

Speed ratio

$$\frac{V_{max}}{V_{min}} = 2.5$$

$$V_{min} = \frac{1800}{2.5} = 720$$

$$1800 \rightarrow 720$$

$$\frac{\text{steps}}{\text{div}} = \frac{1800 - 720}{(N-1)}$$

$$\phi = \frac{1080}{17} = 63$$

AP

nearby = 6

$$720, (720+63) (720+2 \times 63) \dots 1300$$

$$720, 864 \dots 1300$$

$$\phi = 63 \quad \phi_{GP} = N-1 \sqrt{R}$$

Maximum & spindle speed ratio = $\frac{1800}{720} = 2.5$

720 rpm spindle speed = $\frac{720}{2.5}$

$$\frac{2.5}{2.25} = 1.113 \text{ --- ① } \frac{720}{1.113} = 647$$

$$\frac{630}{8/3} = 10.5$$

$$\phi_{GP} = N-1 \sqrt{R}$$

$$3 \text{ steps} = \frac{120}{3} = 40 \text{ steps}$$

$$(1.113)^6 = \phi_2 = 1.9$$

$$(1.113)^{17} = \phi = 1.2$$

$\phi = 1.2$

$$800, \frac{800}{1.2}, \frac{800}{(1.2)^2} \dots 355$$

$$800, 666, 555 \dots 355$$

$$2.25 \quad \phi_{GP} = N-1 \sqrt{R}$$

$$(\phi_{GP})^{N-1} = R$$

$$(\phi_{GP})^{17} = \frac{N_{max}}{N_{min}}$$

$$\phi_{GP} = \left(\frac{800}{N_{min}} \right)^{\frac{1}{17}}$$

$$= 1.2$$

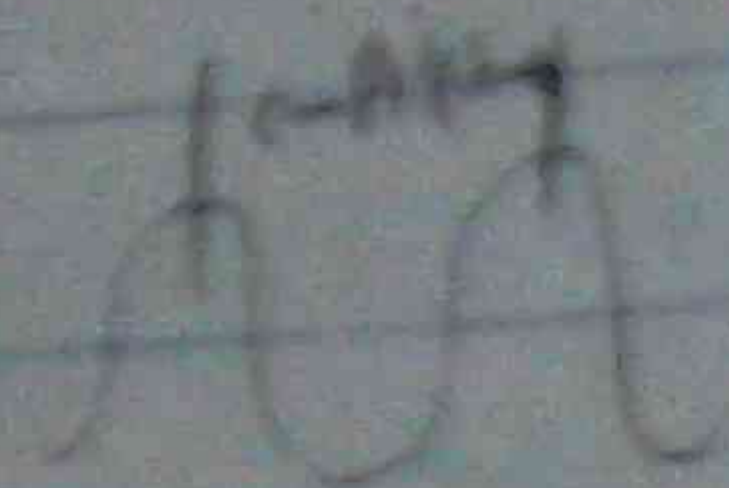
$$800, \frac{800}{1.2}, \frac{800}{(1.2)^2}$$

$$800, 666, 555 \dots 355$$

$$1.105$$

Screws and screw cutting

Pitch
Distance between one thread and the next one



Lead
Distance that one thread advances in one

turn

Start

number of thread = number of start

Lead = Pitch \times No. of thread
(or)
No. of starts.

Tapping size

method for finding the diameter of tapping hole.

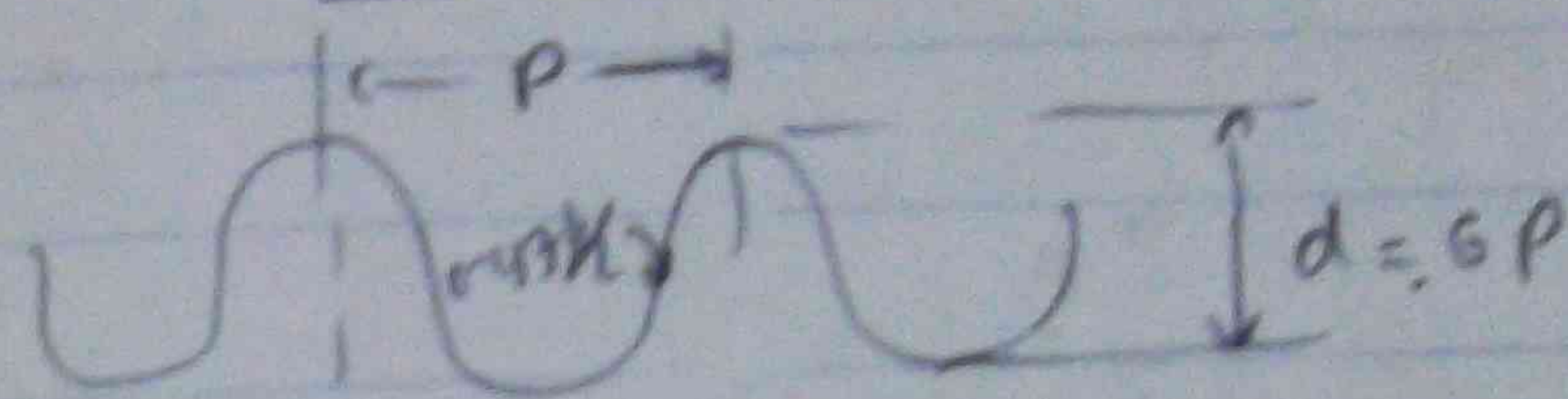
Tapping size

diameter of tapping hole = $1.33p$

from top dia. of screw

B.A. (British Association) thread

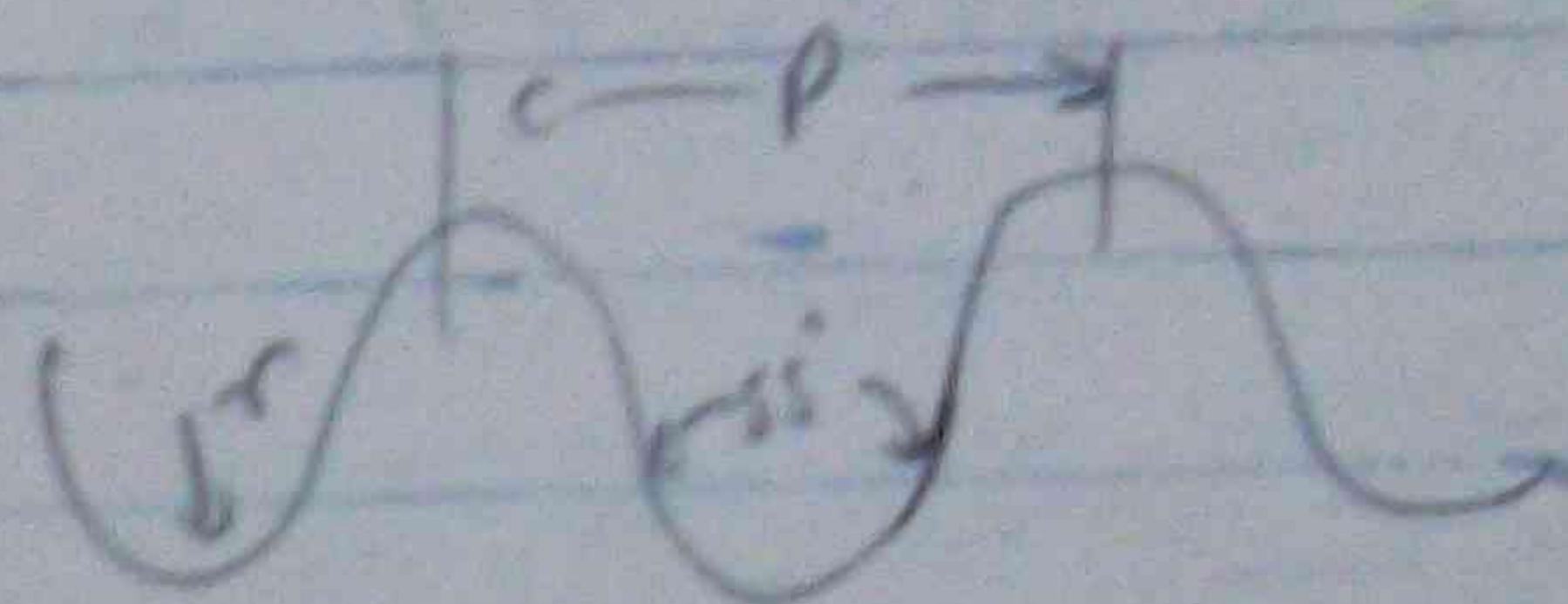
① used for screws less than $\frac{1}{4}$ in diameter
② for instrument



$$r = \frac{2p}{11}$$

$$d = 0.6p$$

Whitworth thread



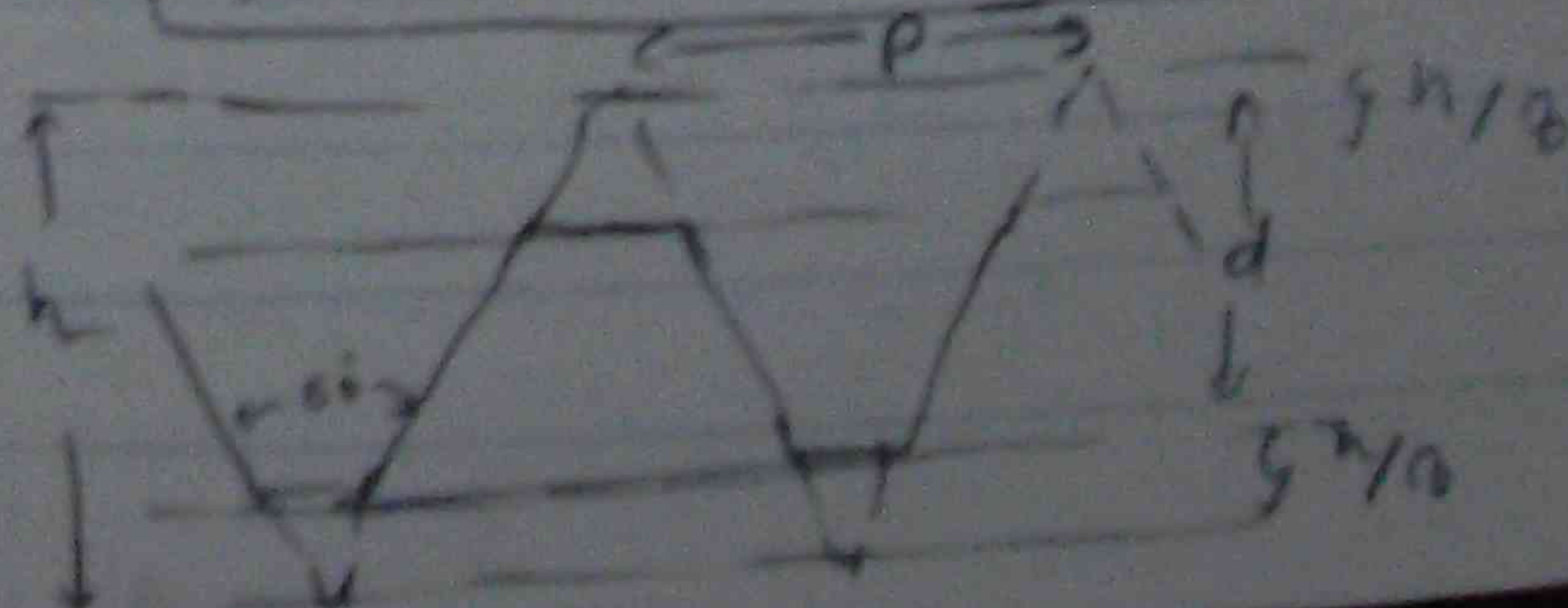
$$d = 0.64p$$

$$r = 0.137p$$

Unified thread



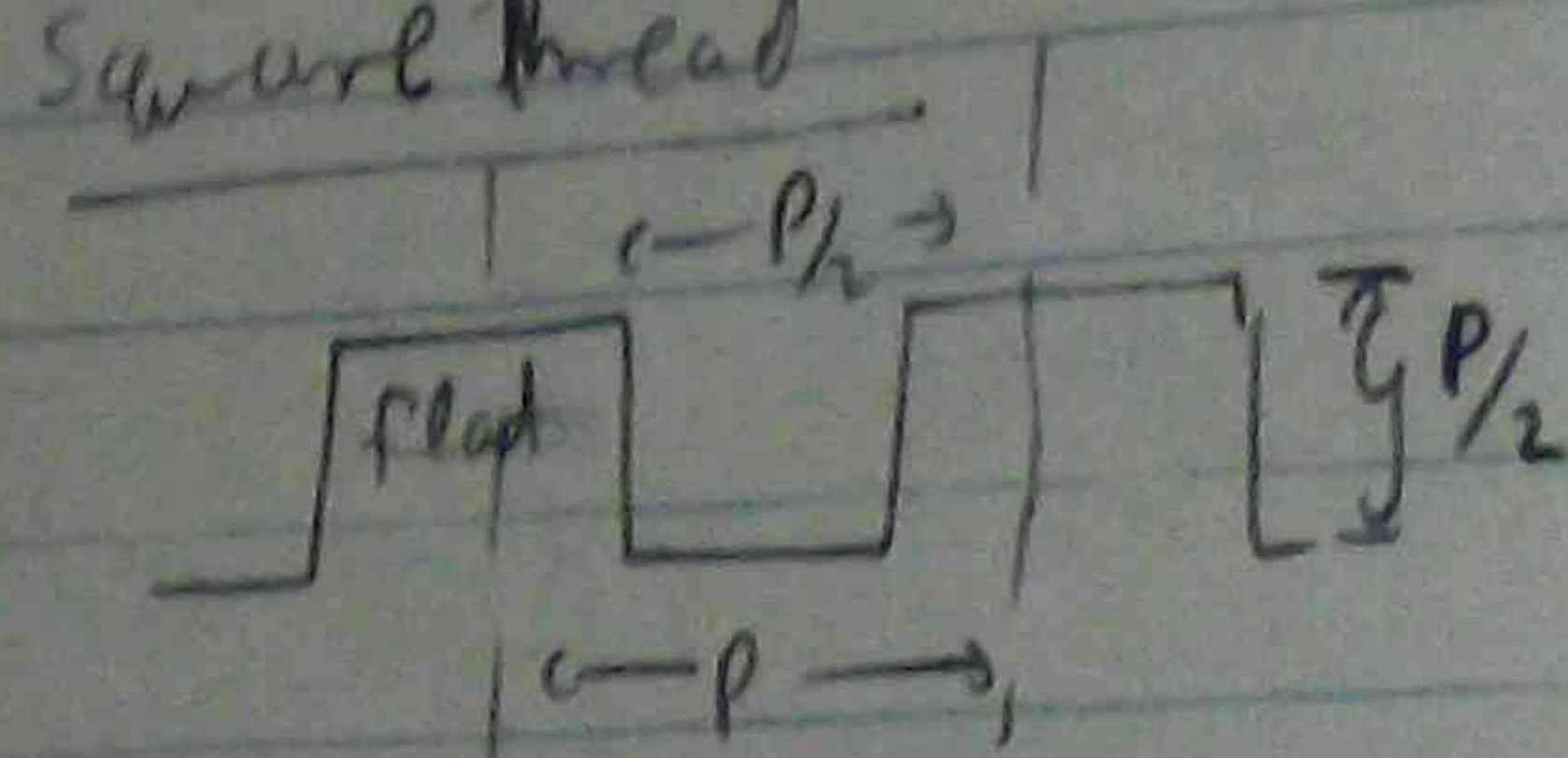
American standard & International standard metric



$$d = 0.65p$$

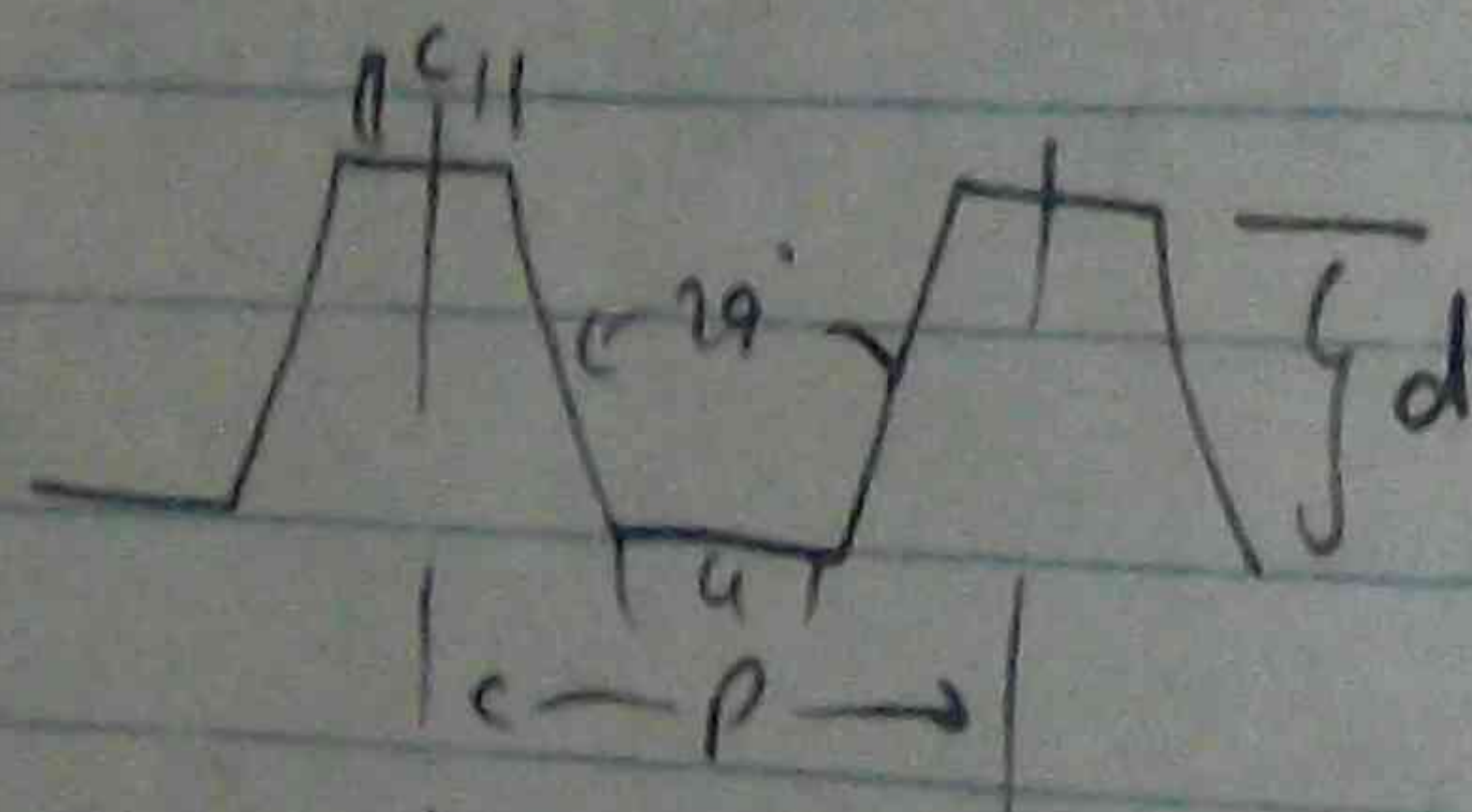
$$\text{Tapping size} = \text{Top dia of thread} - 1.3p$$

Square thread



Acme thread

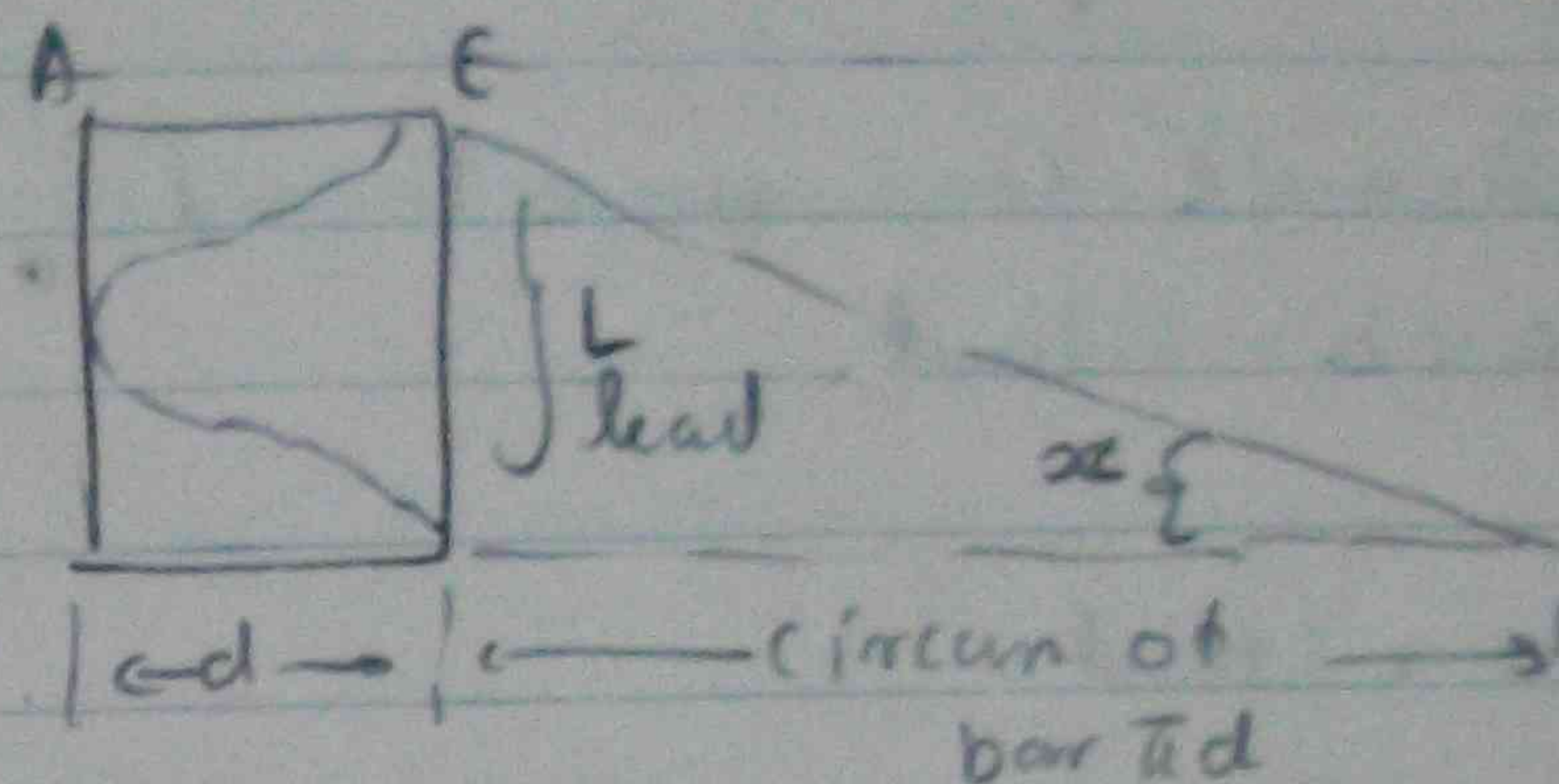
It is easier to engage a split nut than square thread.



for $a = 0.37p$ $d = \frac{p}{2} + 0.01 \text{ in}$
 $a = 0.3707p = 0.0052$

$$\text{Tap dia} = \text{Screw dia} + 0.020 \text{ in}$$

Helix angle



The angle which the thread makes with the square end of the bar (A-E)

$$\frac{\text{Lead}}{\pi d} = \tan \alpha$$

$d =$ top and root dia. of thread.

Tool setting for coarse thread

- It ~~should~~ should know the helix angle of thread.
- It necessary to slope the tool over that angle
- If it is not done the tool will foul the side of the thread.

Example 1

Find the helix angle for a square thread $1\frac{1}{2}$ in diameter $\frac{1}{4}$ in pitch 3 start.

$$\text{Lead} = \text{Pitch} \times \text{Start} \\ = \frac{1}{4} \times 3 = \frac{3}{4}$$

$$\text{Helix angle } \phi \text{ in } x = \frac{\text{Lead}}{\pi \times d} = \frac{\frac{3}{4}}{3.14 \times 1\frac{1}{2}} \text{ (mean dia)}$$

mean dia = Prof. dia - Pitch

$$= 1\frac{1}{2} - \frac{1}{4} \times \frac{1}{2} = 1\frac{3}{8} \text{ in}$$

$$\tan \phi = \frac{\frac{3}{4}}{3.14 \times 1\frac{3}{8}} = 0.1735$$

$$\phi = 9.51^\circ = 10^\circ$$

Screw through its nut

Nut travel if screw

$$12 \text{ tpi} = \text{1 turn of screw cut}$$

$$\text{Screw } \frac{1}{12} \text{ in rev. of 11}$$

Lead of screw

$$\text{Lead of screw} = \frac{1}{12} \text{ in}$$

Example 2

The tail stock of a lathe is set over by means of a screw $\frac{1}{2}$ in with 12 tpi. Find how many turns of screw are required to set it over $\frac{5}{32}$ in.

$$12 \text{ tpi} = 1 \text{ turn} \rightarrow \frac{1}{12} \text{ in}$$

$$\therefore \frac{1}{12} \text{ in rev. of 1 turn} \\ \frac{\frac{5}{32}}{\frac{1}{12}} = 2 = \frac{5}{32} \times \frac{12}{1} = 1\frac{7}{8}$$

Design

1 turn and 8 corners of hexagon

$$1\frac{5}{8} \times$$

$$\therefore \frac{1}{12} \text{ in rev. of 1 turn} = \frac{1}{12} \text{ in}$$

$$\therefore 12 \text{ turns of rev. of 1 in}$$

$$1\frac{5}{8} \times 2 = 1\frac{5}{8} \times \frac{1}{12}$$

$$= 0.153 \text{ in}$$

$$\frac{5}{32} = 0.156$$

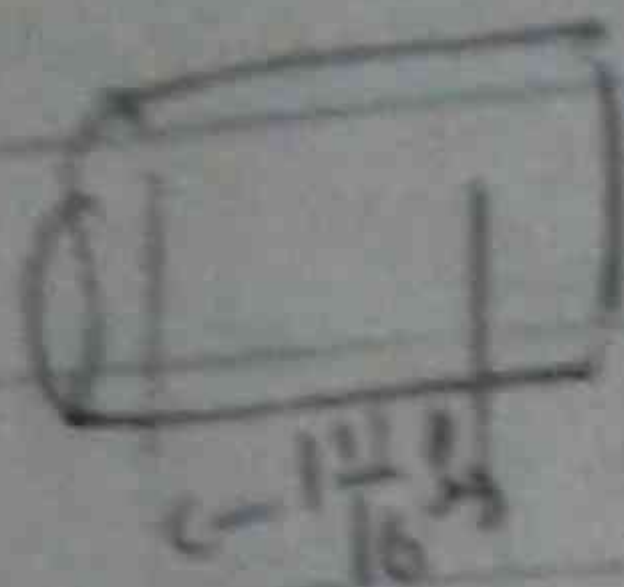
$$= 1\frac{5}{8} \text{ turn of rev. of 1 in}$$

250 divisions of 1 division of $\frac{1}{1000}$ in of rev.

$$\text{rev. of 1 in} = \frac{2}{1000} \text{ of rev. of 1 in}$$

Exercise 1

- ① A square threaded screw has 5 starts. The dist. measured over 3 pitches as shown is $1\frac{11}{16}$ in. Find the lead.



$$\text{Lead} = \frac{\text{Pitch} \times \text{No. of starts}}{\text{Length}}$$

pitch length

$$\text{Pitch} = 1\frac{11}{16} \text{ in.}$$

$$1 - 1 = 2 = \frac{22}{16 \times 3} = \frac{9}{16} \text{ in.}$$

$$\text{Lead} = \frac{9}{16} \times 5 = \frac{45}{16} = 2\frac{13}{16} \text{ in.}$$

- ② A screw is 0.4 in pitch, 4 start. At what speed will a nut travel along this screw if it is rotated at 30 rev/min?

$$\begin{aligned} \text{Lead} &= \frac{\text{Length travelled}^{\text{of}}}{\text{Pitch}} \times \text{No. of start} \\ &= 0.4 \text{ in} \times 4 \\ &= 1.6 \text{ in} \end{aligned}$$

$$\therefore 1 \text{ turn} \approx 1.6 \text{ in}$$

$$30 \text{ ————— } 2 = 48 \text{ in}$$

$$\therefore = 48 \text{ in/min} = 4 \text{ ft/min}$$

- ③ Find the width of the turning tool for finishing the threads of a square thread 2 in lead 3 start.

$$\text{Lead} = \frac{\text{Length travelled}^{\text{of}}}{\text{Pitch}} \times \text{No. of start}$$

$$2 = \frac{\text{Length of pitch}}{3}$$

$$\text{Length of pitch} = \frac{2}{3} \text{ in}$$

$$\therefore P = \frac{2}{3}$$

$$\text{width} = P/2 = \frac{2}{3} \times \frac{1}{2} = \frac{1}{3} \text{ in}$$

- ④ Find to the nearest $\frac{1}{64}$ in. the tapping size for the following threads (a) $\frac{3}{8}$ in x 16 tpi withworth (b) 6mm x 1mm pitch metric (c) $\frac{1}{4}$ in x 4 tpi (d) 1 in x 10 tpi withworth form (e) $\frac{3}{4}$ x 10 tpi USS

Withworth

(a) Tapping size = Tapping hole dia =

$$\text{Pitch} = \frac{1}{16} \text{ in for 16 threads/in 1 inch}$$

$$\text{Tap dia} = \text{Tap dia} - 1.33P$$

$$= \frac{3}{8} - 1.33 \times \frac{1}{16}$$

$$= \frac{6 - 1.33 \times 1}{16} = \frac{4.67}{16} = .292 \text{ in}$$

metric

$$= \frac{4.72}{16} = .295 \text{ in}$$

(b) Tap dia = Tap dia - 1.3P

$$= 6 - 1.3 \times 1 = 6 - 1.3 = 4.7 \text{ mm}$$

Acme Thread

(c)

$$\text{Tap dia} = \text{Screw dia} + 0.02 \text{ in}$$

$$= [1\frac{1}{4} \text{ in} - P] + 0.02$$

$$= [1\frac{1}{4} - \frac{1}{4}] + 0.02 = 1.02 \text{ in}$$



(d) 1 in 10 tpi withworth form

(e) $\frac{3}{4}$ x 10 tpi USS

$$\text{Tapping size} = \text{Tap dia} - 1.3P$$

$$= \frac{3}{4} - 1.3 \times \frac{1}{10}$$

$$= 0.75 - 0.13$$

$$= 0.62 \text{ in}$$

⑤ Calculate the mean (pitch) dia of the following threads

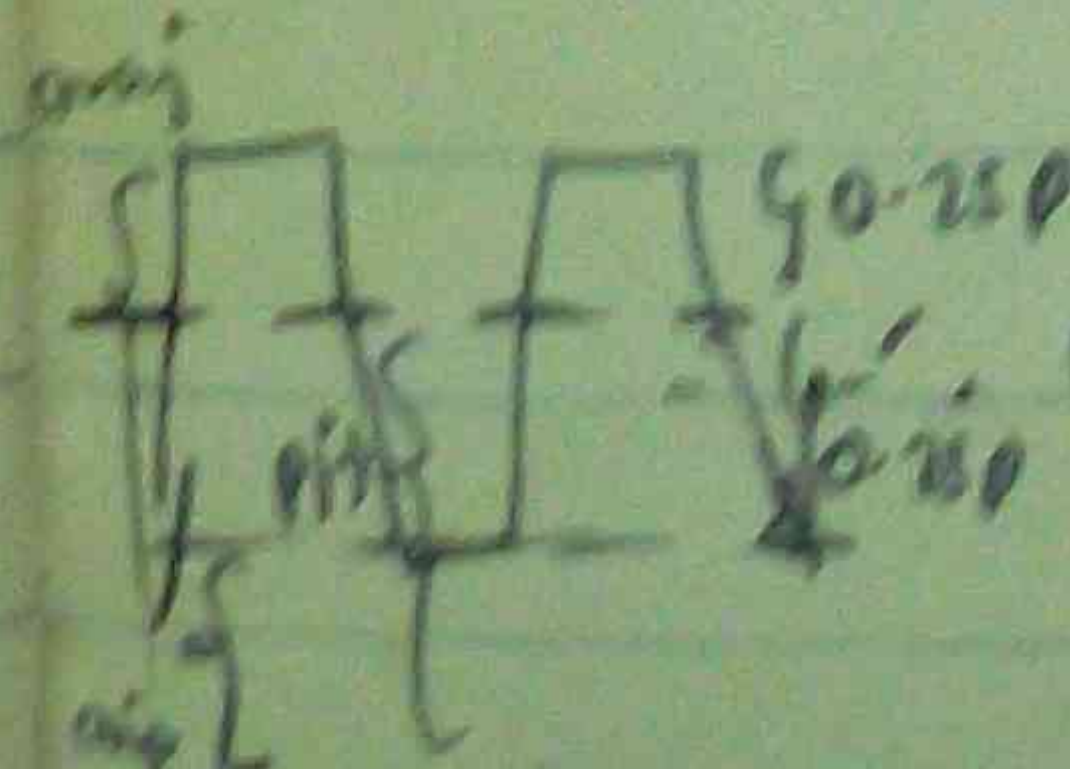
(a) 1 in dia: x 6 tpi (b) $\frac{3}{4}$ in x 12 tpi

(c) 6mm x 1mm pitch metric

(d) 1 in x 8 tpi withworth.

