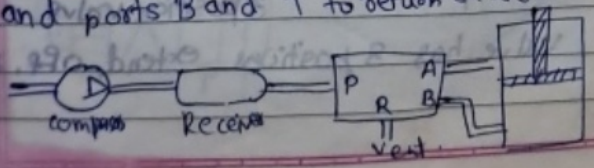
Control valves:-
2 types.
Infinite Position valve can take up any position between open and closed and can be used to modulate flow or pressure.
eg Relief valves.
Finite Position valves used to allow or block flow of fluid.

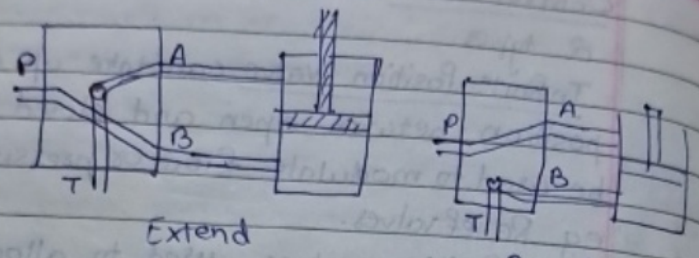
Analogy is comparison bet^n light dimmer and a simple on/off switch.

Connection to a valve are termed as ports.

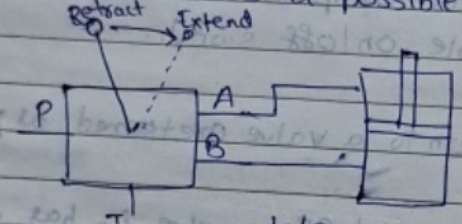
A simple on/off valve :. has 2 ports
Most control valves have 4 ports.
Load is connected to ports labelled A & B
Pressure supply to P. return air is vented from port R.
To extend the ram Ports P and B are connected to deliver fluid and ports A and T are connected to return fluid. To retract the ram. Ports P and A are connected to deliver fluid and ports B and T to return fluid.



Internal valve operation.

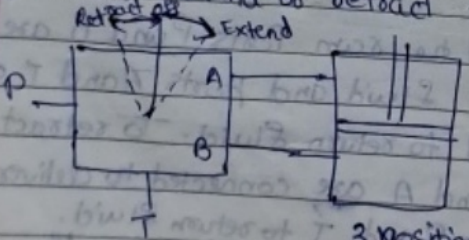


Another consideration is the no of control positions shows 2 possible control schemes



4/2 valve.
2 position valve.

Ram is controlled by a lever with 2 position extend or retract. This valve has 2 control positions extend or retract.



4/3 valve.
3 position valve.
valve has 3 positions extend, off, retract.

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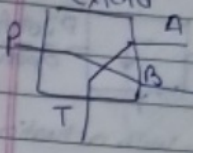

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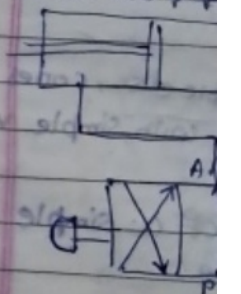

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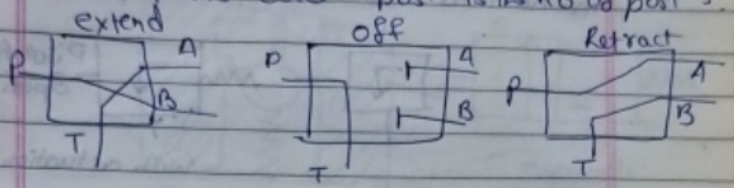
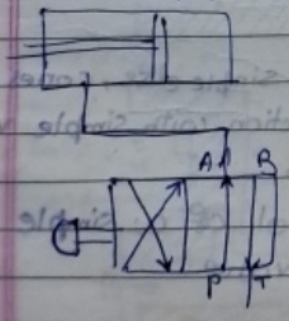
Finite position valve are commonly described as port/position valve where port is the no of ports and posⁿ is the no of posⁿs.



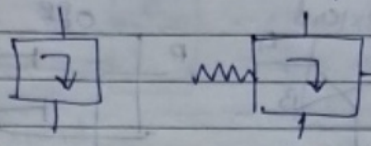
A complete valve description thus needs no of ports, no. of posⁿs and the control actⁿ.

Designations given to ports are:
Working lines - A, B, C.
Pressure supply P
Exhaust / Return R, S, T
Control (Pilot) lines - Z, Y, X.

Arrow headed lines represent direct^n of flow.
Shut off positions are represented by T



Basic infinite position valve is represented by a single square with the valve being shown in normal or non-operated position.



with actuation symbol.

Spring pushes the valve right decreasing flow, and pilot pressure pushes the valve left increasing flow.

Types of control valve

3 types
poppet valves
Spool valves
Rotary valves.

Poppet Valve:-

In poppet valve, simple disc, cones or balls are used in conjunction with simple valve seats to control flow.

Const^n and symbol of a simple 2/2 Normally closed valve.

youtube.com/wat

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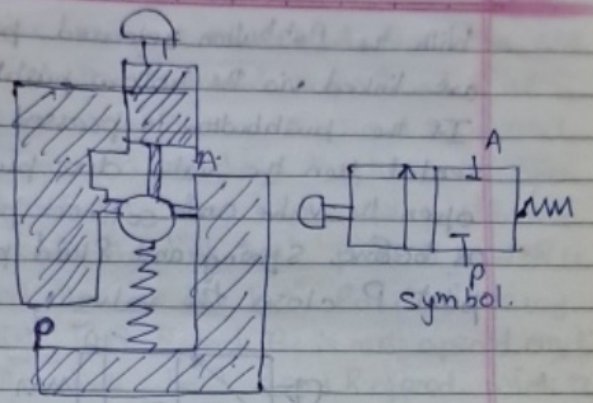
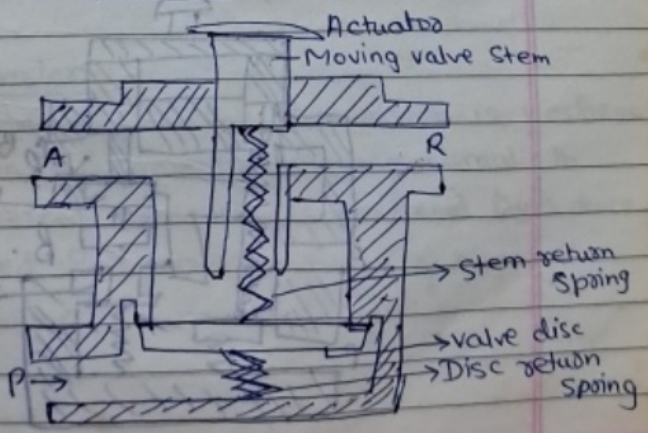
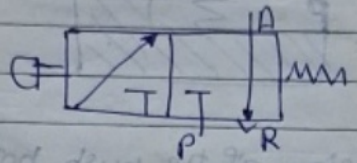


depression of the push botton lifts the ball of its seat and allows fluid to flow from Port P to port A. When the button is released, Spring and fluid pressure force the ball up again closing the valve.

3/2 Poppet valve :-

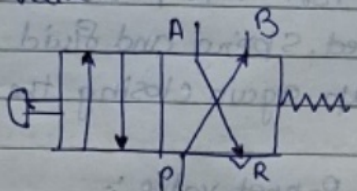


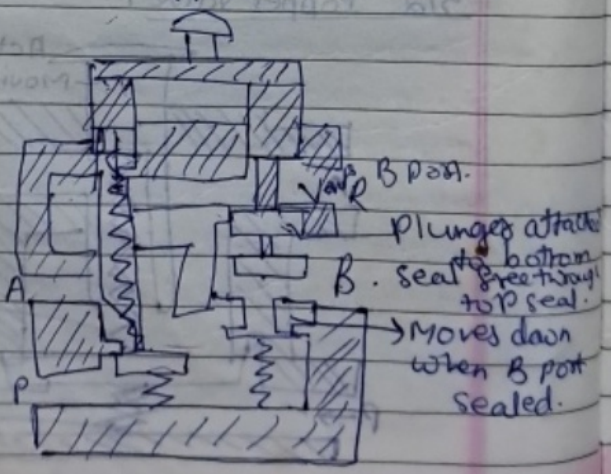
With the flashbutton released ports A and R are linked via the hollow pushbutton stem. If the pushbutton is pressed, port R is first sealed then the valve disc pushed down to open the valve and connect ports P and A as before. Spring and fluid pressure from port P close the valve.



symbol

4/2 way valve:





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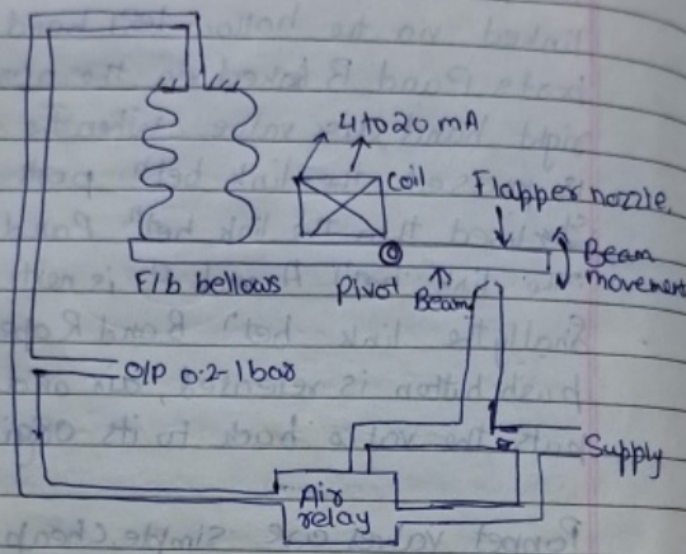
4/2 valve using 2 stems and disc valves. With the pushbutton released, ports A and R are linked via the hollow left hand stem and ports P and B linked via the normally-open right hand disc valve. When the pushbutton is pressed, the link betⁿ ports A and R is 1st closed then the link betⁿ P and B closed. The link betⁿ A and P is next opened and finally the link betⁿ B and R opened. When the push button is released, air and spring pressure puts the valve back to its original state.

Poppet valves are simple, cheap and robust disadvantage is the force needed to operate them.
Normally found in low pressure pneumatic systems.

Converters :-
Electric to pneumatic conversion is performed by an I-P converter while pneumatic to electrical conversion is performed by a device called P-I converter.

I - P converters :-

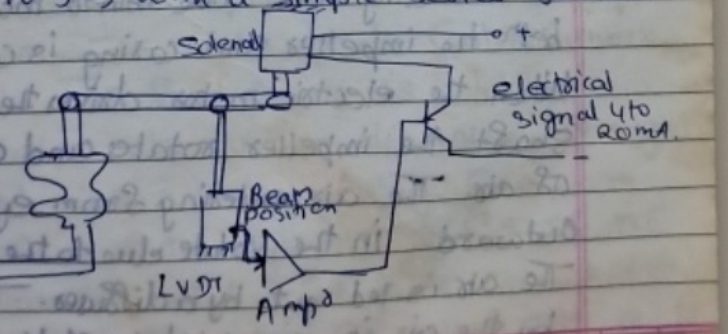


based on force balance principle and flapper nozzle. Electrical current is passed through the coil and results in a rotational displacement of the beam. The resulting pressure change at the flapper nozzle gap is volume boosted by the air relay and applied a balancing force by bellows at the other end of the beam. A balance results when the force from the bellows (proportional to O/P pressure) equals the force from the coil (proportional to i/p signal).

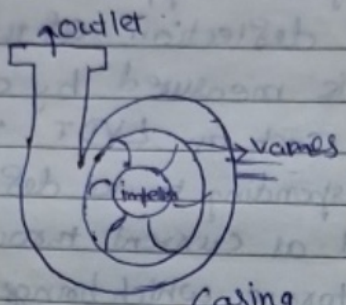
P - I converter:

uses the force balance principle. I/P pressure signal is applied to bellows and produces a deflection of the beam. This deflection is measured by a position transducer such as LVDT. The electrical signal corresponding to the defl^n is amplified and applied as current through a coil to produce a torque which brings the beam back to the null position. At balance, the coil force (∝ to O/P current) matches the force from the bellows (∝ to i/p signal pressure. Zero offset (4mA) in the electrical signal is sufficient to drive the ampl^3 allowing the 2 signal wires to also act as the supply line. This is known as 2 wire opt^n

Most P-I converters operate over a wide voltage range (15 to 30V). The current signal of 4 to 20mA is converted to v.ltg (1 to 5V) with a simple series resistor.



Centrifugal Compressor : (MD Desai Pg 341)

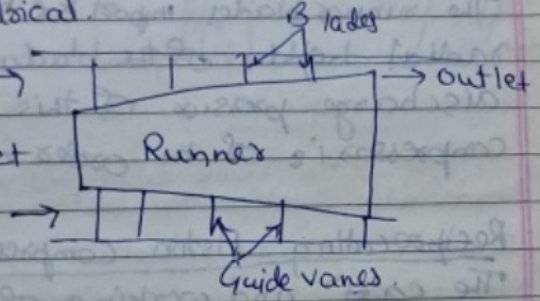


It has a circular eye at the centre, it is connected to the inlet through which the air enters. It has a rotating element called an impeller. The impeller carries number of curved blades. The impeller shaft is mechanically coupled to drive shaft which is given power by an electric motor. The casing has circular cross-section. The impeller shaft is eccentric wrt the casing. Between the periphery of the impeller and casing the radial distance is increasing from some min to max. The cavity betn the impeller and casing is called volute. When the electric motor drives the impeller shaft the impeller rotates and creates flow of air. The air entering from eye is thrown outward in the volute due to the kinetic energy. The air is led out by a diffuser. The KE stored by the air is converted to static pressure

as it move through the volute and diffuser. The pressure developed by this type of compressor is low. It is of the order of $3.5 kg/cm^2$.

Axial flow compressor

The outer shape of the compressor is cylindrical.



rotor shaft carries a rotating element called runner. The runner is a cylinder with variable radius. The radius is min on LHS and ↑ to max. value on RHS. So, the outer surface is tapered. Unit is called tapered runner. It carries blades called runner blades. The fixed casing is a hollow cylinder with uniform diameter. It carries fixed guide vanes projecting from inner surface of the cylinder. On inlet side the vanes are called inlet guide vanes and on outlet side the vanes are called exit guide vanes.

fixed vanes and runner blades are arranged in alternate positions. The inlet opening on LHS in larger than the eye of centrifuged compressor. The air enters from the left through inlet guide vanes. When the rotor rotates the air moves towards right. Due to tapered rotor the available space decreases as the air moves towards right. The air is compressed. The runner blades impart KE to the fluid. The radial height of the blades towards discharge pressure of this type of compressor is of the order of 7kg/cm^2.

Reciprocating Piston Compressor :-

The constn and working of a reciprocating piston compressor or. It has a hollow cylinder with a piston and inlet outlet valve. piston is connected by a crank shaft to the driving motor. When the piston is at extreme right the vol betn the piston and cylinder is zero. As the piston moves towards left the volume is increased. There is no pressure of low pressure on RHS of the piston. It creates Suction. The inlet valve opens and atmospheric air enters the cylinder. In ext. left posn of the piston full cylinder is filled with air.

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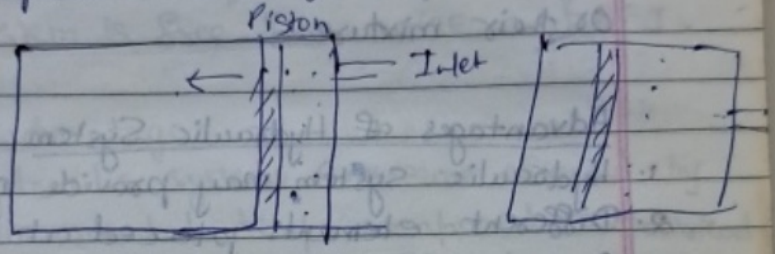
Now if the piston starts moving back towards right, it compresses the air. The inlet valve closes, outlet valve opens when the pressure is sufficiently raised and allows the compressed air to go out



Hydraulic System

With respect to control system the term hydraulics is taken mainly with reference to liquids which are considered to be non-compressible. Pneumatics mainly concerns with compressible fluids like air, gas vapor or their mixture.

Advantages of Hydraulic System

1. Hydraulic system may provide more power.
2. Different elements placed at some distance can be controlled by hydraulic System.
3. Hydraulic systems are better than mechanical systems which require localized control In some applications.
4. Fine wires and tiny components of electronic system have more chances of failure in aircraft applns due to shocks and vibrations. Hydraulic system has no such problem.
5. Hydraulic system is self lubricating.
6. High pressure hydraulic systems can develop very large actuating forces which can develop high accelerations and accurate positioning of heavy mechanical loads.
7. Weight and size of hydraulic motor for same power rating is less than the electrical motor.
8. Hydraulic systems are mechanically strong.

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9. Hydraulic system has small time const. it is much faster in response compared to electric motor.
10. Electronic devices are susceptible to noise and radio freq interference. Hydraulic system is free from noise and RFI.

Disadvantage:-

1. Hydraulic systems are more affected by environmental temp. compared to electrical system. viscosity is affected by temp.
2. Hydraulic systems are not suitable for contact less remote opt^{n} like electronic system.
3. For pneumatic system air is freely available. for hydraulic oil is not freely available.
4. If one part of hydraulic system has a problem whole system may be interrupted.
5. The leakage of hydraulic oil spoils the floor, creates many problems and requires immediate cleaning.
6. In pneumatic system the exhaust air can be vent to atmosphere. Hydraulic line requires return path and sump for collection.

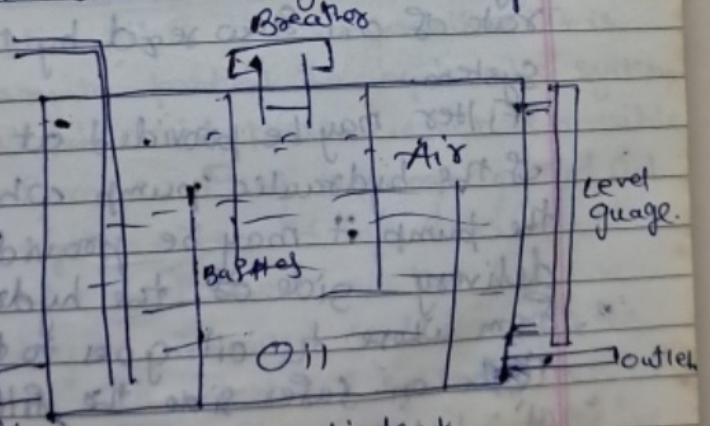
Components of Hydraulic System.