$$1 \text{ in dia} \Rightarrow \text{major} = 1 \text{ in}$$

$$P = \frac{1}{6}$$



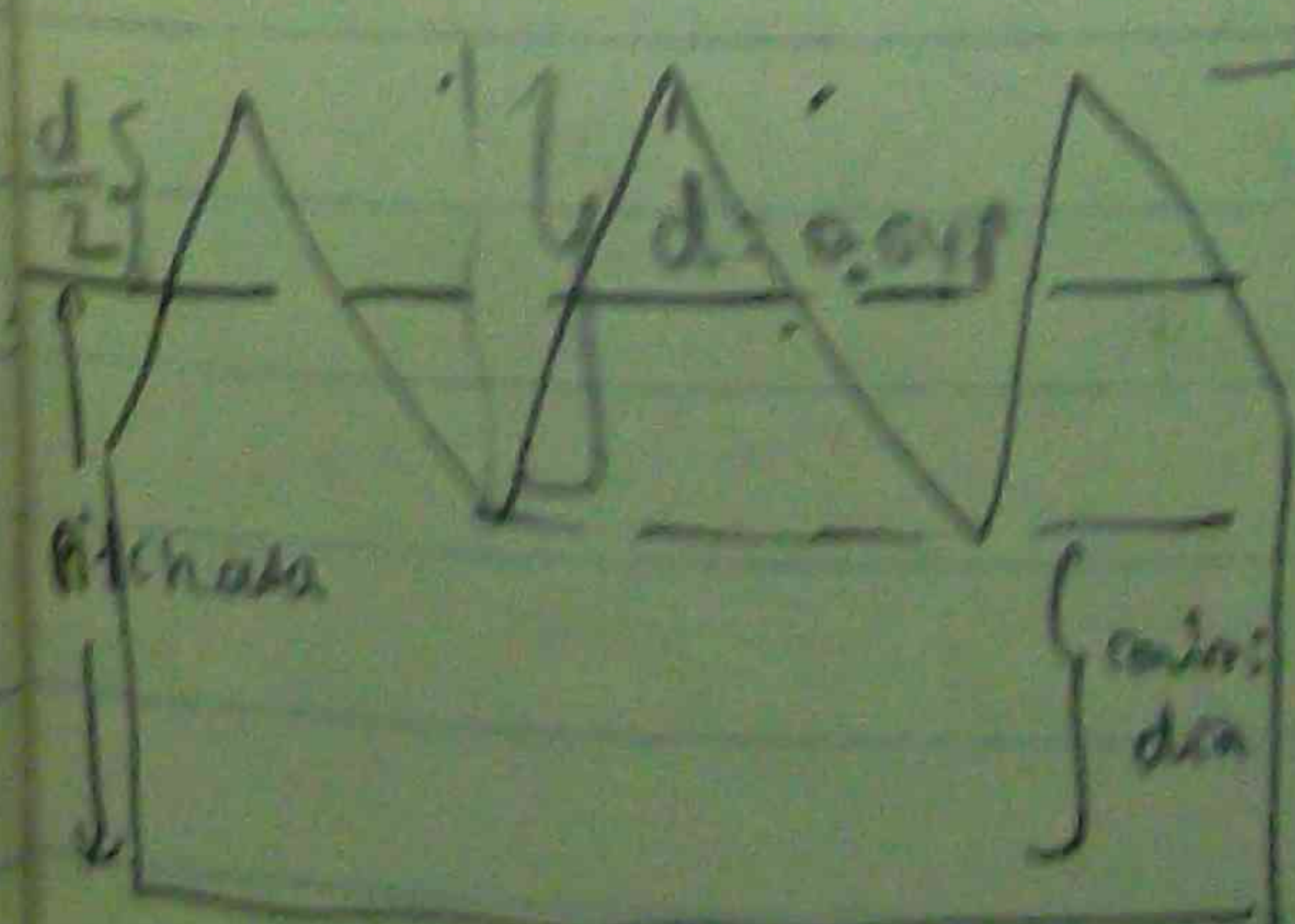
$$\text{mean dia} = \text{major dia} - \text{Tap drill size}$$

$$= [1 - P] + 0.02 + 0.25P$$

$$= [1 - \frac{1}{6}] + 0.02 + 0.25 \times \frac{1}{6}$$

$$= \frac{5}{6} + 0.02 + \frac{0.25}{6}$$

$$= \frac{5.87}{6} = .978 \text{ in}$$



$$\text{withworth min} = \text{maj} - 2 \times d =$$

$$\text{mean} = \text{maj} - d$$

0.56 Whitworth
1 in 8 tpi

$$\begin{aligned} \text{Thread} &= \text{Top dia} + \left(\frac{d}{2}\right) \times 2 \\ &= [\text{Top} - 2 \times 0.64P] + 0.64P \\ &= \text{Top} - 0.64P \\ &= 1 - 0.64 \times \frac{1}{8} \\ &= 1 - 0.08 = 0.92 \text{ in} \end{aligned}$$

mean dia =

⑥ calculate the helix angle of 1 in dia 6 tpi Acme thread.

$$\begin{aligned} \tan \alpha &= \frac{\text{lead}}{\pi d} \\ \tan \alpha &= \frac{\frac{1}{6} \times (m)}{3.14 \times 1} \end{aligned}$$

6 tpi

⑦ A screw of 1 1/2 mm pitch was required the nearest that could be cut was 16.9 tpi calculate the error in number of threads.

$$\text{Pitch} = \frac{1.5}{16.9} \text{ mm}$$

$$\therefore \text{1 thread movement} = \frac{1.5}{16.9} \text{ mm}$$

$$10 \text{ } \frac{\quad}{\quad} 2 = 1.9 \text{ mm}$$

$$= 1.9 \text{ mm} = \frac{1.9}{2.54} = 0.75 \text{ in}$$

$$16.9 \text{ tpi}$$

$$16.9 \text{ thread} = 1 \text{ in}$$

$$10 \text{ } \frac{\quad}{\quad} 2 = \frac{10}{16.9} = 0.59 \text{ in}$$

$$\text{error} = \frac{0.6 - 0.5}{0.6} \times 100 = \%$$

⑧ Find the angle of tilt for the tool when cutting a 4 start square thread 3/8 in pitch 1 1/2 in top dia:

$$\begin{aligned} \tan \alpha &= \frac{\text{lead}}{\pi \times d} = \frac{4 \times \frac{3}{8}}{\pi \times [1\frac{1}{2} - \frac{P}{2}]} \\ &= \frac{1.5}{3.14 \times [1.5 - \frac{3}{8} \times \frac{1}{2}]} \\ &= \frac{1.5}{3.14 \times [1.5 - 0.1875]} = \frac{47.3}{1.3125} = 36.3 \end{aligned}$$

$$\alpha = \tan^{-1} 36.3 = 88.4^\circ = 90^\circ$$

- ⑦ A slide is moved by a hexagon loaded screw $\frac{1}{2}$ in diameter x 16 tpi using the hexagon as indicators find the number of turns to give the nearest movement to 0.36 in.

$$\frac{1}{2} \text{ dia (top)} - \frac{1}{16} \times \frac{1}{2} = \frac{1}{2} - \frac{1}{32} = \frac{15}{32} = 0.46875 \text{ in}$$

$$0.46875 \text{ in} \rightarrow 1 \text{ turn}$$

$$0.36 \text{ in} \div 0.46875 = 0.768 \text{ turn} = \frac{8}{10} \text{ turns} \times$$

$$1 \text{ turn} = \frac{1}{16} \text{ in}$$

$$\frac{1}{16} \text{ in} = 1 \text{ turn}$$

$$0.36 \text{ in} \div \frac{1}{16} = 0.36 \times 16 = 5.76 = 5 \frac{3}{4} \text{ turns} \times$$

Stems and 5 corners of hexagon

$$5 \frac{3}{8} \times \frac{1}{16} = \frac{35}{6} \times \frac{1}{16} = \frac{35}{96} = 0.364 \text{ in}$$

$$\therefore 5 \frac{3}{8} \text{ turns} \text{ per } 24 \times$$

- ⑩ The screw actuating the cross-slide of lathe has 6 threads per in and the indicating dial is divided into 100 divisions. By how much will the dia. of a job be reduced by putting on a cut of 1 division?

$$1 \text{ in} = 6 \text{ thread} \quad \text{Pitch} = \frac{1}{6} \text{ in}$$

$$\text{movement of } \frac{1}{100} \text{ division}$$

$$\text{movement for each division} = \frac{\text{Pitch of screw in}}{\text{in } (\frac{1}{100} \text{ this in})} = \frac{\frac{1}{6} \text{ in}}{100} = \frac{1}{600} \text{ in}$$

$$\text{(or) } 100 \text{ division} = \frac{1}{6} \text{ in per } 100$$

$$1 \text{ in} \div 600 = \frac{1}{600} \text{ in} \times$$

round steel

$$\frac{1}{6} \div 100$$

$$= \frac{1}{600} \text{ in} \times$$

$$\text{(or) } 1 \text{ in} = \frac{1}{100} \text{ division} \quad \frac{1}{100} \text{ in} = 1 \text{ division}$$

$$1 \text{ in} = \frac{1}{100} \text{ division}$$

$$\frac{1}{6} \text{ in} \div 2 = \frac{1}{600} \text{ division}$$

Engine Stroke - 2 stroke engine

Fan To draw rapid stream of air, in and to radiator. The fan is mounted on water pump and belt driven crank shaft. Some older engines had fan mounted directly on the shaft. As 2 stroke

Thermostat

around thermostat temp. in cooling systems are automatically maintained by a calibrated thermo static valve. It usually located in upper part of cylinder head or water manifold leading to radiator. Opening or closing of thermostat is controlled by coolant in cooling system. During warming period. The thermostat is closed when coolant is heated it is opened. opening 133°F to 145°F fully open 160°F

Pressure cap To operate at a higher temp. the cooling system is pressurized by filter cap contains pressure relief and vacuum valve. The press. relief valve is held against by its return spring, when the press. within radiator reaches pre determined Pt. Spring is compressed allowing excessive press. to be released into and back overboard.

cooling system pressurized from 12 to 17 PSI

Antifreeze Soln

3 parts water to 1 part antifreeze

- ① methyl alcohol ② ethyl alcohol
- ③ glycerine ④ ethyl benzene alcohol

Cooling System Troubleshooting

Petrol engine oil.

Engine Lubrication

journal, bearing surface, moving parts & oil film.

Factor determining grade of oil used

- ① Rubbing or surface speed of the bearing high rubbing speed → oil with considerable and dense qualities.
- ② Bearing speed and clearance high speed less clearance → lighter oil
- ③ Bearing load increase → high viscosity. Same SAE no → same viscosity, same temp. single grade L10 → SAE 5 heavier SAE 40 multi viscosity SAE 5W-10 multi grade oil - 15 10-40 starting characteristics, warm weather operation

below 10°F SAE 5W SAE 5W-20
 bet. 10°F & 32°F SAE 10W SAE 10W-30
 above 32°F SAE 30 SAE 10W-30
 (SAE 5W is recommended for high speed engine)

Sludge forming

oil deterioration by a temp. more rapid (organism)
 situation caused by unburned FO (cold weather, frequent start/stop, acid formation)

water - solid operation

crank forming - combustion chamber

metal - powdered metal

oil & fuel - intake air

Lubrication system

by gravity } (or)
 by pressure } (or)

Oil pressure

oil pressure, oil under pressure
 directed to various moving parts

Lubrication — ① friction ② oil leakage
 ③ heat ④ heat loss ⑤ oil
 an oxide metal moving

Oil pressure

oil pressure PIP, regulating valve
 excessive pressure of pump & oil

Crankcase ventilation

reduce sludge forming

ventilated by air drawn through the filter
 in the oil filter cap

After passing through the air chamber
 and crankcase. The air and fumes left the engine
 through a road draft tube

The fan is opening was below the
 engine where the movement of the piston
 air help exhaust the crankcase frame.
 The fumes are drawn into intake manifold then
 through the engine again

SAE 10W-30 → cold weather

SAE 10W-30 → warm

Force feed

Driven by oil pump, ball main and connecting bearings, crankshaft bearing, V/V lifters, timing gears or chain driving crankshaft.

Pushrod ball, jacket joint, rocker arm bearing. Crankshaft carry oil from main bearing to connecting rod bearing.

Typically piston, piston are lubricated by spray oil from side from connecting rods.

Parts of l/o system

① oil pump - crankcase gear pump oil from crankshaft & spiral gear crankshaft gear pump. Oil is sent to oil filter, gear, sliding valve oil strainer. A fine mesh screen acts as a strainer and is located in oil pan. It may be attached directly to oil pump or may be connected to oil pump via oil suction tube.

Strainer, piston - free to float at near top of oil level. Therefore they can draw clean oil as sediment and foreign particles tend to settle at bottom of oil pan.

oil pressure relief valve

oil line governor ball & or plunger screw
ABM excessive pressure relief

oil filter paper, filtering materials, fine mesh screen.

Bypass system

Early oil filter bypass by pass by relief valve. If oil is dirty, oil bypasses filter and goes directly to oil pan. If oil is clean, oil passes through filter to main oil manifold or gallery. It is distributed to working parts of engine.

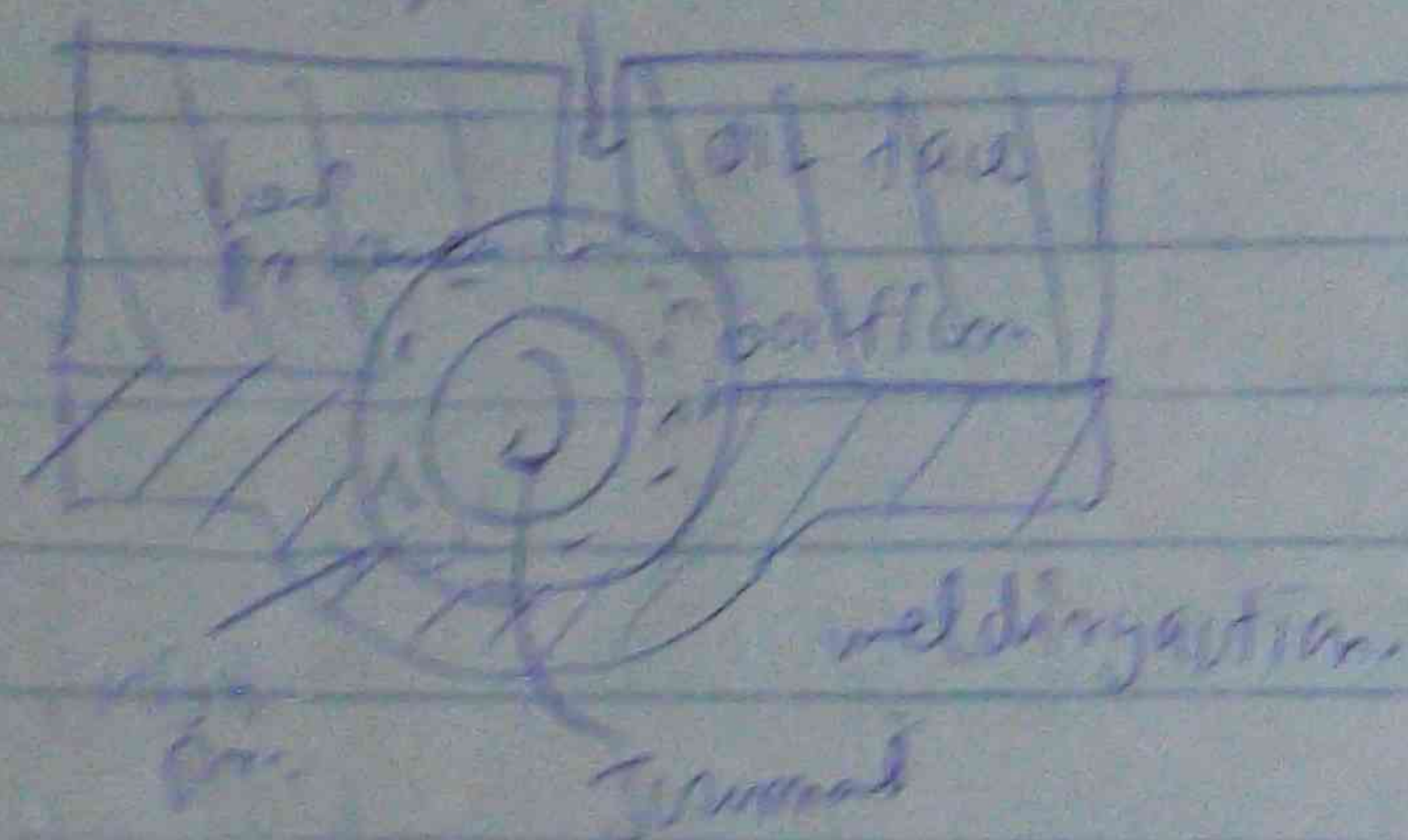
Full flow - engine working parts pass through filter. Oil flows through filter to main oil manifold or gallery. It is distributed to working parts of engine.

oil pan - pressure relief valve, engine oil, crankshaft neck, oil reservoir, oil reservoir, oil reservoir.

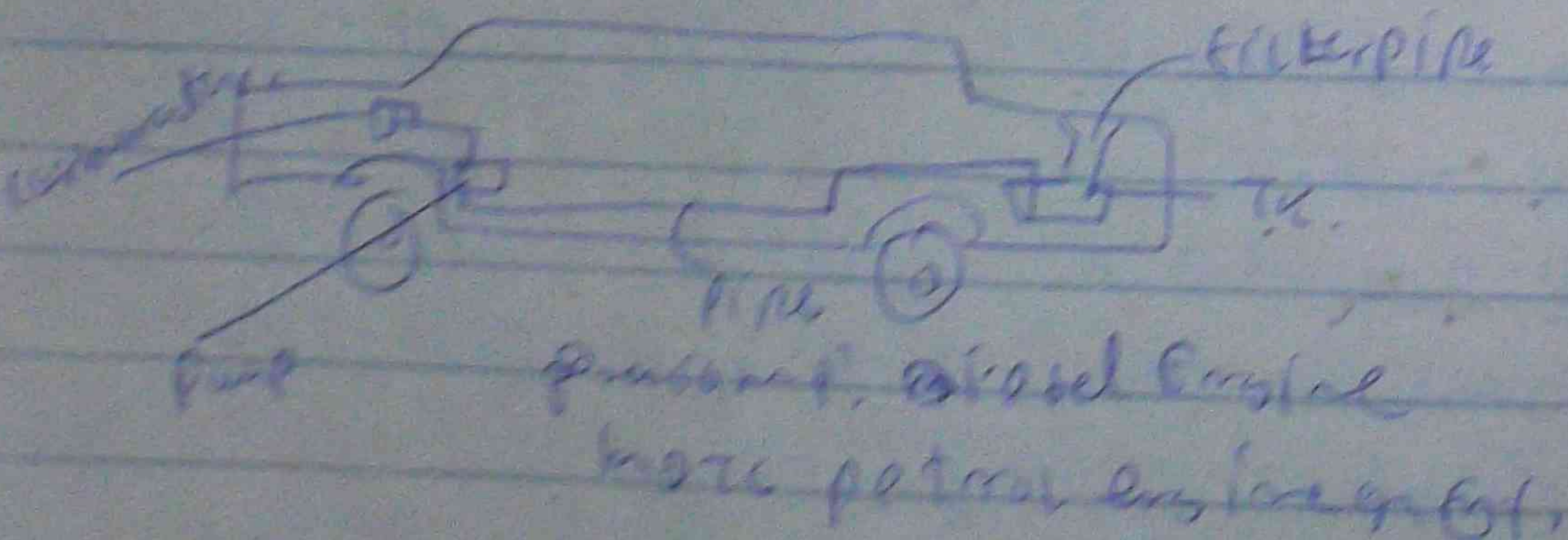
Crankcase ventilation

Naturally, dilution of l/o in crankcase vent to atmosphere. Ventilation of crankcase to atmosphere is necessary for crankcase ventilation. It is done by oil pan.

positive cranking ventilation system
 enabled by a pump system containing a pump oil of
 transmission oil



oil pump oil pump, plunger oil pump, gear pump
 (motor oil)
Fuel system



clutch gear box

auto transmission oil

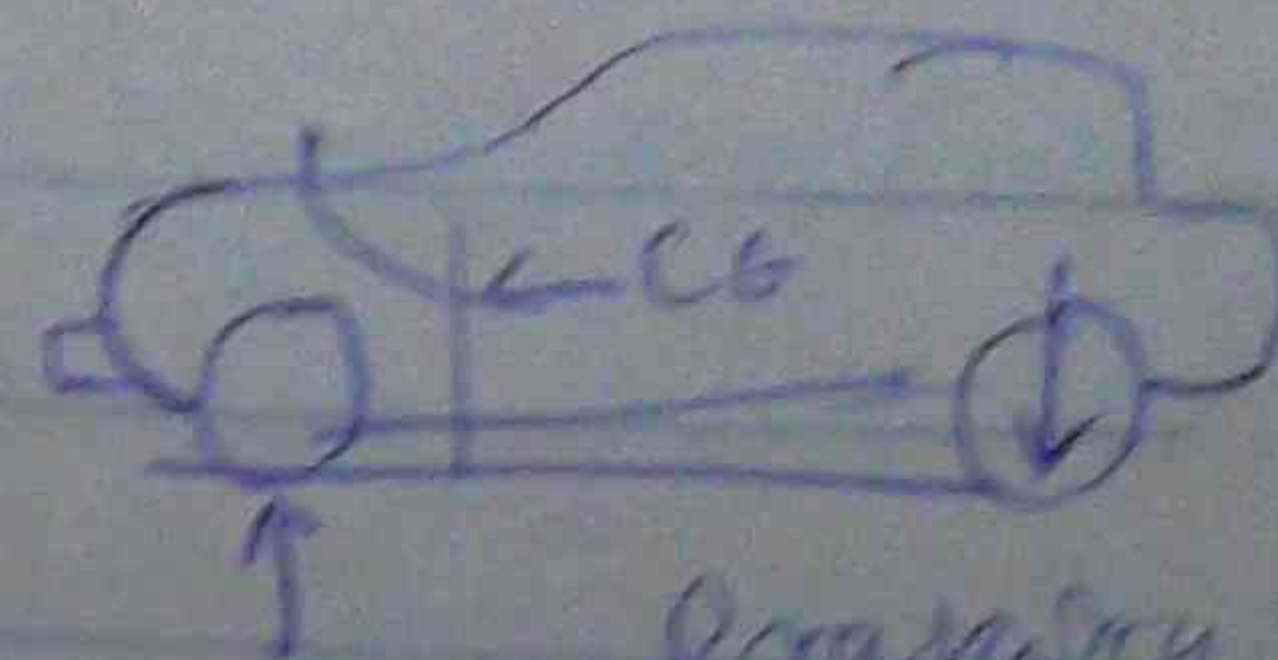
clutch
fluid drive
 auto transmission oil

Battery

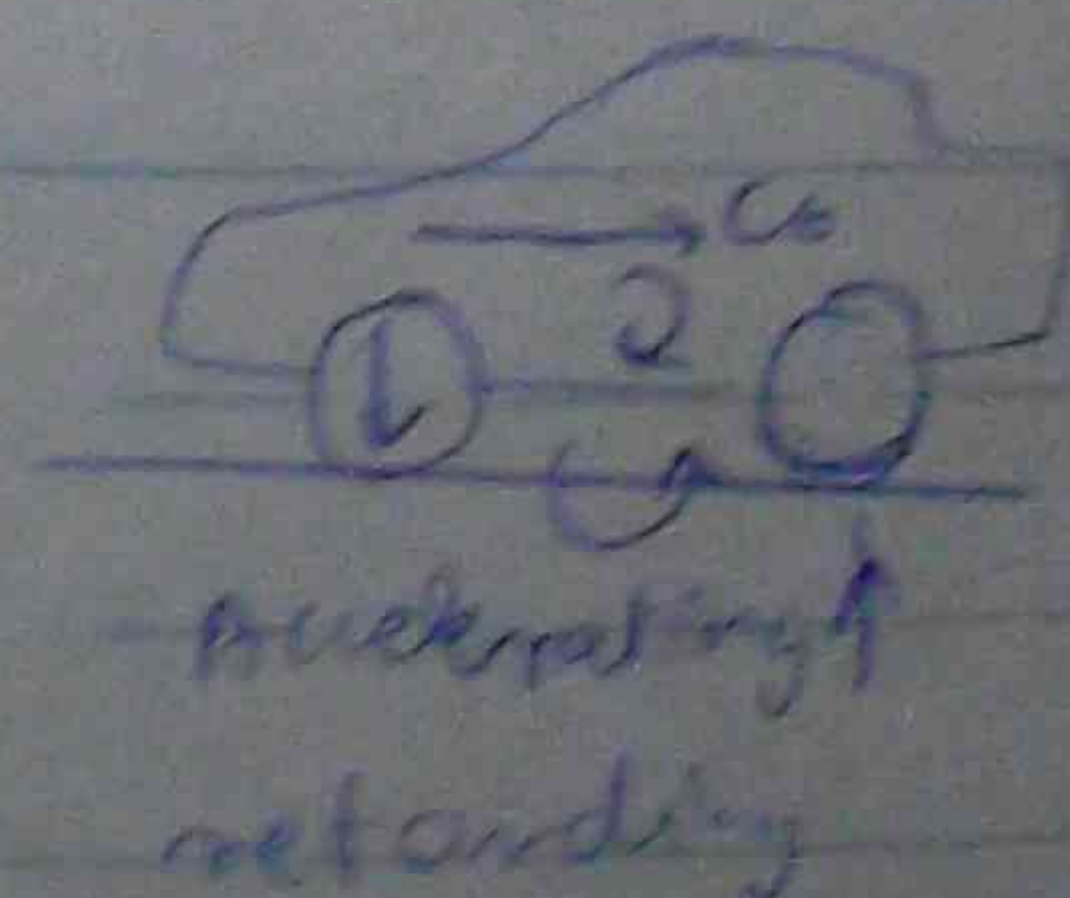
protection of battery

Braking system & chassis notes
(Braking system)

The operation performed in braking is reversed of that carried out in acceleration.



The most energy of fuel is converted to heat



The weight transfer to front wheel during braking is important because it enables a greater braking torque to be applied to front wheel than to rear wheel causing skidding. Braking system has advantage of

Thus to employ a brake at 60% approx on braking effort & forward force can be operated - mechanically, hydraulically, electrically, light vehicle, dangerous, air line & pne.

Functions of brakes

First in emergency they must bring the vehicle to rest in shortest possible distance -
- apply large braking torque on brake drum
- control vehicle in descending

Braking system

wheel brake - (service brake)

directly by means of brakes acting on a drum attached to wheel

Transmission brake - indirectly, through the transmission by a brake acting on a drum on the main shaft of gearbox or bevel pinion or worm, shaft of final drive

Braking Torque $T_b \sim 4\% \text{ Torque on brake drum}$

Tyre not brakes

Friction brake, fluid brake, electric brake are confined to heavy vehicles and are not used on cars.

- Large braking efforts at high vehicle speeds
- very little bc at low speeds and
- more at a time when the road wheels are not rotated.

Friction brake

- vast majority of brakes

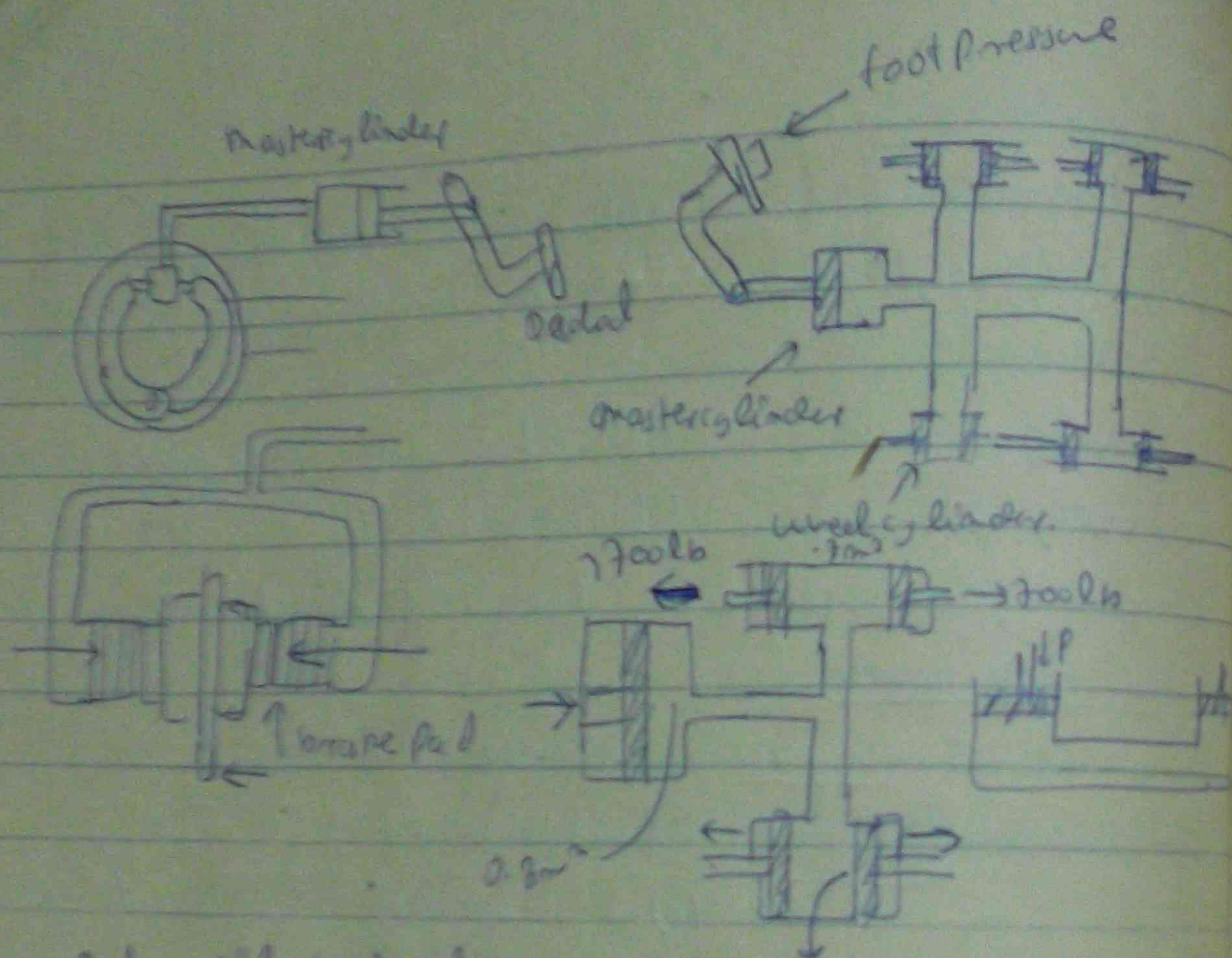
- divided into ① Drum brakes

② Disc brakes according to whether the brake member is drum or disc

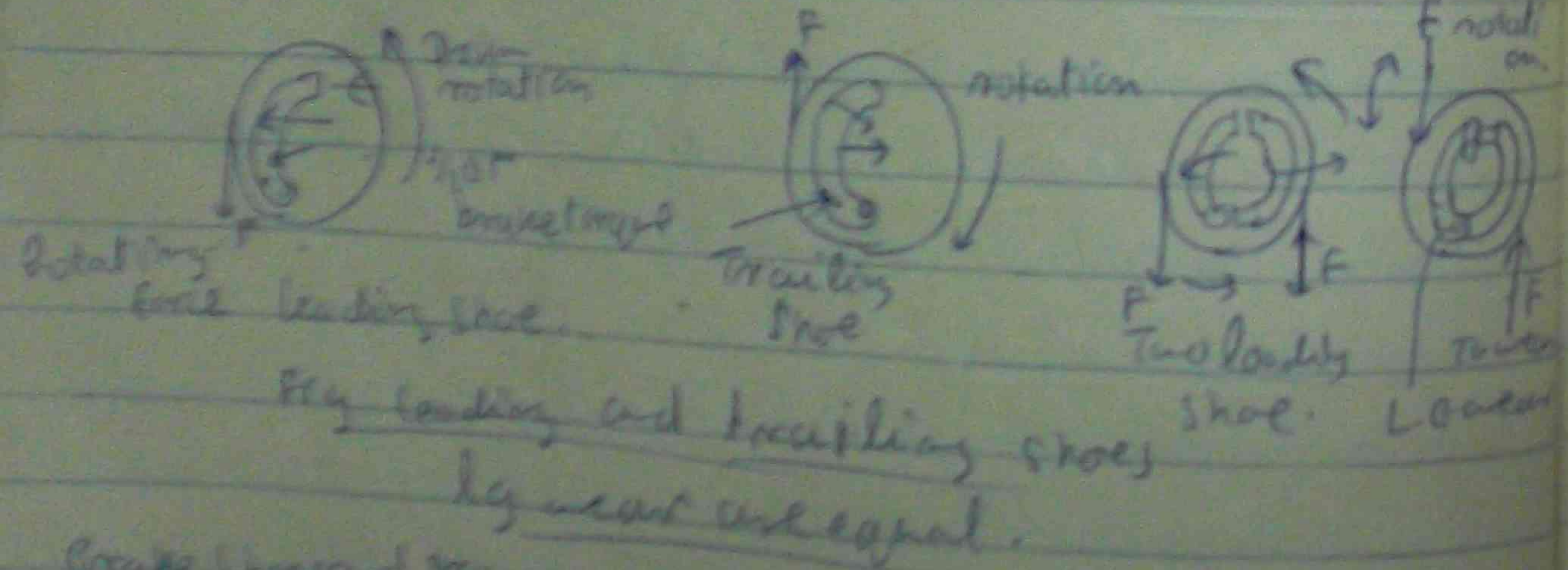
Drum brakes - are still widely used and are invariably expanding brakes in which the brake shoes are brought into contact with the inside of the brake drum by means of an expanding mechanism.

Disc brakes

- Brakes using flat disc as the friction surface
- the commonest type for the front wheels of cars and are often used for a wheel and commercial vehicles.



Automobile hydraulic system transmits motion & force
(change in amount of force)



Brake shoes and drum

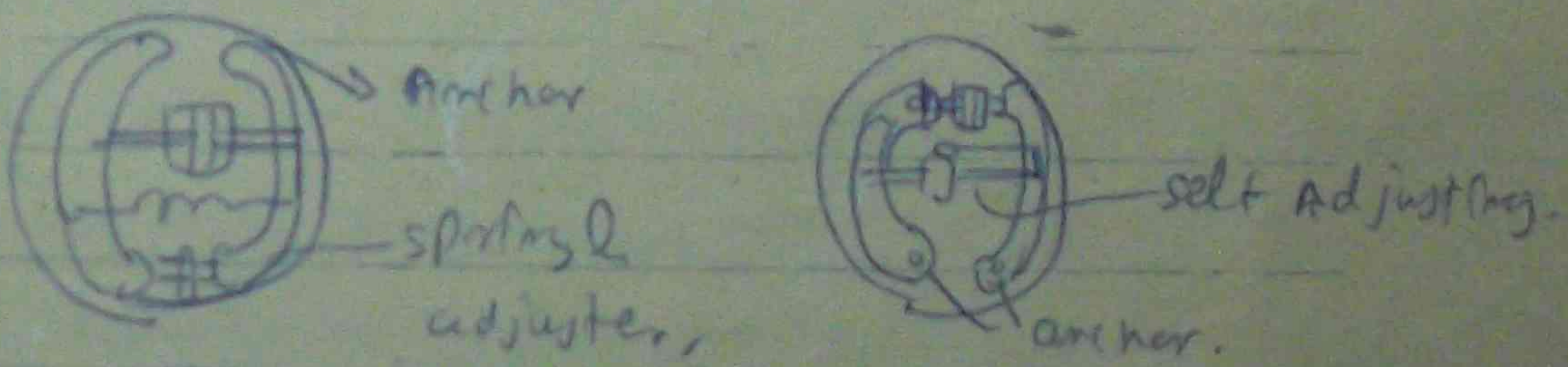
mineralized - asbestos is the basis of most
brake and clutch lining.

Figures illustrate in good friction and heat
resistance properties

Shoe material Pressed steel or cast iron (for heavy
vehicles)

semi-metallic asbestos - Brass or zinc wires
impregnated with asbestos
bent, light and subjected
to pressure and heat to
improve heat conductivity from
woven metal.

Dual servo design



when the brakes are applied the secondary shoe moves
outward against the drum. At the same time the primary
shoe also makes contact with the drum, but the direction
of drum rotation causes the primary to push against
the secondary at the spring and adjuster end. This creates
a wedging effect on secondary shoe against the drum
and therefore its performance. The extra performance
comes with extra foot pr. on the brake pedal
and is called a self servo effect.

Loading trailing design



Inspect the brake linings

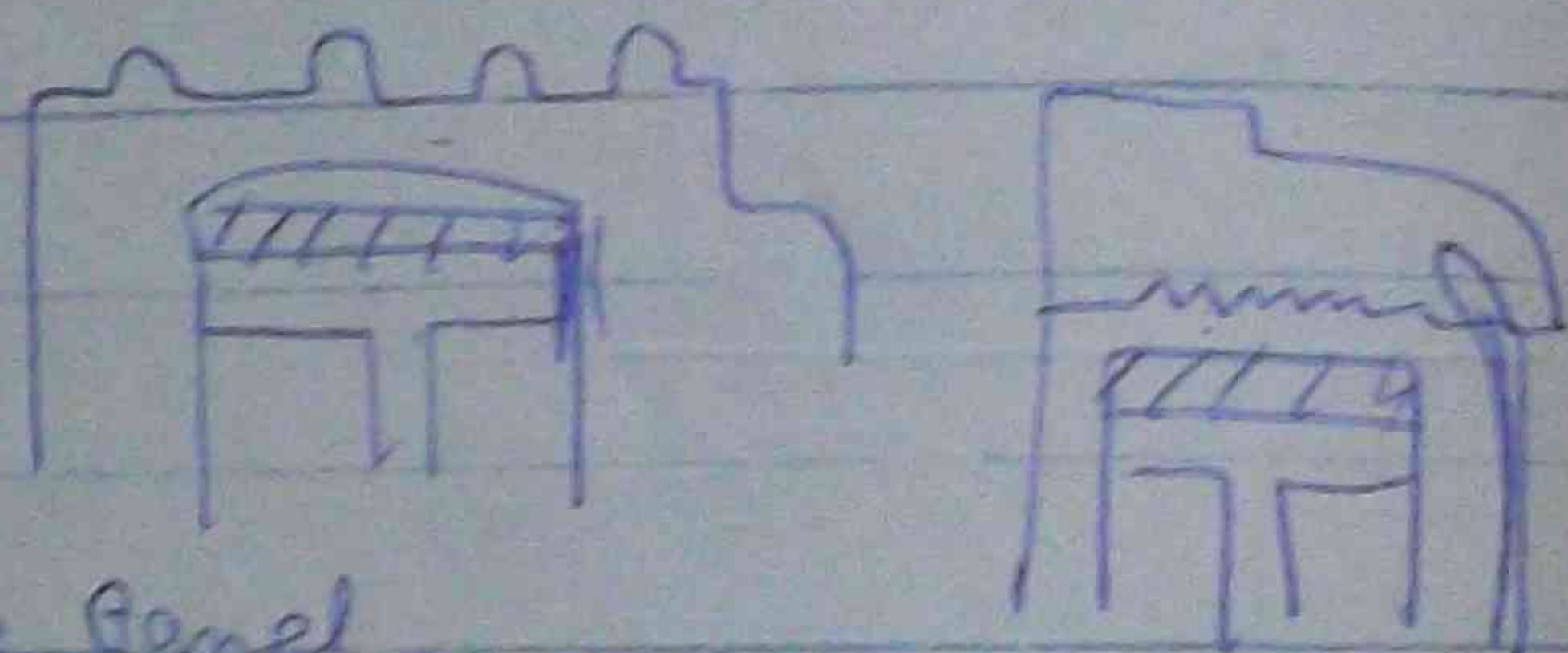
Hard spot

scored

Bell mounted

If they are worn to within $1/16$ in (6mm) of a bonded shoe or riveted head, replace the shoes. The rear brakes do only about 25-35% of work so they typically out last the front brakes on 2:1 basis.

Adjusting for wear



Threaded

The great majority of cars & panel

using drum brakes have had some type of

mechanism to automatically take up the slack caused by lining wear, so brake pedal travel would not change significantly during the life of lining.

Essentially, these are ratchet mechanisms that react when the brakes are applied with car moving backward. A plate operates against a tooth wheel and picks up the next tooth when lining wear permits that additional travel. This maintains a constant clearance between drum & lining.

These self adjusting mechanisms rarely cause

long service problem

Some of the defect find a worn brake drum.

In many cases the max. inside dia. that came safely will be stamped on drum at factory. Beyond this the drum is too thin and is subject to cracking or breakage or cam warping under heat.

wheel cylinder

- checking piston 2 in dia. & where, for scoring corrosion & wear

- installing new rubber piston cap be at seals

- lubricate with brake fluid when installing the piston.

Disc brake

Disc and friction pads bonded to steel hub or backing plate.

When braking, fluid from cylinder passes to both piston and creates an equal opposite force on each pad. released the pads & piston retracted (either by the sealing rings or retractor device) adjacent to the disc. Adjustment wear is automatic.

Advantages of the disc brake are: -

- (a) The friction surfaces are exposed to the airstream except from the pad areas.
- (b) Although higher temperatures can be reached with discs than with drums, radial expansion and the negligible lateral expansion have no effect on brake geometry.
- (c) - Due to manufacturing differences a greater range of ingredients can be used in friction pads than in linings. This permits a wider choice of characteristics.
- (d) Lack of the self-wrapping action of the two leading shoe brake results in more consistent braking, equally effective in reverse.
- (e) Being self-adjusting with negligible clearance a high mechanical advantage can be obtained in the hydraulic system.
- (f) Easier inspection and removal of friction material.

Disadvantages of the disc brake are: -

- (a) Although larger piston areas are used than for drum brakes, lack of self-wrapping action may necessitate a vacuum servo in some

cars to reduce the pedal force needed.

- (b) mud, water and dirt are largely thrown off by centrifugal force, but under adverse conditions dirt shields may be necessary and these somewhat restrict air flow and cooling.

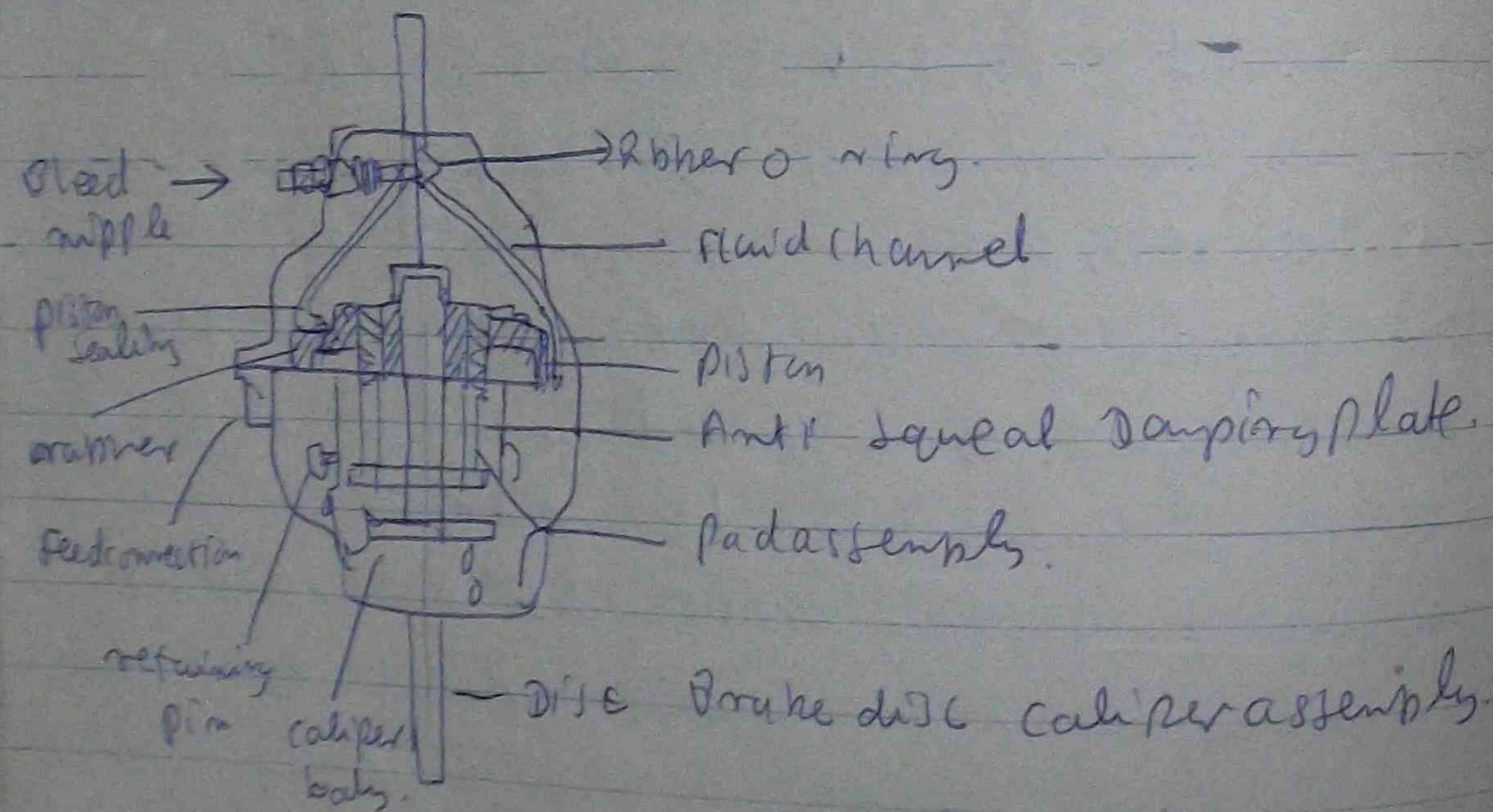
Brake layouts

Typical layouts, taking advantage of weight transfer, are twin leading shoe or disc brakes at the front, where their powerful action can be utilised, and single leading shoe brakes at the rear.

For a constant braking efficiency the retarding force required increases in proportion to the vehicle's weight. Brake shoe forces are required for heavier vehicles that cannot be obtained from the driver's unaided effort. For high performance cars and commercial vehicles up to about 7 tonnes (7000 kg) a servo mechanism which adds to the driver's effort can be used. For heavier vehicles and also a trailer it is a power operation where the driver exerts only a controlling action - is employed.

Maintenance

Adjustment for lining wear is almost always carried out at the brake shoes. In some cases, provision is also made to centralise the shoes in the brake drum. Adjustment is usually required at 10000 km intervals. Pads and linings should be inspected for wear at 20000 km intervals and dust removed from the brake drums. Care should be taken not to blow this out, as asbestos particles are a health hazard.



Maintenance of the fluid level (usually a mixture of glycerine and alcohol) is essential to prevent air entering the system. The reservoir

level should be checked every 10000 km and the cause of any serious loss of fluid established. A slight drop in level as the disc pads wear and the pistons move inward is normal.

If air has entered the system, bleeding will be necessary. The usual procedure is to ensure the reservoir is topped up, then to clean (and unclog, if necessary) the bleed nipple and attach a short length of tubing. This terminates below the surface of a quantity of brake fluid in a clean glass container. The bleed nipple is now unscrewed about half a turn and the brake pedal operated with slow full strokes, allowing it to return freely. The reservoir level will fall rapidly during bleeding and must be constantly replenished. When the discharged fluid is free from bubbles the nipple is tightened on a down stroke of the pedal. The operation is repeated at the other bleed points, keeping the reservoir continuously recharged with new fluid.

Brake defects

Excessive Pedal Travel

- (a) Brake shoe adjustment needed
- (b) Fluid leakage (faulty seal)
- (c) Piston or pads 'sunk back' by disc or hub
- (d) caused by distortion or loose wheel bearings

Spongy Pedal Action

- (a) Air trapped in hydraulic system

Brake Shoe Squeal

- (a) Linings or pads contaminated with oil or grease or brake fluid
- (b) Loose mountings, anchor pins, hair plate
- (c) Caliper, suspension spring or wheel bearings loose
- (d) Seized distorted or corroded drums or discs
- (e) Too much type of friction material used.

Brake Pulling to one side

- (a) May be brake shoe defects affecting one drum or disc
- (b) Unbalanced tyre pressure, tyre or tread pattern

- (c) by vibration compensation defective brake shoe

Brake Drag

- (a) Adjustment too tight

- (b) Hand brake seized or incorrectly adjusted.

- (c) Piston or pad assembly seized

- (d) Brake pedal preventing piston from returning fully and opening port to reservoir

- (e) Hose or pipe blocked.

'Hard' pedal - High Pedal Force Needed

- (a) Seized wheel cylinder or caliper pistons

- (b) Worn contaminated glazed or incorrect type of friction material

Brake Squeal

- (a) Wet linings or pads

- (b) Worn contaminated pads or lining, dust in drum

- (c) Loose mountings

- (d) Damping Shim or spring defective

CITASIS NOTES

Frame

It - In order to provide a rigid structural foundation for the car body and to provide a stable fastening for the suspension system.

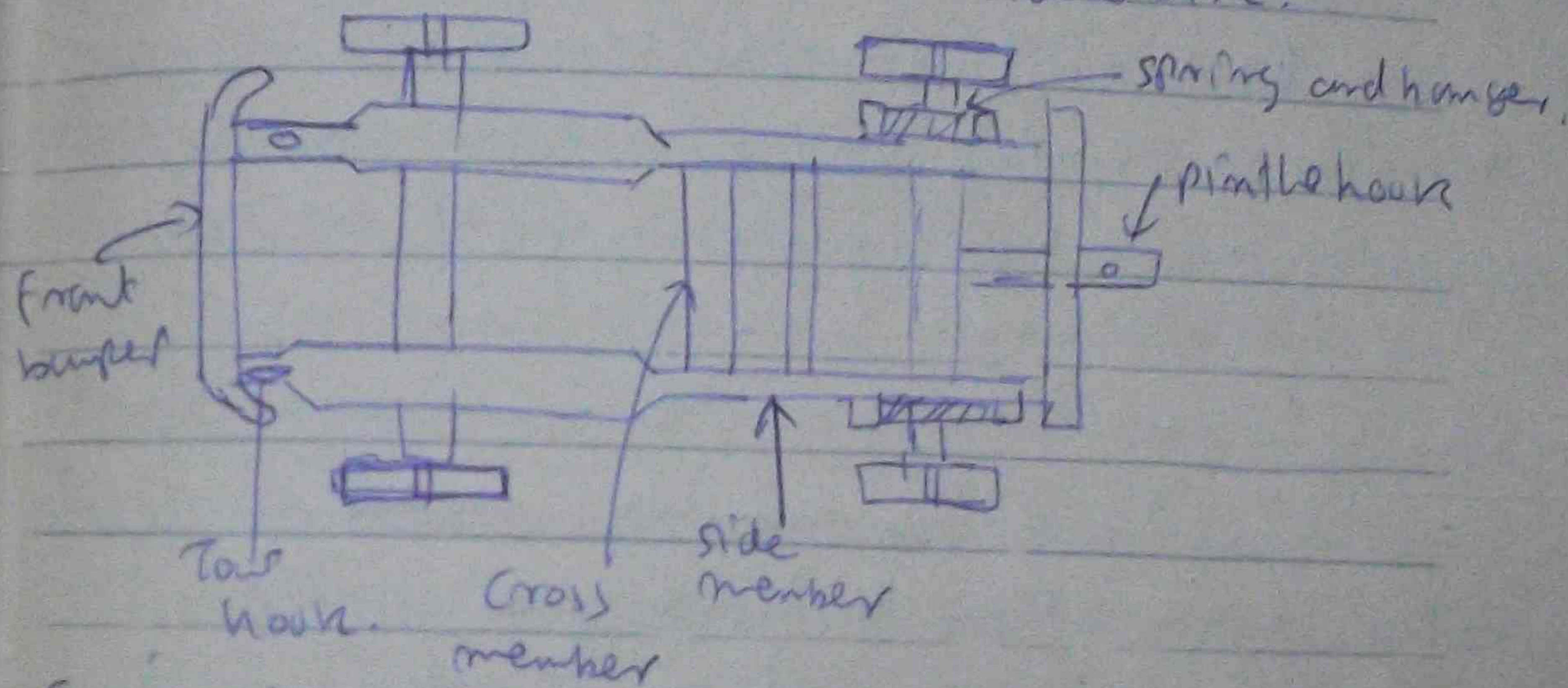
Two types are commonly used today.

- (1) separate steel frame (The body is bolted) by using body mounting brackets on the frame
- (2) The integral frame (frame and body are built as a unit and welded together)

Type 1 It consists of two longitudinal beams known as side members are of different cross section along. Their length, their height being greater at the heavier loaded points. where their strength must be increased. sometimes used reinforcement plates. The side members are interconnected by lateral beams or cross member.

The front end of the side member carry bumper and tow hook; the rear ends are interconnected by cross member, one with a trailing axle hook is secured (on truck) for better stability, the unit of frame fastened to each other by gussets and cover plates.

The frame is mounted by means of springs on rear and front axles of automobile.



Suspension

The resilient linkage between the frame and the axles. It softens the road shocks taken by the wheel by of a moving automobile and transmits the punching, breaking and twisting forces from the axle to the frame.

Types of suspension system.

- (a) leaf (b) coil (c) tension bar (d) air springs
- (e) some elliptical leaf spring

It consists of a number of flat steel springs of varying length, bolted together in to a single unit by centre bolt and reformed clips. It is fastened to the front or rear axles by U bolts. The end of the

Spring are mounted to the frame by means of spring hanger and shackles. Shackle is used for allowing deflection of extension. Some rear suspension consists of main spring and auxiliary spring. Some rear springs of front axle are installed to car.

coil spring

They are made of special spring rods heated and wound in the shape of spiral coil. One end is firmly fastened to the frame, the other to the axle or suspension device.

(c) Torsion bar

It consists of a long spring steel bar one end is fixed to a non movable mounting the other end is free to turn.

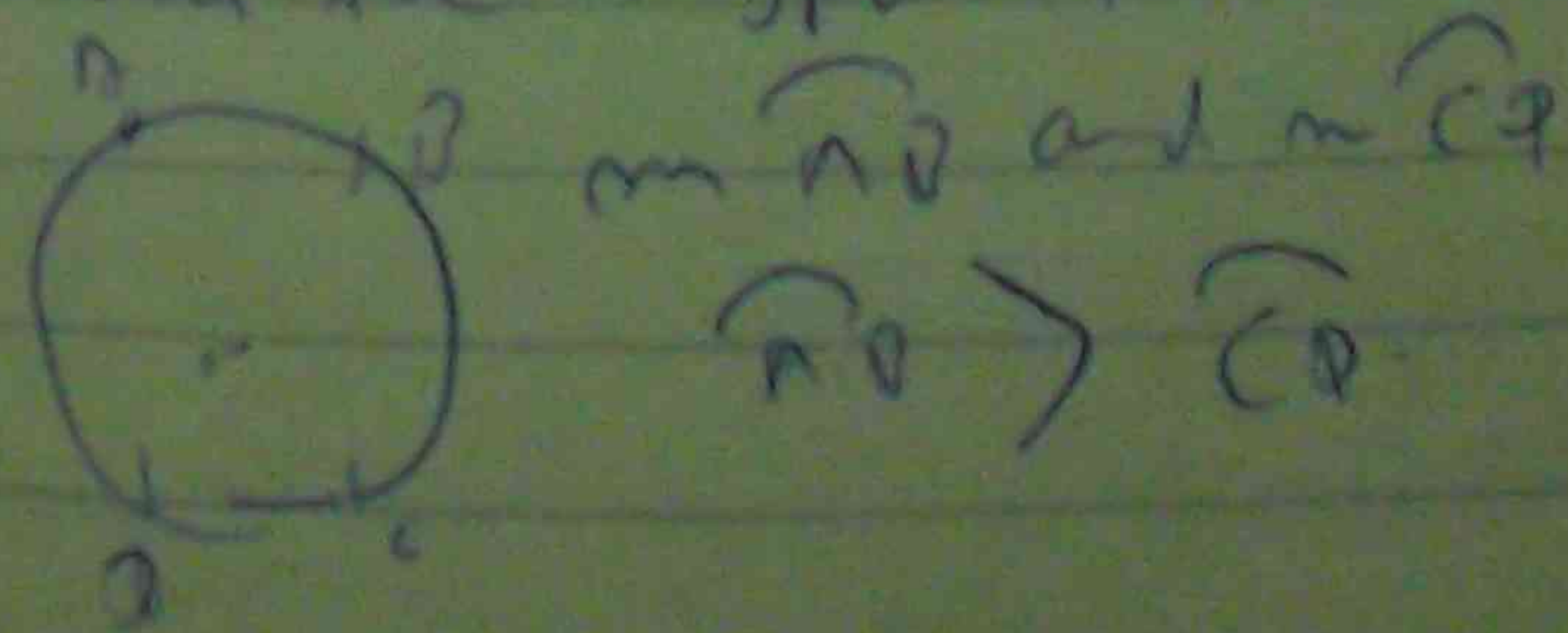
(d) Air spring

It consists of a hollow steel container with flexible diaphragm as stroke used across one end. The diaphragm extended upward part across the container. The steel container is fastened to the frame. The plunger (with

diaphragm) is secured to the axle. Proper air pressure in steel container is supplied by air compressor. Spring action is impacted by diaphragm, flexing up and down against the compressed air inside container.

Front wheels independent system

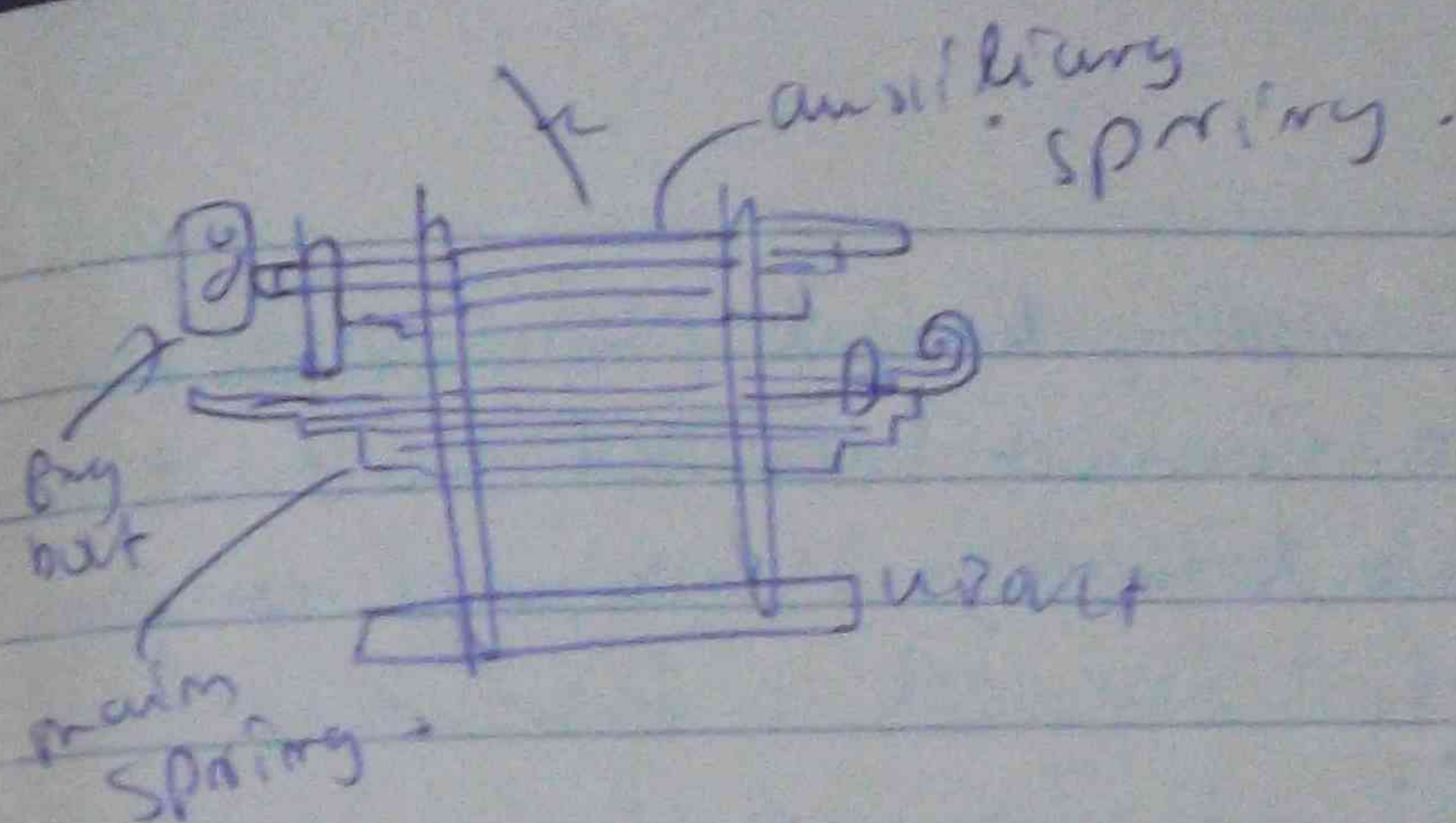
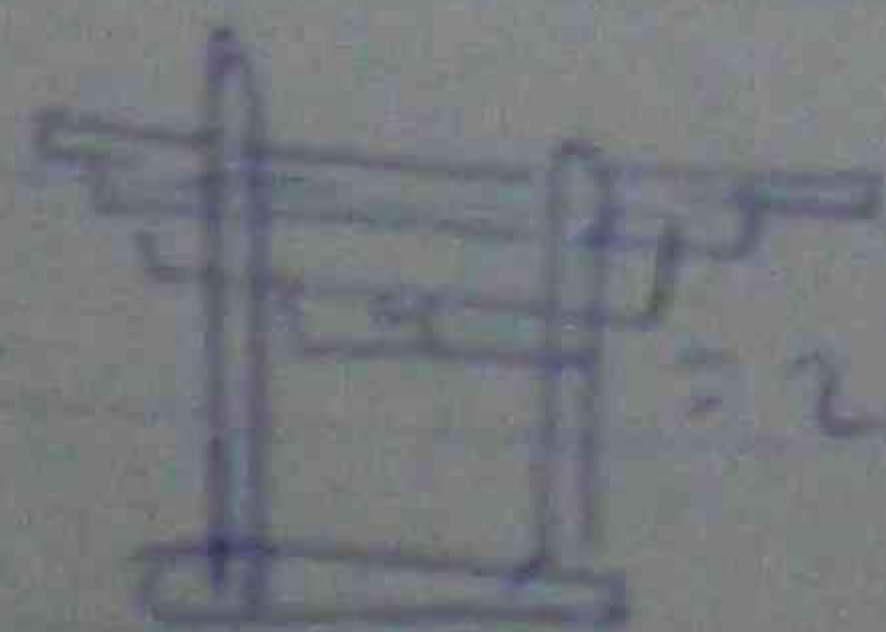
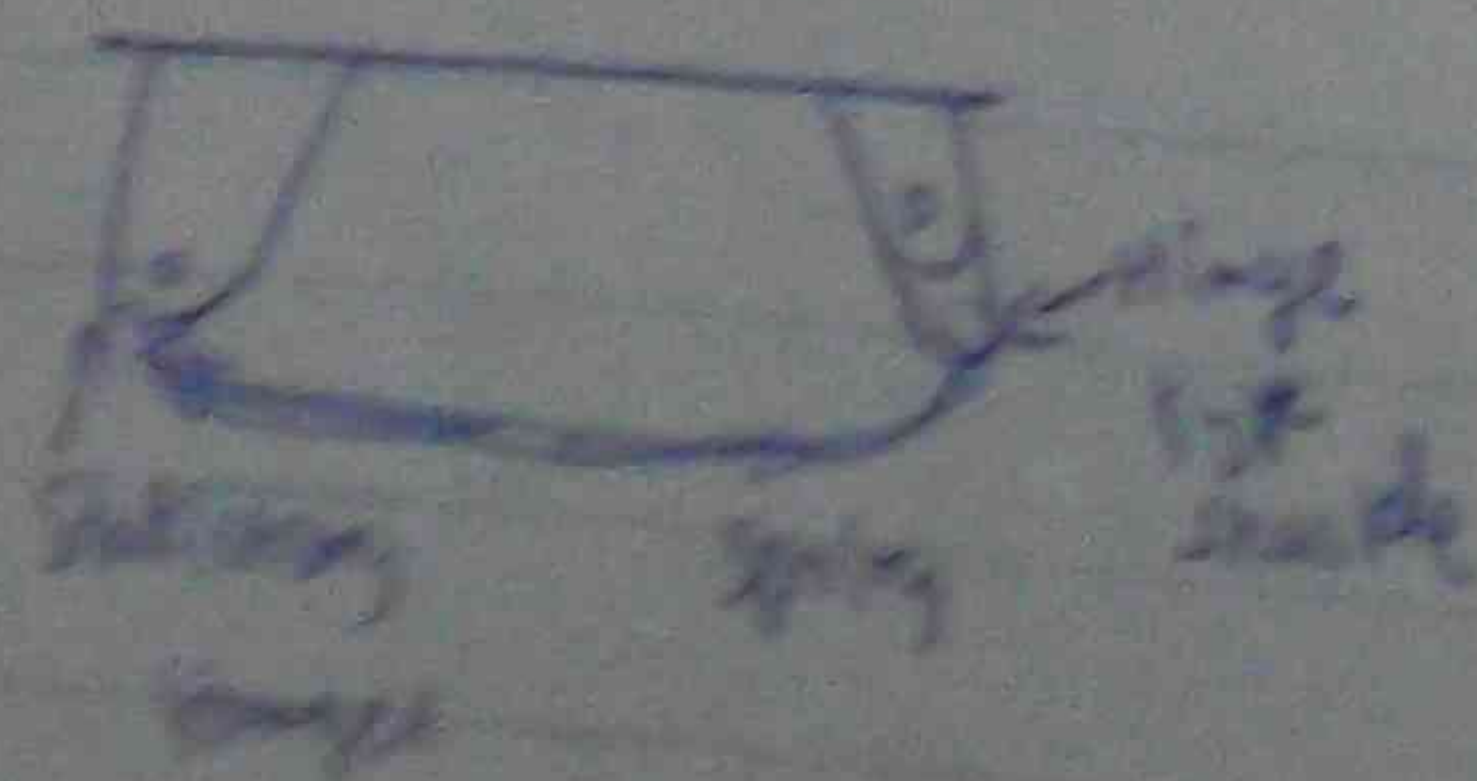
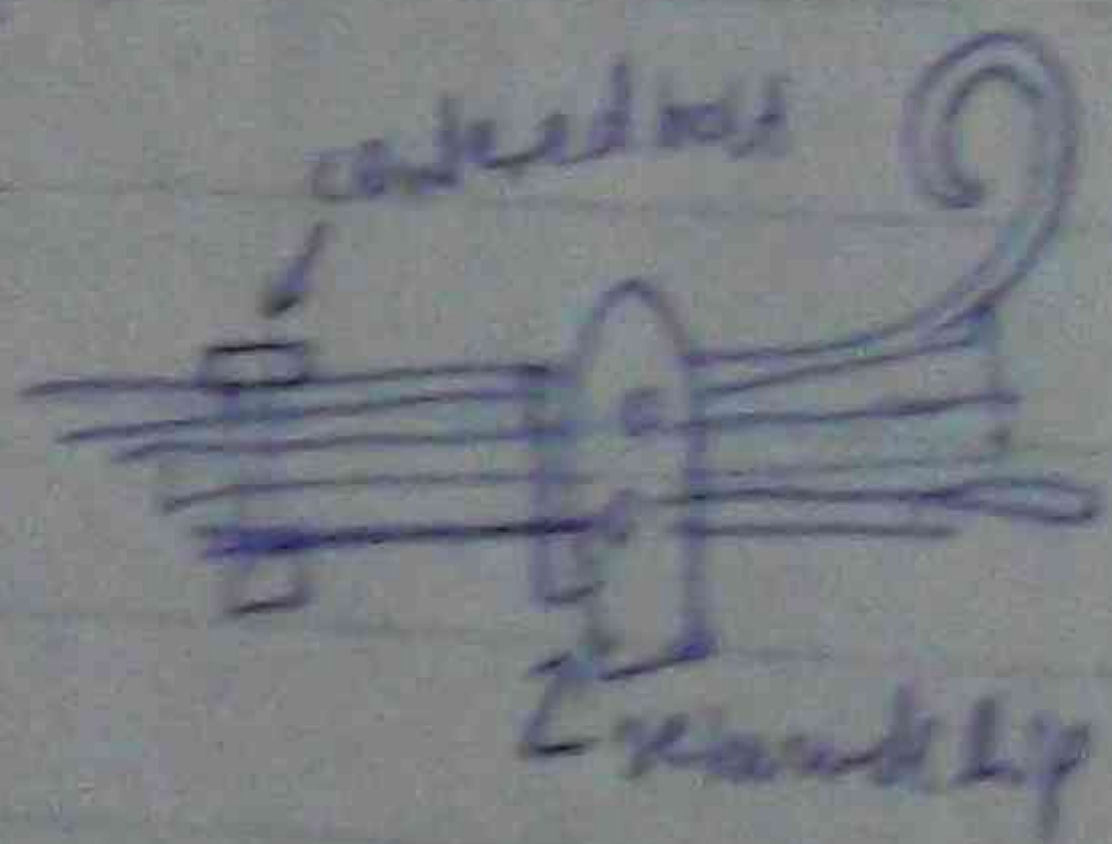
X- The angular vibration of steering wheels may be due to the road unevenness. α must be small when it is very big vibration of wheel occurs which is called caused by gyroscopic effect. ~~note~~ For automobile with beam type axle suspension when θ is big, gyroscopic movement tends to turn road wheel about the steering about the Kingpin



For automobile with beam type axle
beam type suspension.

Front wheels Independent suspension

The angular vibration of steering
wheels may be due to road unevenness
and to make small when it is
very big vibration of the wheel occurs
which is gyroscopic moment tends to
return the steering road about the
steering axis.



Shock absorber

A damping device to overcome spring oscillation
types are type opposed piston. Hydraulic double direction
action or telescopic type.