1. Hydraulic Tank.
2. Filter
3. Pumps
4. Accumulator
5. Relief valves
6. Check valve.
7. Needle valve.

Hydraulic Tank

is reservoir of hydraulic oil reqd to develop necessary power. It is a metallic or fibre tank with certain length X, width Y and ht Z. The product XYZ determines the volumetric capacity of the tank. There is an inlet pipe to fill the hydraulic tank with oil. There is a sight glass type simple level indicator. Near the bottom there is outlet connection to supply the oil to O/P side. There is a level switch on the lower side of the tank. When the oil level reaches the reqd mini level it operates so that the oil filling device is made on or alarm is given. The oil tank is a closed one. At the top it has a breather. When the oil level rises the air on

upper side of the oil level should be vented out otherwise it will be compressed and develop pressure acting on oil surface. Similarly when oil level goes down the space created should be filled with air otherwise it may develop vaccum. This inflow and outflow of air is facilitated by a breather on the top of the tank. It also carries an air filter so that solid particles in the air are prevented from entering the tank. Tank has baffle plates forming different sectn in the tank. Due to baffle plate the incoming oil will settle down in the tank. Level fluctuation due to flow and formation of bubbles is avoided by baffle plates. Strainers help in reducing turbulence at inlet flow and give filtering action.



Hydraulic tank.

Filters:

When hydraulic oil passes through various components of the system dirt, dust and metal particles may be added to the oil and contaminate it. Pumps, motors and valves have number of moving components. Due to motion of the moving part wrt the stationary part there is lot of wears and tears. In this process metal particles and other solid particles are released and get mixed with hydraulic oil. In closed cycle Hyd. Sys. the same oil may be used again and again. Before reusing the oil it is necessary to filter it out to remove solid impurities. Hy Filters have pressure rating deciding the press at which oil can be filtered by them. The filters are rated for certain rate of oil flow reqd by the hydraulic system.

Filter may be provided at the suction side of the hydraulic pump where oil enters the pump, it may be provided at the delivery side of the hydraulic pump from where the oil goes to the system. To be on safer side the filters are provided at inlet as well as discharge side. Filters are also provided individually for each component to avoid failure and maintain

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Pumps:-
Hyd. Oil reqd at different pts in the hydraulic system is pumped by hyd. pumps.

- Accumulators:-
In some hydraulic systems the flow requirement of pressurised oil is not const. but fluctuating. The accumulator stores the pressurized fluid when the system demand is less and at peak demand it releases the pressured oil and delivers peak power. It smoothens out the pressure fluctuations developed by pump discharge, it absorbs hydraulic shocks and gives damping effect

Relief valves :-
Hydraulic oil is non-compressible. It is necessary to protect the hydraulic system against abnormal pressure. It is possible by relief valve. Pump is pumping Hyd Oil to the system when the sys does not utilize the pressurized oil the pressure may try to increase and damage the system. In electrical system there are fuses and ckt breakers to protect the sys.

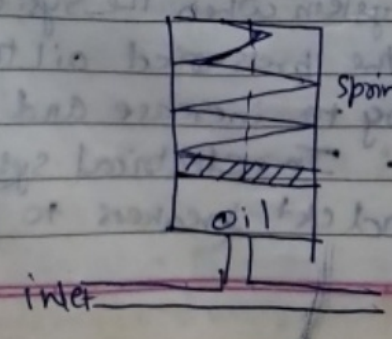
The relief valve has a plug, closing the opening to tank due to Spring force acting on it. When the system press exceeds the set value of pressure the press force compresses the spring moves the valve plug upward. The port opens to tank. So the hydraulic oil will be diverted to the tank. and the system pressure settles to the normal value.

Check valve:-
To control unidirectional flow.

Needle valve:-
to control the rate of hydraulic flow

Types of Accumulators:-
1). Spring loaded Accumulator
2) Weight loaded "
3) Pressurized Gas ".

(1)



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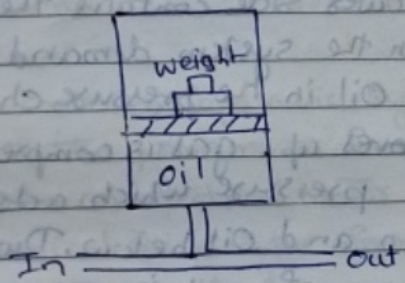
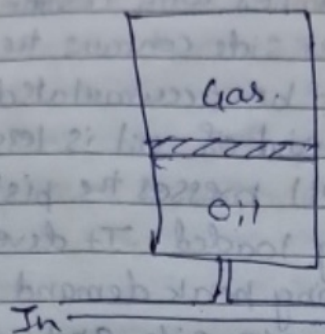
There is a chamber with certain volumetric capacity. Lower side contains the hydraulic oil which can be accumulated in the chamber. When the demand of oil is less the accumulating oil presses the piston upward. Piston is spring loaded. It develops the pressure. During peak demand this pressurized oil flows to o/p side and supplements the flow. As the oil is delivered pressure ↓ piston moves down. It can be mounted in any posⁿ.

2.



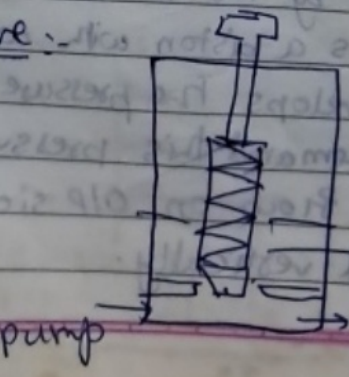
lower side of the chamber is filled with surplus oil coming from i/p side and not utilized by the o/p side. On the oil surface there is a piston with weight resting on it. It develops the pressure on oil. During peak demand this pressurized oil adds to normal flow on o/p side. It can be mounted vertically.

(2)



uses gas pressure. upper part of the chamber is filled with certain vol of pressurized gas on upper side of the piston. lower side contains the hydraulic oil. When the system demand decreases, the extra oil in the pressure chamber accum piston moves up. gas is compressed, raising the gas pressure which acts downward on piston and oil below. During peak dem the outflow of oil is supplemented by the pressurized oil from the chamber. can be mounted in any position.

Relief valve :-

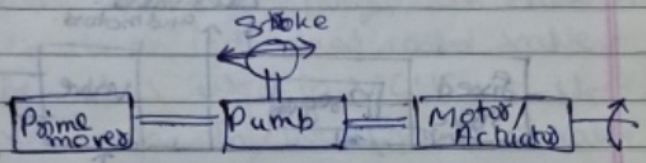


Classification of Hydraulic Systems

From opⁿ point of view HS in 2 categories.

Pump controlled HS
valve controlled HS

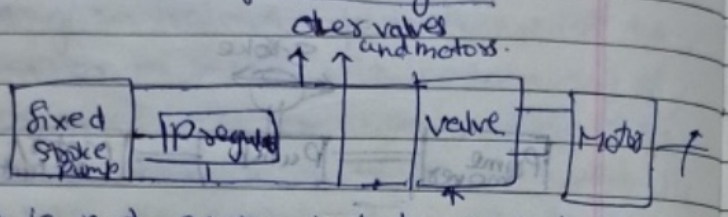
Pump Controlled HS:-



Pump controlled hydraulic system has a prime movers. The prime mover for the hydraulic system may be an electrical motor or any form of mechanical drive in the form of engine or turbine. It provides the necessary mechanical power and energy. The next major unit in the pump controlled HS is the hydraulic pump. The hydraulic oil is stored in a pond or reservoir called the sump. It is usually at ground level. From the sump the hydraulic pump has to pump the reqd amount of hydraulic oil/time. It has to create the volumetric flow rate reqd by the system and this flow is to be established through the pipeline

The pump fluid is utilized by the hydraulic motor or actuator. The power received by the hydraulic motor is decided by the pressure and flow rate. This type of system is suitable if only one motor or actuator is to be controlled by the pump.

Valve Controlled Hydraulic System



It is not economical to use individual pumps with prime movers for individual motors or actuators. In is this case we use VCHS. It is const pressure VCHS. One common large pump is used. driven by electrical prime mover. The motor supplies necessary mechanical power and drives the hydraulic pump. It is a fixed stroke pump because the control is not to be provided by the pump. The pump has to displace sufficient amount of oil to meet the total volumetric flow rate of different hydraulic motors or actuators. O/P pressure of pump should be high enough to ensure pressure necessary for number of motors and actuators

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operating from the same system. From the o/p of the hydraulic pump there is a distⁿ of hydraulic oil for different systems. Initial o/p hydraulic line may be common from which there are various branchings of the hydraulic oil. Hydraulic pump is filtered by a pressure regulator in the main line before branching. It maintains specified pressure at the o/p of the pump. In each branch there is an individual control valve. The valves used in VCHS are closed centre mode. In closed posⁿ of valve there is no flow from the supply except leakage, when the motor is to be operated the valve is opened and provides the necessary flow at const press.

2nd type of VCS is called const flow VCS. The valve used to operate in open centre mode. ie in the so called OFF posⁿ, the valve is open but the fluid directly flows to the sump. The other posⁿ is fully ON during which the fluid is made to flow to the hydraulic motor or actuator. In the intermediate position fluid partly flows to the motor or actuator and partly to the sump. In OFF posⁿ when

Pneumatic System	Electronic System
Low initial cost	High initial cost
Simple design	Complex design
Short start-up period	Long start-up period
Air signal is more compatible with control valves.	is less compatible with control valves
Low accuracy & fast speed of response	high accuracy & low speed of response
Less maintence	Maintenance is req to overcome electrical noise
Can be installed in hazardous environments containing flammable gases	Installation in hazardous areas require use of proper explosion proof housing.

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the whole fluid goes to the sump. The supply pressure is low. When partly or fully oil is supplied to the motor the pressure This arrangement does not require any pressure regulator. To avoid emergency by excessive pressure rise a pressure Relief valve is provide.

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Pressure Regulation :-

Consider a system where load is raised or lowered by a hydraulic cylinder. With valve V_1 open, fluid flows from the pump to the cylinder, with both pressure guages P_1 and P_2 indicating a pressure of F/A. With valves V_1 closed and V_2 open, the load falls with with fluid being returned to the tank. With the load falling, gauge P_2 will still show a pressure of F/A, but at P_1 the pump is dead ended leading to a continual increase in pressure as the pump delivers fluid into the pipe.

Some method is needed to keep the ~~pump~~ P_1 at safe level. To achieve this, pressure regulating valve V_3 has been included. This is normally closed (no connection between P and T) while the pressure is below some preset level (called the cracking pressure) Once the cracking pressure is reached valve V_3 starts to open bleeding fluid back to the tank. As the pressure increases, valve V_3 opens more until at a pressure called the full flow pressure, the valve is fully open. With valve V_1 closed, all fluid from the pump returns to the tank

via the pressure regulating valve. and P_1 settles somewhere between cracking and full flow Pressure.

Cracking pressure of a relief valve must be higher than a System's working pressure. leading to a fall in System pressure as valve V_1 opens and external work is performed.

(Valve working is similar to pneumatic regulator)

The diff bet" cracking and full flow pressure is called the pressure override

The steady (non-working) system pressure will lie somewhere within the pressure override with the actual value determined by pipe sizes and characteristics of the pressure RV itself.

If the quiescent pressure is required to be precisely defined a small pressure override is needed. This pressure override is related to spring tension in a simple relief valve.

When a small or precisely defined override is reqd a balanced piston relief valve is used

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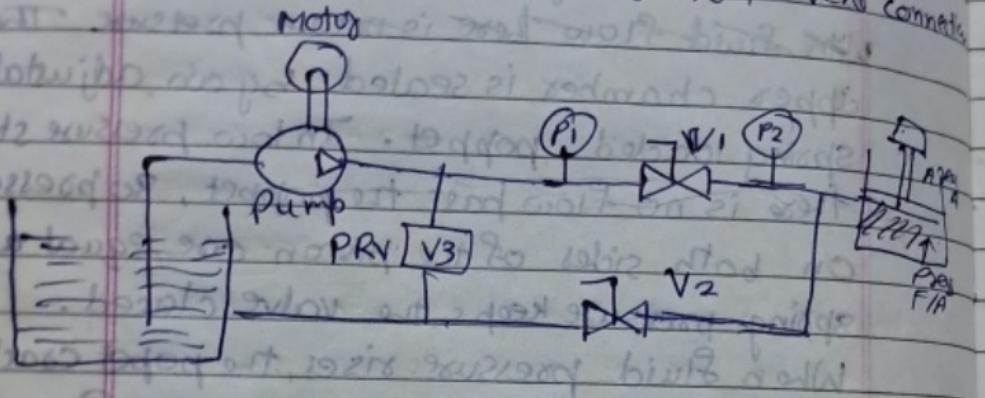
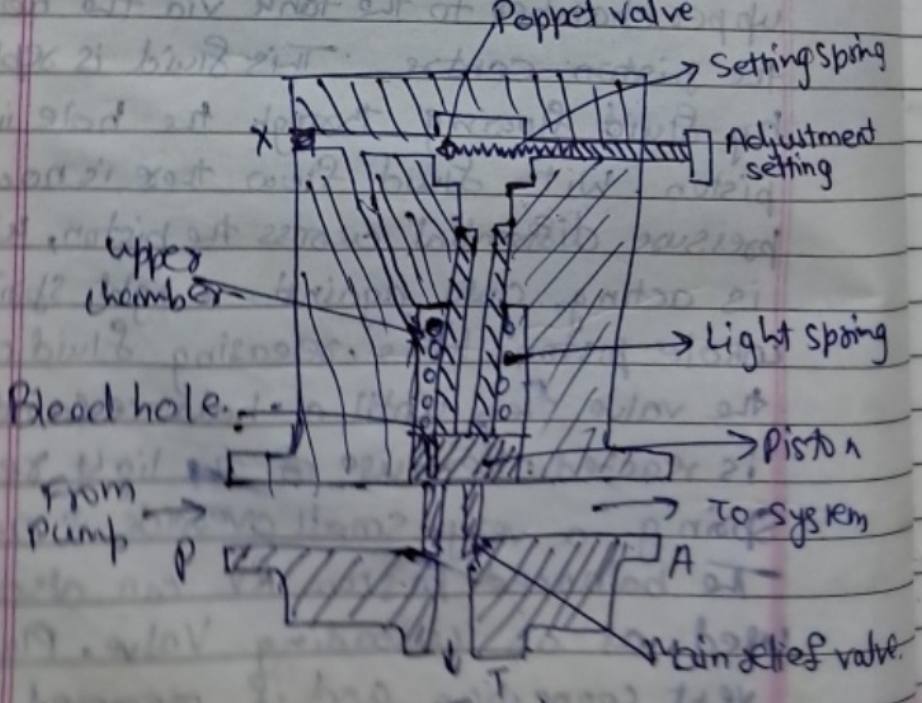
The piston in this valve is free moving, but is normally held in lowered position by a light spring, blocking flow to the tank. Fluid is permitted to pass to the upper chamber through a small hole in the piston. ~~With fluid flow here is now a pressure~~ The upper chamber is sealed by an adjustable spring loaded poppet. In low pressure stat, there is no flow past the poppet, so pressure on both sides of the piston are equal and spring pressure keeps the valve closed. When fluid pressure rises, the popet cracks and a small flow of fluid passes from the upper chamber to the tank via the hole in the piston centre. This fluid is replenished by fluid flowing through the hole in the piston. With fluid flow there is now a pressure differential across the piston, which is acting only against a light spring. The whole piston lifts, releasing fluid around the valve stem until a balance condition is reached. Because of the light restoring spring a very small override is achieved. The balanced piston RV can also be used as an unloading valve. Plug X is a vent connection and if removed, fluid flows from the main line through the

piston. As before, this causes the piston to rise and flow to be dumped to the tank. Controlled loading and unloading can be achieved by the use of a finite position valve connected to the vent connection





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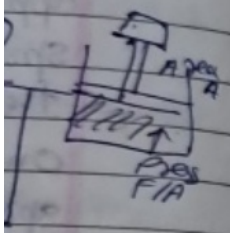

...setting spring

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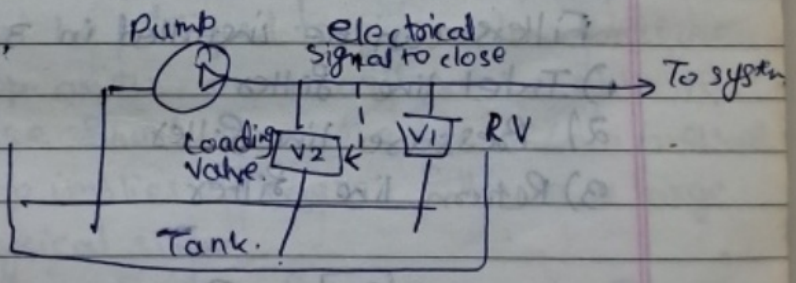
...relief valve.

When no useful work is being performed all fluid from the pump is pressurised to a high pressure then dumped back to the tank through the PRV. This eq motor power and substantial waste of power energy put into the fluid is converted to heat leading to a rise in fluid temp.

Pump types

Loading valves:

Power = Pos x Flow rate shows that allowing excess fluid from a pump to return to the tank by a pressure relief valve is wasteful of energy and can lead to a rapid rise in temperature of the fluid as the wasted energy is converted to heat. It is normally undesirable to start and stop the pump to match load requirements. as this causes shock loads to pump, motor and couplings



Vi is a normal PRV regulating pressure and returning excess fluid to the tank as described earlier. The additional valve V2 is opened or closed by an external electrical or hydraulic signal. With valve V2 open all the pump o/p flow is returned to the tank at low

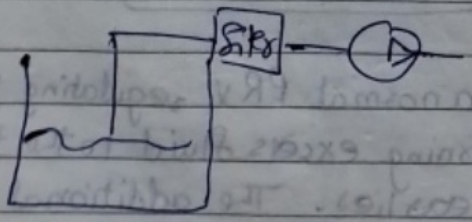
pressure with minimal energy cost When fluid is req'd in the system the control signal closes valve V_2, pressure rises to the setting of valve V_1 and the system performs as normal. Valve V_2 is called a pump loading or a pump unloading valve according to the interpretation of the control signal here.