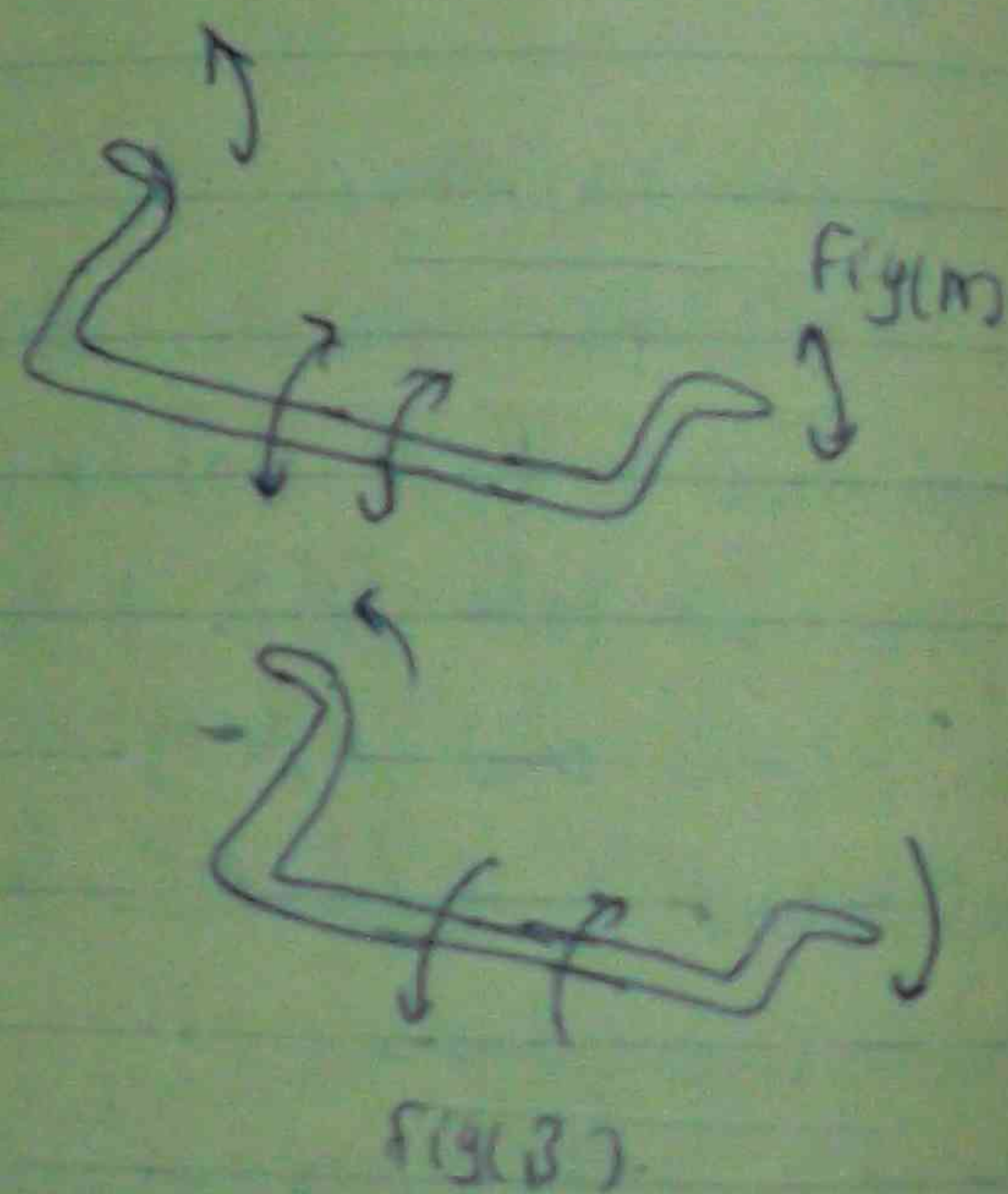
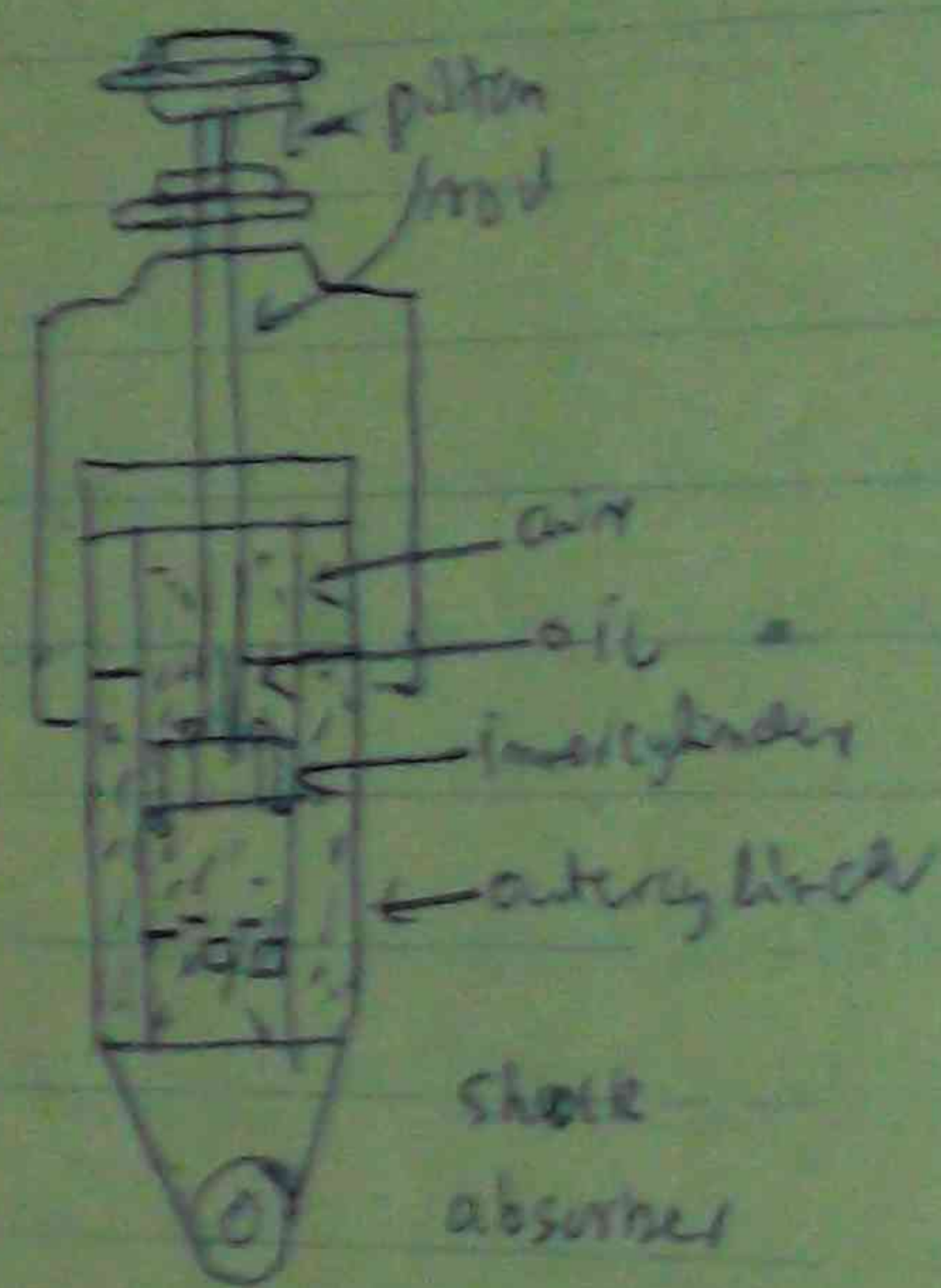
one end of it is mounted to frame and other is
attached to the axle.

Telescopic type

It consists of an inner cylinder, outer cylinder
piston, piston rod and valves. It is filled with low viscosity
oil. Needs valves (in the piston and at the bottom of
the inner cylinder). control the movement of hydraulic
fluid with shock absorber.
usually incorporated in the suspension made of spring
steel.

It is (or frame) moving up and down, but is not
clipping, but offers no torsional resistance.

In (a) foam is drifting to right pressing down on and lifting up on 2. Pressure is built up to allow traction. Resistance to falling will minimize rolling.



Tyres

They serve two main functions. They provide a cushioning action that the jerks caused by road irregularities (forming a part of suspension system). They also provide proper traction (to drive forward, steering, fast stoppings).

They are constructed of various types of rubbers, fabric and steel wire.

The tyre consists of an outer casing and a

inner tube. The tube is provided with a valve through which it is inflated with air. The casing holds the tube in rim, protects it against damage and ensure reliable adhesion of the wheel to the road. It consists of a carcass with bead wire and a tread with sidewalls.

The carcass which is the main body of the casing is made of several plies of sturdy rubberized cord with rubber layers in between. The thin wheel head wires are inserted in torings and wrapped in rubber fabric. These rays are installed into the heads of the carcass to improve their strength. The tread protects the car against damage and has a special pattern for better gripping of the ground.

Tyre size designation

7.00 → 13 10.00 → 20
Tyre tube diameter inside of rim



Tube less type

No rubber inner tube is used, the tyre and rim form a leak proof unit. It often has a thin rubber lining. The head area has tiny sealing grooves. Air is admitted to the tube less tyre by means of a valve stem placed in the rim.

Table 1 Tyre section

(Aim: Right fit of tyre beads in head)

Seat of wheel rim

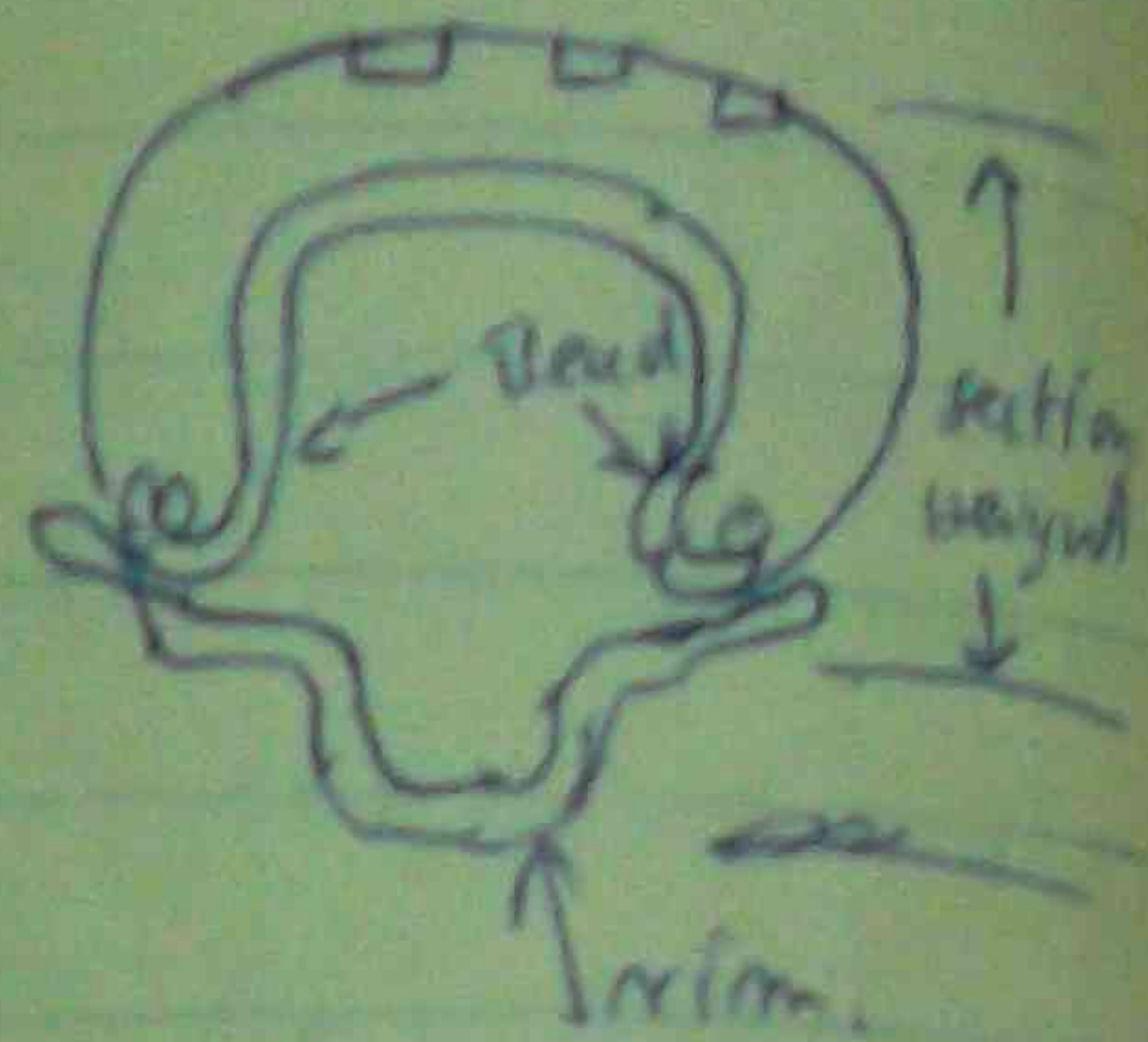
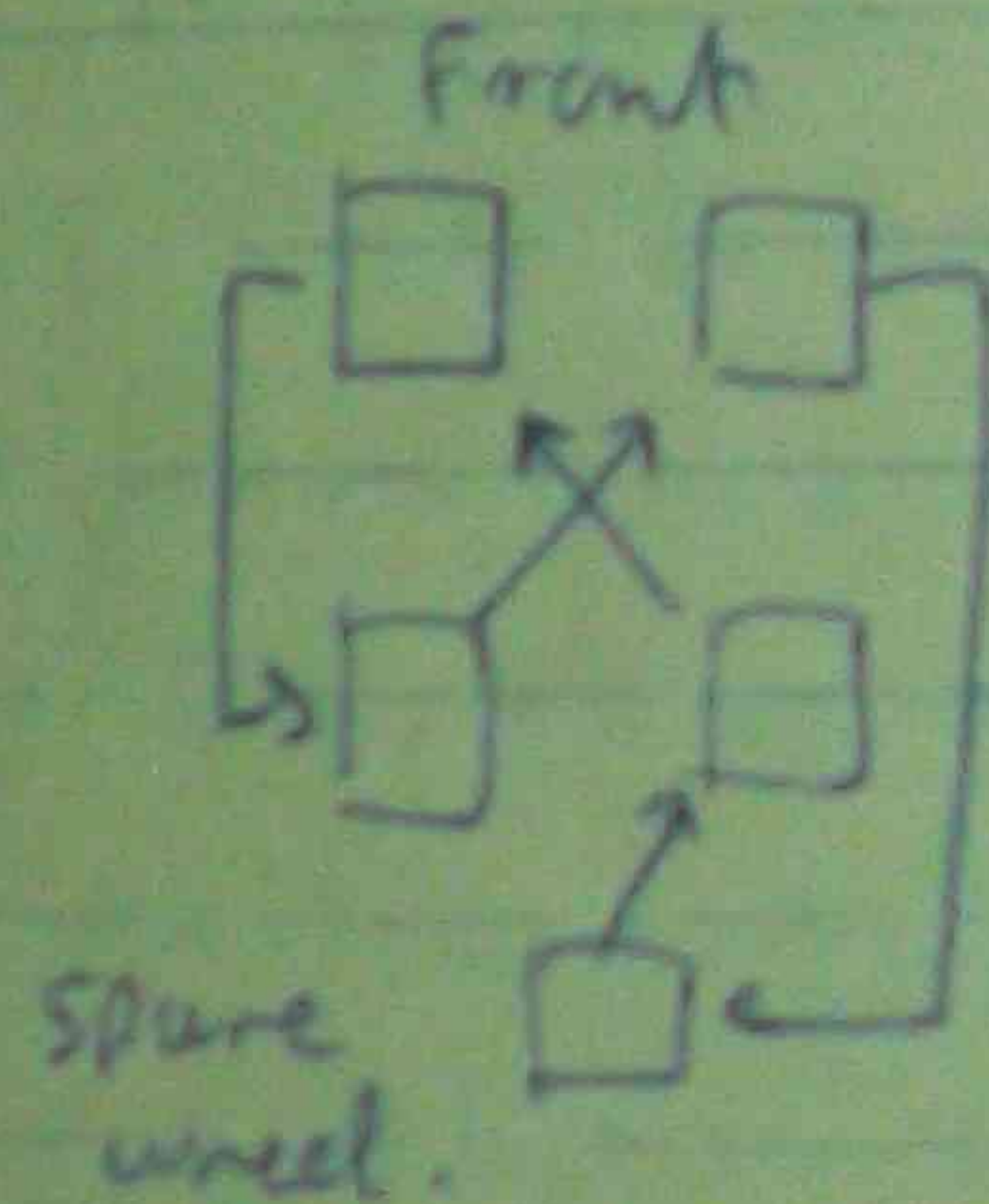
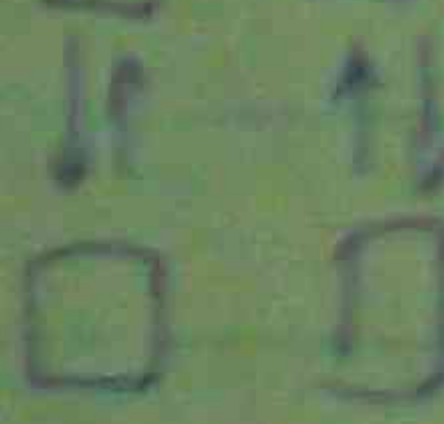
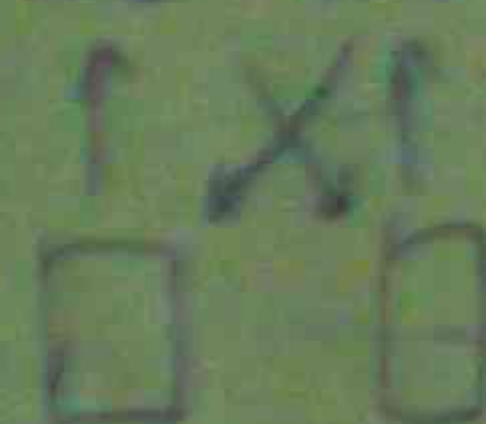
Tyre rotation pattern

To compensate individual tyre wear (linear, etc.) advise to rotate the tyre about every 5000, 8000 kilometers

Front



Front



by cap nuts provided with internal and external thread. Whereas the outer wheel is installed on the cap nuts and fastened with chambered nuts screwed on the external threads of the cap nuts.

Front wheel alignment

(i) camber angle δ

The angle between the centered line of the tyre

and the vertical. This angle varies from 0.5 to 1°

Results → Reduce the steering effort.

• Reduces the loads applied to the wheel outer bearing transfer it to large inner bearing.

The required camber angle is obtained by and adequate setting of the steering knuckle.

(ii) caster angle α is formed by the king pin axis and the line to the wheel rolling plane (in the longitudinal plane of the automobile). (See fig. 3-4)

(iii) King pin inclination angle β is formed by the king pin axis and the line to the wheel rolling plane (in the lateral plane of automobile) (See fig. 5 and 6)

Disc wheel

It consists of a steel hub: a stamped steel disc and a steel rim. Flat sectional rims is welded or riveted to the disc. The disc is fastened to the hub by studs and nuts with a tapered chamber. To prevent bearing nuts from working loose in motion. Beads of both and 4 wheels have 8 and 16 threads respectively. The nuts with 1/4" thread are marked by special marks on the faces.

The inner wheel of the rear axle is fastened

(7) & (8) angles improve stabilization of wheel (ie) their ability to retain automatically the position required for the straight ahead movement of vehicle.

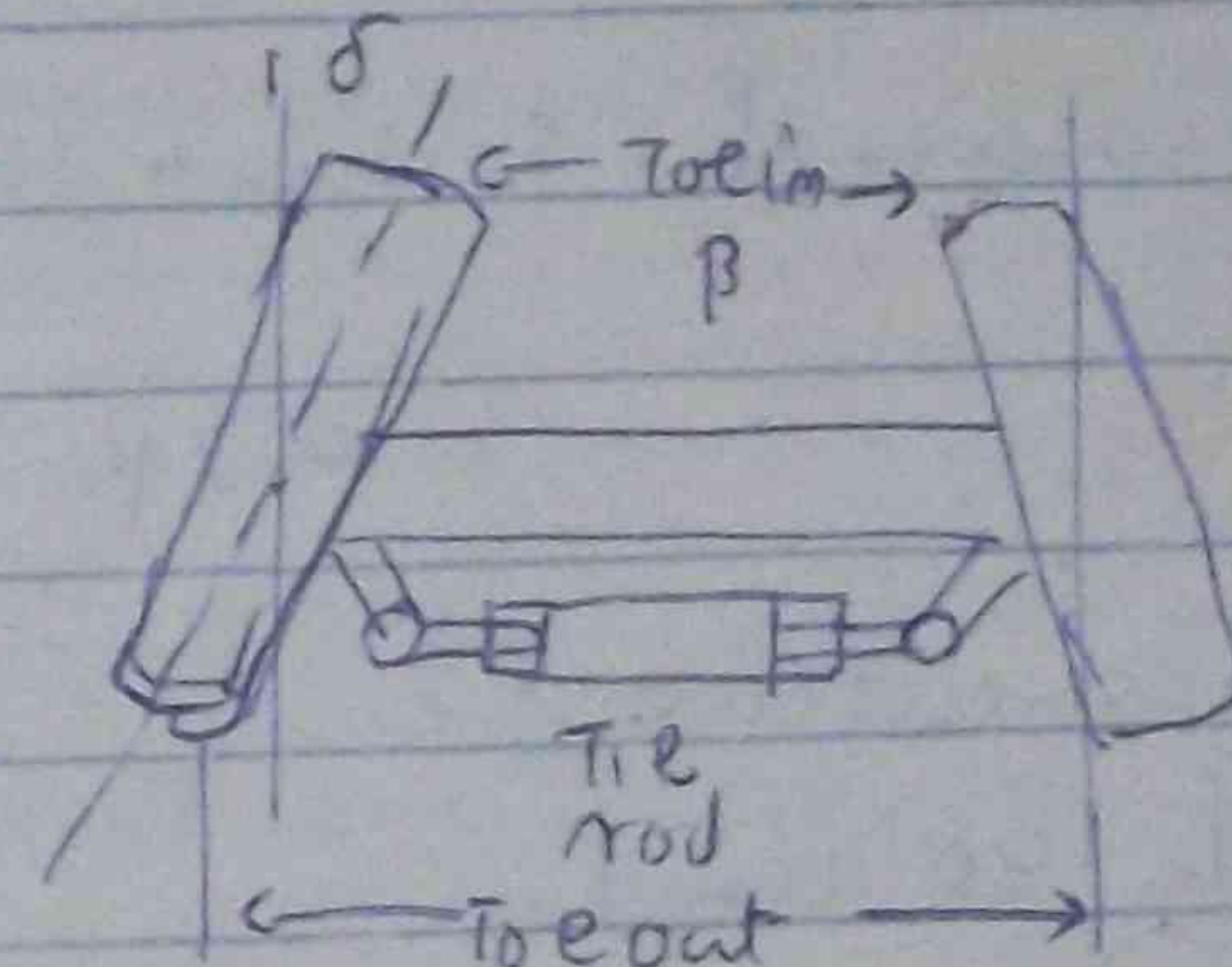
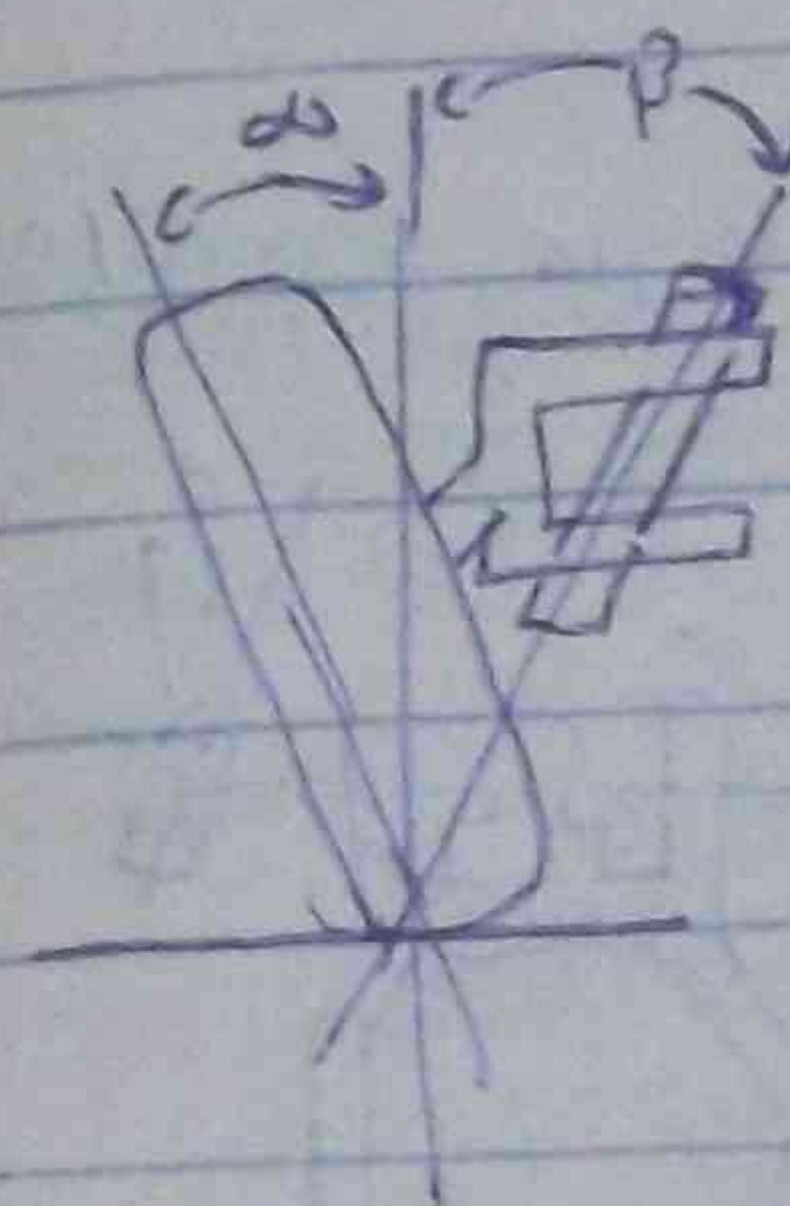
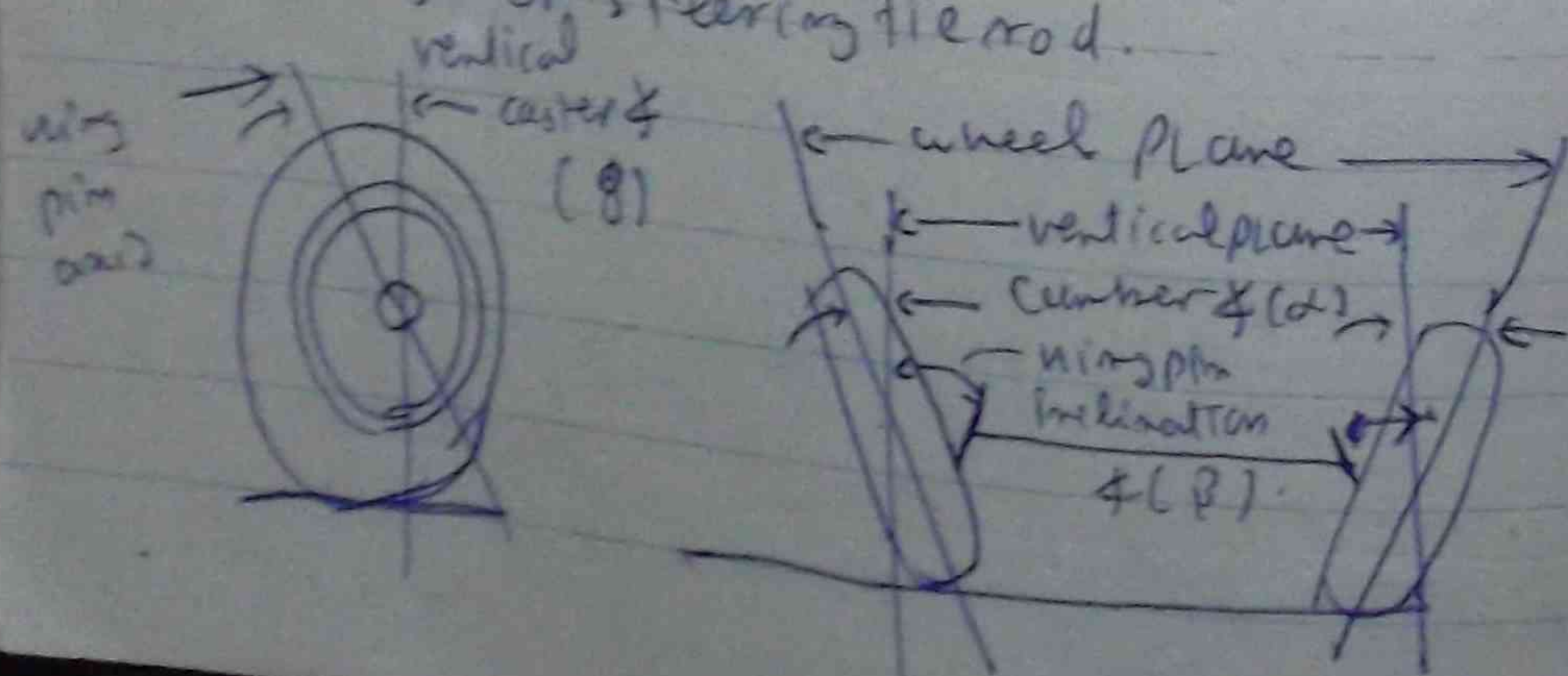
counter movement.

(4) TOE IN (angle δ)

The difference of the distance between the inner sidewalls of front wheel tyres in their front and rear parts. (A-B should be 2-3 mm generally 4 mm). Cambered wheel have a tendency to roll apart and to play in the steering linkage. Therefore the toe in ensures parallel rolling of the wheel in the presence of camber.

$\delta = (15 \text{ to } 20\% \text{ of } \alpha)$

The toe in of the wheel is set by adjusting the length of steering tie rod.



Steering

- To change the direction of automobile movement by turning the front wheels, with respect to immovable front axle.

- Steering gear consists of steering wheel, steering column, with steering shaft, steering mechanism and steering geometry.

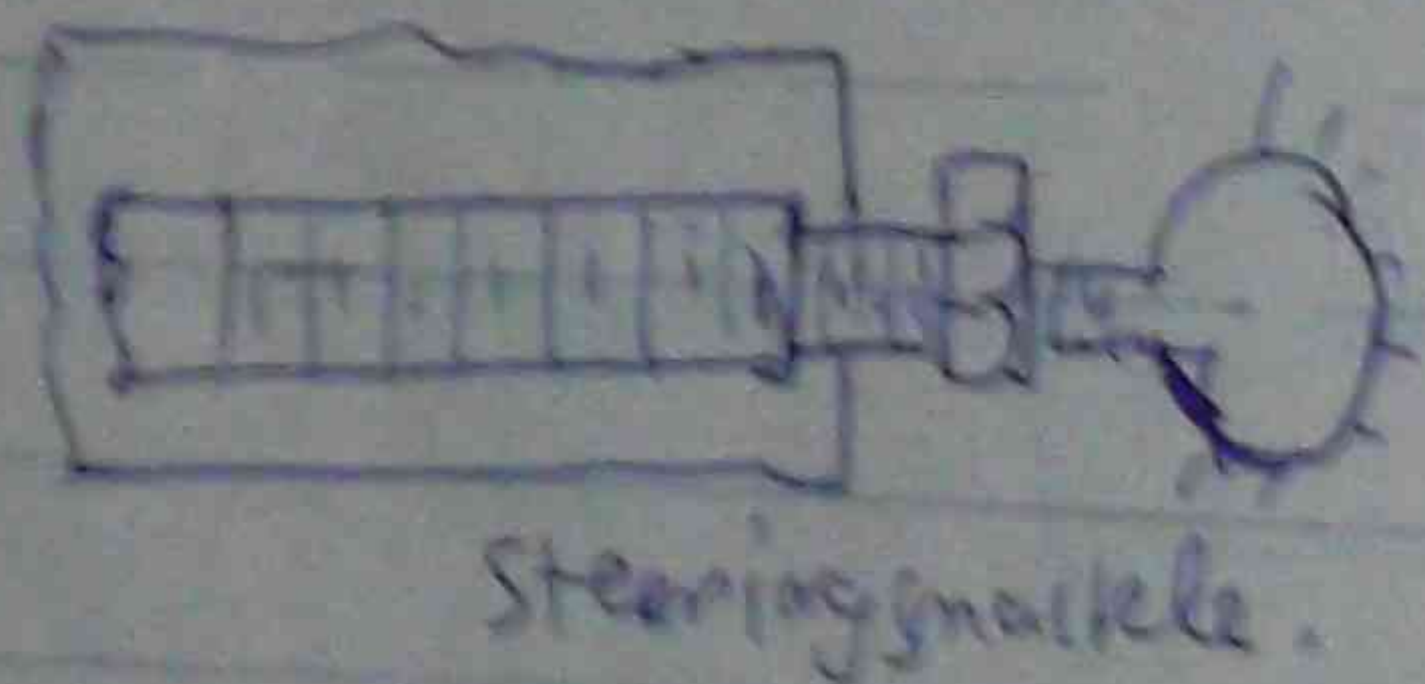
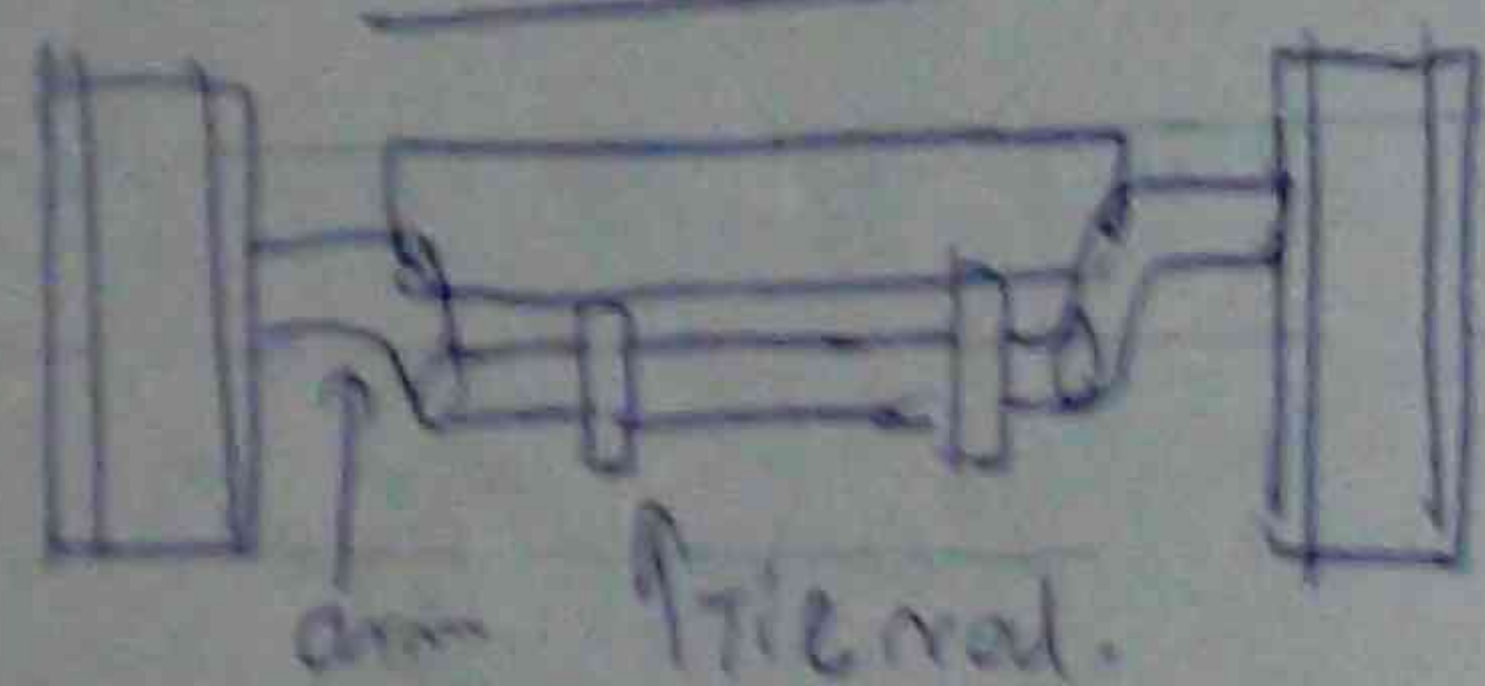
- In order that the wheels may roll freely without side slip, it is necessary that they should all move about a common centre. This centre will be on a line drawn through the rear axle where lines drawn through the centres of the front wheels intersect.

To achieve this common centre, the inner wheel must turn through a greater angle than the outer wheel so the wheels which are parallel over an automobile moving forward along a straight line, do not remain parallel when the automobile turns.

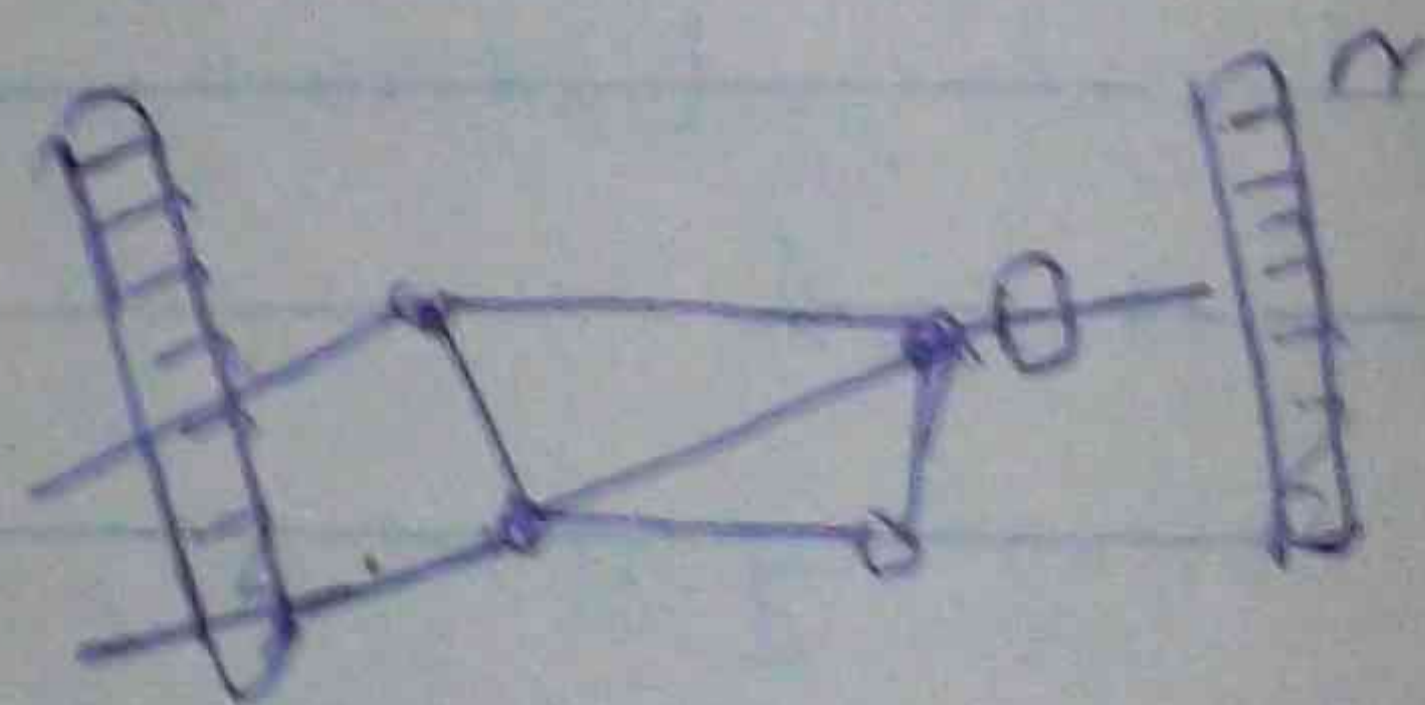
This is due to the fact that the inner wheel when turning follows a curve of smaller radius

than the outer wheel. So must turn through greater angle.

The required condition is approximately obtained by introducing steering geometry. Front wheel axle beam



The steering knuckle has threaded heads, screwed on the axle and secured (clamping bolts). The R.R. ~~on~~ hands has a right hand thread & L.H. thread - left & right. On rotation the moving part the knuckle it becomes possible to change the distance between arms. They adjusting the toe & in front wheel.



Type of steering

rack & pinion

worm gear

power steering type.

Service: cylinder with moving piston rack. oil pump. By turning steering wheel. Valve assembly will operate as follows:

- operating pressure of piston = 65-70 kg/cm².
- by oil pump which aid the steering wheel.
- carrier to turn = 0

Internal components

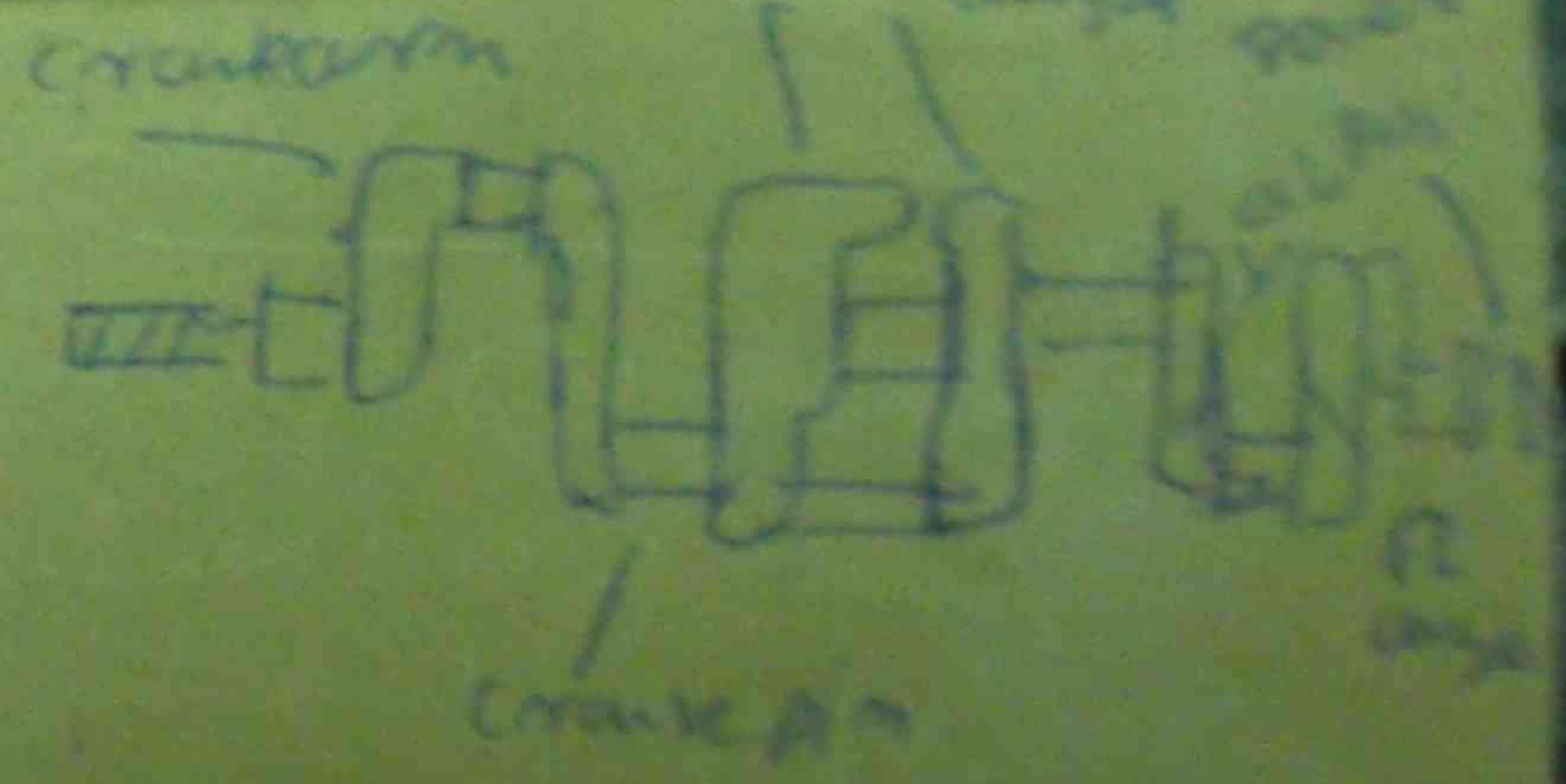
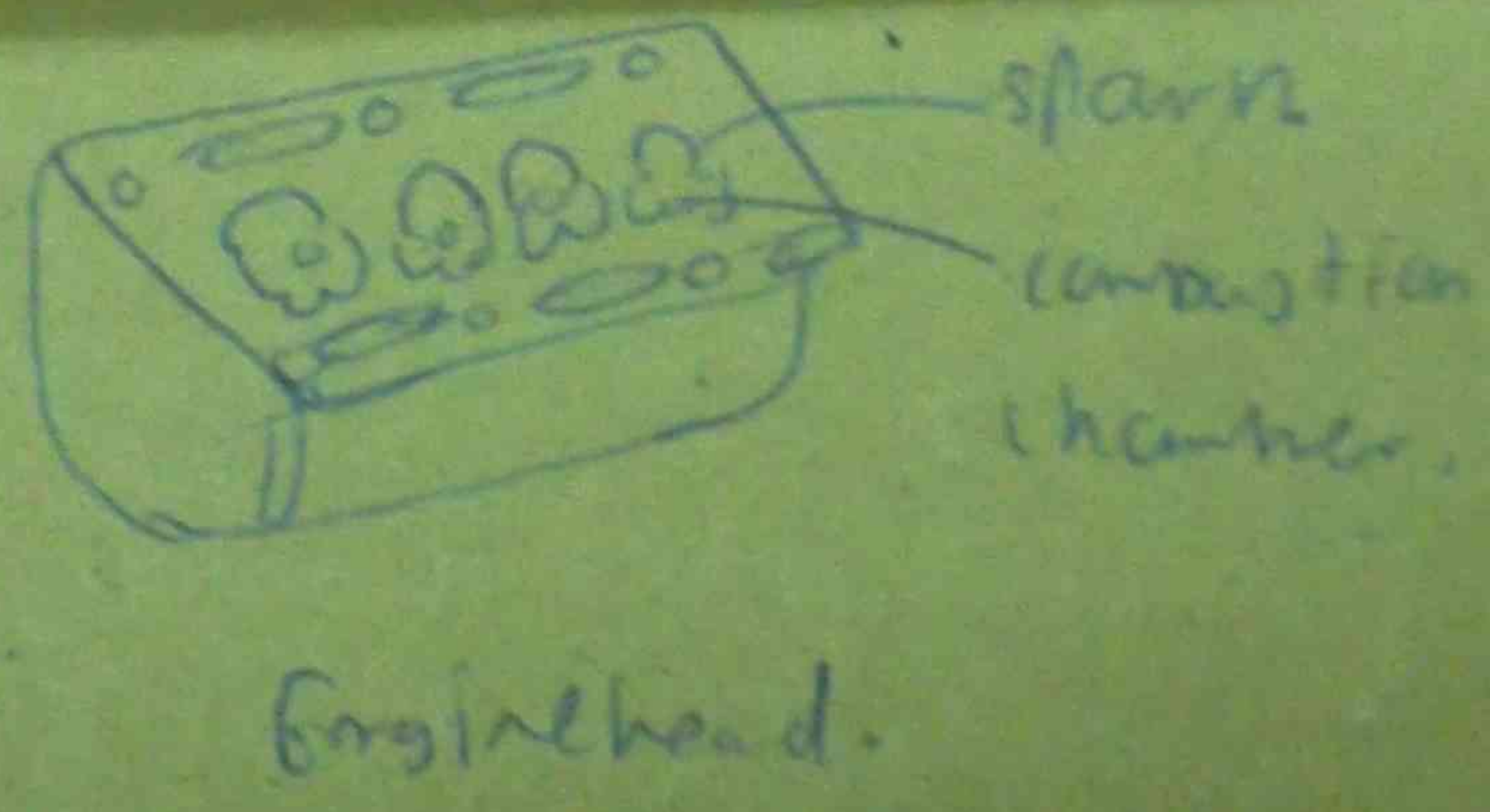
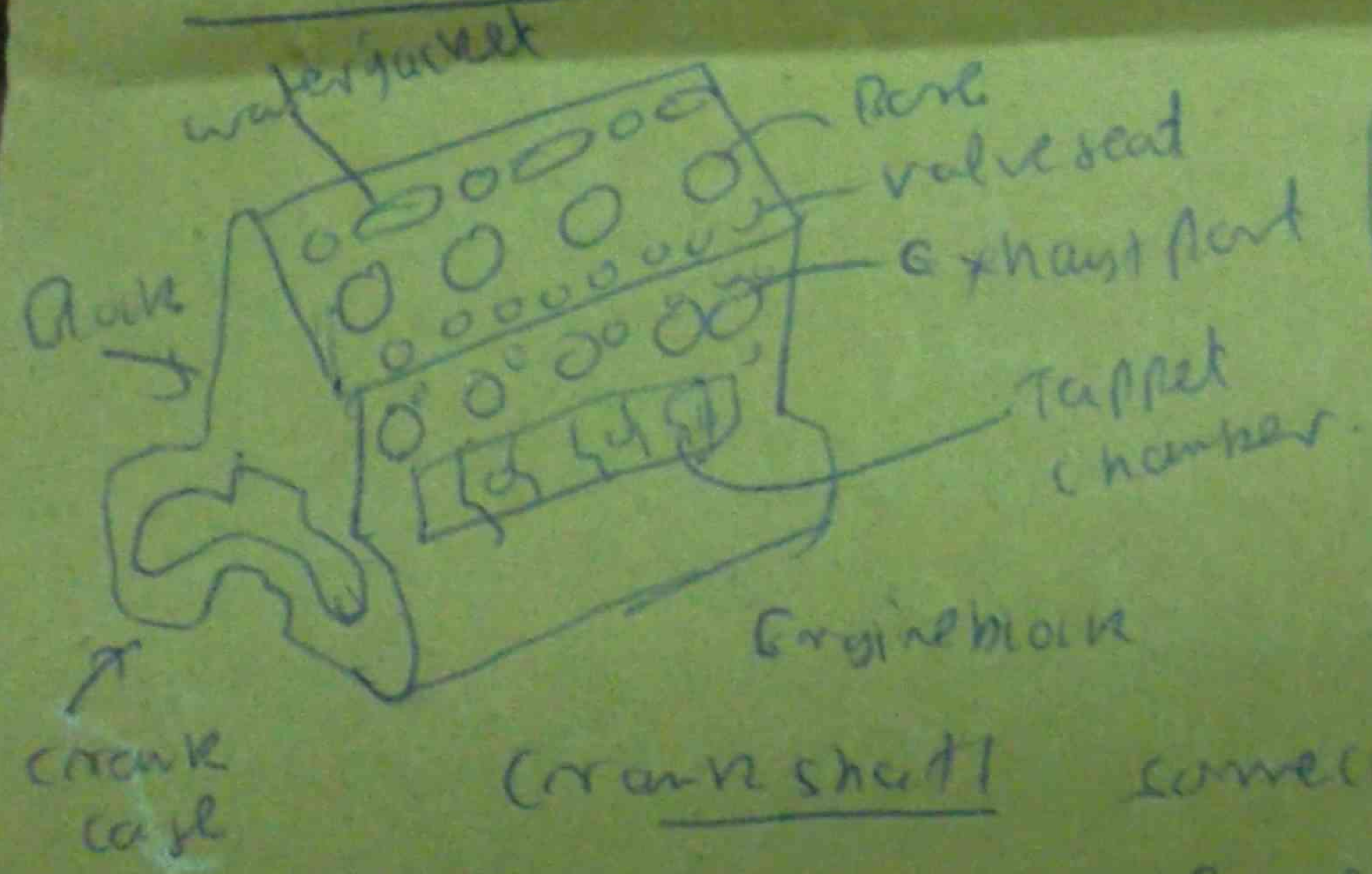
Parts & Components

Engine block, Head, crankshaft, camshaft, connecting rod, piston, piston ring, piston pin, valves, oil pan, manifold, engine bearing.

Engine block Grey cast iron, aluminium alloy cylinder bore, crankshaft, camshaft, bearing rod, Lubric, water jacket and oil.

Types V Type, radial, watercooled, side valve, head valve

Engine head Dark grey or white cast iron / aluminium alloy

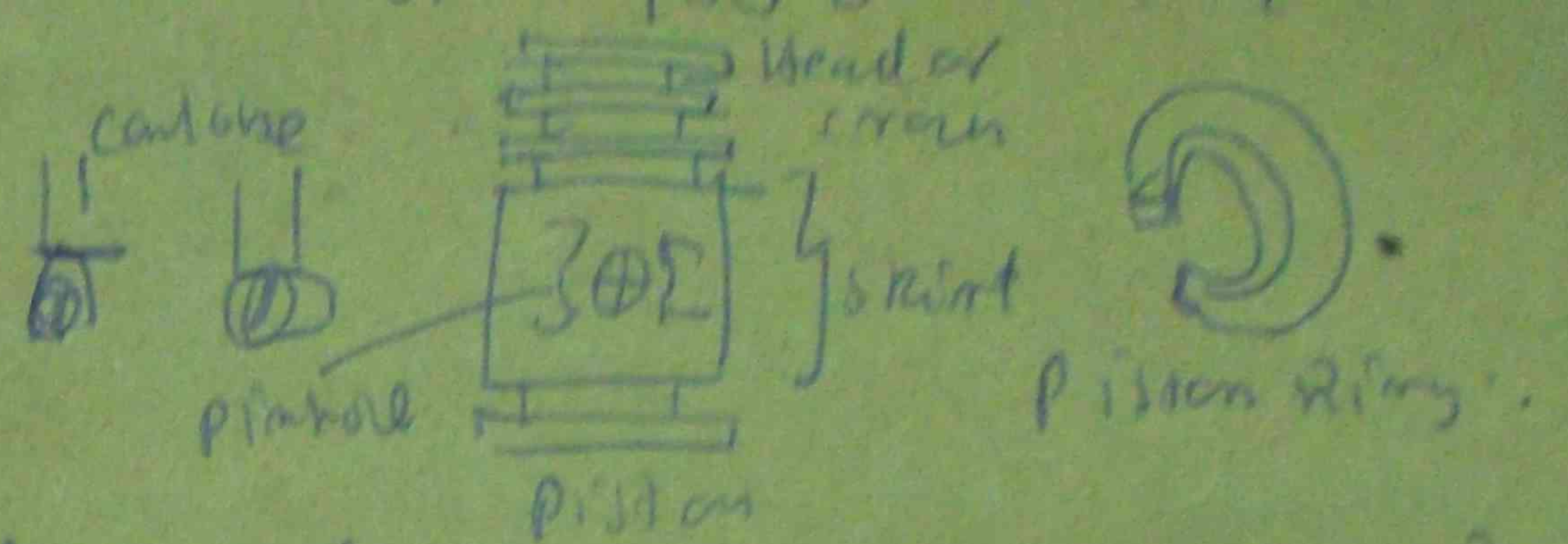
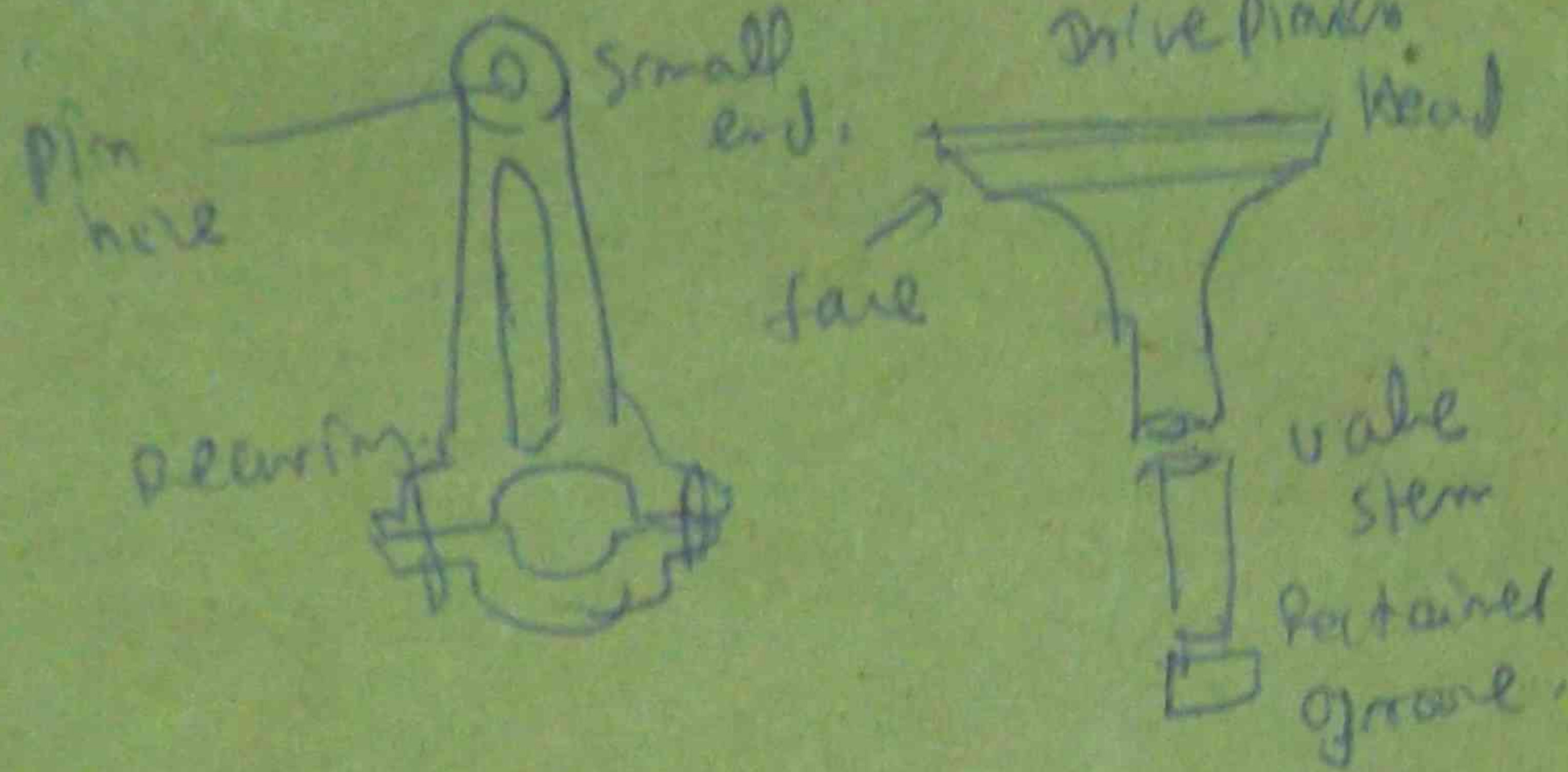
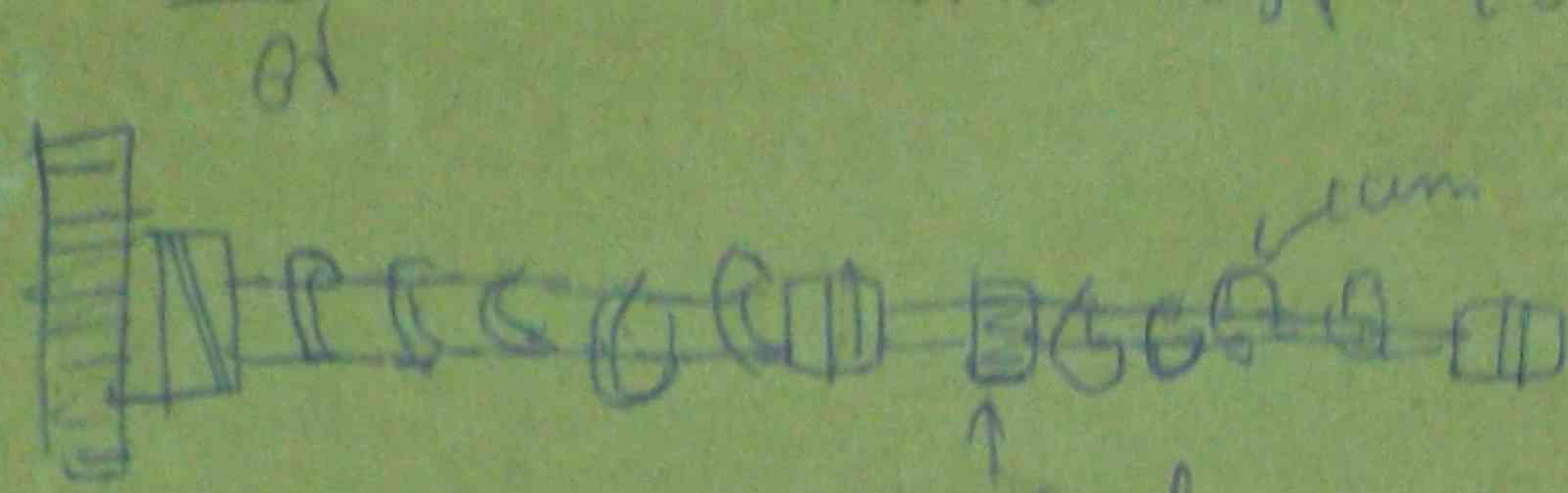


Crankshaft connecting rod & connecting rod pin

Cam shaft → Cam shaft drive, can be driven by gear, belt, or chain. 2 stroke oil crank, cam shaft of 4 stroke engine. 4 cycle engine.

Connecting rod piston, crankshaft & crank

Piston aluminium alloy / cast iron

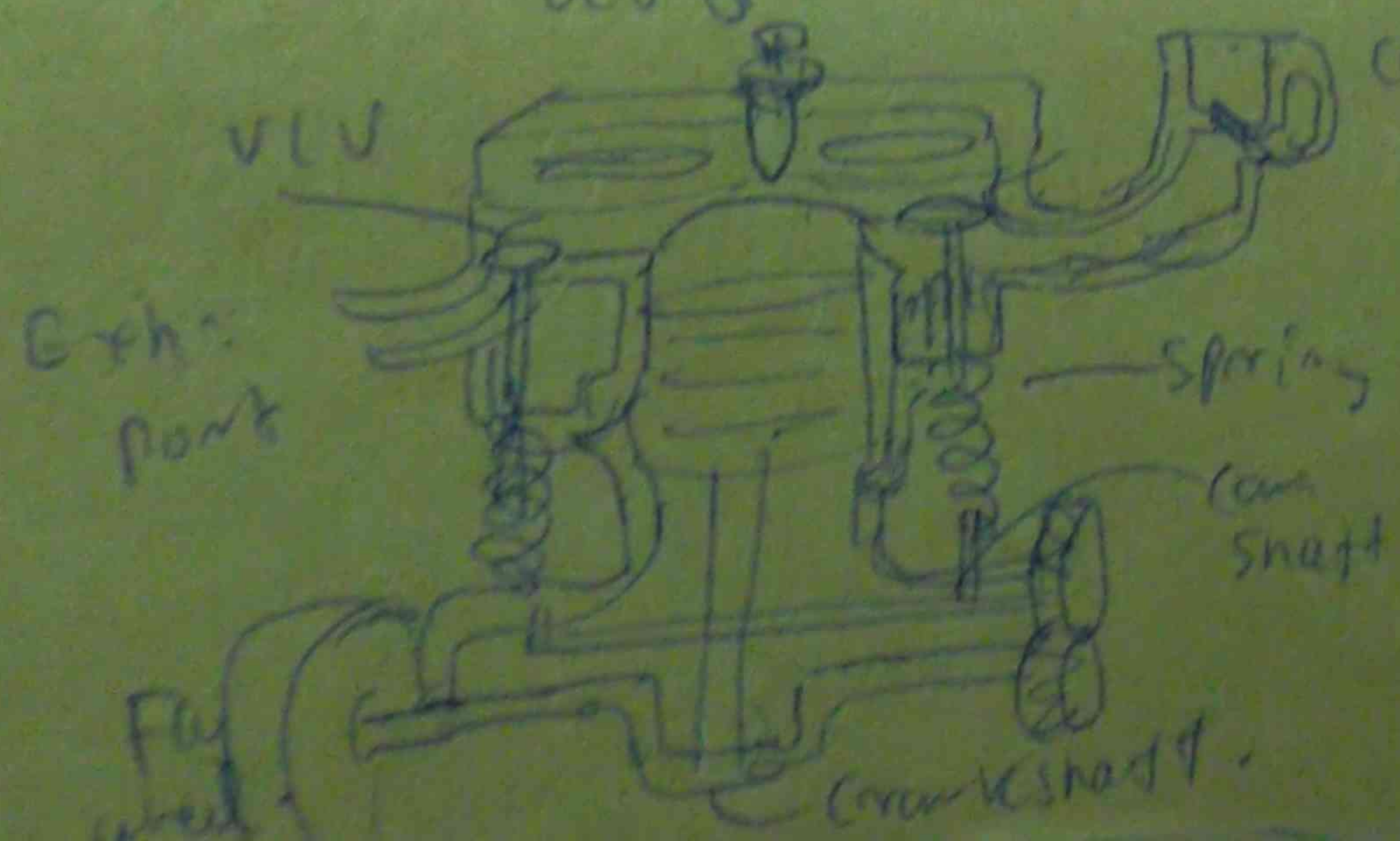


Piston ring cyl. 1.4. Piston 0.1-0.17
 2-4. Piston 0.1-0.17
 Cast iron, alloy steel
 Piston pin piston, connecting rod and
 Piston pin piston, connecting rod and

V/V - cyl. 0.1-0.17
 Can shaft - V/V 0.1-0.17

oil pan crank case 0.1-0.17
manifold carb. rod 0.1-0.17

Bearing 0.1-0.17
 and



Carburetor V/V mechanism
 Pallet type Tappet clearance 0.1-0.17
 Can shaft 0.1-0.17

Steno in over head vlv, VLV Timing
(more, over f. Diesel eng 97 @ 21)

Engine alignment

Battery, P. under an up use 21

Trouble shooting

petrol engine CHAPTER 21

oil 9-11

cooling system

Air cooling system

Air cooled engines are cooled by direct flow of air over the cylinder
surfaces and head. { motorcycles, scooter, airplanes }

Combustion 4000 F, High temp oil film breaks down.

Remove unwanted heat, maintain efficient temp.

Fresh air is supplied by fan or blower. Sometimes built in to engine design.

Air cooled engines are higher temp than other types.

moving parts not greater expansion.

Small engine big clearance, film, fan to force air. Stirred, aluminium.

Liquid cool system

to expose as large an area as possible
radiating surface by means of engine driven fan. and by farward motion of
vehicle. The heat is carried by air stream.
coolant circulated through head, block, cylinder, radiator.
It is controlled by T.C.V.

Parts list

radiator \rightarrow for cooling
water pump \rightarrow circulation
thermostat \rightarrow temperature control

pressure cap - pressurization

bypass VLV

fan \rightarrow air stream.

Jacket, \rightarrow Diesel engine G.O.

Radiator

To cool the coolant received from engine, made of Cu or
brass. It consists of inlet π , outlet π & core.

Two F.R. may be located at top & bottom of core.
overflow tube connected to filler pipe permits excess
coolant to escape. when ever excessive pressure built up.

Water P/P cooling system employs a centrifugal water P/P to
maintain circulation.

commonly used in G.E. G.O.

KN 415

(Metallurgy & Production Technology)

(G.T.I, m.T course)

CONTROL
INTEGRATED

Contents

Characteristics of Diesel Engines

Ac, Dc Generators for Diesel Drives

Voltage Regulation of Ac/Dc Generators

parallel operation

Engine Governor

Self operation of Diesel plant

Auto-control and alarm of Diesel Engines

Electric Starting of Diesel Engine

Starting and stopping generators and voltage regulators

Installation and maintenance of generators & voltage regulators.

CHAPTER (1)

CHARACTERISTICS OF DIESEL ENGINES

The high efficiency with which the Diesel Engine converts the heat energy of fuel into mechanical power (compression ignition engine). It becomes an accepted prime mover in the size range from $1\frac{1}{2}$ to 24000 HP.

Advantage of Diesel Engines used as prime mover

- ① High economy
- ② Economy at light load
- ③ Cheap fuel
- ④ Economy in small size
- ⑤ Use economy
- ⑥ Lightness and compactness
- ⑦ Quick starting
- ⑧ Fr.: in labour.
- ⑨ Freedom from misfired.

Application

- ① Small, medium size of electric stations (50000 kW)
- ② Stand by power for hydro electric stations
- ③ Emergency plants
- ④ Portable and floating power plants
- ⑤ Diesel electric propulsion for ships of small and moderate size
- ⑥ Auxiliary power & emergency power on ship board.

Emergency Plants

Prevent flooding of oil storage vaults during a power outage emergency.

Diesel Electric propulsion for ships

Extensive use for marine propulsion because they combine the fuel economy of diesel engine with light weight, saving in space, flexibility in operation, ease of control of electric transmission. Diesel engine is provided with an ordinary governor and runs a generator at constant speed. Diesel generating units are extensively used to supply ship's service and emergency power.

CHAPTER (I)

AC, DC Generators

AC generators are continuous rated also rise on armature with no over loaded capacity. 20% lag g. pf.

Generators classified as

- ① Engine type
- ② Flywheel type
- ③ coupled type
- ④ belt type.