Filters:-

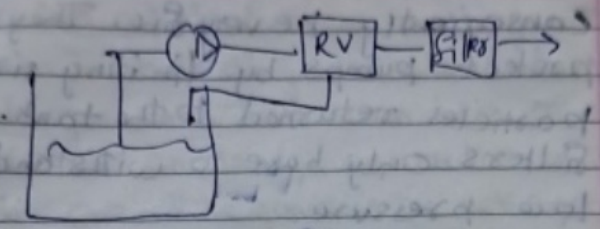
Filters are used to prevent dirt entering the vulnerable parts of the system, and are generally specified in microns or meshes per linear inch.

Filters can be installed in 3 places.

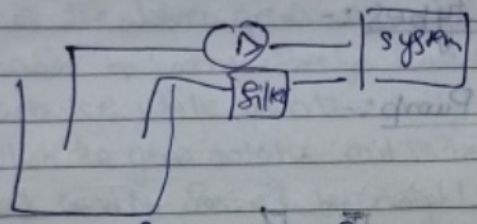
1) Inlet line filter
2) Pressure line filter
3) Return line filter.



inlet line filter.



Pressure line filter



Return line filter.

Inlet line filters protect the pump, but must be designed to give a low pressure drop or the pump will not be able to raise fluid from the tank. Low pressure drop implies a coarse filter or a large physical size.

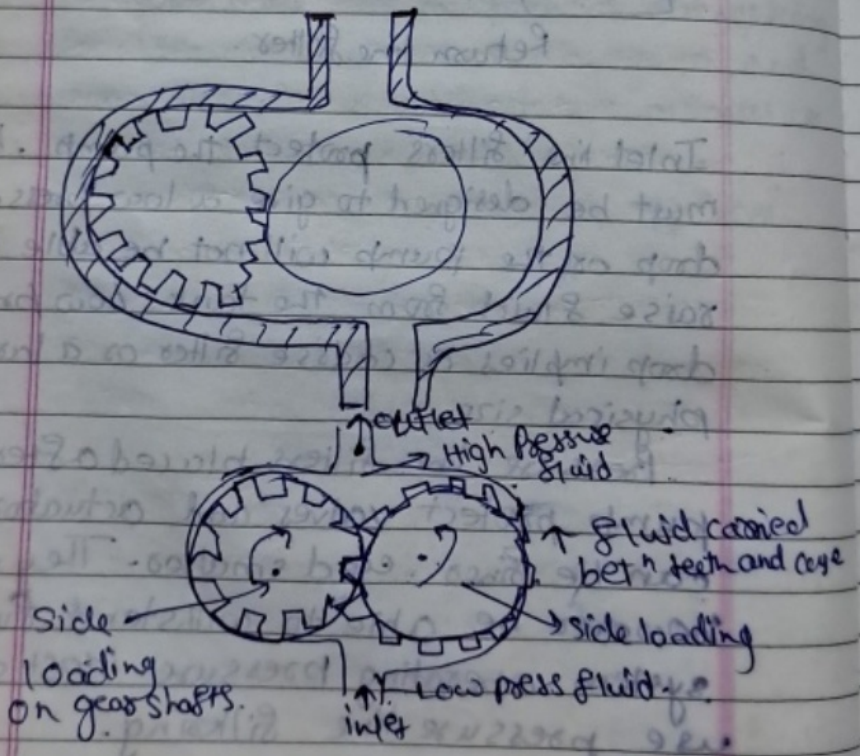
Pressure line filters placed after the pump protect valves and actuators and can be finer and smaller. They must, however be able to withstand full system operating pressure. Most systems use pressure line filtering.

Return line filters may have a relatively high pressure drop and can

consequently be very fine. They serve to protect pumps by limiting size of particles returned to the tank. These filters only have to withstand a low pressure.

Pump types :-

Gear Pump :-



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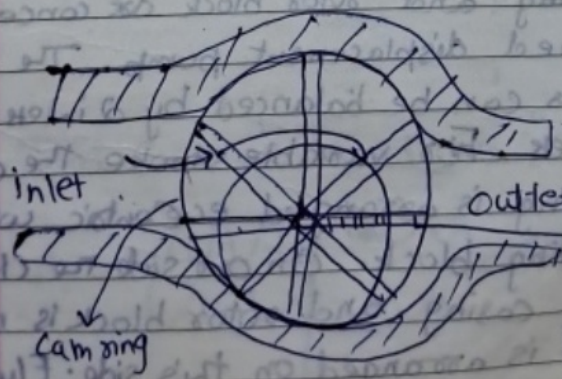
It has a pair of gears meshing with each other. This pair of gears is housed in an oblong casing. There is an inlet of oil on one side and there is an outlet on the other side. One of the gears is the active gear connected to the driving shaft. The other is idle gear. It is the driven gear. mounted on a stationary shaft to move freely. One gear rotates clockwise while the other rotates anticlockwise When the gear rotates oil is trapped in the axial cavity formed by neighbouring teeth. When the gears pass near the inlet the oil is taken in and trapped. While rotating the trapped oil reaches the outlet port and delivers out there.

Vane Pump:-



There is an external casing of hollow cylindrical form. Within the cylinder there is a rotor block. The rotor block carries no of vanes. The vanes are carried by radial slots in the rotor block and are free to move radially. The prime mover coupled to the rotor axis rotates the rotor block. due to high speed of rotation the vanes try to come out by centrifugal force. They occupy outer most posit^{n} in the radial direct which avoids leakage of the fluid. The fluid is trapped bet^{n} the vanes. When they pass near the inlet port on one side they collect the fluid and when they reach the outlet port the trapped fluid is discharged. Entering fluid is at low pressure and leaves at high pressure. If the outer casing and rotor block are concentric it is a fixed displacement pump. The hydraulic forces can be balanced by 2 inlets and 2 outlets. For variable stroke the outer casing is arranged eccentric wrt the rotating block. On one side the clearance bet casing and rotor block is more. Inlet is arranged on this side. Fluid enters and is trapped bet^{n} vanes. As the rotor rotates the available clearance ↓

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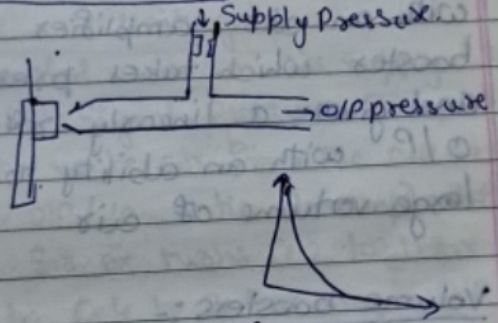
Oil cannot be compressed. Outlet is provided on this side. High pressure oil is discharged from it. Due to centrifugal force the vanes maintain close contact with the outer case. Sometimes vanes are pressurized or vanes are spring loaded for proper contact.

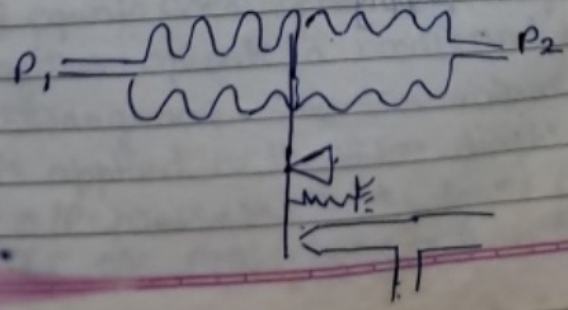
Process control pneumatics :-

Flapper Nozzle Amp^{r}



Gap pressure relationship

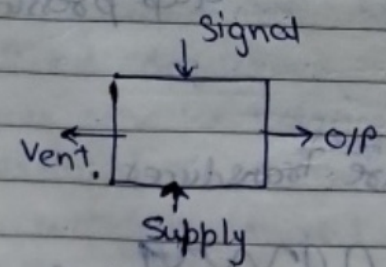
Diff Pressure Transducer

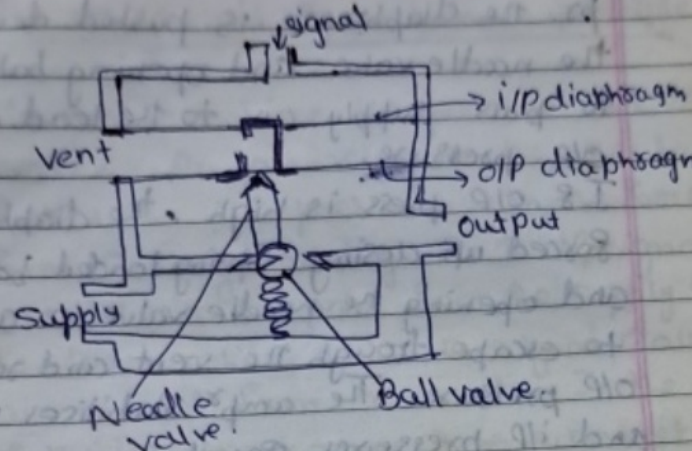


diff in pressure bet^n P_1 and P_2 causes a force on the flapper. Assuming $P_1 > P_2$ the top of the flapper is pushed to the right until the force from $P_1 - P_2$ is matched by the force from the spring extension. The O/P pressure is thus determined by the diff press and flow through the orifice plate.

A flapper nozzle is usually combined with an air amplifier or volume booster which takes pressure as i/p and gives a linearly related pressure O/P with an ability to supply a large volume of air.

Volume boosters :-





unity gain.

It is provided with an air supply (2-4 bar) and an i/p signal pressure. The amp^r admits air to, or vents air from the o/p to maintain a const o/p/i/p ratio. An amp^r with a gain of two for ex turns 0.2 to 1 bar signal range to 0.4 to 2 bar range. O/P press controlled by the amp^r has the ability to provide a large air volume and can drive large capacity loads.

Unity gain amp^r is show it consists of 2 equal area linked diaphragms which together operate a needle and ball valve arrangement. The low volume i/p signal is applied to the upper diaphragm and the o/p pressure to the lower diaphragm If o/p press is lower than the inlet

pr. the diaphragm is pushed down closing the nozzle valve and opening ball valve to pass supply air to the load and ↑ O/P pressure.

If O/P press is high, the diaphragm is forced up closing Spring loaded ball valve and opening the needle valve to allow air to escape through the vent and reduce O/P pressure. The amp^r stabilises with O/P and i/P pressures equal

i/P port has a small and practically const volume which can be controlled directly by flapper nozzle. O/P pressure tracks changes in inlet pressure but with the ability to supply a large vol of air.

Amp^r balances when forces on the 2 diaphragms are equal and opposite.

Equal area diaphragms have been used in the unity gain amp^r. The area of the i/P diaphragm is ∂ the area of the O/P diaphragm. For balance the O/P press must be twice the i/P pressure giving a gain of two.

$$\text{gain} = \frac{\text{i/P area}}{\text{O/P area}}$$

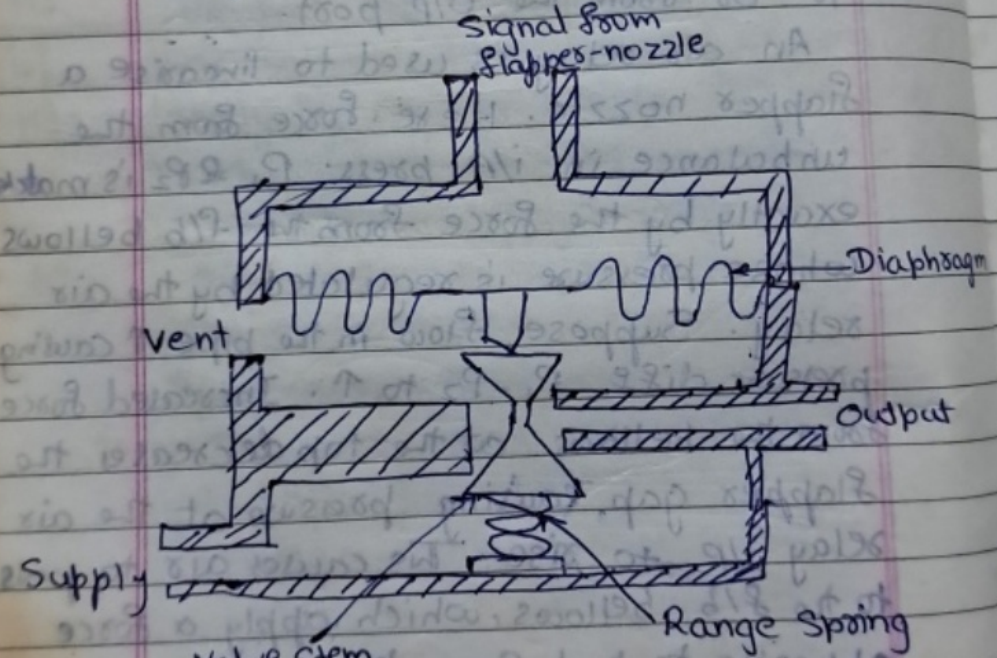
Air relay and force balance principle

Air amp's balance i/p pressure and o/p pressure. An air relay on the other hand balances i/p pressure with the force from a range spring. An ↑ i/p signal causes air to pass from the supply to the load, while a ↓ i/p signal causes air to vent from the load. In the centre of the i/p signal range, there is no net flow to or from the o/p port.

An air relay is used to linearise a flapper nozzle. Here force from the unbalance in i/p press. P_1 & P_2 is matched exactly by the force from the f/b bellows whose pressure is regulated by the air relay. Suppose flow in the pipe ↑ causing pressure diff $P_1 - P_2$ to ↑. Increased force from the bellows at the top decreases the flapper gap causing pressure at the air relay i/p to rise. This causes air to pass to the f/b bellows, which apply a force opposite to that from the signal bellows. The system balances when the i/p pressure from the flapper nozzle to the air relay (pt A) is at the centre of its range. At which pt the air relay neither passes

air nozz vents the f/b bellows. This corresponds to a fixed flapper nozzle gap.

Press in the f/b bellows is adjusted by the air relay to maintain a const flapper nozzle gap. The force from the f/b bellows thus matches the force from the i/p signal bellows. and O/P pressure is directly proportional to $(P_i - P_2)$ The O/P pressure driven directly from the air relay can deliver a large air volume.



Air relay. (A tg)

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Diaphragm

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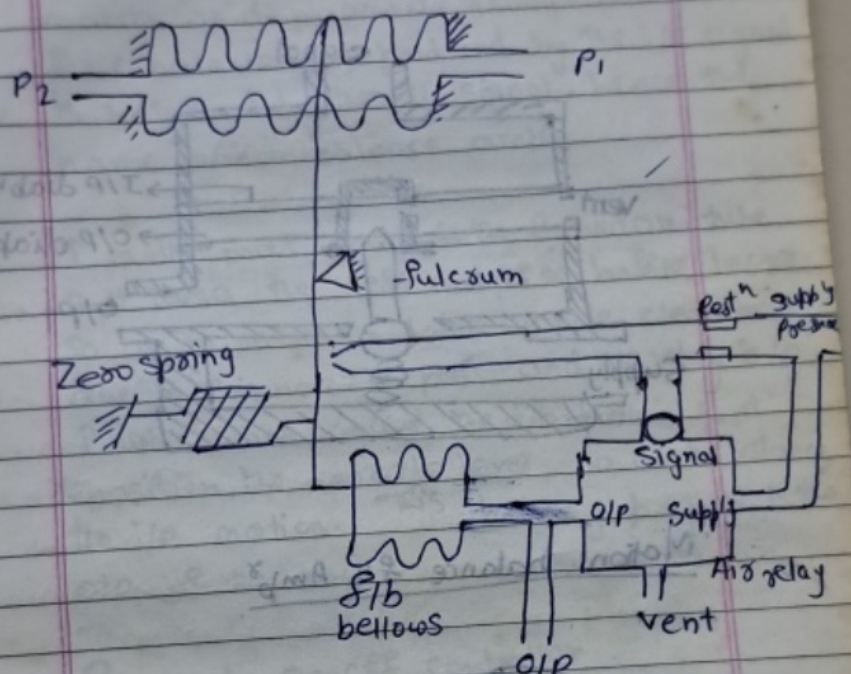
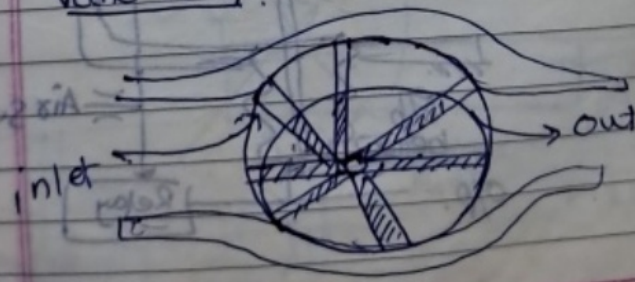
Face balance Principle



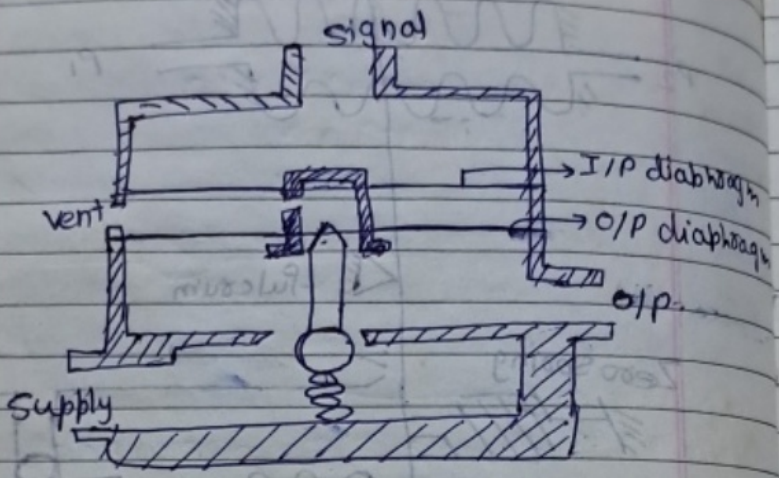
O/P
$K(P_1 - P_2) + C$
(K, C) const.