Engine Type

- no shaft bearings or bed plate

- The stator is mounted on sole plates on the foundation

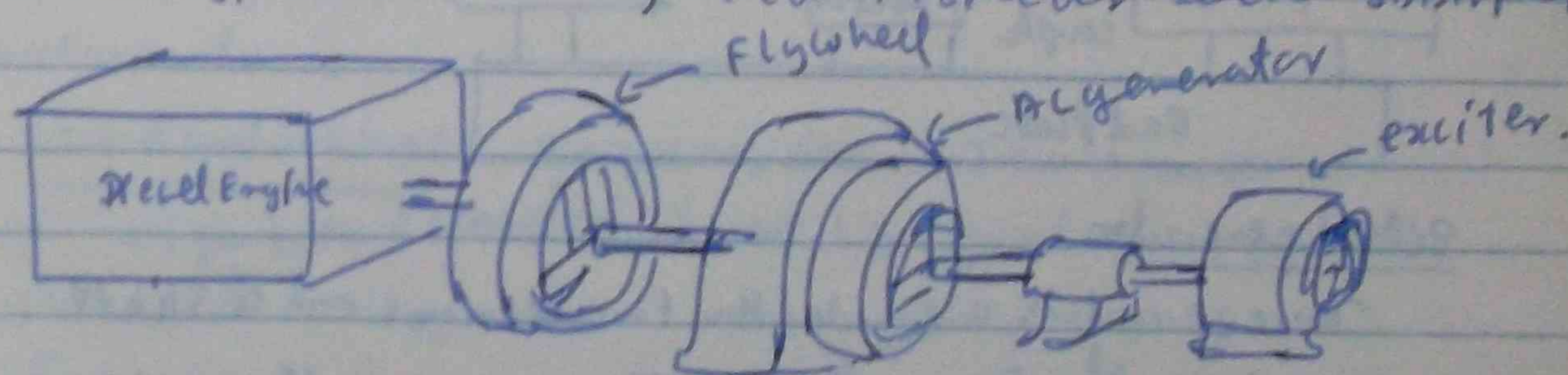
or on the engine bed plate.

- stator holds AC armature and rotor carries the DC field.

- The rotor is mounted on engine shaft or extension. Here it is as closely as possible to engine itself.

The bearings are furnished by engine builder.

This type is commonly used for speeds below 3000 rpm.



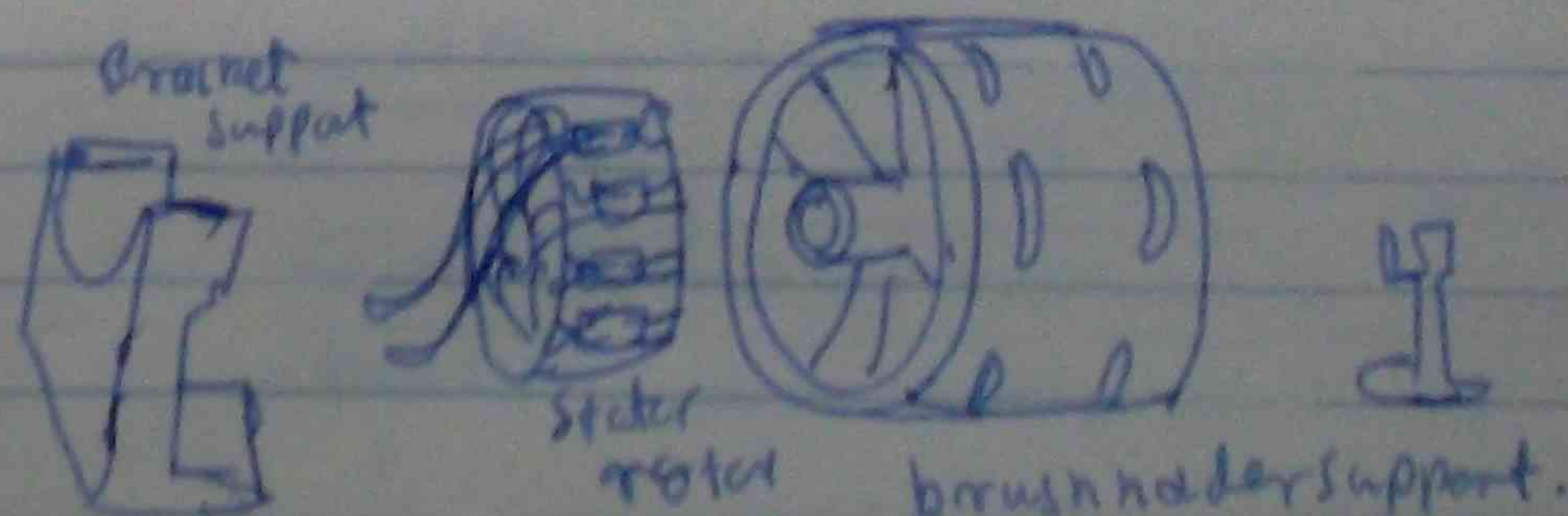
Diesel Driven Engine Type AC generator.

Flywheel Type

- consists of a rotor with a heavy external rim which surrounds and rotates around stator.

- rotor carries DC field, while AC wdg. are stationary

- applied when space is at premium



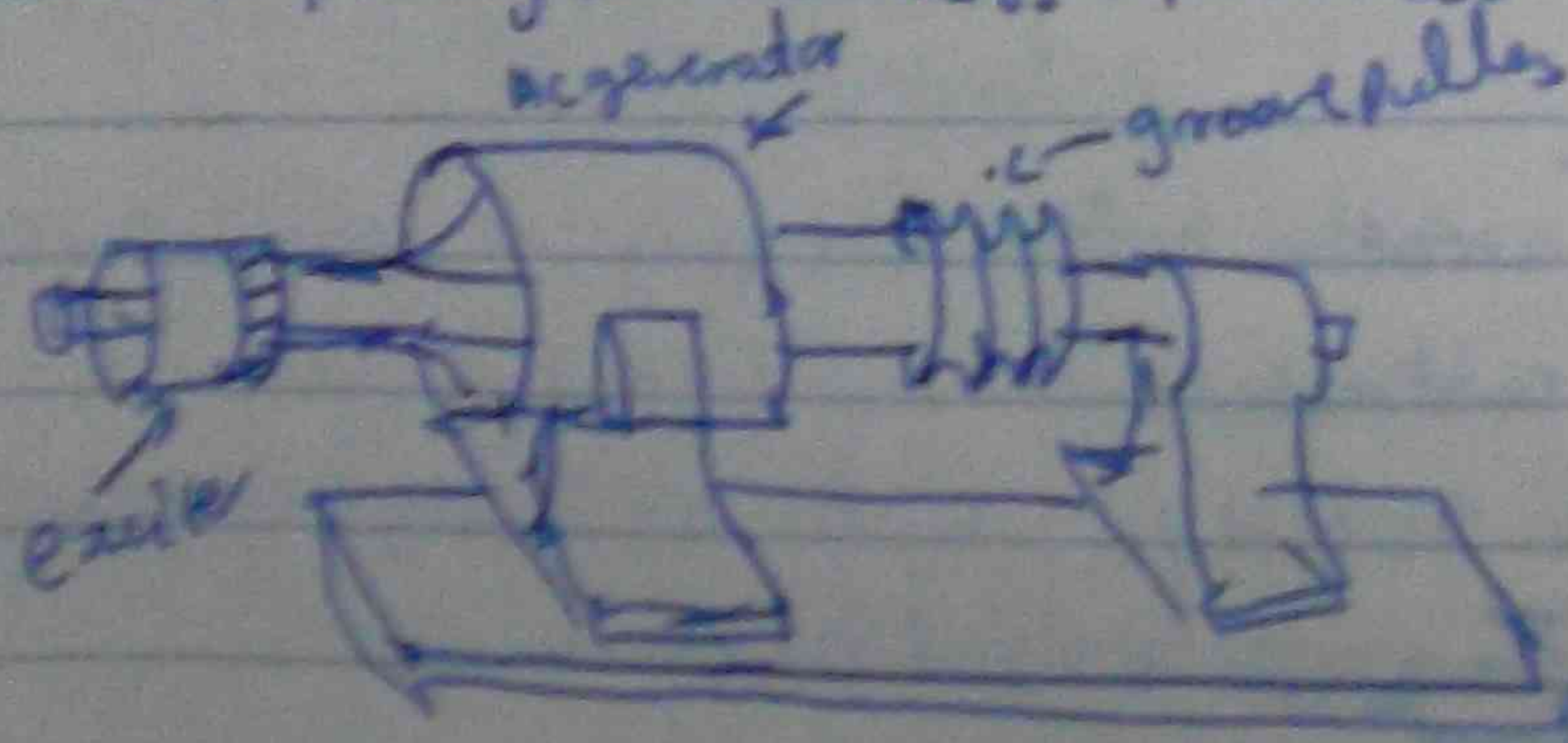
coupled type generators

The coupled type generator has a bed plate, shaft and bearings and usually a belt coupling on driving end as shown. The main units are compact and facilitate holding the bearings in line used for speed of 500 rpm or more.



Belted generator

These generators are made with two bearings and a shaft extension for pulley in small size. There are rails under bed plate and jacking device. Also often used with hydro generator.



Damper windings

- For diesel driven engine.
- need for // operation.
- consist of round bars of solid copper each pole are short circuited by connecting each bar to flat cast-iron.
- To prevent hunting (overrun of rotor & deviation from normal condition).
- Tending to hold rotor in its normal load position with armature.

Standard voltage 240, 480, 600, 2300, 2400

High speed (coupled type) generators 1200, 1500

Standard rating

Frequency 60 Hz, 25 Hz, 50 Hz

Speed $N = \frac{120f}{P}$

High speed AC generators

no. of poles	4	6	8	10	12	14
60 cycles speed	1800	1200	900	720	600	514

Engine Type AC generators

no. of poles	16	18	20	22	24	26	28	30	32	36
60 cycle speed	450	400	360	327	300	273	257	240	225	200
no. of poles	40	44	48	52	56	60	66	72	80	90
60 cycle speed	180	164	150	138	129	120	110	100	90	80

Exciter & Field Rheostats

The function of the exciter of an AC generator is to generate direct current for energizing the field poles of main generator. The voltage produced by an AC generator is controlled by varying the strength of its field magnetism, which in turn depends upon the amount of DC flowing through the excitation pole pieces.

When AC voltage is controlled by hand two rheostats are generally provided for regulating the exciting currents.

Small ones in field ckt. regulated the voltage of direct current generated by exciter and larger ones in the field circuit of alternating current generator which, for any given exciter voltage, will control the excitation current.

The current in field ckt. of exciter is much less than that in field ckt. of AC generator. For this reason most of regulation is done by varying the direct current voltage.

The usual plan is for each alternating current generator to have its individual exciter driven from main engine.

The exciter may be direct-driven in which case it is mounted at other end of main generator or it may be driven by V belt or chain from the engine crankshaft extension.

Slow speed diesel engine → the exciter at high speed can be used with (a) improve voltage regulation.

(b) occupy less space (3) cost less than direct connected exciter.

Belt driven are placed outboard bearing or stand above outside board bearing. (4) exciter or regulator mounted on generator.

In large diesel plants with many units excitation current is sometimes furnished by motor generator set.

Ventilation Small machines are usually constructed so that ventilating air is drawn in directly from room and after passing through the machine, is discharged back in to the room. On larger machines end of bells are enclosed and ventilating ducts are used to introduce and discharge the air.

Fans

Forced blower fans are attached to rotors of most generators to assist in forcing ventilating air through the machine. Some times inclined blades are used.

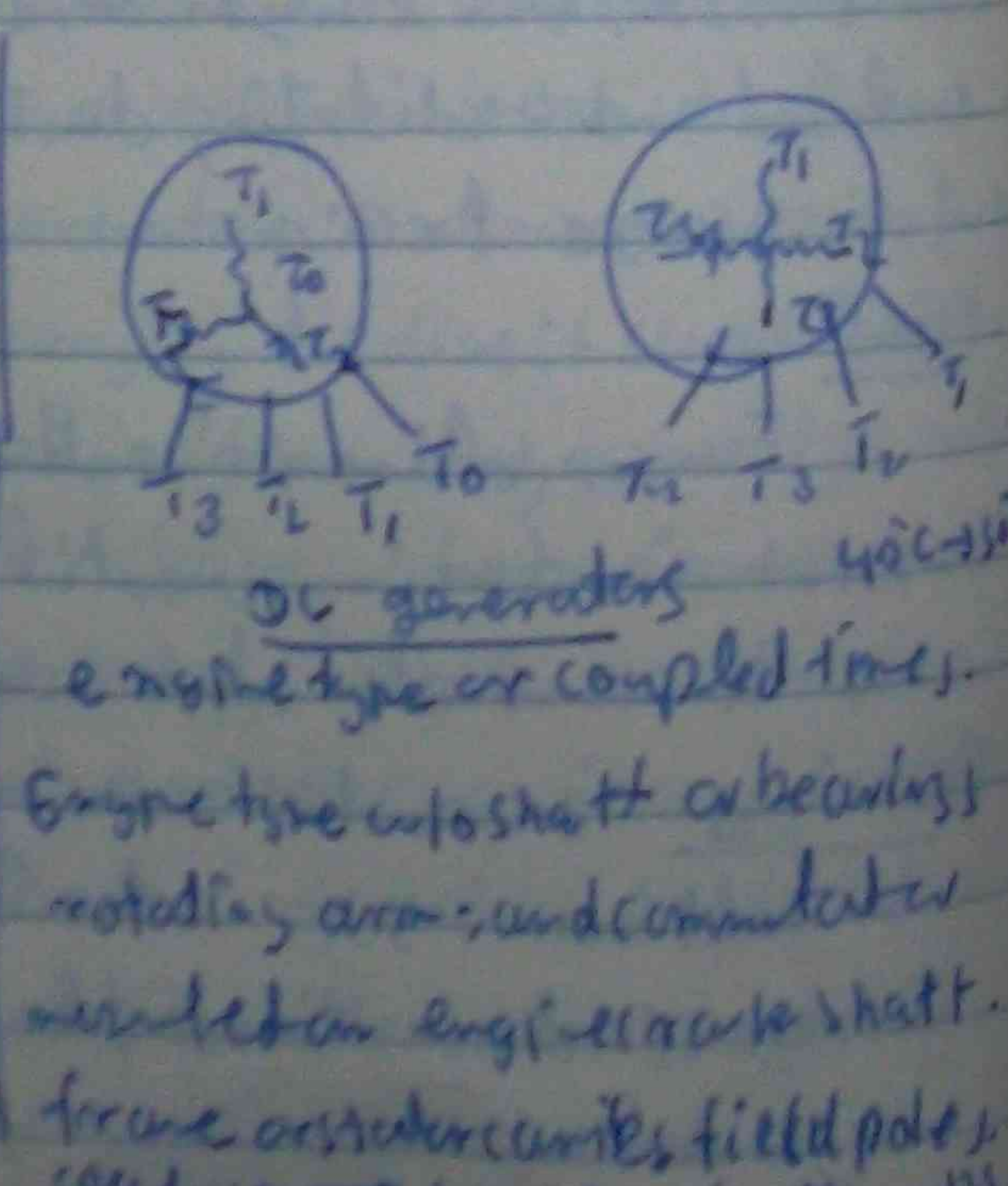
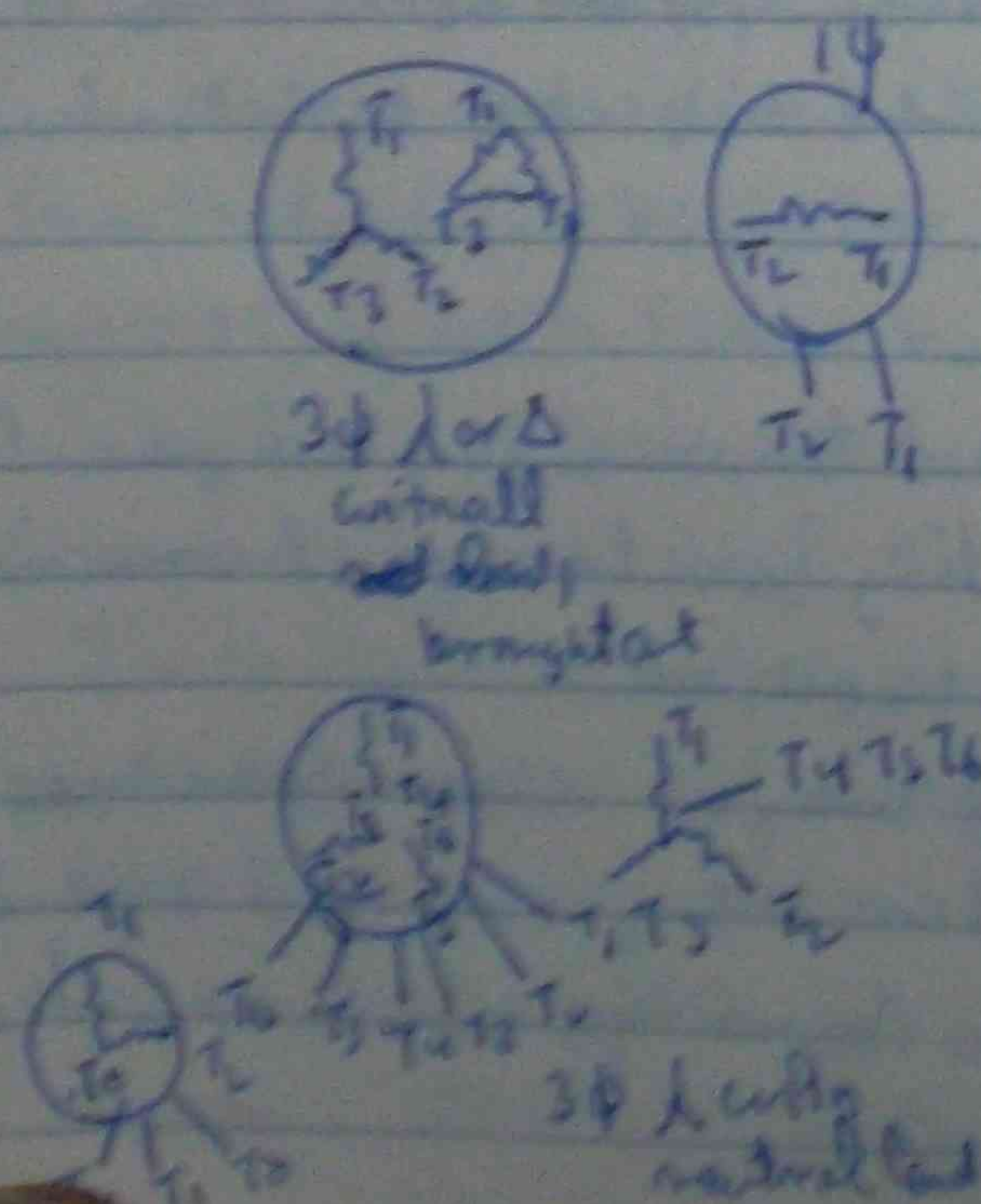
Bearings Generator bearings may be either sleeve type or ball bearings. The latter being confined generally to high speed machines. Sleeve bearings are lubricated by means of oil rings.

Insulated Pedestals

High variations in magnetic flux of AC machines may tend to set up a current through ckt: formed by shaft bearings & bed plate. If such current is allowed to flow it causes destructive effect on frame and bearings.

To avoid this trouble most pedestals are insulated from bed plate so as to prevent current flow of current. As method of insulating about $\frac{1}{16}$ " in thick is placed bet: bottom of pedestal and toe bed plate. and insulating tubes and washers are used ~~also~~ around the bolts and dowsels.

Load arrangement and Phase sequence



Speed 110 → 190 rpm - 60 Hz
coupled → 220 → 3600 rpm 125 V 1250

CHAPTER (III)

Voltage Regulation of DC/AC generators

DC Need for regulators

Good voltage regulation is not without external regulating device. The voltage regulation of DC generator and Diesel engine engine combination depends upon the speed regulation of engine or generator.

unless the engine is equipped with a governor, the speed at full load will be less than that at no load. Regulators are used to obtain constant voltage from generators reqd: to run in wide range of speed. such as generators connected to diesel driven compressors and pumps.

Another common application is the control of voltage impressed upon a storage battery that is being charged from variable voltage source.

When DC generators are operated in parallel, automatic voltage regulators offer further advantages in fault clearing and load equalization.

Automatic regulators make it unnecessary to use equalizer connections and switching gear for the

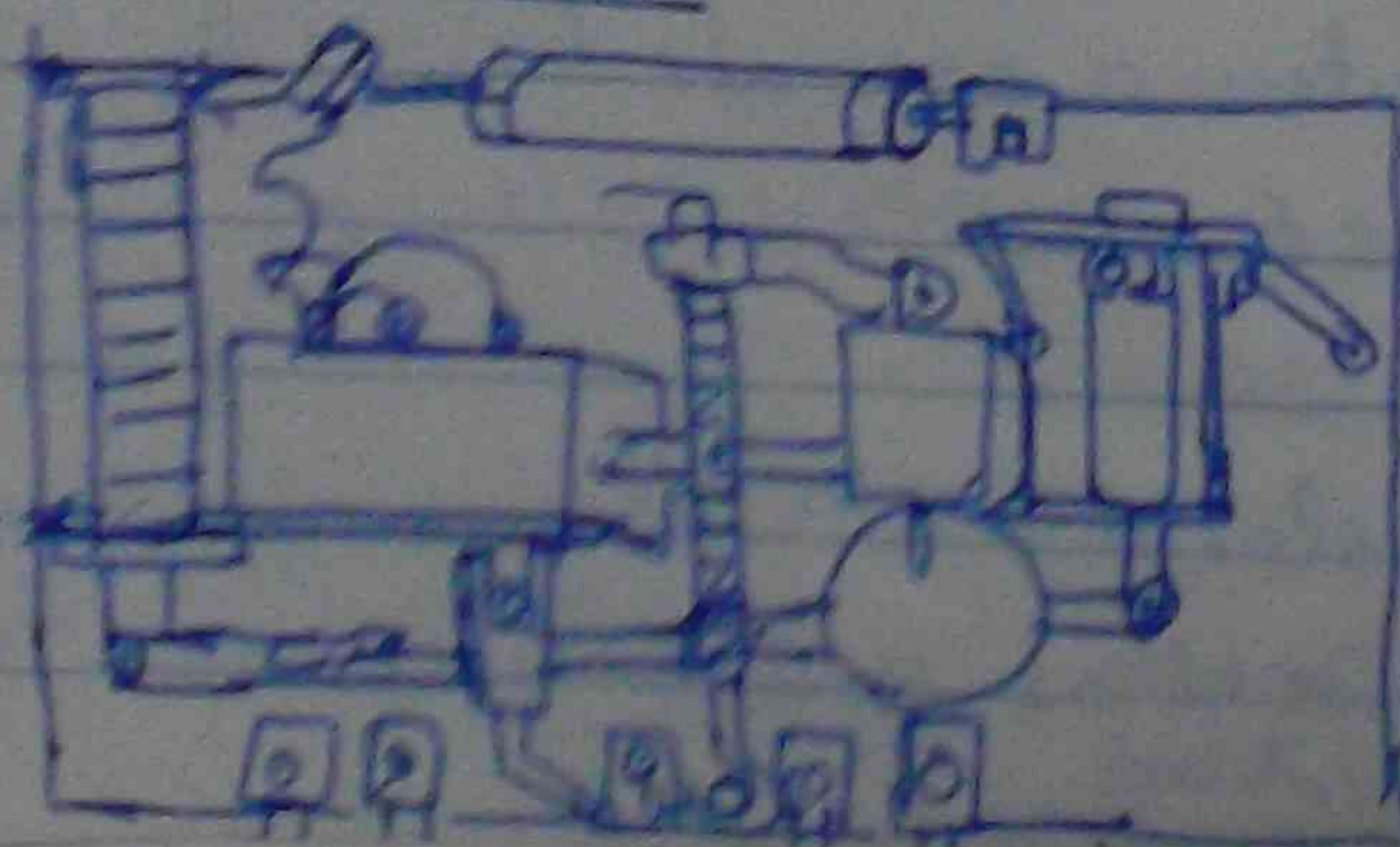
Carbon Pile - Automatic regulators make it feasible to use simple shunt wound machine.

Effect of sudden load changes

When a heavy increase in load is suddenly imposed upon ordinary compound wound gen., the magnetic lag of field poles prevents the series field building up its strength fast enough to offset the increased voltage drop at generator terminals. Also, the shunt field is weakened by reduced voltage applied to it. Consequently a momentary dip in voltage takes place until stronger series field becomes effective.

Auto. regulator tends to reduce voltage dips caused by sudden heavy load. When voltage starts to fall, the regulator applies max. field current. This over-excites the generator for short time until its normal voltage is restored.

Carbon Pile regulator



- used for regulating generator voltage.
- consists of carbon resistors.
- lever mechanism varies the pressure on carbon

pile and thus adjusts its resistance.

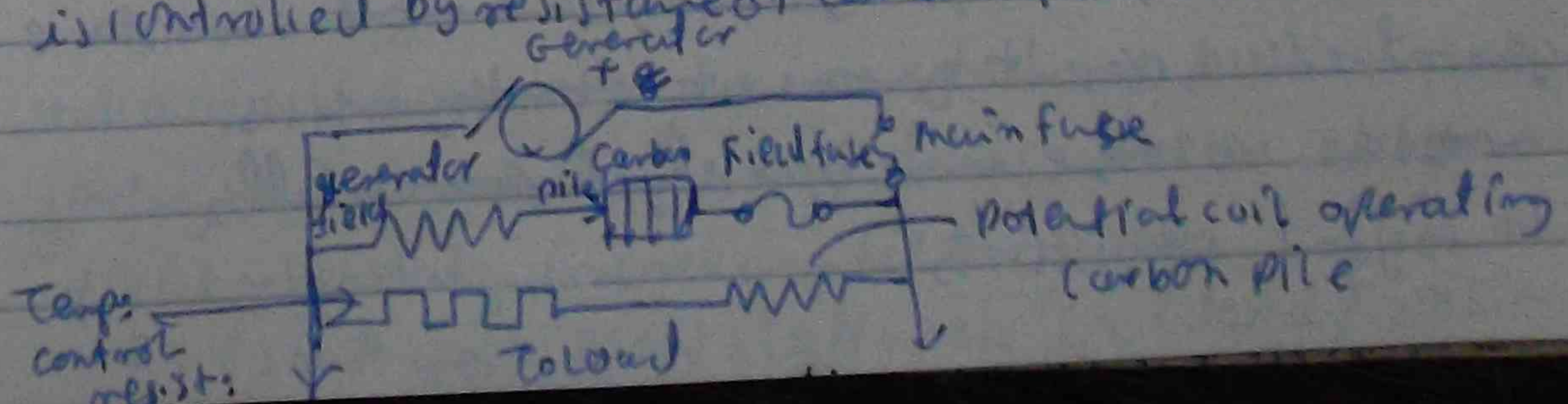
The pressure on the piles or disks depends upon the pull exerted by solenoid.

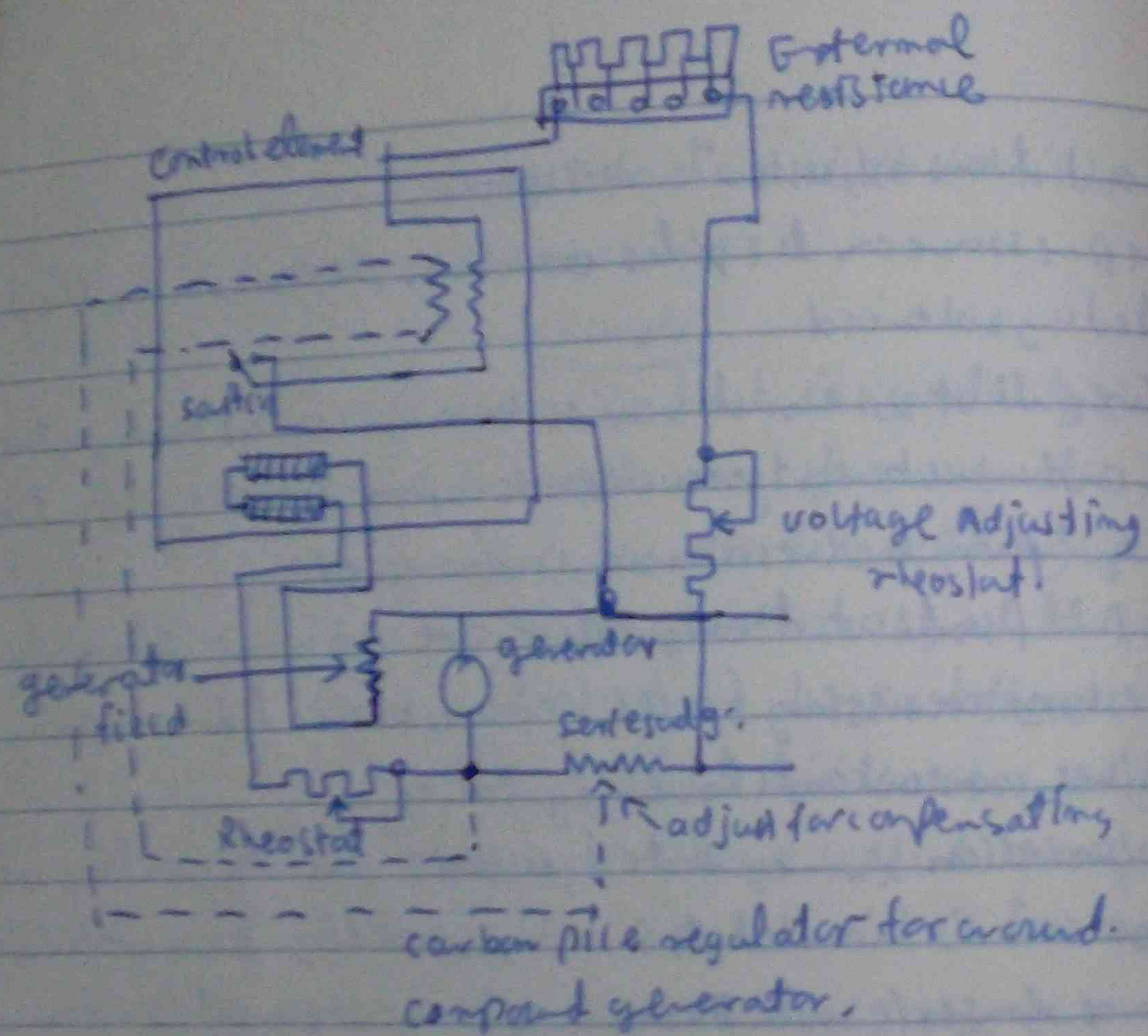
The pull of solenoid varies through current through the coil and which in turn depends upon the voltage of the circuit to which the solenoid is connected.

All parts of the regulator are mechanically balanced the necessary resisting forces being obtained from springs. This gives constant and close regulation.

Variation in regulated voltage due to heating of voltage coil is limited to 5% by inserting zero coefficient resistance in series with the coil. closer compensation can be had when necessary. Adjustment is provided so that any desired voltage may be obtained within the limit of regulator.

The generator in this case is controlled to give the proper voltage throughout changing speeds & load by amount of current supplied to shunt field and field current is controlled by resistance of carbon pile in series with field.





Vibrating Type regulator

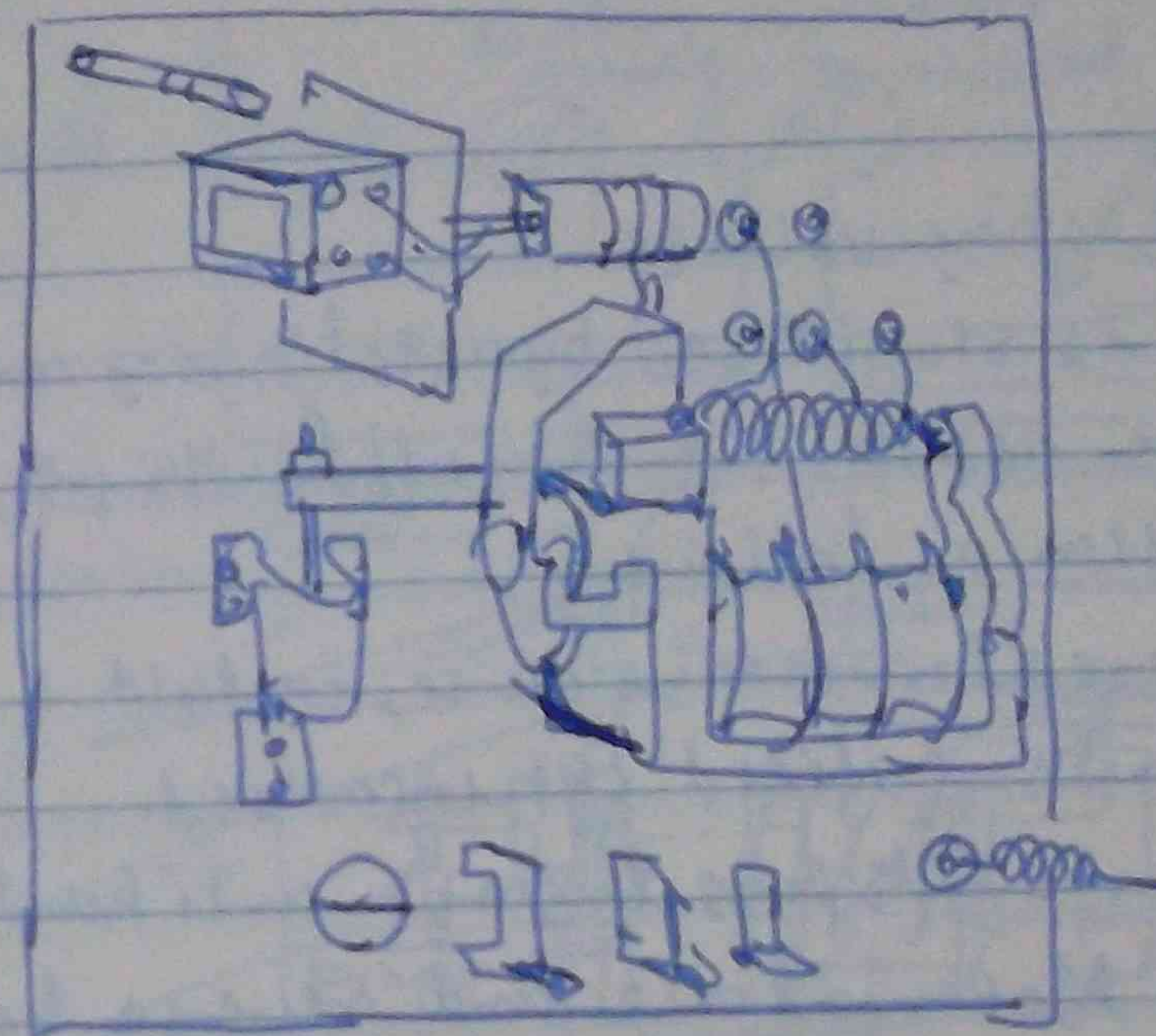
- used for supplying lighting and power load where power loads is subject to sudden changes and.

They operate on the principle that when a regulating resistor is short circuited, a large voltage is available to bring the existing current quickly to desired value.

The action consists of rapidly cutting in and out a resistance in generator field circuit by means of vibrating contacts.

- restore voltage more quickly & powerfully.

It has good sensitivity.



vibrating regulator

Operating without relay

It consists of stationary main and an auxiliary coil. a moving coil which is directly connected to centre shunt contact and two stationary contacts.

The magnetic circuit consists of a soft iron casting, the core of the stationary coils extending in to moving coil which is wound on non magnetic spool. A spring closes the right and centre contacts and pull of moving coil separate them. The right and center contacts shunt the field rheostat and on application requiring wider range.

- Fall in generator voltage the attraction of the stationary and moving coils is weakened and as upon the spring closes contacts C_1 and D is shorted. The main field rheostat, increasing field current.

R_3 (shunt gen. field itself when C_2 closed) by rising voltage.

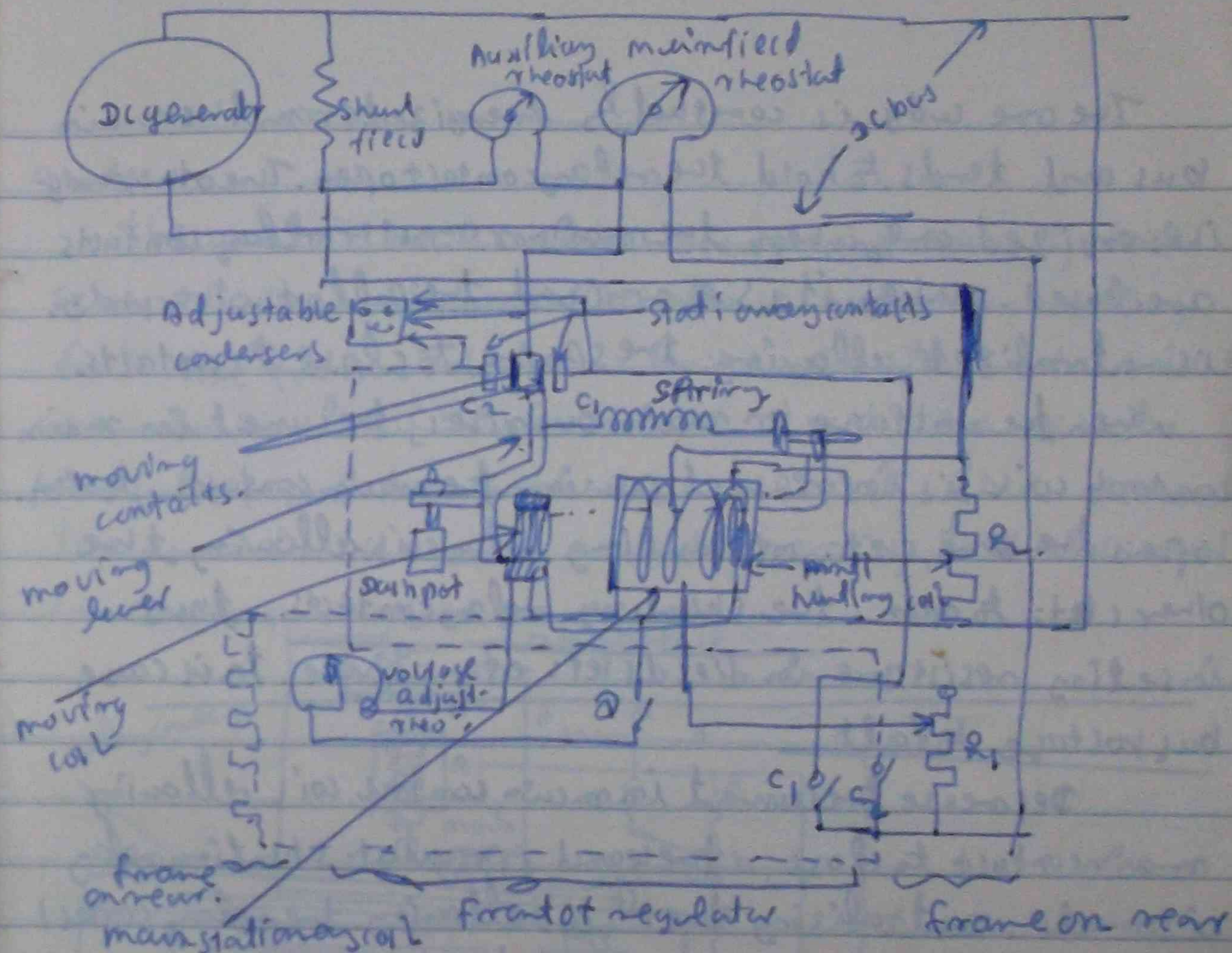
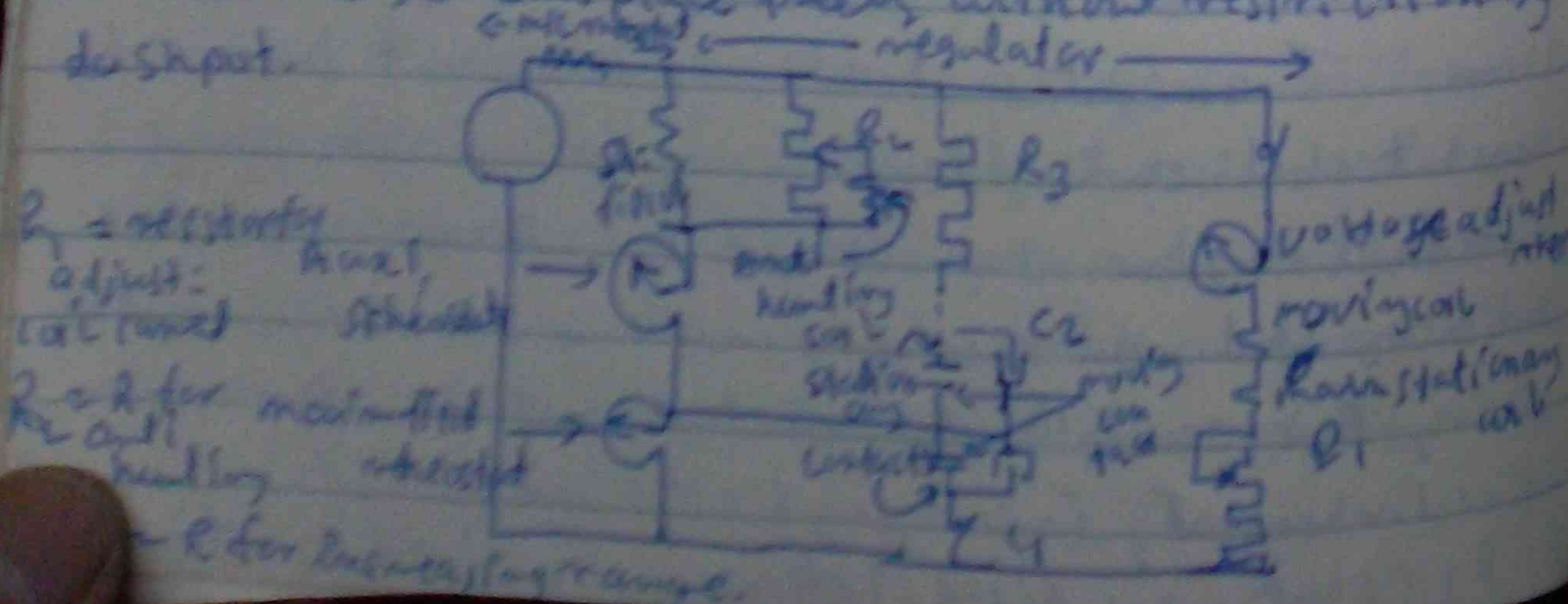
$R_1 \rightarrow$ used for adjusting voltage.

The regulator is stabilized by a stationary anti hunting coil and adjustable resistor which are // with gen. shunt field. Their action as follows -

- when a decrease in voltage causes contact 1 to close
- current through shunt field ckt increased.
- causing more current to pass through anti hunting coil.
- This causes C_1 to open at once and reverse the action, so that continuous rapid vibration is produced.

(similar to bell buzzer). This action gives the field rheostat what is termed effective resistance, and this in turn determines the generated voltage. condensers are used across shunting contacts to prevent sparking.

liquid dash dashpot is connected to end of lower arm by helical spring. The spring permits normal oscillations to take place freely without restriction by dashpot.



Relay Type voltage regulator

is used for large size $\&$ for controlling // $\&$ gen. from single regulator. secondary shunting relays for gen. field rheostat. 3 shunting relays can be controlled by contacts of main control element.

control element winding energized from the main bus. The shunting relay has 2 coils and each coil has two ends. The polarity of one end is bucking to that of other.

The one wdg: is constantly energized from the main bus and tends to hold the relay contact open. The other wdg: is energized only when the main or master relay contacts are closed. When it is energized the pull or other wdg: is neutralized allowing the spring to close the contacts.

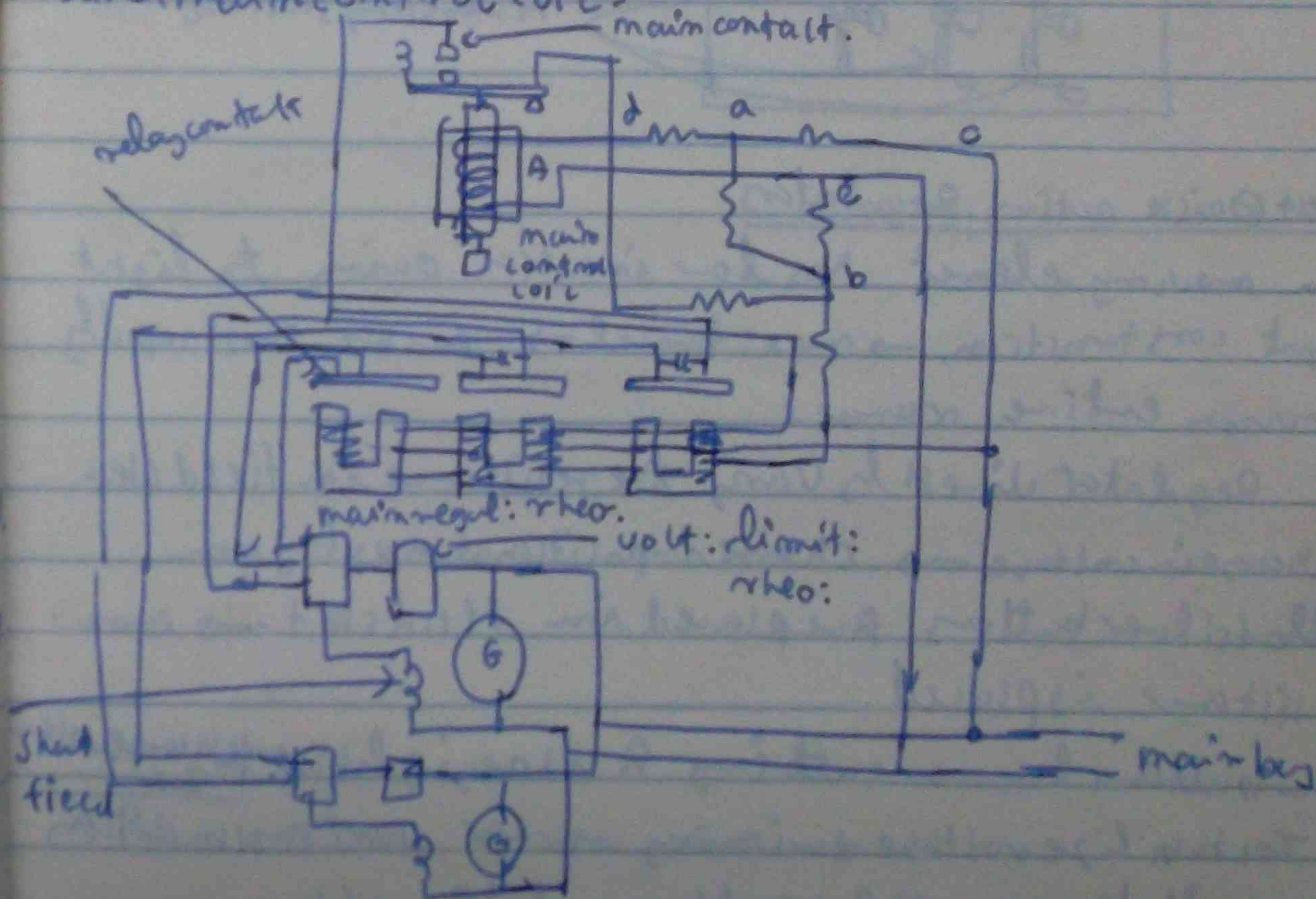
When the voltage on main bus rises, the current in main control coil is increased, causing the main contacts to open the one ckt: of shunting relay coil allowing the other ckt: to open the shunting relay contacts. Thus increasing resistance in field ckt: of machine. This causes bus voltage to fall.

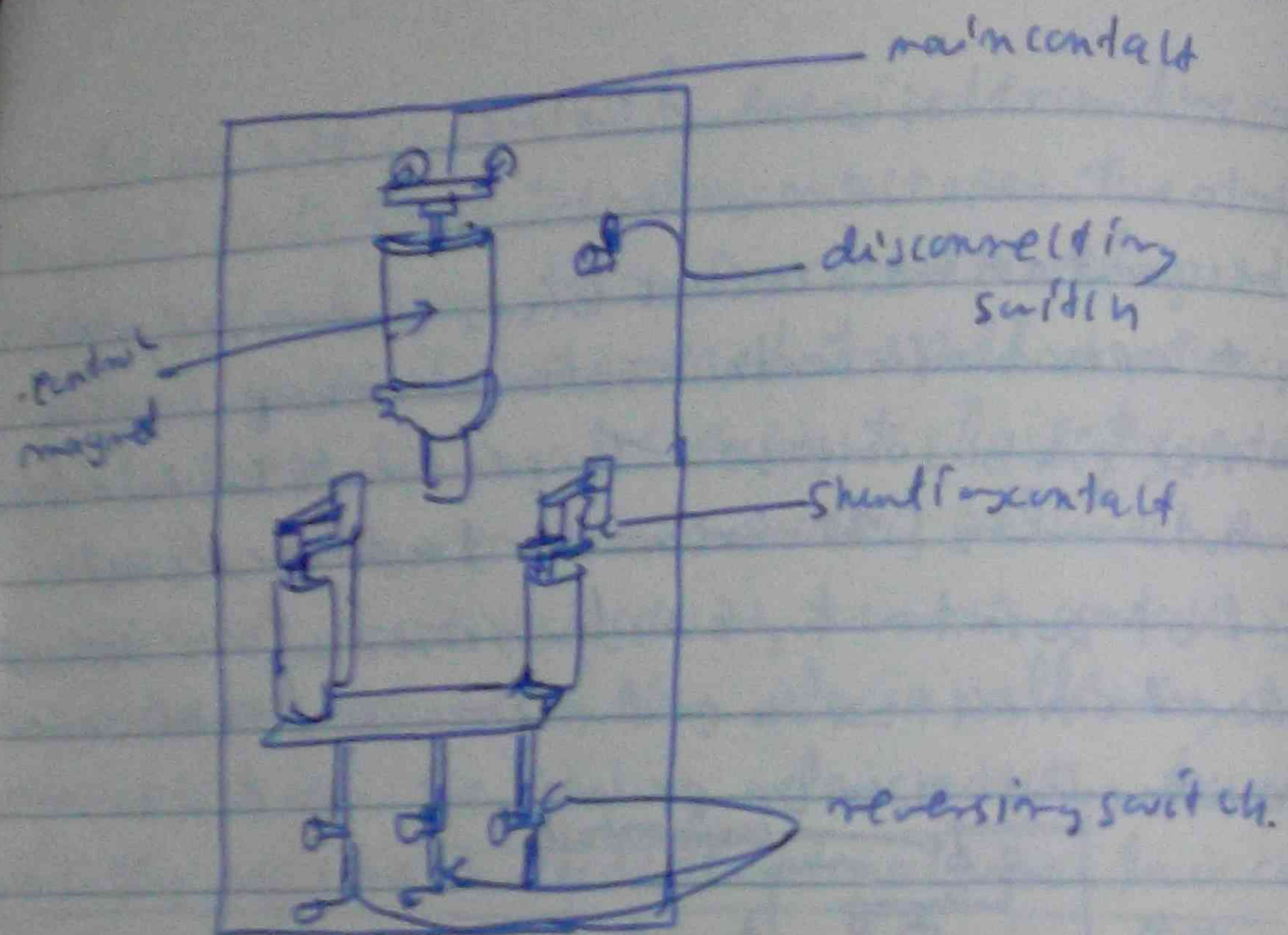
Decrease because of increase in main control coil allowing main contact to close, the second circuit of shunting relay is made neutralizing the 1st and allowing the relay contact to close. This short ckt: the field rheostat which raises the bus voltage. The cycle is repeated. The cycle is repeated. The purpose of this connection is to speed up the action by causing the main contacts to operate even before the regular has had time to go through the whole cycle of voltage regulation just described.

This is accomplished by resistor bet: points a and b. The resistances between points. The resistances bet: c-a-b are so proportioned just described. When the main contacts close and the ckt: of shunting relay is

made.

The current in main control coil is increased, which tends to open main contact at once without waiting for a rise in bus voltage. This is due to the fact that when both relay ckt: are made. The difference bet: potential of point a and b is decreased, thus decreasing the current in ckt: a-b and increasing the current in main control coil.





Direct acting regulators

- moving element has low inertia owing to light weight construction. \rightarrow max. travel \rightarrow enable most rapidly traverse entire range.

Regulator directly varies the resistance in field circuit \rightarrow change in position of moving arm
- all other buttons are placed in field circuit \rightarrow max. resistance is placed.

- button loss \rightarrow nothing & is negligible. $\frac{1}{2}$ change in R
To stabilize voltage swimming under various conditions of excitation change & result regulating effect is

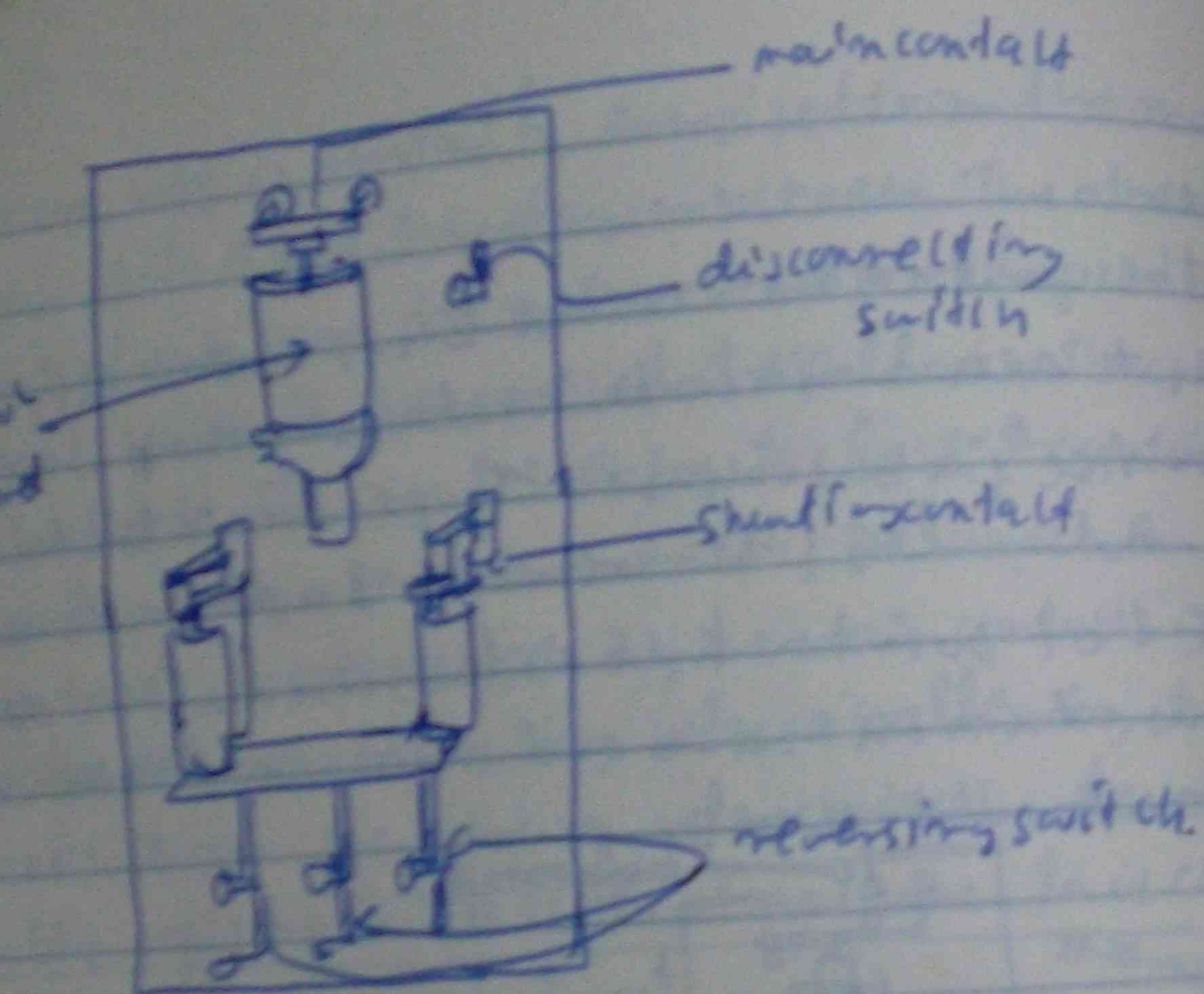
Flight

Test steady \rightarrow no effect.

Testing of materials

Extraction metallurgy

way of separation of impurities from metal
Impurities are separated from metal



at quick acting regulators

- moving element has low inertia owing to light construction. \rightarrow max. travel \rightarrow enable most rapidly across entire range.

Regulator directly vary the resistance in field circuit \rightarrow change in position of moving arm. All silver buttons are placed in field circuit \rightarrow max. resistance is placed.

- buttons loose withing & disengagible. $\frac{114 \text{ mV}}{2.2}$
To obtain 120 voltage during running under various conditions
at excitation change & result

Flight

instead of no effect.

Testing of materials

Extraction Metallurgy

way of extraction of metal from its ore. Topurification of metal.

Physical Metallurgy (3rd year metallurgy)

Heat treatment
 Mechanical properties
 Corrosion
 Metallurgical defects
 Rolling, casting, forging, extrusion, powder metallurgy

Physical Metallurgy

Structure

Metal strength

Corrosion

Phase

Heat

Metallurgical defects

Rolling

Met

Met

Testing of materials

Physical properties of materials

① Mechanical properties

② Physical properties

③ Chemical properties

④ Electrical properties

⑤ Thermal properties

⑥ Mechanical properties of materials

⑦ Physical properties of materials

⑧ Chemical properties of materials

metal, alloy, ceramic, polymer, composite

Chemical Test - For element & compound

metallurgical Test - Internal structure of metal

Physical properties of materials

Mechanical Test - mechanical properties (hardness)

Toughness, ductility, elasticity

Plasticity, malleability, brittleness

(Chemical Test)

Quantitative spectroscopy or crystalline structure

or spectrum of metal and compound

or composition of materials

Introduction

The purpose of this study is to investigate the effect of the concentration of the solution on the rate of the reaction. The reaction is the decomposition of hydrogen peroxide into water and oxygen gas. The rate of the reaction is measured by the volume of oxygen gas produced over a period of time.

Materials and Methods

The materials used in this experiment are hydrogen peroxide solution, potassium iodide solution, and a catalyst. The method involves measuring the volume of oxygen gas produced over a period of time for different concentrations of hydrogen peroxide solution.

Results and Discussion

The results show that the rate of the reaction increases with the concentration of the hydrogen peroxide solution. This is because there are more reactant molecules available to undergo the reaction.

concentration of the solution. The rate of the reaction is measured by the volume of oxygen gas produced over a period of time. The results show that the rate of the reaction increases with the concentration of the hydrogen peroxide solution.

Conclusion

The conclusion of this study is that the rate of the reaction increases with the concentration of the hydrogen peroxide solution. This is because there are more reactant molecules available to undergo the reaction.

The rate of the reaction is measured by the volume of oxygen gas produced over a period of time. The results show that the rate of the reaction increases with the concentration of the hydrogen peroxide solution.

References

1. Chemistry: Principles and Reactions, 6th Edition, by R.C. Weast, CRC Press, 1974.
2. General Chemistry, 5th Edition, by D.C. Tietz, McGraw-Hill, 1974.

9

ultra sonic testing
radiation of defect of p & d
ultra sonic vibration of p & d
wave generated in p & d
coverage of p & d

Surface Inspection

ultra sonic testing
radiation of defect of p & d
ultra sonic vibration of p & d
wave generated in p & d
coverage of p & d

Fluorescent Penetrant Method

casting, drying, etc. etc. etc.
ultra violet light source
fluorescent powder
etc. etc. etc.

6

ultra sonic Testing

radiation of defect of p & d
ultra sonic vibration of p & d
wave generated in p & d
coverage of p & d

magnetic particle detection

ultra sonic testing
radiation of defect of p & d
ultra sonic vibration of p & d
wave generated in p & d
coverage of p & d

Fluorescent Penetrant Method

casting, drying, etc. etc. etc.
ultra violet light source
fluorescent powder
etc. etc. etc.

New Test

on oxide hardness, impact, resilience
compression fatigue test and

Revealing recrystallization (5th year met.)

Industrial Shaping Machine

metallography, microscopy, metallography
metallography

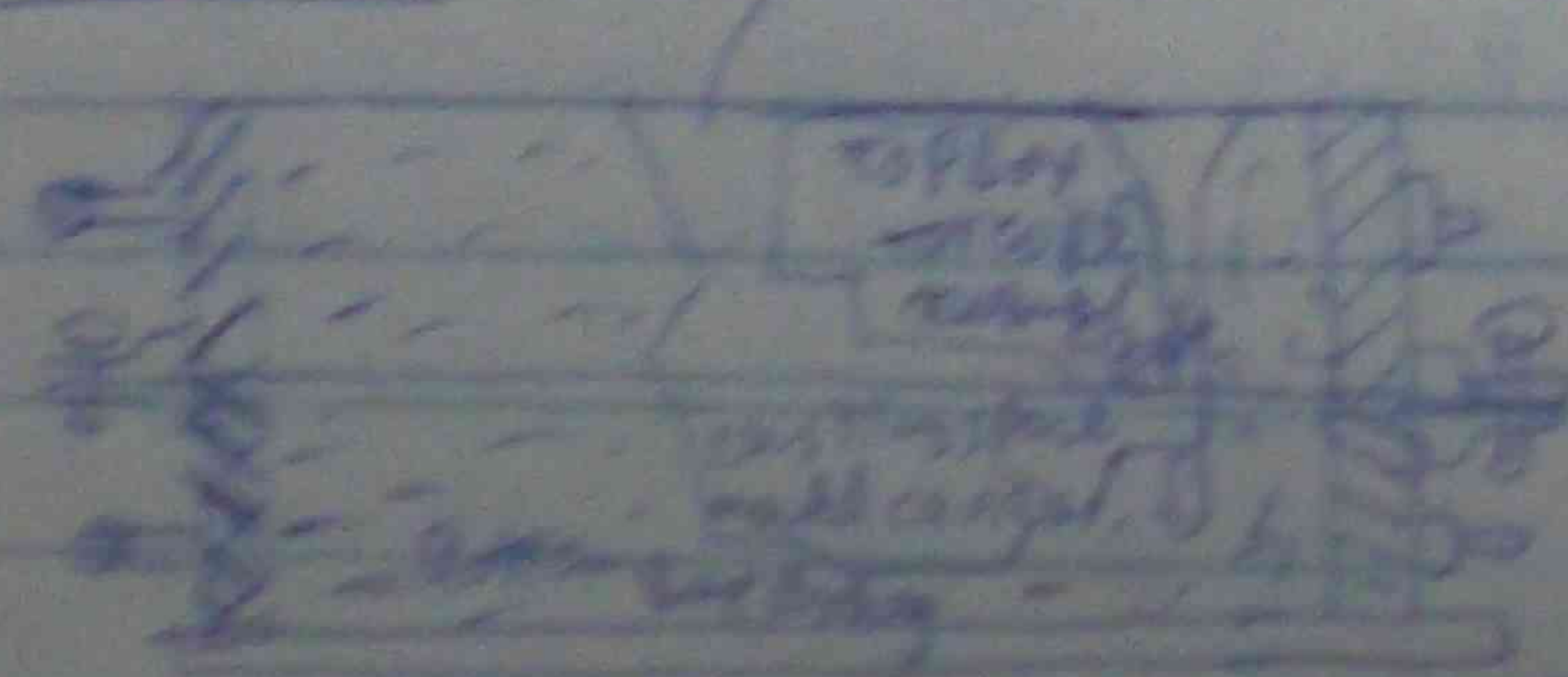
casting process mechanical working process of

metal

casting process

metal or alloy of liquid metal in mold and solidified in shape

Sand casting



of metal in liquid state is cast into shape of solid metal or liquid metal is cast into shape of solid metal

for casting of metal in liquid state, pattern is used to make the shape of solid metal or liquid metal is cast into shape of solid metal

the pattern is used to make the shape of solid metal or liquid metal is cast into shape of solid metal

of metal in liquid state is cast into shape of solid metal or liquid metal is cast into shape of solid metal

the pattern is used to make the shape of solid metal or liquid metal is cast into shape of solid metal

2. casting

Gravity Cast (mg)

[illegible]

pressure casting

casting sand of 1000 to 1500 grains
metal 2000: liquid metal of 1000 grains
and weight 1000: 1000 grains of 1000 grains of 1000 grains
of 1000: mechanically, hydraulically, pneumatically
of 1000: 1000 grains of 1000 grains of 1000 grains
of 1000: 1000 grains of 1000 grains of 1000 grains
of 1000: 1000 grains of 1000 grains of 1000 grains

Disorder: amphetamine psychosis
2nd. best. liquid ketamine, 100 mg over 20
and 100 mg 15 min.

Centrifugal casting

design - mould of good material, rigid
 mass, 1100 x 1000 x 100 mm. It is made of
 cast iron or steel. It is fixed on a base
 of centrifugal force (0.2 to 0.3) and is fixed
 on a base of 1100 x 1000 x 100 mm.

Defects

Primary defects are those which are caused by the nature of the metal or the conditions of the furnace. They are not caused by the pouring process.

Hot metal poured into a mold at a slow rate will cause a slow pouring of the liquid metal. This will cause a high level of turbulence in the mold. This turbulence will cause a high level of oxidation of the metal. This oxidation will cause a high level of porosity in the metal.

Secondary pipe cavity

Secondary pipe cavity is a defect which is caused by the nature of the metal or the conditions of the furnace. It is not caused by the pouring process.

Loose center

Loose center is a defect which is caused by the nature of the metal or the conditions of the furnace. It is not caused by the pouring process.

Defects due to dissolved gases

Shrinkage holes

Shrinkage holes are caused by the contraction of the metal as it cools. They are not caused by the pouring process.

Deep seated blow hole

Deep seated blow holes are caused by the presence of gas in the metal. They are not caused by the pouring process.

Rolling blow holes are caused by the presence of gas in the metal. They are not caused by the pouring process.

Defects due to pouring condition

Cold lap

Cold lap is a defect which is caused by the pouring condition. It is not caused by the nature of the metal or the conditions of the furnace.