Vane Pump

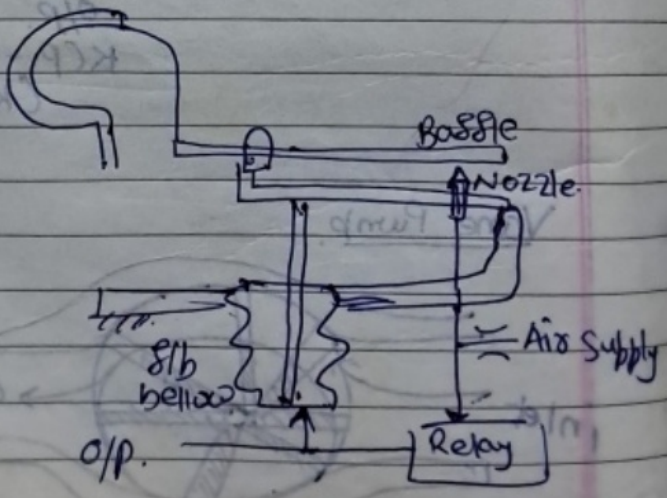


P = F/A using area less ports.

Volume booster



Motion balance f/b Amp^{r}



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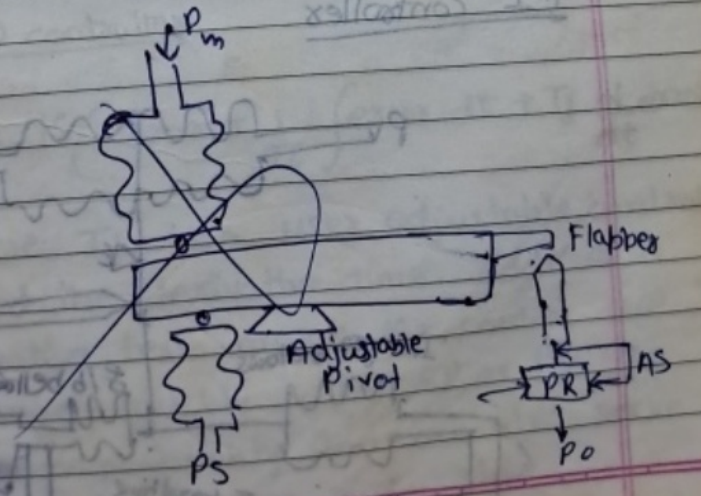
The amp^{n} consists of a Bourdon tube, FNA with the relay and f/b bellows. In this motion or displacement rather than force in force balance amp^{n} produced by the i/p signal is balanced by the f/b signal, hence the name motion balance amp^{n}.

↑ in i/p pegs unwinds the Bourdon tube that raise the left end of the baffle lever so as to reduce the baffle nozzle clearance due to this nozzle pegs and relay o/p ↑ which acts against the f/b bellow that reposition the nozzle lever so as to balance the i/p motion. This balancing pressure is the o/p of the amp^{n}.

Pneumatic on-off controller.

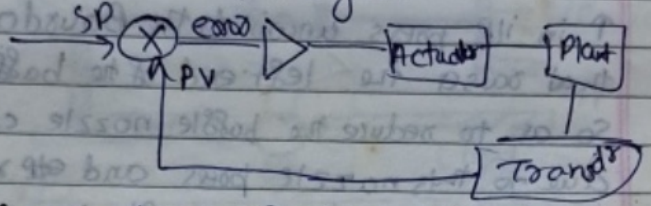


Pneumatic Proportional Controller

O/P signal is simply the error signal multiplied by gain

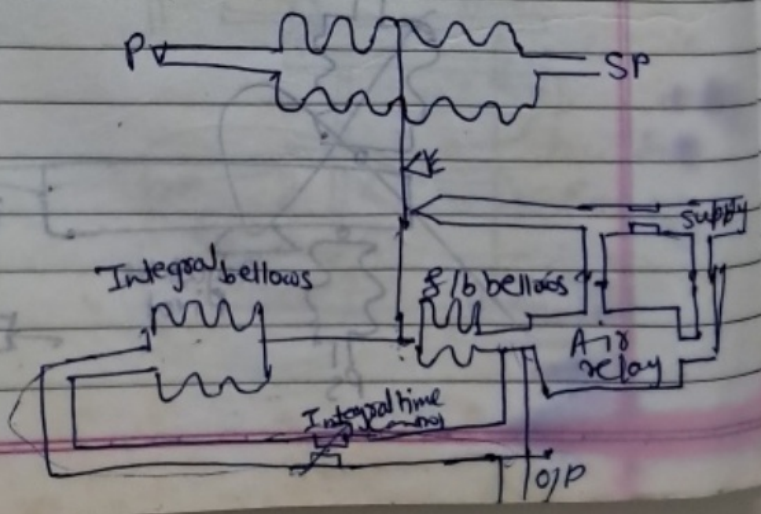
$$O/P = K \times error$$
$$K \times (SP - PV)$$

K is gain



Comparison of this with FB transmitter shows that diff pr $(P_1 - P_2)$ performs the same funth as SP-PV we can thus construct a simple P controller. Gain can be set by moving the pivot posth.

PI controller



$$O/P = K\left(\text{error} + \frac{1}{T_i}\int \text{error}\, dt\right)$$

is called P+I controller. The const T_i called the integral time is set by the user. As long as the error exists the controller O/P creeps up or down to a rate determined by T_i. Only when there is no error is the controller O/P const.

Integral bellows oppose the action of the f/b bellows with the rate of change of pressure limited by the T_i setting valve. Controller balances the correct flapper nozzle gap to give zero error, with PV = SP and equal forces from the integral and f/b bellows.

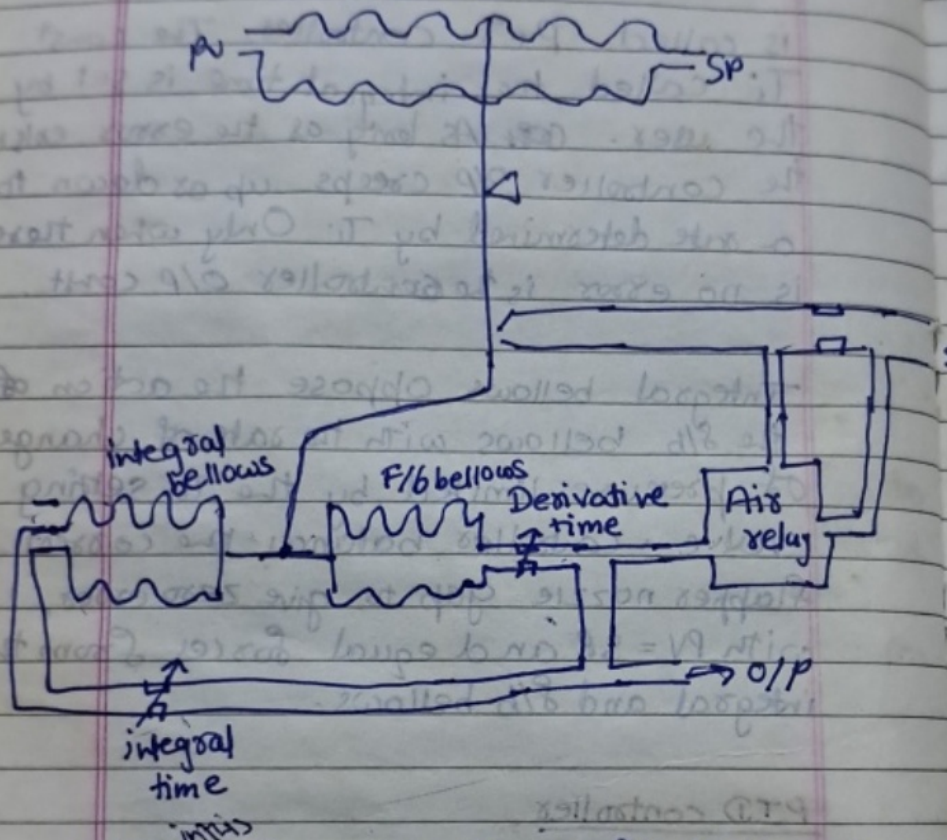
PID controller

$$OP = K\left(\text{error} + \frac{1}{T_i}\int \text{error}\, dt + T_d \frac{d\,\text{error}}{dt}\right)$$

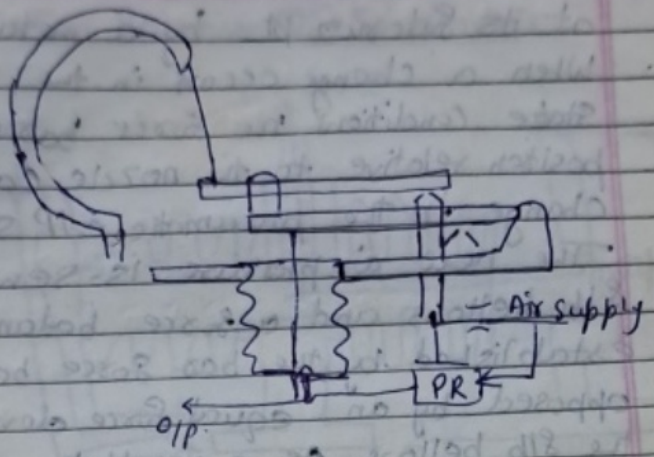
where T_d is a user adjustable control, called the derivative time. Addtn of a derivative term makes the control O/P change quickly when SP or PV are changing quickly, and can also serve to make a system more stable

PID controller

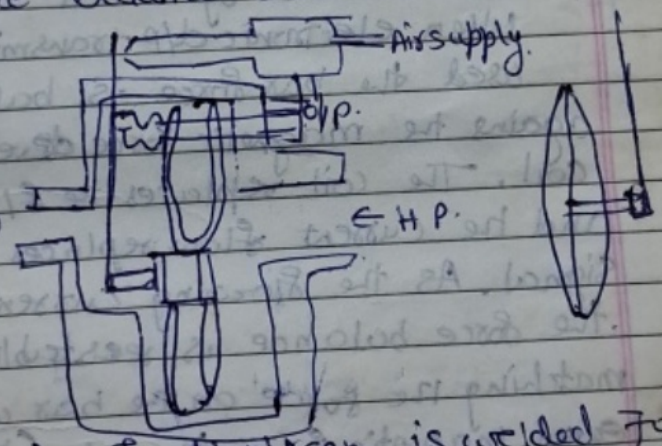
First D, Then P and then I



Where the action of the f/b bellows has been delayed. The 3 user adjustable terms in Exp (K, Ti and Td) are set beam pivot point and 2 bleeders to give the best plant response



Force Balance D/P Transmitter.

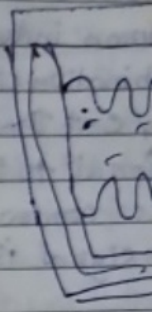


A pair of diaphragm is welded to opposite sides of the d/p capsule and the space betn them is filled with liquid. The diff pressure to be detected is applied to the 2 sides of this diaphragm capsule. The resulting force is then brought out via the force bar. which is sealed

at its fulcrum pt by a metallic diaphragm. When a change occur in the steady state condition the force bar changes its position relative to the nozzle causing a change in the pneumatic O/P signal. The new air pressure is sensed by the f/b bellows and a force balance is established by the bar force being opposed by an equal force developed in the f/b bellows. As a result the O/P signal is maintained in proportion to the diff pressure sensed by the cell.

When electronic d/p transmitters are used the bar force is balanced against the magnetic force developed in a coil. The coil replaces the f/b bellows and the current flow replaces the O/P air signal. As the flowing current is changed the force balance is reestablished by matching the force on the bar with an equal magnetic force thus the current O/P signal is proportional to the pressure differential in the cell.

Motion Bal



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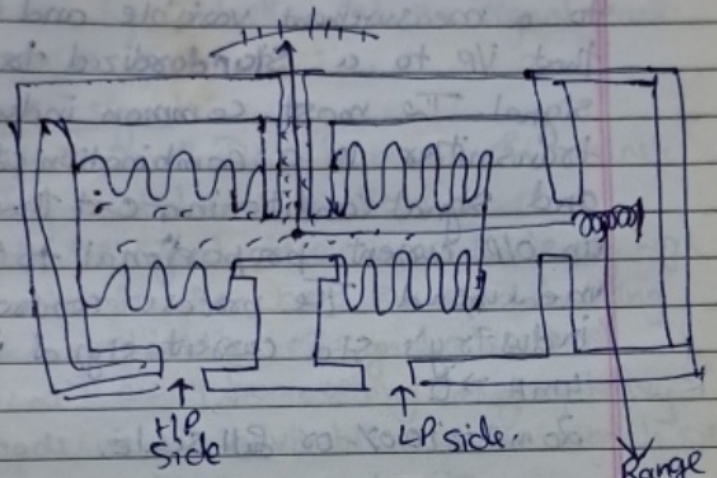
Pneumatic
Motion Balance D/P Transmitter



Digital process control pg 252

Transmitter

Transmitter is a transducer that responds to a measurement variable and converts that i/p to a standardized transmission signal. The most common industrial transmitter is a combination of a transducer and signal conditioning ckt that produces an O/P current proportional to the measured. The process control industry's std current signal is 4 to 20 mA
4mA → 0.
20mA → 100% or full scale.

Current is used because it is not affected by wire impedance and noise as are voltage signals when transmitted over long distances.

Voltage Signal

DC vltg signal cannot be accurately measured in systems in which a current is allowed to flow.
DC vltg signals must be made immune to noise by filtering techniques at the receiving inst and by shielding the leads.

AC vltg signals are not readily measured at low levels because of the difficulty

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Current signals
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in removing noise & spurious volt^g peaks caused by induction onto the signal leads.

Current signals

4 to 20 mA DC because of intrinsic safety related considerations.

Both the signal levels are sufficiently high to minimize the need for special wiring although shielding of signal cables and locat^n away from wiring carrying heavy loads is still advisable when the signals are to be used as computer i/ps.

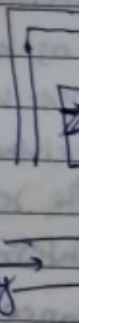
Desirable Transmitter features:

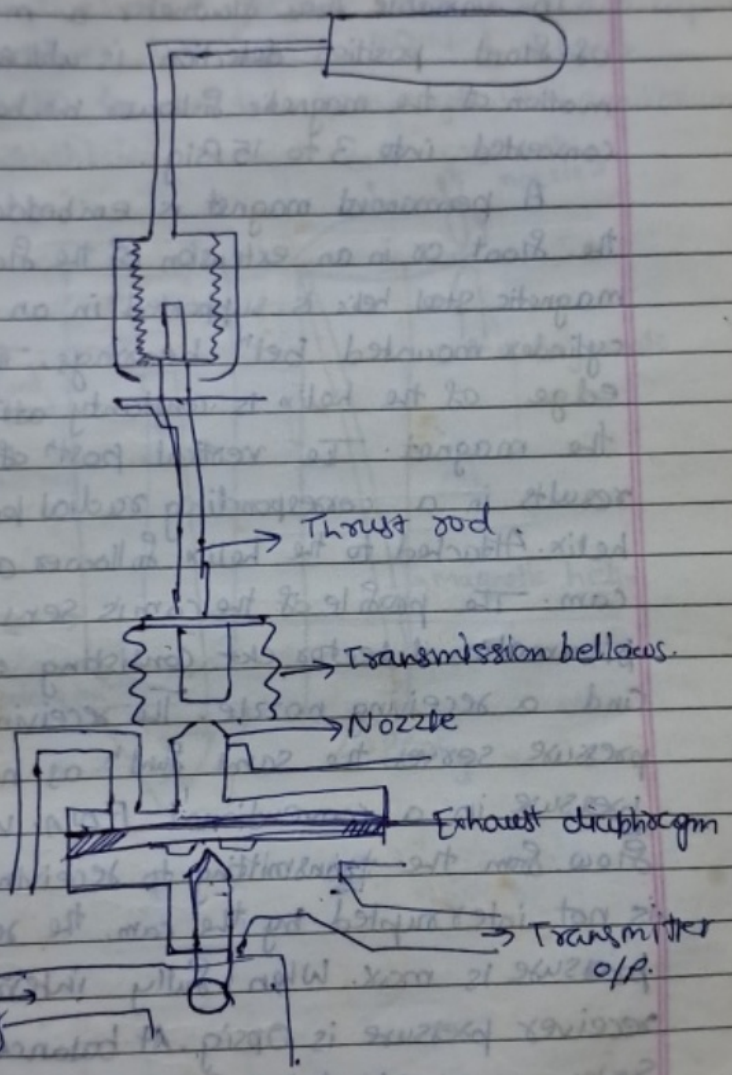
1. Small size and weight for easy installation and maintainence
2. Rugged design to withstand industrial environ^n
3. Minimum dependence on environmental cond^n for accuracy, good temp stability.
4. Elimination of the need for adjustment due to load or line resistance variations.
5. Convenient and accurate field calibration and maintainence.
6. Output Compatible with both measuring and controlling instruments.

Temperature Transmitter (Filled)

Pneumatic temperature transmitters are almost force balance type.

Pressure thermometers are employed. As the bulb senses the process temperature the pressure of the fill gas varies according to the gas laws. The fill gas pressure creates a force downward on the thermal system bellows. This force acts through the thrust rod and is counterbalanced by the force resulting from transmitted air pressure acting upward on the transmitter bellows. An increase in process temp increases fill gas pressure, which pushes down the thrust rod baffling off the nozzle. The consequent increase in nozzle backpressure pushes the exhaust diaphragm and pilot plunger down closing the exhaust seat and opening the supply port until the increase in transmitted pressure acting on the transmission bellows results in force balance.

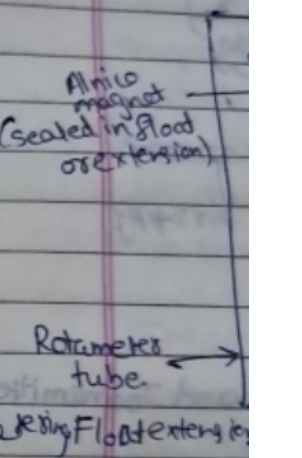



Thrust rod.
Transmission bellows.
Nozzle
Exhaust diaphragm
Transmitter
O/P.
Air
supply

Variable Area Flow Transmitter

In variable Area flowmeter a magnetic means of float position detection is utilized. The motion of the magnetic follower mechanism then is converted into 3 to 15 Psig.

A permanent magnet is embedded in either the float or in an extension of the float. A magnetic steel helix is supported in an aluminium cylinder mounted bet^{n} bearings. The leading edge of the helix is constanty attracted to the magnet. The vertical post^{n} of the float results in a corresponding radial post^{n} of the helix. Attached to the helix follower assembly is a cam. The profile of the cam is sensed by a pneumatic detector ckt consisting of a transmitting and a receiving nozzle. The receiving nozzle pressure serves the same funt^{n} as nozzle back pressure in a conventional F.V.A. When the flow from the transmitting to receiving nozzle is not interrupted by the cam, the receiver pressure is max. When fully interrupted receiver pressure is 0psig. At balance the detector system is throttled by following the cam profile As the float rises, the cam rotates in a direction of ↓ displacement. As the cam edge moves away from the detector nozzles, the ↑ receiver nozzle pressure acts on the relay and results



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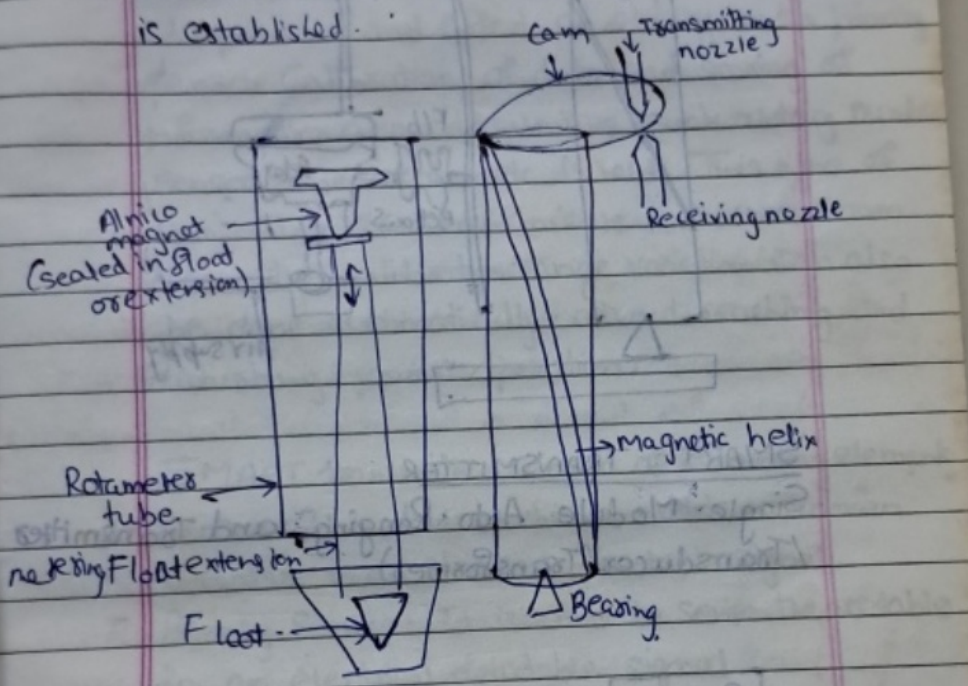
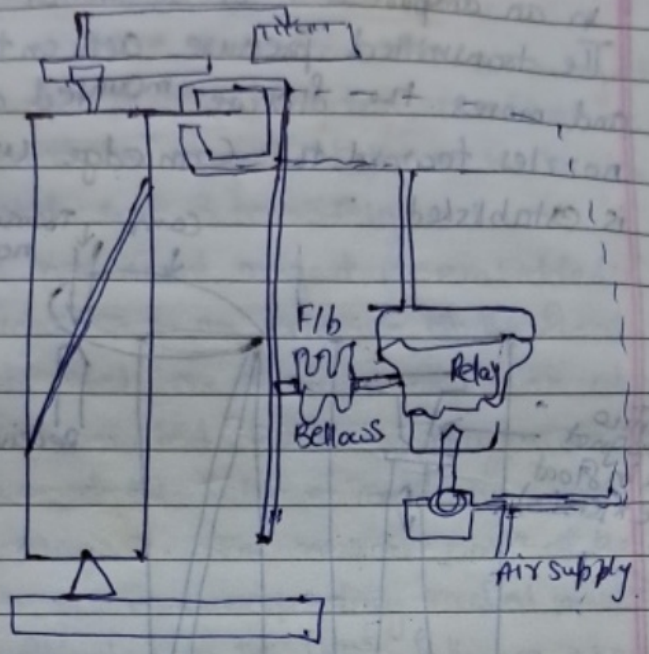
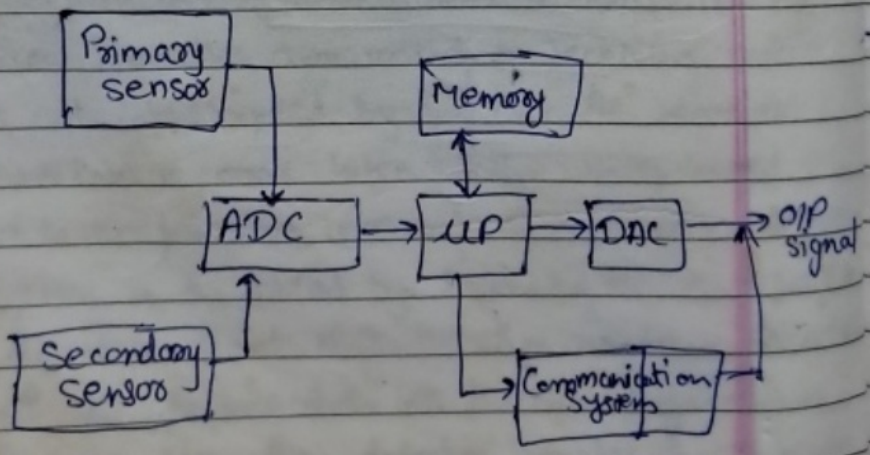
in an amplified ↑ in transmitted pressure.
The transmitted pressure acts on the B/b capsule and moves the flexure mounted detector nozzles toward the cam edge until equilibrium is established.





SMART TRANSMITTER

Single Module Auto Ranging and Transmitter /Transducer/Transformer)



It is a device in which µP system is used to correct non-linearity and errors of primary sensor through interpolation of calibration data held in the memory or to compensate and effect of 2ndary on the primary sensor. Calibration of data and storing of information about transmitter such as tag number, sensor type, location etc is held. This type of transmitter can communicate with control room hence the calibration, range variation can also be done automatically without reaching and disturbing process operation.

SMART transmitter consists of following elements.

1. Sensor: It is device which converts unknown variable in an electrical detectable signal.
2. Primary Sensor: It is used to sense the variable in an electrical detectable signal.
3. Secondary Sensor: It adjusts primary sensor to measure the physical parameter.
4. A to D It converts analog signal to digital form.
5. DAC:- It converts digital signal to analog O/p (4-20 mA)
6. Communication System:- Facilitates to communicate the user betn field and control room.
7. Memory: uses to store information of physical parameter, which is in digital form. It stores

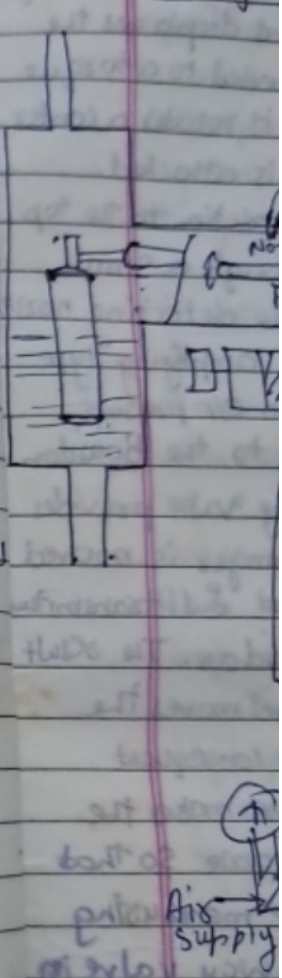
Transmitter

O/P signal

range value, transmitter configuration. correction constants, trimming constants, special tasks etc.
Micro computer:- does following functions:
Sensor linearization. Range. damping and self diagnosis.
engg units: Communication and temperature correction for ambient temperature.

Advantages of SMART Transmitter over conventional Transmitter:

1. Typical O/P available is 4-20mA which can be converted into a digital form in SMART transmitter which is not possible in conventional transmitter
2. Internal compensation is available for static pressure & ambient temperature.
3. Remote or online calibration is possible w/o need to bypass instrument from the process.
4. Can linearise non-linear signal.



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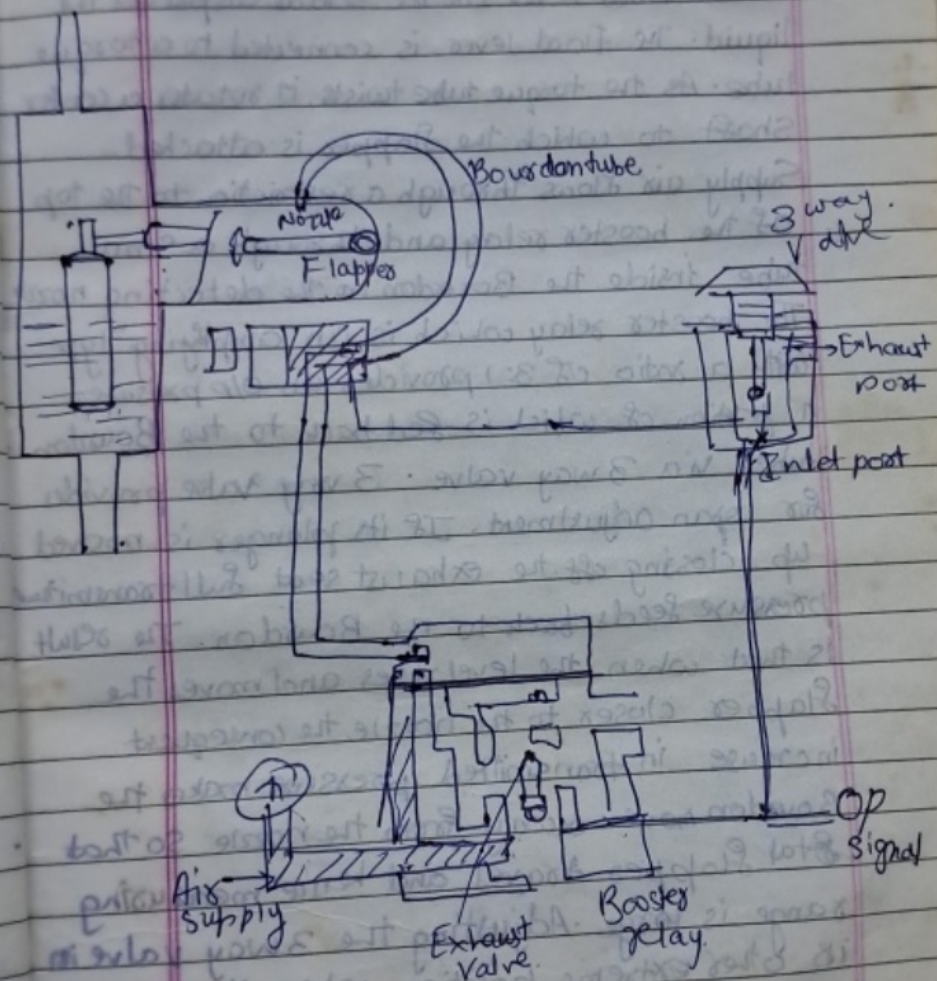
Buoyancy Transmitter



Changes in level directly affect the net weight on the float lever as the float displaces the liquid. The float lever is connected to a torque tube. As the torque tube twists, it rotates a center shaft to which the flapper is attached. Supply air flows through a restriction to the top of the booster relay and through a small tube inside the Bourdon to the detecting nozzle. The booster relay which is an amplifying type with a ratio of 3:1 provides an o/p pressure, a portion of which is fed back to the Bourdon tube via 3 way valve. 3 way valve provides for span adjustment. If its plunger is moved up, closing off the exhaust seat full transmitter pressure feeds back to the Bourdon. The result is that when the level rises and moves the flapper closer to the nozzle, the consequent increase in transmitted pressure makes the Bourdon move away from the nozzle so that total flapper travel and hence measuring range is large. Adjusting the 3 way valve in its other extreme position where it closes off transmitted pressure results in practically on-off action at the nozzle, representing the narrowest range of measurements. Normally the 3 way valve is adjusted somewhere betn these limits.

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4-20mA

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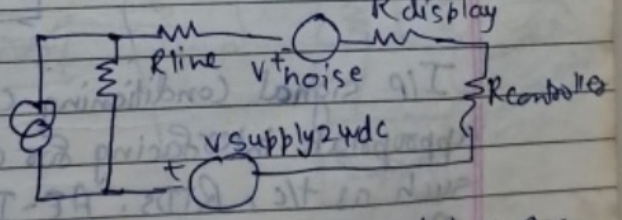
They can be used to measure density or specific gravity as well as level.

With pneumatic transmitters, there is a transmission lag that increases with the length of transmission tubing.

4-20mA Transmitter

A simplified current loop is shown. An ideal Norton current source composed of Isignal and Rsignal models the 4-20mA transmitter. The line resistance is shown as Rline and Vnoise represents random induced loop noise.

A 500 Ω controller and a 250 Ω digital display are connected in series with the signal current. The loop is powered by a 24 Vdc supply.



Advantages of this type current loop are. Signal vltg at any load is (Isignal * Rload) which is independent of supply vltg variations and line resistance

loop noise at a load is reduced by the factor. Rload / Sum all Rload + Rline + Rsignal

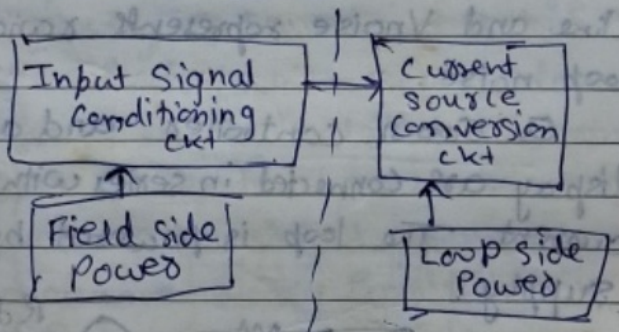
Random induced loop noise vltg at any load is Vnoise * (Rload) / (Sum of all Rload + Rline + Rsignal)

Supply vltg variations are reduced at any load by the same factor

Multiple loads can be series connected in a transmitter loop providing considerable control and display opportunities.

Multiple series loads, wide variation in supply vltg and some inherent noise immunity are advantages of current loop transmitter.

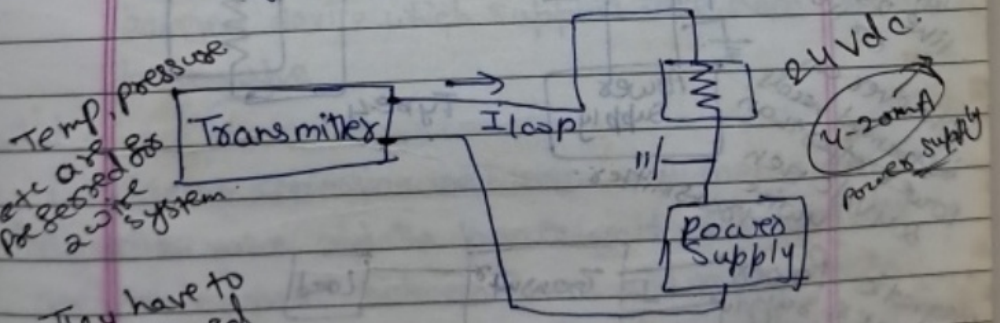
Ckt Block of 4-20mA



I/P signal conditioning ckt provide appropriate interfacing for all types of ips such as t/c, RTDs, AC-DC vltg & currents Strain guages. Many 4-20mA modules have smart signal conditioning functionality that provide linearization and mathematical manipulations.

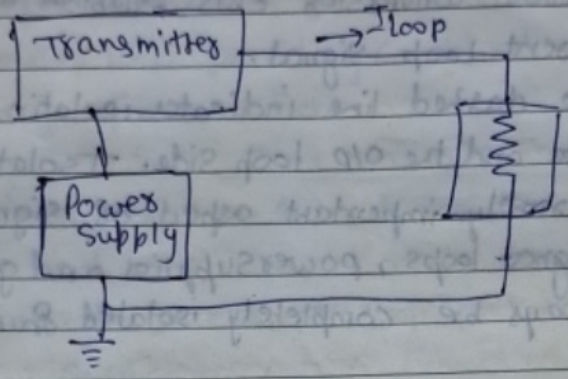
Power ckts generate all the necessary internal vltgs reqd and are energized from either a local power source or the actual current loop.
Current conversion ckts establish the 4-20mA current loop signal.
The dashed line indicates isolation betⁿ the field side and the o/p loop side. Isolatⁿ is an extremely important aspect of signal transmissn. Signal loops, power supplies and grounds should always be completely isolated from each other.

3 basic types of Transmitter.
2 wire transmitter energized by the loop current where the loop source vltg is included in the receiver. The transmitter floats and signal ground is in the receiver.



Main Purpose of this design is to reduce wiring cost, Standardisation of ckts i.e to keep all at the same ground potential.

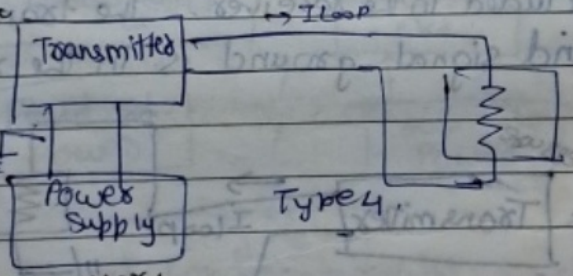
3 wire transmitter energized by a supply vltg at the transmitter. The transmitter sources the loop current. Transmitter common is connected to receiver common.



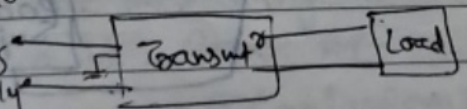
4 wire transmitter energized by a supply vltg at the transmitter. Transmitter sources the loop current to a floating receiving load

has the flexibility to utilize any power like 230 vac, 24 vdc or 110 vac.

Wherever an instrument needs power other than 24 Vdc then 4 wire transmitter.



magnetic flow meters, mass flow meters, ultrasonic flow meters.



Real active display

Powered with 120 V and drives 4-20mA

Bridge type arrangements used in the control

4 wire system

CONTROL VALVES

Terminology:-

Control valve:- A power (hydraulic, pneumatic, electric) operated device which modifies the fluid flow rate in a process control system. It consists of a valve connected to an actuator mechanism that is capable of changing the posⁿ of a flow controlling element in the valve in response to a signal from the controlling system.

Valve:- is a device used for the control of fluid flow. It consists of a fluid retaining assembly, one or more ports between end openings and a movable closure member which opens, restricts or closes the port(s).

Actuator:- is a fluid powered or electrically powered device which supplies force and motion to a valve

Motion conversion mechanism:- A mechanism betⁿ the valve and the power unit of the actuator to convert between linear and rotary motion. The conversion can be from linear actuator action to rotary valve operation or from rotary actuator action to linear valve operation.

Body :- The part of the valve which is the main pressure boundary. It also provides the pipe connecting ends, the fluid flow passages and may support the seating surface and the valve closure member.

Bonnet :- Portion of the valve pressure retaining boundary which may guide the stem and contains the packing box and stem seal.

Gate :- A flat or wedge shaped sliding element that modifies the flow rate with either linear or rotary motion.

Ball :- A spherically shaped part which uses a portion of a spherical surface or an internal path to modify flow rate with rotary motion.

Plug :- A cylindrical part which moves in the flow stream with linear motion to modify the flow rate and which may or may not have a contoured portion to provide flow characterization.

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Seal ring:- A part that is assembled in the valve body and may provide part of the flow control orifice

Stem:- The rod, shaft or spindle which connects the valve actuator with the closure member.

Components of Control valve

Actuator Spring:- A spring to move the actuator stem in a direct^{n} opposite to that created by diaphragm pressure.

Actuator Stem:- A rod like extension of the diaphragm plate to permit convenient external connection.

Bellows Seal Bonnet :- A bonnet which uses a bellows for sealing against leakage of controlled fluid around the valve plug stem.

Bonnet Assembly:- An assembly including the port through which a valve plug stem moves and means for sealing against leakage may be accomplished by packing or bellows.

Bottom flange:- A part which closes a valve body opening opposite to the bonnet assembly

Cage :- A hollow cylindrical trim element that is a guide to align the movement of a valve plug with a seat ring and also retain the seat ring in the valve body.

Extension bonnet :- A bonnet with an extension bet^{n} the packing box assembly and bonnet flange for hot and cold service.

Guide Bushing: A bushing in a bonnet, bottom flange or body to align the movement of a valve plug with a seat ring.

Packing box assembly :- The part of the bonnet assembly used to seat against the leakage around the valve plug stem.

Port guide :- A design on which the plug is aligned by the body ports.

Seat :- That portion of the seat ring or valve body which valve plug contacts for closure

Stem Guided :- A special case of top guided in which the valve plug is aligned by a guide acting on the valve plug stem.

Trim:- The inside part of the valve which come in contact with fluid like seat ring stem plug etc.

Valve ~~Body~~:- A housing for internal valve parts having inlet and outlet flow connections.

Valve Plug:- A movable part which provides variable restriction in a port.

Control Valve characteristics:-
The amount of fluid passing through a valve at any time depends upon the opening bet^n the plug and seat. Hence there is a relationship bet^n stem posit^n, plug posit^n and rate of flow which is described in terms of flow characteristics of a valve. These characteristics define the flow behaviour as the valve operates through the rated stroke.
Two types of valve characteristics are
1) Inherent
2) Installed

Inherent characteristics are considered when constant pressure drop is maintained across the valve,
Installed characteristics are considered when

valve is applied to particular flow system so that pressure drop across it changes with flow.

Inherent characteristics of the control valve describes the relationship bet^n the controller O/P signal recovered by the valve actuator and the flow through the valve when:

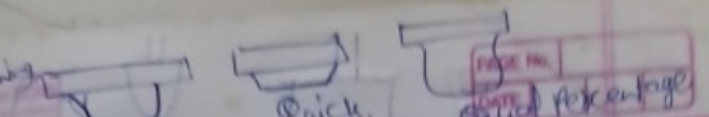
1) the actuator is linear
2) pressure diff across the valve is const
3) process fluid is not flushing or cavitating.

According to Valve characteristics control valves are classified as

1) Quick opening
2) Linear
3) Equal %age.

Quick opening

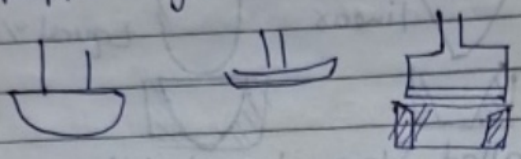
A relatively small motion of valve stem results in max possible flowrate through valve. Such a valve may allow 90% of max flowrate with only 30% stem travel.



$Q = KY^2$ Y - valve opening
K const

Q = flow at const Pressdrop.

This type of valve is used for full on-off control. Valve plug should be disc type or poppet type.



Linear characteristic :-

linear relationship bet^n valve opening and flow at a const press drop. it gives equal increment of flow per increment of stem travel at a const press. drop.

$Q = KY$

Preferred for processes that are slow in nature.

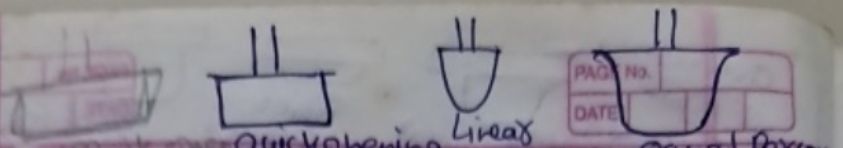
Equal %age :-

$Q = be^{ay}$

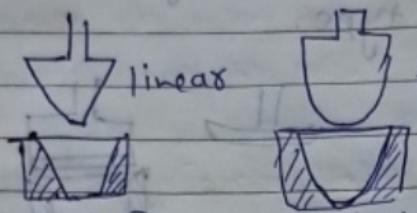
a, b const

e - natural log.

equal increments in valve travel produce equal %age changes in flow at a const pressure drop based on the flow just before the stem position is changed.



plug for equal % valve is generally a hollow cylinder with V shaped ports on the side. Flow area rises more rapidly with lift as the valve opens.



Installed flow characteristics:-

Selection criteria

Normally closed valve:- A valve with means provided to move to and/or hold in its closed position without actuator energy supply. Fail close

Fail close :- A cond^n wherein the valve closure member moves to an closed position when the actuating energy source fails. (steam valve).

Fail open :- A cond^n wherein the valve closure member moves to an open post^n when the actuating energy source fails. (cooling valve).

Normally open :- A valve with means provided to move to/or hold in its wide open post^n w/o actuator energy supply

Rangeability, turndown :- The ratio of the largest flow coefficient to the smallest flow coefficient within which the deviation from the specified inherent flow characteristic does not exceed the stated limits.

Valve flow coefficient (C_v) :- Number of US gallon/min of 60°F water that will flow through a valve with one psi pressure drop under stated condition. It is also called as capacity of control valve.

Rated travel :- Linear movement of the valve plug from the closed position to rated full open position.

Rated C_v : The value of C_v at the rated full open position of the valve plug.

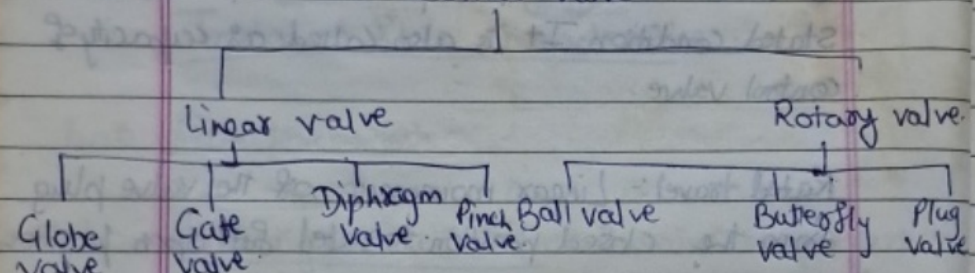
Static unbalance :- It is the net force produced on the valve plug in its closed position by fluid pressure acting upon it.

Dynamic unbalance :- Net force produced on the valve plug in any stated open position by the fluid forces acting upon it.

Leakage :- Quantity of fluid passing through an assembled valve when valve is in fully

closed position under seated closer forces with pressure differential and temp as specified. Leakage is commonly measured and may be experienced as % age of capacity at rated travel or as a commutative quantity over specified time.

on the basis of motion



Gate Valve

- Various types of Gate valve are
Knife Gate - throttling characteristic
V - insert creates parabolic flow characte
Plate and disc : resistance to heat and corrosion
Positioned disc: control flow of high pressure oil wells.

Advantages

produces reduced turbulence and noise
has fast response
provide tight shut off

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Rotary valve.
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Disadvantage (Ctd)

Globe valve & Diphragm valve
available in sizes from 6.5mm to 50mm and can operate upto 200 psi pressure over a temp range of -34°C to 177°C.

Advantages:-
High capacity at lower cost is possible
Self cleaning and sealing due to the use of diaphragm.
In case of low pressure, application provides tight shut off.
can handle slurry and chemicals.

Disadvantages:
Poor control characteristic
Slow response speed with low rangeability
Diaphragm life is small hence frequent shutdown.
Not suitable for high pressure drop across the valve.

Pinch valve (Clamp valve)
Advantages:-
High capacity
economical
Self cleaning action, good for slurries

Flowing medium does not contact working parts.
High abrasion and corrosion resistive.

Disadvantages:-
Poor control characteristics.
Relative low operating temp and pressure.
Not good for high pressure drop appl'ns.
Slow response.

Butterfly valve :-
Advantages:
High capacity
Economical, especially in large size.
High recovery characteristics
Self cleaning
Minimum space for installation.

Disadvantages
Operating torque increases if valve is large or pressure drop is increased.
Tight shut off is required.
Throttling control is limited.

Suitable for wide variety of fluid appl'ns

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Needle Valve :-

Check Valve :-

Advantages

1. Economical
2. Minimum space for installation
3. good for low pressure drop app^{ln}.

Disadvantages

1. Not suitable for high pressure drop.
2. Poor control characteristics.
3. Slow response.

Ball valve
Globe valve.

Solenoid valve

Globe Valve :-

Types
Single seated
Double Seated

Single Seated	Double seated.
most widely used	old design not much in use.

Single Seated	Double Seated
require only one body opening for the bonnet and have less closure subject to leakage.	Shut off is poor as it is not mechanically possible to have both plugs contact the seat at the same time.
it is less susceptible to vibration. Fluid passage is more streamlined and less subject to fouling.	There is an unbalanced force due to upper and lower plug diameter difference. More susceptible to vibrations

Split Body valves

It is used for handling slurries, gummy fluids and for corrosive services. The seat ring is clamped between the body halves and the body is easily disassembled. Easy in maintainence.

Valve gain

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Solenoid

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Valve gain and loop gain

The gain of any device is its output divided by its input. For a linear (const gain) valve the valve gain (C_v) is the max flow divided by the valve stroke in %.

When a loop is tuned to provide quarter amplitude damping the controller gain is adjusted until the overall loop gain (the product of gains of all the loop components) reaches 0.5.

Solenoid valves :-

Solenoid valve is an electrically actuated valve which has zero %age opening or 100 % opening as ON-OFF valve type. They move in a St line and ∴ require a cam or other mechanical convertes to operate rotary valves. They are available in two or three way designs with power requirements ranging from 10 to 30 watts with 6 to 440 V AC or 6 to 115 V DC power supplies. Solenoids consisting of a soft iron core that can move within the field set up by the surrounding coil are used extensively for moving valve stems.

A solenoid valve consists of the valve body, a magnetic core attached to

the stem and disc and a solenoid coil. The magnetic core moves in a tube that is closed at the top and sealed at the bottom allowing the valve to be packless. A small spring assists the release and initial closing of the valve. The valve is electrically energised to open. Stronger springs are used to overcome the friction of packing when reqd. Reversing the valve plug causes reverse action.

There are 4 types of solenoid valves.

① 2 way: These valves are normally useful for shut-off purpose and have 1 inlet and one outlet connection. designed for normally open or close operation.

② 3 way: They have 3 connections and 2 orifices. One orifice is closed when other is open. They are used for diversion of fluid streams, operating of diphragm valves and cylinders for loading or unloading.

③ 4 way: operation of double acting cylinders may be accomplished with this valve.

④ Pilot operated valve which incorporates a pilot orifice opens and releases

pressure from piston or dia the valve.

Smart Control

The Intelligen improve the communicati µP base tuning and or Controller locating the dedicating it on critical l nonlinearities electronicall valve. Sma electric mo the valve apt^n. Smar and re co pressure valve tra reqd chan valves directly upstream

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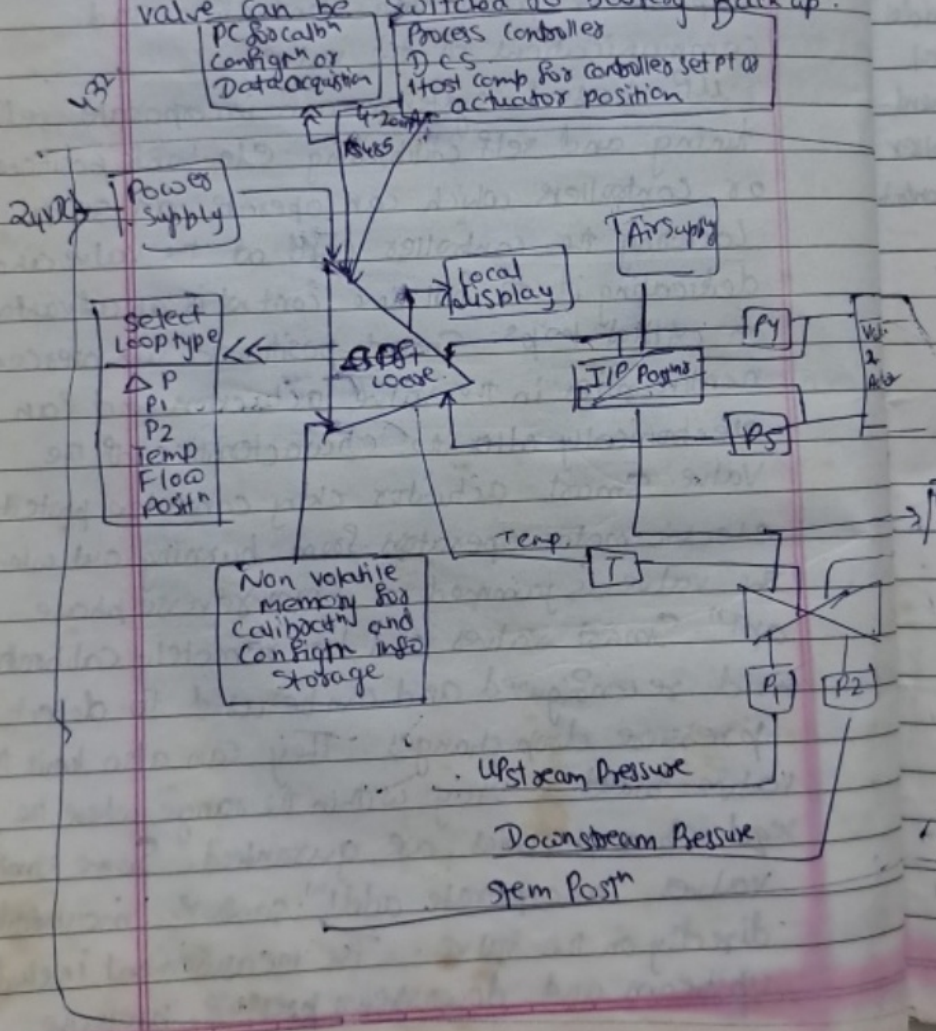
pressure from the upper part of the valve piston or diaphragm to the outlet side of the valve.

Smart Control Valves

The intelligence provided by µP can improve the positioning, protection and communications of the valve.

µP based systems can incorporate self tuning and self calibrating electronic positioners or controllers which can operate on set-pt. locating the controller card at the valve and dedicating it to full time control is an advantage on critical loops. Smart positioners can overcome nonlinearities in the valve actuators and can electronically alter the characteristics of the valve. Smart actuator ckts can also protect electric motor operators from burning out when the valve is jammed or from reverse phase opⁿ. Smart valves can be remotely calibrated and reconfigured and can be used to detect pressure drop changes. They can also limit the valve travel to stay within the range where the reqd characteristics are guaranteed. Some smart valves incorporate addⁿˡ sensors mounted directly on the valve. The measurement include upstream and downstream pressure, pressure

difference, flow, process fluid temperature, stem position, actuator operating pressure. These values are also provided with local indicators and with the ability of remote calibration of transmitters or controllers. Upon failure of the electrical power supply the valve can be switched to battery back up.



Actuators:-

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Valve Positi

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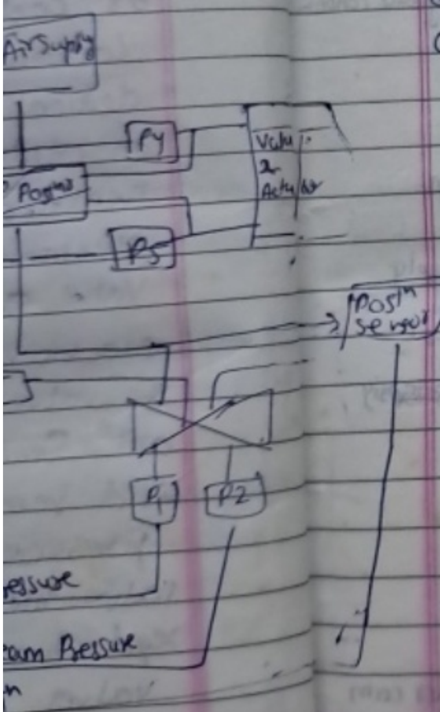


Acutators :-

An actuator is that portion of a value that responds to the applied signal and causes the motion resulting in modification of fluid flow. Thus an actuator is any device that causes the valve stem to move. It may be a manually positioned device such as a handwheel or level. The manual actuator may be open-closed or it may be manually positioned at any position between fully open and fully closed. Other actuators are operated by compressed air, hydraulics and electricity.

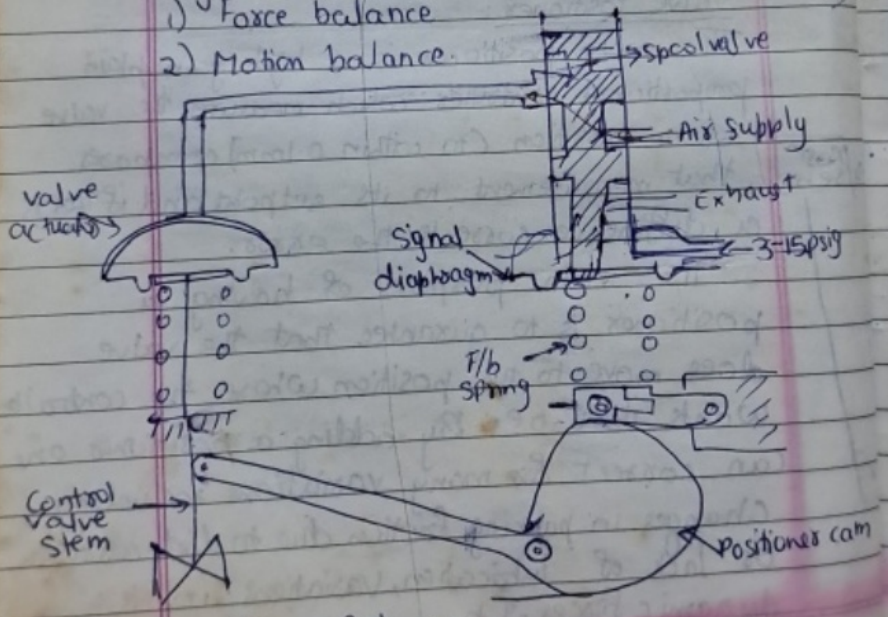
Valve Positioner :-

The ~~main~~ positioner is a high gain plain proportional controller which measures the valve stem position (to within 0.1mm) compares that measurement to its setpoint and if there is a difference corrects the error.

The main purpose of having a positioner is to guarantee that the valve does move to the position where the controller wants it to be. By adding a positioner one can correct for many variations including changes in packing friction due to dirt, corrosion or lack of lubrication, variations in the dynamic forces of the process. The positioner

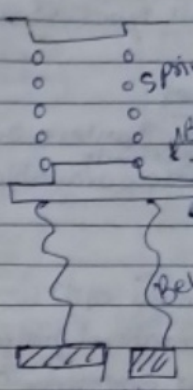
can allow for split ranging the controller signal bet" more than one valve, can increase the actuator speed by increasing the pressure or volume of the actuator air signal, and can modify the valve characteristics by cams or electronic function generators. The positioner provides a substantial improvement in valve and control loop performance with the greatest improvement realized on slow control loops with low controller gains used for level, temperature or analytical contr

Types of positioners
1) Force balance
2) Motion balance.



Force Balance

Motion balance



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spool valve

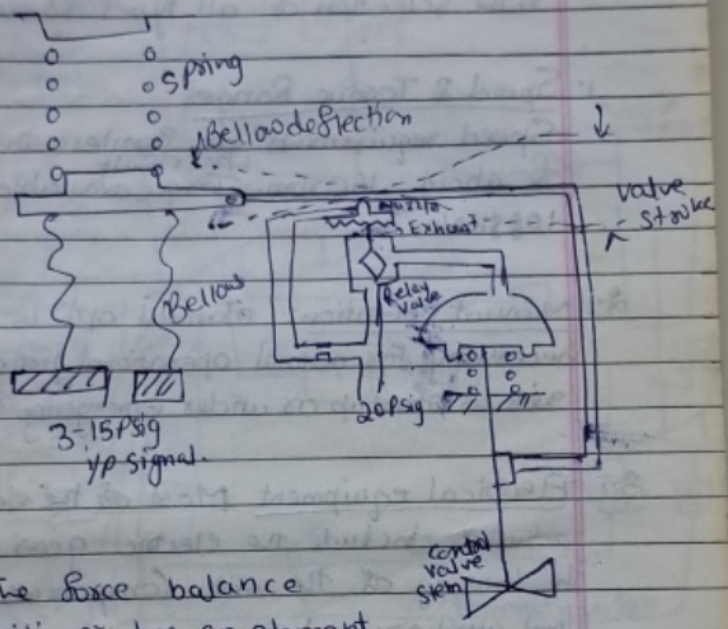
Air supply

Exhaust

3-15psig

Positioner cam

Motion balance:



The force balance positioner has an element that compares the force generated by the i/p signal with the force generated by the F/B spring connected to the valve stem. The motion balance positioner compares the motion of an input bellows or diphragm with linkage attached to the valve stem.

Selection Criteria of Actuators:

Following are the characteristics to be considered in the selection of all types of actuators

1. Speed & Torque Ranges
Speed requirements vary from less than 1rpm to about 160rpm. Torque available is about 10 kNm.

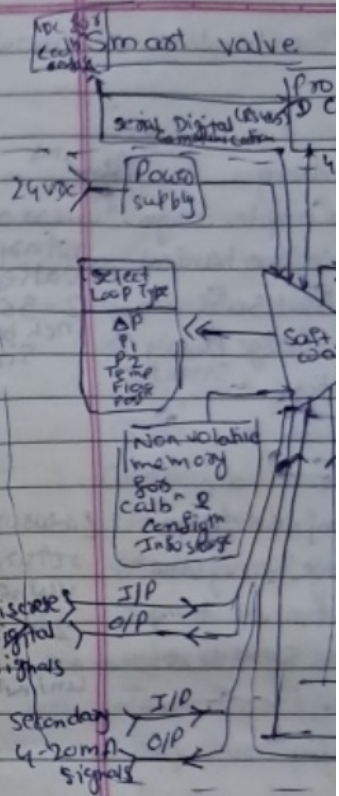
2. Manual Operation: Manual opt^n is sometimes necessary for normal operational procedures such as startup or under emergency cond^{ns}

3. Electrical equipment Most of the electric actuators include the electric gears within the housing of the unit. Components such as limit auxiliary and torque switches must be housed on the unit.

4. Maintenance is an important parameter to be considered.

5. Mounting methods involved.

6. Adaptability to control -



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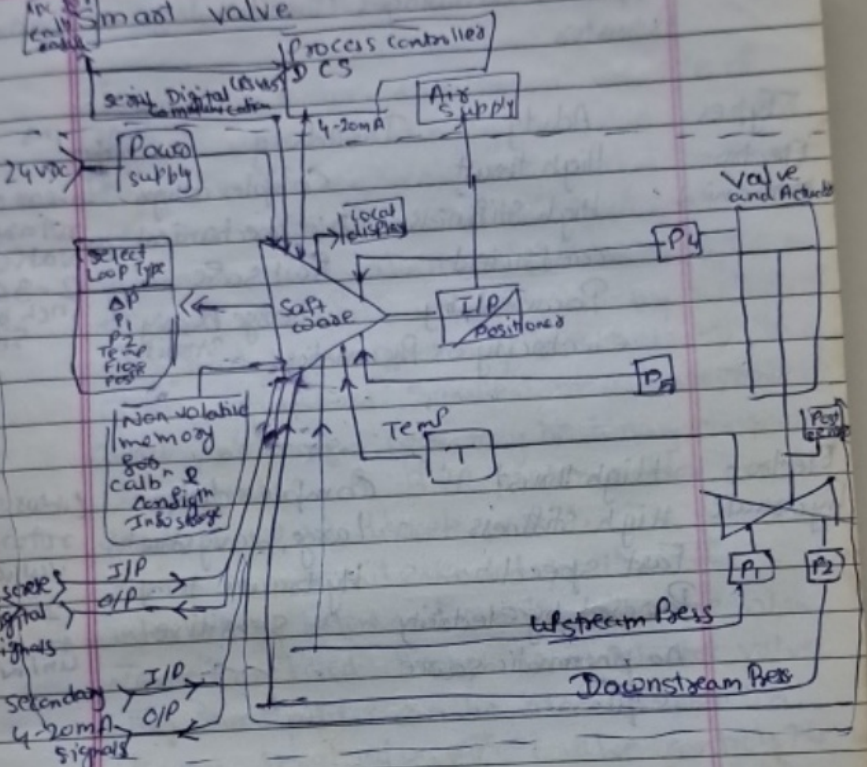
Smart valve



Appln, Advantages Disadvantages of Various Actuators.

Types	Advtg	DisAdvtg	Applns
Electro-mechanical	High thrust High stiffness coefficient. Powered by electricity or Pneumatics	Complex design No mechanical fail safe Large heavy structure	Linear or rotary valves 2-36 inch body size
Electro-hydraulic	High thrust High stiffness Fast speed Powered by electricity no pneumatic source reqd.	Complex design Large, heavy structure Hydraulic temp sensitive	Linear or rotary valves 2 inch to unlimited
Electric	Direct interface with computer system	Large structure Low thrust No mechanical fail Slow speed.	Linear valves ½-2 inch body size

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ow speed.	inch body
	size.

Digital Valve Actuator

Digital actuators can accept the O/P of digital computers directly w/o d/A converters. Only on-off elements are needed for their operation. No. of O/P positⁿs that can be achieved is equal to 2^n, where n is the no of i/ps. Resolutⁿ is established by the no of i/ps and by the operating code selected for a given requirement. Smallest move achievable is called 1bit move. Code may be binary, complemtry binary, pulse A 3 I/P piston adder assembly produces 8 bit discrete postⁿs. The adders are shown in 6 bit extended postⁿ. The interlocking pistons and sleeves will move when vented or filled through their selector valves. This same adder can be used to postⁿ a 4 way spool valve. Spool valve controls the postⁿ of a large diameter piston actuator or force amplr.

Electromechanical Actuator (Print out).

Pneumatic
Hydraulic Actuator :-

At the top there is a cylindrical inlet connection for the pneumatic i/p signal. Below the inlet chamber there is a pressure chamber. It is made up of lower part of chamber and top cover, a diaphragm, diaphragm backing plate, pneumatic interconnection bet^n top chamber and pressure chamber and a stem attached to the top end of the spring and the diaphragm. The lower end of the spring is fixed to the top cover of the pressure chamber. The flexible diaphragm is flat and circular in shape. The boundary of the diaphragm is fixed bet^n the upper and lower part of the pressure chamber. The pressurized air passes through the opening bet^n the 2 chamber to the upper side of the pressure chamber. It exerts force on the diaphragm. Force = air pressure X area of the diaphragm. The diaphragm has a hard flat circular metallic plate in the central region due to which the diaphragm does not deform but tries to displace downwards along with the plate. The movement of the diaphragm and back plate is restrained by the spring.

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Under balanced condn the diaphragm moves vertically downward. A stem is connected to the diaphragm plate and the top free end of the spring. downward movement of the stem is the O/P.

Hydraulic Actuators :-

The linear actuators are piston devices. The motion of the spool regulates the flow of oil to either side of the power cylinder. When the spool moves to the right the oil from the high pressure source enters into the power cylinder and also to the left of the power piston. This creates a differential pressure across the piston which causes the power piston to move to the right, pushing the oil in front of it to the sump. The oil is pressurized by a pump and is recirculated in the system. The load rigidly coupled to the piston moves a distance y from its reference posn in response to the displacement x of the valve spool from its neutral posn.

(Valve Positioner)

Effects on the Performance of the Control valve.

1. Valve positioners are essential for good control loop performance. They can be omitted for the smallest control valves where much of the loop gain is not at the valve
2. There are situations where it may be desirable to slow down valve action also some process needs to start or stop slowly for safety reasons. Such cases can be taken care by having a valve positioner.

Pneumatic valves:-

Time Delay valve:-

are used to delay operations where time based sequences are reqd.

Force Balance Valve Positioner:-

When the controller O/P (3-15psig) is given to the spool valve it causes the Air supply to open and this is passed on to the diaphragm of the valve actuator due to which the valve stem is pushed down. Movement of the valve stem is sensed by the cam positioner which in turn moves and inturn causes feedback

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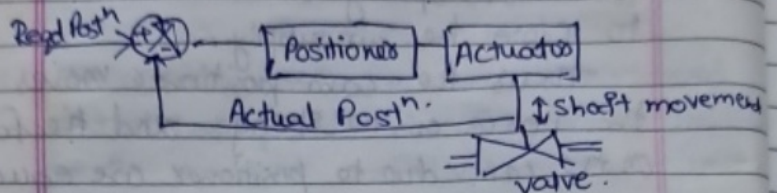
in the s/b spring which causes the diaphragm to close the air supply.

Thus the cam positioner moves until the force on the spring and the force on the cam due to positioner are equal.

Motion Balance Valve Positioner:

Pneumatic supply causes the flapper to move due to which there is change in back pressure. This back pressure is given as input to the diphragm of the valve due to which the stem moves. The movement of the stem is feedback to the flapper so that it either comes close or move away from the nozzle in order to satisfy the set pt.



The actuator postn is converted to a force by the range spring. This is compared with the force from the signal pressure acting on the input diaphragm.

Pneumatic Actuators:-

1) Linear Spring / Diaphragm
2) Linear Piston
3) Rotary Spring / diaphragm
4) Rotary Piston.

Types	Advantage	Disadvtg	Applⁿ.
1. Linear Spring/ diaphragm	Low cost Moderate thrust Small Package Simple design Excellent control w or wb control devices.	Slow speed Instability Lack of stiffness	Linear valves ½-8 inch body size.

Linear Piston

Rotary diphragm

Rotary Piston

Piston Act

Linear Piston	Low cost Moderate thrust Long stroke Excellent control with control device	Slow speed Instability Lack of stiffness	Linear valve ½ - 6 inch body size
Rotary diphragm	Low cost Small package Simple design Easily reversible Excellent control with control device	Low thrust Slow sped Instability.	Rotary valves 1-6 inch body size
Rotary Piston	Low cost Good control with control device	Slow Speed Large Spring compression	1-24 inch body size

sadvtg	Appln.
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instability	valves
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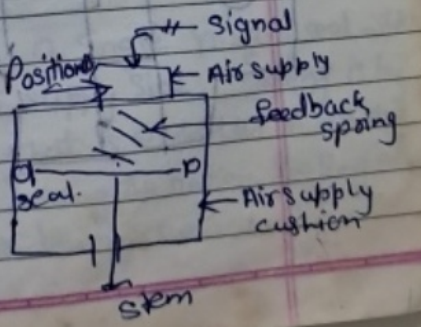
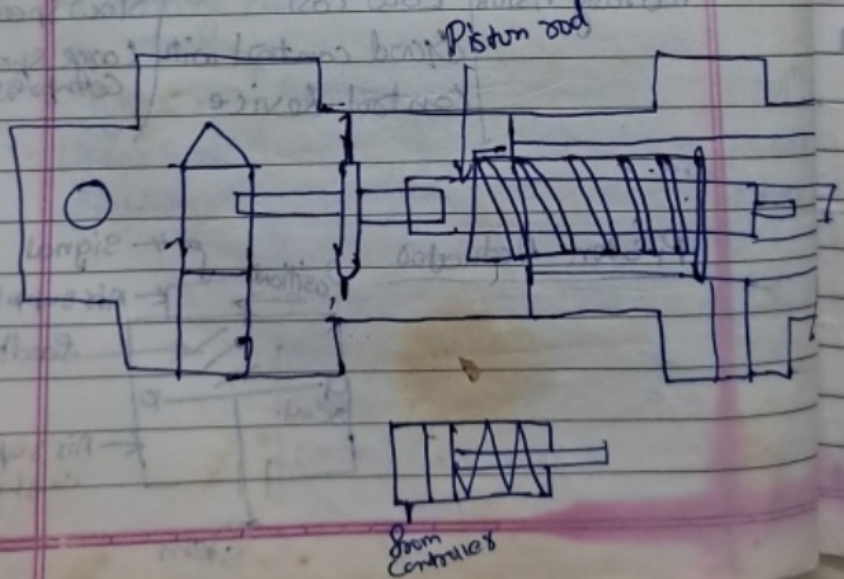
Piston Actuator



utilizes a fixed air pressure known as cushion to oppose the controller signal. In order to use such an actuator for throttling purpose it is necessary to have a positioner. The positioner senses the actuator motion and causes the valve to move accordingly.

Linear Piston Actuator :- (Pneumatic cylinder) Cylinder is an actuator which is used for the conversion of energy into useful work. O/P signal is controlled by the control system and the actuator responds to the control signal via the control element.

Single acting Cylinders :-



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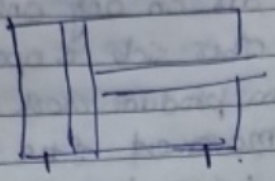
Single acting cylinder is used to apply the compressed air on only one side of the piston face. The other side is open to atmosphere. The cylinder can produce work in only one direction. The return movement of the piston is effected by a built in spring or by the application of an external force. The spring force of the built in spring is designed to return the piston to its start position with a reasonably high speed under no load conditions.

For single acting cylinders with built in spring, the stroke is limited by the natural length of the spring. The constn and simplicity of opth of the single acting cylinder makes it particularly suitable for compact, short stroke length cylinders for following applns.

- Transferring
- Centering
- Ejecting.

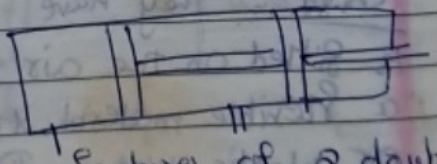
Constn:- They have a single piston seal which is fitted on the air supply side. Sealing is by a flexible material that is embedded in a metal or plastic piston. During the motion, sealing edges slide over the cylinder bearing surface.

Double acting Cylinder



The construction principle of a double acting cylinder is similar to that of the single-acting cylinder. There is no return spring and the two ports are used alternatively as supply and exhaust ports. The cylinder is able to carry out work in both directions of motion. The force transferred by the piston rod is greater for the forward stroke than for the return stroke, as the effective piston surface is reduced on the piston rod side by the cross-sectional area of the piston rod.

Double rod Tandem cylinder



are having the features of a double acting cylinders which have been joined to form a single unit. By this arrangement

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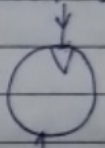

Pneumatic

Rotary Actuators
Rack and
Cylinders
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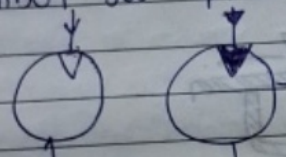
and with the simultaneous loading of both pistons, the force on the piston rod is almost doubled. This type of design is suitable for applications where a large force is reqd but the cylinder diameter is restricted.

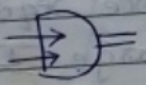
Rotary Actuators :-
Devices which transform pneumatic energy into mechanical rotary movement with the possibility of continuous motion is known as pneumatic actuator or motor.

Symbol for pneumatic and hydraulic motor



Internal leakage ; Drain always occurs in hydraulic motors and a drain line is used to return the leakage fluid to the tank.

Rotary Actuators



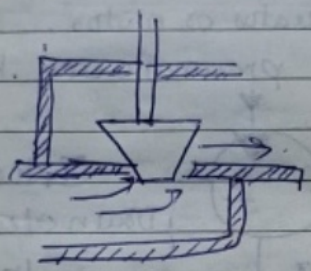
Rack and pinion actuator with dual acting cylinder

A rack and pinion can be housed with the pinion on the valve shaft and the rack positioned by almost any linear valve actuator. The rack can be operated by a double ended piston

Flow control valves:-

All valves work by putting a variable restriction in the flow path. There are 3 basic types of flow control valves. i) Plug valve, Butterfly valve 3) Ball valve

Of these the Globe valve is most common. This controls flow by varying the vertical plug position which alters the size of the orifice bet^n the tapered plug and valve seat.

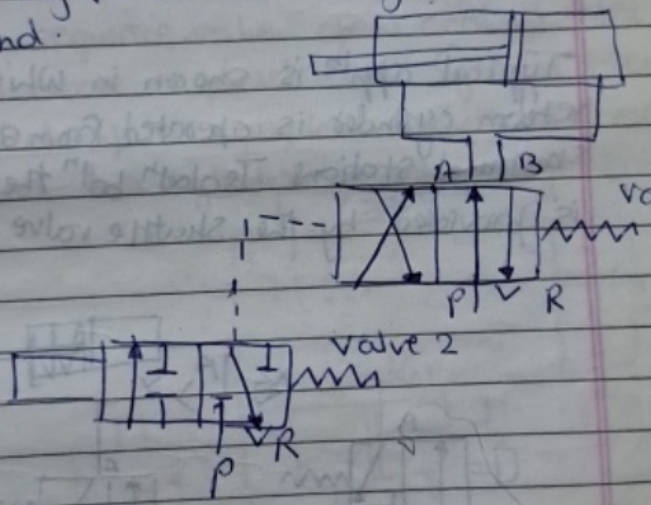


Pilot operated valves

With large capacity pneumatic valves the operating force reqd to move the valve can be large. If the reqd force is too large for a solenoid or manual opt^n a 2 stage process called pilot operat^n is used.

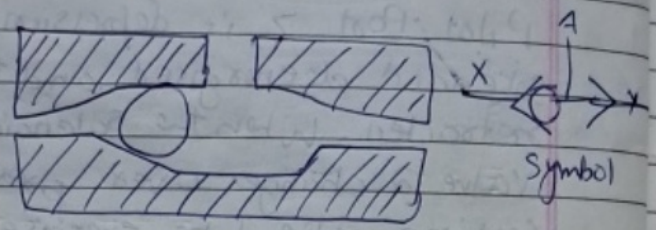
Principle is shown. Valve 1 is the main operating valve used to move the ram. The operating force reqd to

move the valve is too large for direct opⁿ by a solenoid so a 2nd smaller valve 2 known as the pilot valve is added to allow the main valve to be operated by a system pressure. Pilot pressure lines are shown dotted
Pilot Port 2 is depressurized with the solenoid deenergised and the ram is retracted. When the solenoid is energised valve 2 changes over pressurising 2. causing valve 1 to energise and the ram to extend.

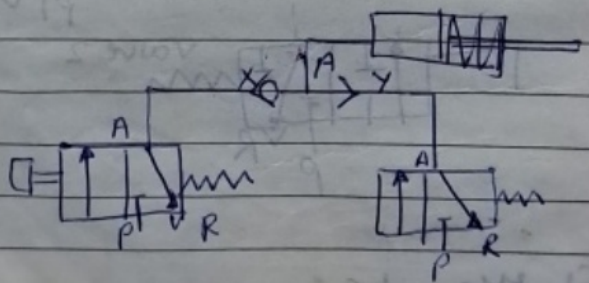


Shuttle valve :-
also known as double check valve allows pressure in a line to be obtained from alternative sources. It is formerly a two

It consists of a ball inside a cylinder. If pressure is applied to port X, the ball is blown to the right blocking port Y and linking ports X and A. Similarly, pressure to port Y alone connects ports Y and A and blocks X



Typical appln is shown in which a spring return cylinder is operated from either of two manual stations. Isolation between the 2 stations is provided by the shuttle valve.



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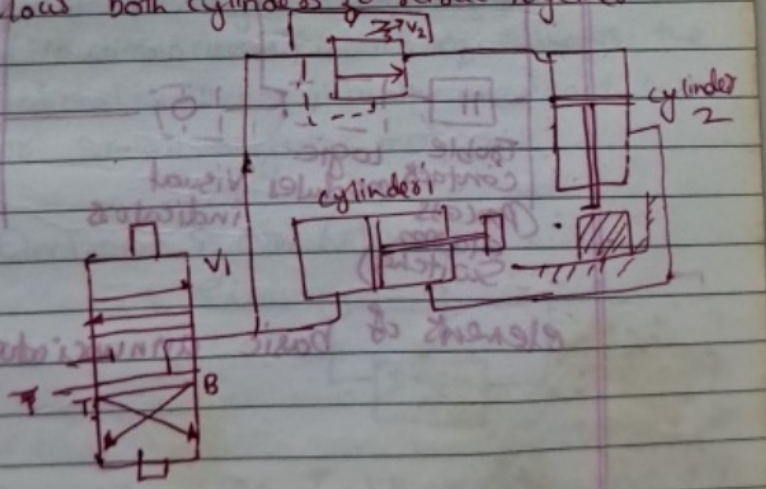
Sequence valves :-

is a valve used where a set of operations are to be controlled in a pressure related sequence.

Eg- where a workpiece is pushed into position by cylinder 1 and clamped by cylinder 2.

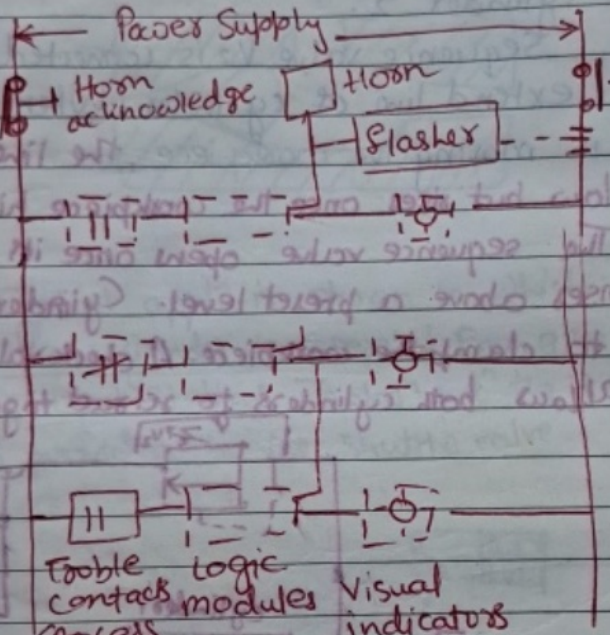
Sequence valve V_2 is connected to the extend line of cylinder 1. When this cylinder is moving the workpiece, the line pressure is low but rises once the workpiece hits the end stop. The sequence valve opens once its inlet pressure rises above a preset level. Cylinder 2 then operates to clamp the workpiece. A check valve across V_2 allows both cylinders to retract together.



Time delay valves :-

They are used to delay opⁿs where time based sequences are reqd.

Alarm Annunciator diagram



elements of basic annunciator system.

Sq root extractor:-

It is commonly reqd to linearize signals from differential type flow transmitters.

They are generally of 2 types:

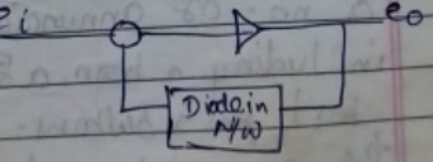
i) Pneumatic Sq root Extractor

Starting with the i/p and o/p at 3psig an ↑ in θ i/p causes the floating pilot link to restrict the pilot nozzle. This ↑ the o/p pressure and moves the o/p f/b bellows upward until balance is restored. Since the length of the floating link is fixed, the angular displacement produced by movement of the o/p bellows follows the relationship

$$\cos\theta = 1 - \frac{x}{L}$$

A plot of angle θ (o/p displacement) versus x (i/p displacement) in this eq shows the relationship to be virtually an exact sq root for small angular motion.

2) Electronic Sq root Extractor



It combines DC amplifier with a -ve f/b diode n/w. As current into the amp^r ↑ the amp^r gain ↓ with decreased f/b resistance

in the diode n/w. The gain varies according to seven st line segments that are approximately the sq root funth. This is accomplished by having 7 diode resistance paths in the f/b n/w automatically parallel to each other with rising i/p. The o/p stabilizes when the diode n/w modified f/b counter balances the i/p.

Thermostat & Humidostat

They have been developed to serve the heating, ventilating and air conditioning indu

Alarm Annunciator :-

Basic annunciator system consists of multiple individual alarm points each connected to trouble contact (alarm switch) a logic module and visual indicator. The individual alarm points are operated from a common power supply and share a no. of annunciator system components including a horn, a flasher and acknowledge test push buttons. In normal opn, the annunciator and individual points are quiescent.

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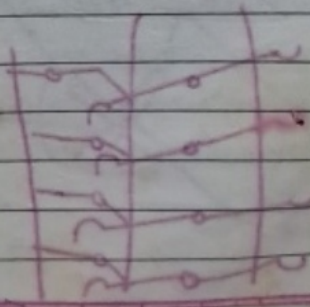
Trouble contact is an alarm switch that monitors a particular process variable and is actuated when variable exceeds preset limits.

It is normally a switch contact that closes or opens the electric ckt to logic module and thereby initiates the alarm condition. That turns on visual indicator for particular alarm point and available signal and flasher for system. The flasher is common to all individual alarm points. Flasher continues to flash until the normal conditions return or it is acknowledge by the operator. The horn acknowledge push button is used to silence the audible signal, stop the flasher and turn the visual indicator on steady.

When normal condition returns, the trouble contact returns to the normal and visual indicator is automatically turned off.



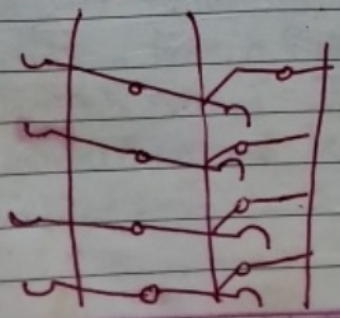
Dampers:-

Dampers are used to control the flow of gases and vapors. Dampers are used to control the flow of solids & to throttle the capacity of fans and compressors. Dampers are suitable for control of large flows at low pressures where high control accuracy is not req'd. Applications include air conditioning syst, furnace draft control.

Types

Multiblade damper

Consists of 2 or more rectangular vanes mounted on shafts one above the other and interconnected so as to rotate together. The vanes are operated by an external lever, which can be positioned manually pneumatically or electrically.



Parallel Damper

Low Leakage d
Fan Suction

Feeder:-

Feeders ca
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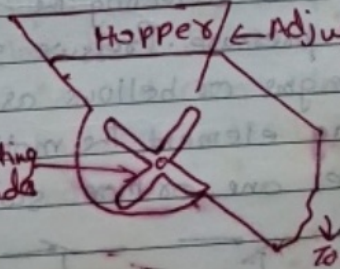
Parallel Damper

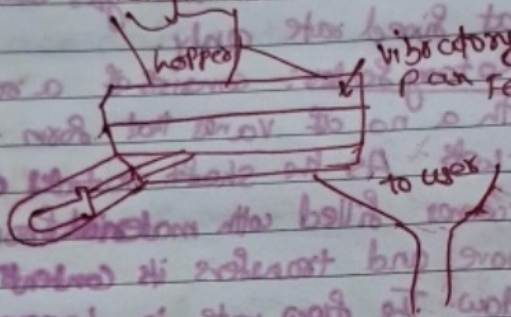
Low leakage design
Fan suction dampers.

Feeder :-
Feeders can be proportioning or of the
const rate type. Proportioning types are
designed to feed chemical dosages in
proportion to the influent waste water
flow rates. Const rate types are designed to feed
at fixed rate only.
Rotary feeder :- consists of a rotating shaft
with a no of vanes that form individual
packets. As the shaft rotates each pocket
becomes filled with material from the hopper
above and transfers its contents to the chute
below. The flow rate is changed by changing
the speed of rotation. This feeder provides
a relatively even flow rate but can handle
only free flowing materials.



Vibratory Feeder :-

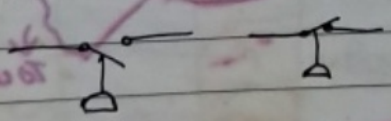
Consists of a feed chute (either open pan or closed tube) that is moved back and forth by the oxillating armature of an electromagnetic driver. Material transfer rate to the treatment process can be adjusted by adjusting the current input to the EM driver which controls the pull of the electromagnet and the length of the stroke.



Switches :-

Pressure Switch

is one detecting the presence of fluid pressure. Pressure switch often use diaphragms or bellows as the pressure sensing element, the motion of which actuates one or more switch contacts.



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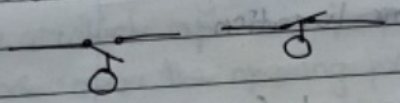
A pressure switch uses a bourdon tube as the pressure sensing element and a glass bulb partially filled with Hg as the electrical switching element. When applied pressure causes the bourdon tube to flex sufficiently the glass bulb tilts far enough to cause the Hg to fall against a pair of electrodes thus completing an electrical ckt.

Level Switches:- A level switch is one detecting the level of liquid or solid in a vessel. Level switches often use floats as the level sensing element the motion of which actuates one or more switch contacts.



Switch mechanism is a mercury tilt bulb, tilted by a magnet's attraction to a steel rod lifted into position by the float. The float directly senses the liquid level, which positions the steel rod either closer to or further away from the magnet. If the rod comes close enough to the magnet, the Hg bottle will tilt and change the switch's status.

Regulator.	Control valve.
Lower cost (in small sizes and ordinary materials of const^{n})	Higher cost
Smaller size	Larger and heavier
Built in controller	External controller
Low installation cost	High installation cost
No remote control set point adjustment is at regulator location.	Local or remote control.
Single mode (proportional only)	Varied control modes possible.
Few applications	More and more complex appl^{ns}.
Limited accessories	Wide variety of accessories.

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More and more
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Relief & Safety valve :-

Pressure Relief Valve :- A generic term that includes safety valves, relief valves and safety relief valves.

Safety Valve :- An automatic pressure relieving device actuated by static pressure upstream of the valve and characterized by rapid full, opening or pop action. It is used for steam gas or vapor service.

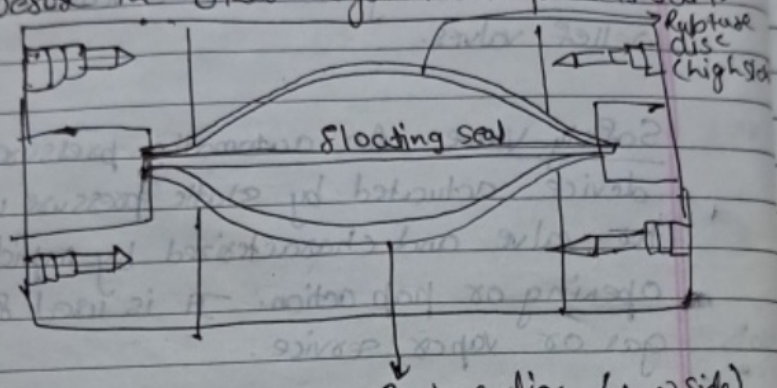
Relief valve :- An automatic pressure relieving device actuated by static pressure upstream of the vave, which opens in proportion to increased pressure over the opening pressure. It is used for liquid service.

Safety Relief Valve :- An automatic pressure actuated relieving devices suitable for use at either a safety or relief valve depending on application.

Rupture disc :-

Rupture disc is a suitable device for relieving over pressure. In its simplest form it consists of a metallic or graphite membrane

That is held betⁿ the phlanges and is designed and manufactured to burst at one predetermined pressure and relieve pressure before the other system components fail.



Applⁿ of Rupture disc

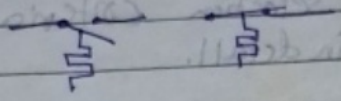
The disc can be used to relieve an inexpensive and inert material to air if process pressure loss can be tolerated.

They are explosion protectors → open about 98% of the total area in a fraction of a second

Temp Switch

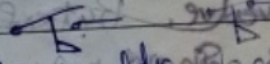
is one detecting the temp of an object

Temp switches often use bimetallic strip as the temp sensing element, the motion of which actuates one or more switch contacts.



Flow switches

is one detecting the flow of some fluid through a pipe. Flow switches often use paddle or ~~float~~ as the flow sensing element, the motion of which actuates one or more switch contacts.



A simple paddle placed in the midst of a fluid stream generates a mechanical force which may be used to actuate a switch mechanism.