(2) Notes on the pouring condition

Liquid pouring top of mold
 Pouring bottom of mold
 Pouring side of mold
 Pouring into mold

③ Notes

pouring of sand in mold
 mold cavity. Liquid metal of sand in mold
 Solid system of sand pouring rate of 10

In the sand 2 included in the sand
 sand. Liquid sand in mold

Notes on the sand mold

pouring of sand in mold

Notes on the sand mold

Notes on the sand mold
 A sand mold of 100
 for 100

Notes on the sand mold
 A sand mold of 100

Notes on the sand mold

Notes on the sand mold
 A sand mold of 100

Notes on the sand mold
 A sand mold of 100

Notes on the sand mold
 A sand mold of 100

Waste

mould cavities: liquid metal and of design
on liquid metal surface in 2000-2005 of 1000
system casting surface of 1000-2000 of 1000
of 1000-2000 of 1000-2000 of 1000
of 1000-2000 of 1000-2000 of 1000

Mechanical Working Process

Mechanical working process on solid metal and liquid
metal and of 1000-2000 of 1000-2000 of 1000
of 1000-2000 of 1000-2000 of 1000
of 1000-2000 of 1000-2000 of 1000
of 1000-2000 of 1000-2000 of 1000
of 1000-2000 of 1000-2000 of 1000
of 1000-2000 of 1000-2000 of 1000

Hot working

Recrystallisation Temp: 0.5 to 0.7 of T_m
of 1000-2000 of 1000-2000 of 1000

- (1) Recrystallisation Temp: 0.5 to 0.7 of T_m
- (2) Recrystallisation Temp: 0.5 to 0.7 of T_m
- (3) Recrystallisation Temp: 0.5 to 0.7 of T_m
- (4) Recrystallisation Temp: 0.5 to 0.7 of T_m

Hot working

(1) Recrystallisation Temp: 0.5 to 0.7 of T_m

(2) Recrystallisation Temp: 0.5 to 0.7 of T_m

Cold working

Recrystallisation Temp: 0.5 to 0.7 of T_m

Hot working

(1) Recrystallisation Temp: 0.5 to 0.7 of T_m

(2) Recrystallisation Temp: 0.5 to 0.7 of T_m

(3) Recrystallisation Temp: 0.5 to 0.7 of T_m

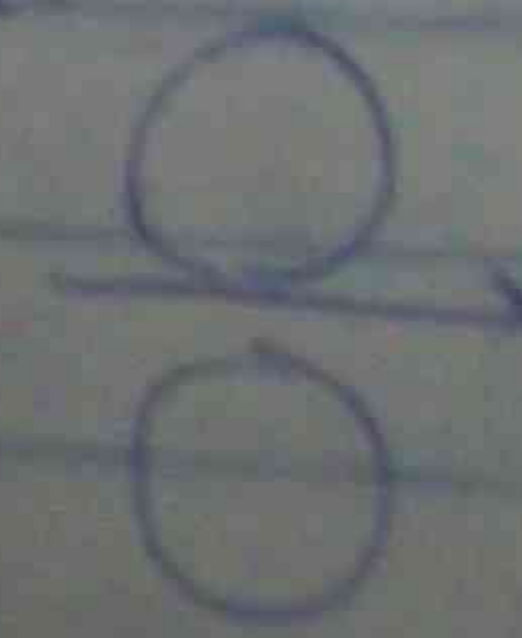
(4) Recrystallisation Temp: 0.5 to 0.7 of T_m

(5) Recrystallisation Temp: 0.5 to 0.7 of T_m

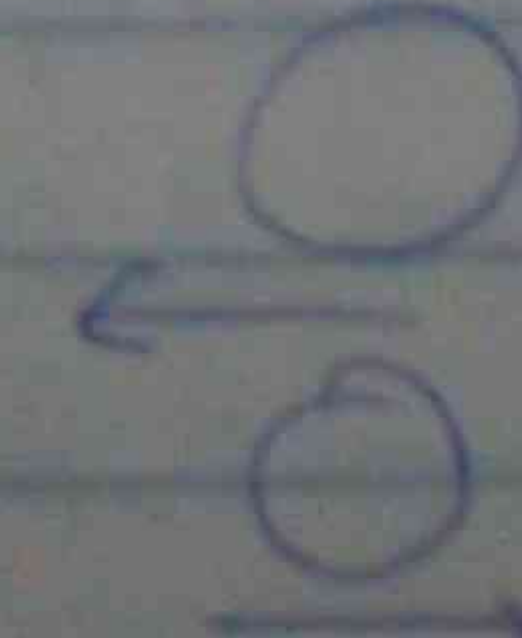
(6) Recrystallisation Temp: 0.5 to 0.7 of T_m

Hot working Process

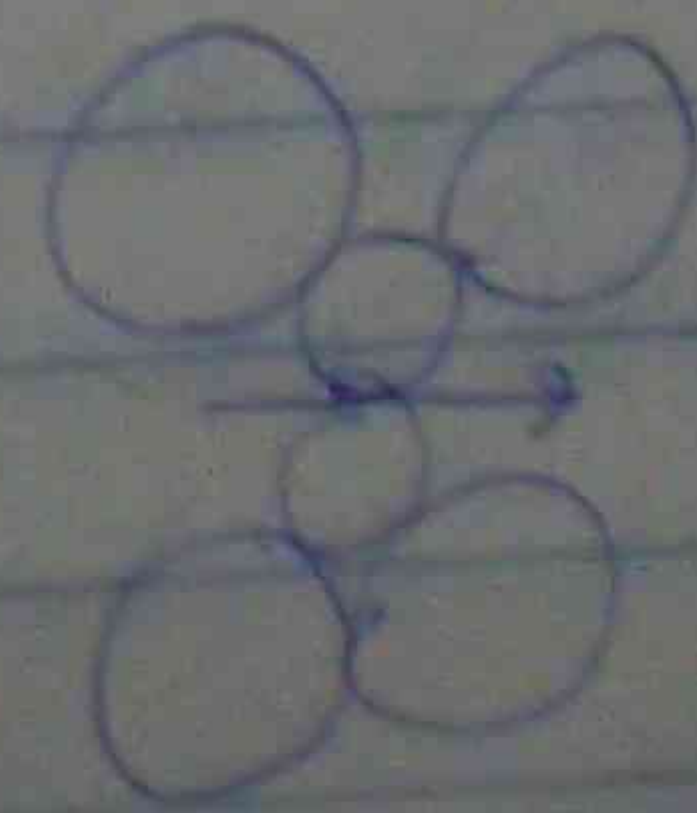
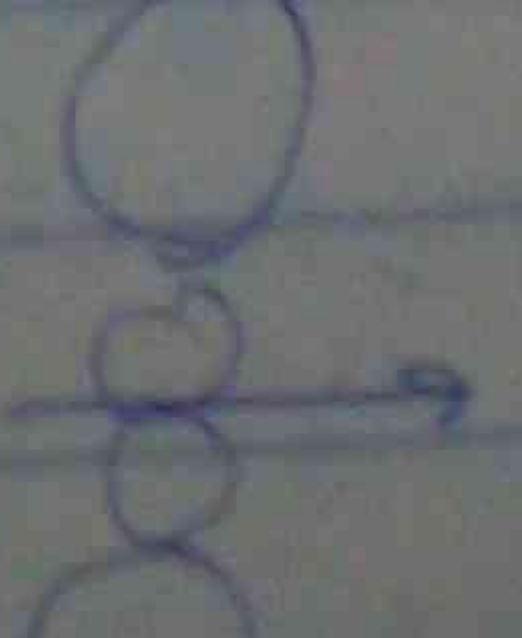
Rolling



2 High

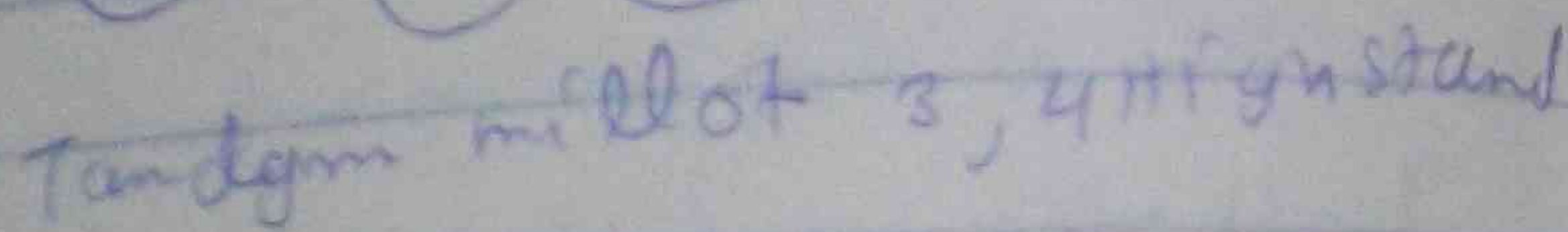


3 High



6 High

6 High

[illegible][illegible]

Drop forging

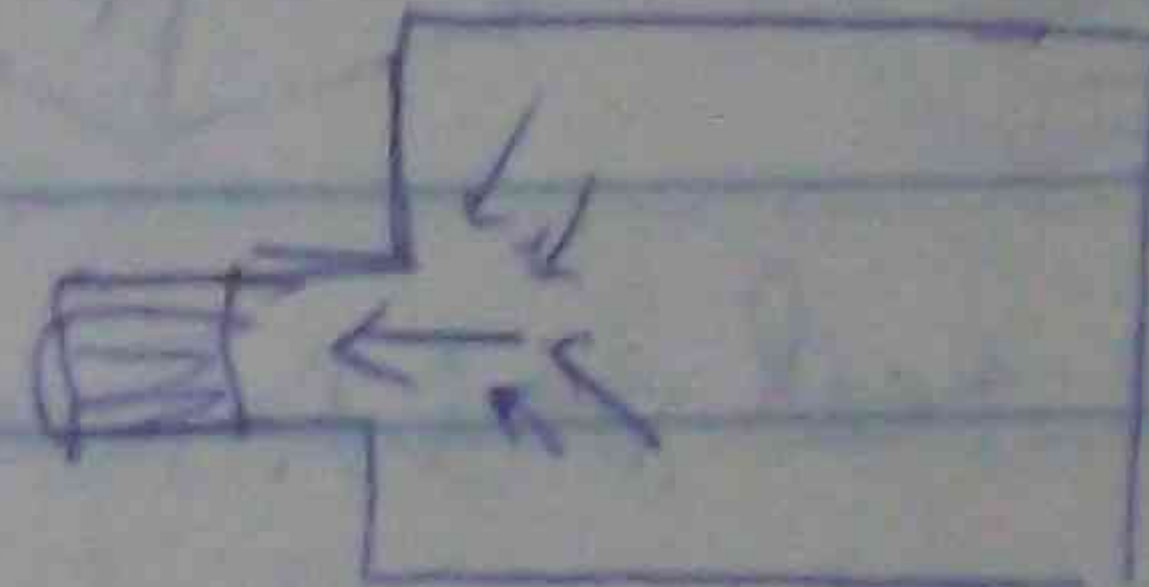
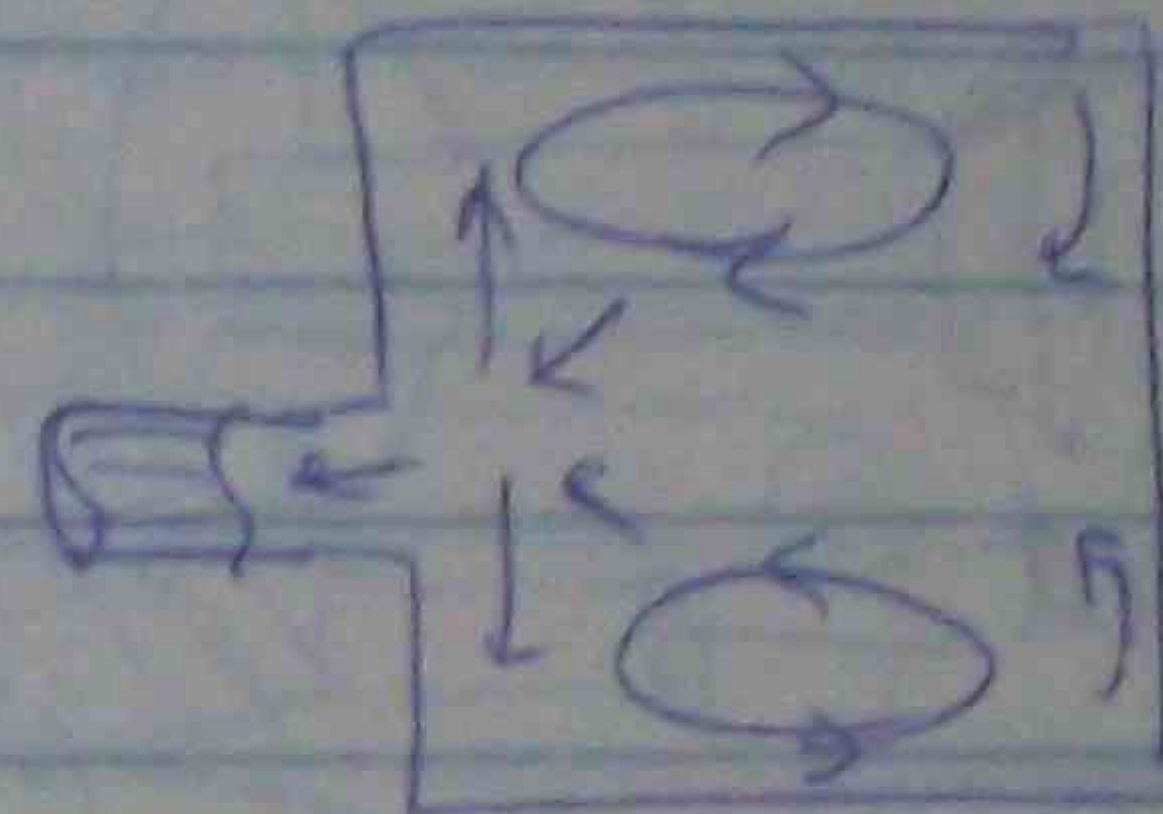
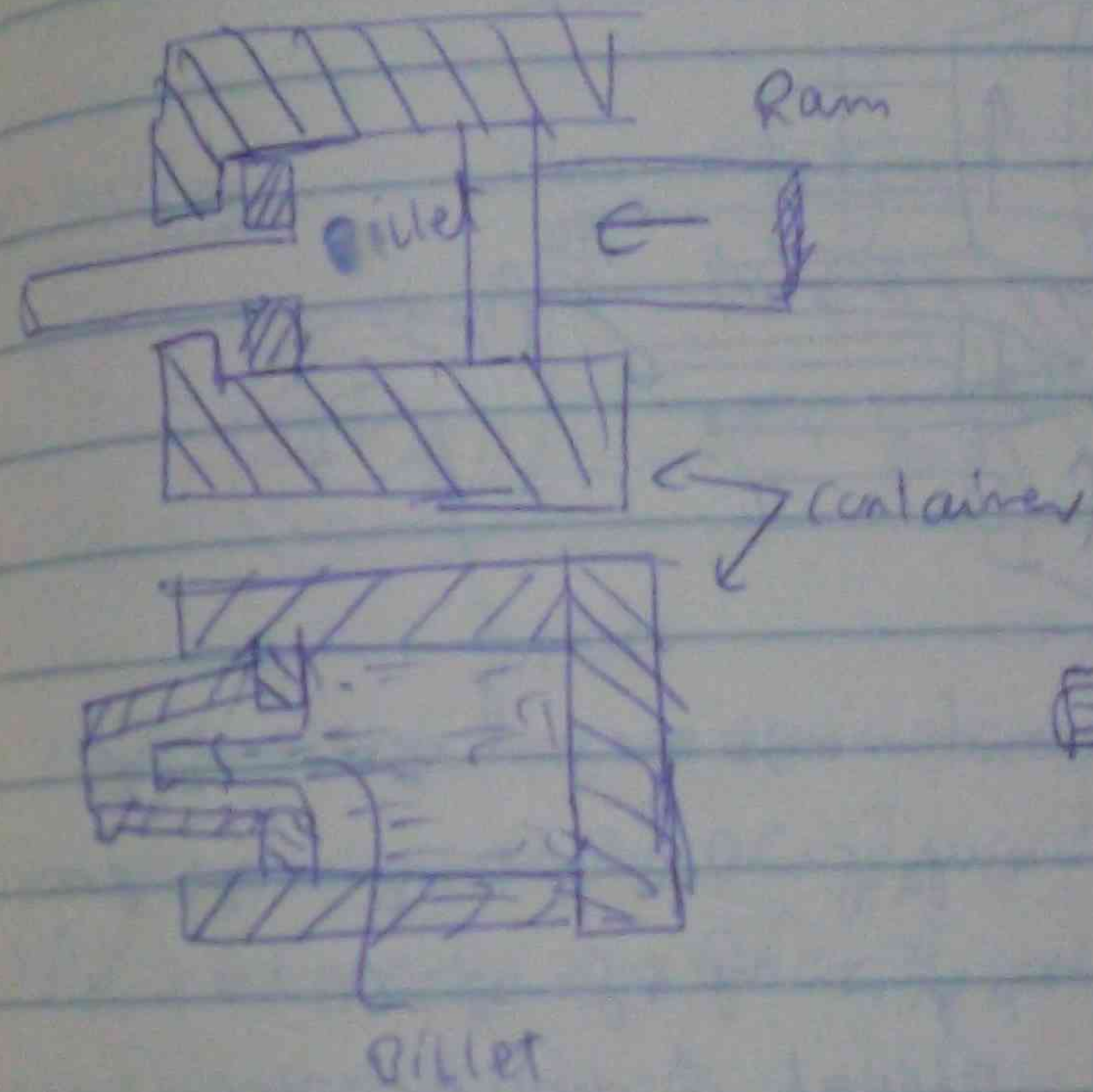
Drop forging is a process of forging in which the workpiece is deformed between two dies. The dies are usually of the shape of the desired part. The workpiece is heated to a temperature between 1100°C and 1200°C. The dies are made of high speed steel or tool steel. The workpiece is placed between the dies and the dies are closed. The workpiece is then deformed by the impact of the dies. The process is repeated until the desired shape is achieved.

Advantages of Drop forging:

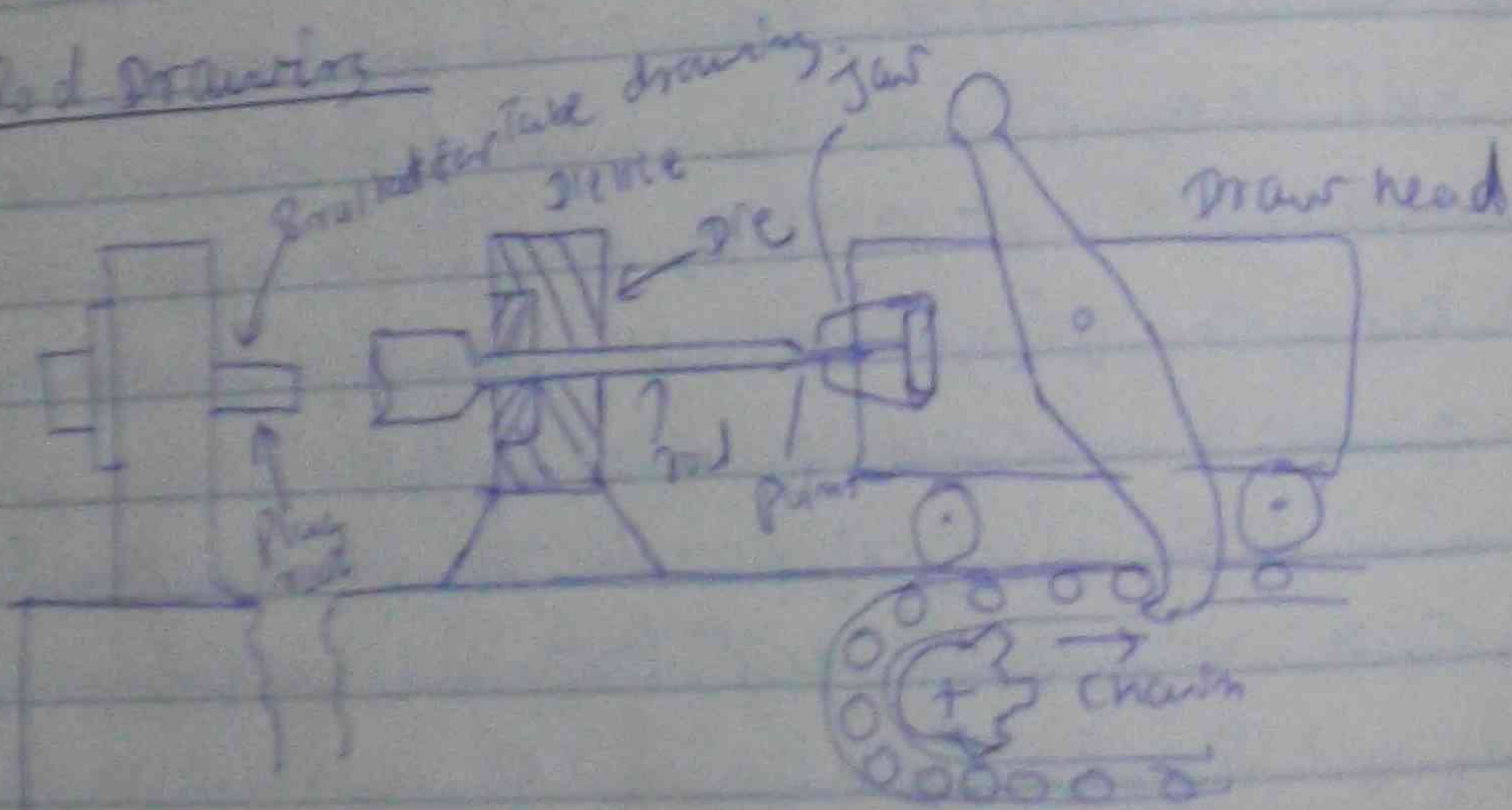
1. High strength and integrity.
2. Good mechanical properties.
3. Low cost.
4. High production rate.
5. Good surface finish.
6. Good dimensional accuracy.
7. Good mechanical properties.
8. Good surface finish.
9. Good dimensional accuracy.
10. Good mechanical properties.

upsetting

D Extrusion

[illegible]

Carded drawings



Draus befindet Spiralrit (hauhin Gl. für 25 m. Gl. 55/56
 55/56, 56/57, 57/58, 58/59, 59/60, 60/61, 61/62, 62/63, 63/64, 64/65, 65/66, 66/67, 67/68, 68/69, 69/70, 70/71, 71/72, 72/73, 73/74, 74/75, 75/76, 76/77, 77/78, 78/79, 79/80, 80/81, 81/82, 82/83, 83/84, 84/85, 85/86, 86/87, 87/88, 88/89, 89/90, 90/91, 91/92, 92/93, 93/94, 94/95, 95/96, 96/97, 97/98, 98/99, 99/100, 100/101, 101/102, 102/103, 103/104, 104/105, 105/106, 106/107, 107/108, 108/109, 109/110, 110/111, 111/112, 112/113, 113/114, 114/115, 115/116, 116/117, 117/118, 118/119, 119/120, 120/121, 121/122, 122/123, 123/124, 124/125, 125/126, 126/127, 127/128, 128/129, 129/130, 130/131, 131/132, 132/133, 133/134, 134/135, 135/136, 136/137, 137/138, 138/139, 139/140, 140/141, 141/142, 142/143, 143/144, 144/145, 145/146, 146/147, 147/148, 148/149, 149/150, 150/151, 151/152, 152/153, 153/154, 154/155, 155/156, 156/157, 157/158, 158/159, 159/160, 160/161, 161/162, 162/163, 163/164, 164/165, 165/166, 166/167, 167/168, 168/169, 169/170, 170/171, 171/172, 172/173, 173/174, 174/175, 175/176, 176/177, 177/178, 178/179, 179/180, 180/181, 181/182, 182/183, 183/184, 184/185, 185/186, 186/187, 187/188, 188/189, 189/190, 190/191, 191/192, 192/193, 193/194, 194/195, 195/196, 196/197, 197/198, 198/199, 199/200, 200/201, 201/202, 202/203, 203/204, 204/205, 205/206, 206/207, 207/208, 208/209, 209/210, 210/211, 211/212, 212/213, 213/214, 214/215, 215/216, 216/217, 217/218, 218/219, 219/220, 220/221, 221/222, 222/223, 223/224, 224/225, 225/226, 226/227, 227/228, 228/229, 229/230, 230/231, 231/232, 232/233, 233/234, 234/235, 235/236, 236/237, 237/238, 238/239, 239/240, 240/241, 241/242, 242/243, 243/244, 244/245, 245/246, 246/247, 247/248, 248/249, 249/250, 250/251, 251/252, 252/253, 253/254, 254/255, 255/256, 256/257, 257/258, 258/259, 259/260, 260/261, 261/262, 262/263, 263/264, 264/265, 265/266, 266/267, 267/268, 268/269, 269/270, 270/271, 271/272, 272/273, 273/274, 274/275, 275/276, 276/277, 277/278, 278/279, 279/280, 280/281, 281/282, 282/283, 283/284, 284/285, 285/286, 286/287, 287/288, 288/289, 289/290, 290/291, 291/292, 292/293, 293/294, 294/295, 295/296, 296/297, 297/298, 298/299, 299/300, 300/301, 301/302, 302/303, 303/304, 304/305, 305/306, 306/307, 307/308, 308/309, 309/310, 310/311, 311/312, 312/313, 313/314, 314/315, 315/316, 316/317, 317/318, 318/319, 319/320, 320/321, 321/322, 322/323, 323/324, 324/325, 325/326, 326/327, 327/328, 328/329, 329/330, 330/331, 331/332, 332/333, 333/334, 334/335, 335/336, 336/337, 337/338, 338/339, 339/340, 340/341, 341/342, 342/343, 343/344, 344/345, 345/346, 346/347, 347/348, 348/349, 349/350, 350/351, 351/352, 352/353, 353/354, 354/355, 355/356, 356/357, 357/358, 358/359, 359/360, 360/361, 361/362, 362/363, 363/364, 364/365, 365/366, 366/367, 367/368, 368/369, 369/370, 370/371, 371/372, 372/373, 373/374, 374/375, 375/376, 376/377, 377/378, 378/379, 379/380, 380/381, 381/382, 382/383, 383/384, 384/385, 385/386, 386/387, 387/388, 388/389, 389/390, 390/391, 391/392, 392/393, 393/394, 394/395, 395/396, 396/397, 397/398, 398/399, 399/400, 400/401, 401/402, 402/403, 403/404, 404/405, 405/406, 406/407, 407/408, 408/409, 409/410, 410/411, 411/412, 412/413, 413/414, 414/415, 415/416, 416/417, 417/418, 418/419, 419/420, 420/421, 421/422, 422/423, 423/424, 424/425, 425/426, 426/427, 427/428, 428/429, 429/430, 430/431, 431/432, 432/433, 433/434, 434/435, 435/436, 436/437, 437/438, 438/439, 439/440, 440/441, 441/442, 442/443, 443/444, 444/445, 445/446, 446/447, 447/448, 448/449, 449/450, 450/451, 451/452, 452/453, 453/454, 454/455, 455/456, 456/457, 457/458, 458/459, 459/460, 460/461, 461/462, 462/463, 463/464, 464/465, 465/466, 466/467, 467/468, 468/469, 469/470, 470/471, 471/472, 472/473, 473/474, 474/475, 475/476, 476/477, 477/478, 478/479, 479/480, 480/481, 481/482, 482/483, 483/484, 484/485, 485/486, 486/487, 487/488, 488/489, 489/490, 490/491, 491/492, 492/493, 493/494, 494/495, 495/496, 496/497, 497/498, 498/499, 499/500, 500/501, 501/502, 502/503, 503/504, 504/505, 505/506, 506/507, 507/508, 508/509, 509/510, 510/511, 511/512, 512/513, 513/514, 514/515, 515/516, 51

(1) Tube Drawing

[illegible]

(2) Water Training

Red draining ground, at the 2nd measurement 7' 6" @
 2nd draw Head 7' 0" capstan Roasting man
 can placed 7' 6" @ 7' 6" - soil 2' 6" & water 9' 6"
 1st of 4' 6" @ 7' 6" on wine 7' 6" @ 7' 6" @ 7' 6"

could pressing

The image contains four hand-drawn diagrams illustrating different metal casting and forming processes:

- Deep drawing:** A vertical cylindrical punch is shown moving downwards into a rectangular block of material. Arrows indicate the downward direction of the punch.
- Die casting:** A cylindrical punch is shown moving downwards into a rectangular block. Labels include "punch" and "Blank holder".
- Drawing:** A vertical cylindrical punch is shown moving downwards into a rectangular block. The label "Drawing" is written to the right.
- Shearing:** A horizontal punch is shown moving to the right, shearing a rectangular block. The label "Shearing" is written below.

3. The film can be placed on a microscope slide and exposed to light. The film is then developed in a solution of 1% sodium thiosulfate (Na₂S₂O₃) in water. The film is then washed in a solution of 1% sodium thiosulfate in water. The film is then dried in a vacuum oven at 60°C for 24 hours.

Spinning

2 turn to size

P13

centre wood

Tail stock spindle

revolving centre

adjustable tail ram pin

Start

Spinning tool

rest

Long top. 2.5 g. on 1000 m. in 1970.

From top of leg. small amount
of circular shape given by orbitals spin like speed 2000 rpm.
if off the flat plate of 200 lb. will be more or less
even if you spin. Diameter of 4 inches. width of 1/2 inch
circular shape of 80 gms tail bar of 1/2 inch of 1/2 inch
of 1/2 inch of 1/2 inch. Point nose spinning foot of
tail bar of 1/2 inch. Tail rest of 1/2 inch. 60 gms. weight of 1/2 inch
from center of 1/2 inch of 1/2 inch of 1/2 inch. 70 gms. 1/2 inch
of 1/2 inch of 1/2 inch.

Large reflector, al: tea pot, hot water bottle
as a source of heat for the purpose of the test. The
reflecting rods are placed in a row of 6 - 60 x 100
cm. and are 2 ft. 6 in.

Forming Particle for an Metal Powder

metal powder up: 20% of 100% metal powder

(2) It is a metal with high melting point and temp. resistant which is used in making of turbine engine parts. It is a metal with high melting point and temp. resistant which is used in making of turbine engine parts.

(17) High melting point ~~3000-4000~~ low melting point ~~100-200~~

eg. 29. d. b. 206. 46. 16 in d. f. 49. 61. 206 Internal structure and: 20. 20. 55. 11

(5) metal casting and machining operations of 1000 scrap losses of 10% i.e. 100, lower unit cost of production 6000 of 50% of 12, 60.

[illegible]

④ 2.60 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 6.00 6.50 7.00 7.50 8.00 8.50 9.00 9.50 10.00 10.50 11.00 11.50 12.00 12.50 13.00 13.50 14.00 14.50 15.00 15.50 16.00 16.50 17.00 17.50 18.00 18.50 19.00 19.50 20.00 20.50 21.00 21.50 22.00 22.50 23.00 23.50 24.00 24.50 25.00 25.50 26.00 26.50 27.00 27.50 28.00 28.50 29.00 29.50 30.00 30.50 31.00 31.50 32.00 32.50 33.00 33.50 34.00 34.50 35.00 35.50 36.00 36.50 37.00 37.50 38.00 38.50 39.00 39.50 40.00 40.50 41.00 41.50 42.00 42.50 43.00 43.50 44.00 44.50 45.00 45.50 46.00 46.50 47.00 47.50 48.00 48.50 49.00 49.50 50.00 50.50 51.00 51.50 52.00 52.50 53.00 53.50 54.00 54.50 55.00 55.50 56.00 56.50 57.00 57.50 58.00 58.50 59.00 59.50 60.00 60.50 61.00 61.50 62.00 62.50 63.00 63.50 64.00 64.50 65.00 65.50 66.00 66.50 67.00 67.50 68.00 68.50 69.00 69.50 70.00 70.50 71.00 71.50 72.00 72.50 73.00 73.50 74.00 74.50 75.00 75.50 76.00 76.50 77.00 77.50 78.00 78.50 79.00 79.50 80.00 80.50 81.00 81.50 82.00 82.50 83.00 83.50 84.00 84.50 85.00 85.50 86.00 86.50 87.00 87.50 88.00 88.50 89.00 89.50 90.00 90.50 91.00 91.50 92.00 92.50 93.00 93.50 94.00 94.50 95.00 95.50 96.00 96.50 97.00 97.50 98.00 98.50 99.00 99.50 100.00 100.50 101.00 101.50 102.00 102.50 103.00 103.50 104.00 104.50 105.00 105.50 106.00 106.50 107.00 107.50 108.00 108.50 109.00 109.50 110.00 110.50 111.00 111.50 112.00 112.50 113.00 113.50 114.00 114.50 115.00 115.50 116.00 116.50 117.00 117.50 118.00 118.50 119.00 119.50 120.00 120.50 121.00 121.50 122.00 122.50 123.00 123.50 124.00 124.50 125.00 125.50 126.00 126.50 127.00 127.50 128.00 128.50 129.00 129.50 130.00 130.50 131.00 131.50 132.00 132.50 133.00 133.50 134.00 134.50 135.00 135.50 136.00 136.50 137.00 137.50 138.00 138.50 139.00 139.50 140.00 140.50 141.00 141.50 142.00 142.50 143.00 143.50 144.00 144.50 145.00 145.50 146.00 146.50 147.00 147.50 148.00 148.50 149.00 149.50 150.00 150.50 151.00 151.50 152.00 152.50 153.00 153.50 154.00 154.50 155.00 155.50 156.00 156.50 157.00 157.50 158.00 158.50 159.00 159.50 160.00 160.50 161.00 161.50 162.00 162.50 163.00 163.50 164.00 164.50 165.00 165.50 166.00 166.50 167.00 167.50 168.00 168.50 169.00 169.50 170.00 170.50 171.00 171.50 172.00 172.50 173.00 173.50 174.00 174.50 175.00 175.50 176.00 176.50 177.00 177.50 178.00 178.50 179.00 179.50 180.00 180.50 181.00 181.50 182.00 182.50 183.00 183.50 184.00 184.50 185.00 185.50 186.00 186.50 187.00 187.50 188.00 188.50 189.00 189.50 190.00 190.50 191.00 191.50 192.00 192.50 193.00 193.50 194.00 194.50 195.00 195.50 196.00 196.50 197.00 197.50 198.00 198.50 199.00 199.50 200.00 200.50 201.00 201.50 202.00 202.50 203.00 203.50 204.00 204.50 205.00 205.50 206.00 206.50 207.00 207.50 208.00 208.50 209.00 209.50 210.00 210.50 211.00 211.50 212.00 212.50 213.00 213.50 214.00 214.50 215.00 215.50 216.00 216.50 217.00 217.50 218.00 218.50 219.00 219.50 220.00 220.50 221.00 221.50 222.00 222.50 223.00 223.50 224.00 224.50 225.00 225.50 226.00 226.50 227.00 227.50 228.00 228.50 229.00 229.50 230.00 230.50 231.00 231.50 232.00 232.50 233.00 233.50 234.00 234.50 235.00 235.50 236.00 236.50 237.00 237.50 238.00 238.50 239.00 239.50 240.00 240.50 241.00 241.50 242.00 242.50 243.00 243.50 244.00 244.50 245.00 245.50 246.00 246.50 247.00 247.50 248.00 248.50 249.00 249.50 250.00 250.50 251.00 251.50 252.00 252.50 253.00 253.50 254.00 254.50 255.00 255.50 256.00 256.50 257.00 257.50 258.00 258.50 259.00 259.50 260.00 260.50 261.00 261.50 262.00 262.50 263.00 263.50 264.00 264.50 265.00 265.50 266.00 266.50 267.00 267.50 268.00 268.50 269.00 269.50 270.00 270.50 271.00 271.50 272.00 272.50 273.00 273.50 274.00 274.50 275.00 275.50 276.00 276.50 277.00 277.50 278.00 278.50 279.00 279.50 280.00 280.50 281.00 281.50 282.00 282.50 283.00 283.50 284.00 284.50 285.00 285.50 286.00 286.50 287.00 287.50 288.00 288.50 289.00 289.50 290.00 290.50 291.00 291.50 292.00 292.50 293.00 293.50 294.00 294.50 295.00 295.50 296.00 296.50 297.00 297.50 298.00 298.50 299.00 299.50 300.00 300.50 301.00 301.50 302.00 302.50 303.00 303.50 304.00 304.50 305.00 305.50 306.00 306.50 307.00 307.50 308.00 30

Mixing and blending

When metal powder is to be used in a die casting machine, it is necessary to mix it with a lubricant. The mixture should be uniform and the particles should be uniformly distributed. The results of the best mixing of metal powders of similar size shape and density are as follows:

Compacting

Compacting operation on metal articles is performed by a die casting machine. The die casting machine is a machine which is used to produce metal parts. The die casting machine consists of a die and a plunger. The die is a hollow shape and the plunger is a solid shape. The plunger is pushed into the die and the metal powder is forced into the die. The amount of powder is controlled by the die and the plunger. The die casting machine is used to produce metal parts of various shapes and sizes.

Pressing or molding

The die casting machine is a machine which is used to produce metal parts. The die casting machine consists of a die and a plunger. The die is a hollow shape and the plunger is a solid shape. The plunger is pushed into the die and the metal powder is forced into the die. The amount of powder is controlled by the die and the plunger. The die casting machine is used to produce metal parts of various shapes and sizes.

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Sintering

Sintering is a process of heating metal powder to a temperature below its melting point. The purpose of sintering is to bond the particles of the powder together. The sintering process is performed in a furnace. The furnace is a chamber in which the metal powder is heated. The temperature of the furnace is controlled by a thermostat. The sintering process is used to produce metal parts of various shapes and sizes.

Uses

Powder metallurgy processes are used to produce metal parts. The powder metallurgy processes are used to produce metal parts of various shapes and sizes. The powder metallurgy processes are used to produce metal parts of various shapes and sizes. The powder metallurgy processes are used to produce metal parts of various shapes and sizes.

Production of Iron and Steel

Line Calcium carbonate CaCO_3 $\xrightarrow{\text{heat}}$ $\text{CaO} + \text{CO}_2$
 CaO is used to remove impurities from the iron ore.
 CaO reacts with SiO_2 to form CaSiO_3 (slag).
 CaO reacts with Al_2O_3 to form CaAl_2O_4 (slag).
 CaO reacts with FeS to form CaS (slag).

Iron Fe_2O_3 is reduced to Fe using CO as a reducing agent.
 $\text{Fe}_2\text{O}_3 + 3\text{CO} \rightarrow 2\text{Fe} + 3\text{CO}_2$
 The Fe is then melted in a blast furnace to produce pig iron.
 Pig iron contains C , Si , Mn , P , and S .
 The C content is about 2-4%.
 The Si content is about 0.5-1%.
 The Mn content is about 0.5-1%.
 The P content is about 0.01-0.05%.
 The S content is about 0.01-0.05%.

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 It contains C , Si , Mn , P , and S .
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Wrought Iron

Wrought iron is made by heating pig iron in a puddle furnace.
 The C content is reduced to about 0.1-0.2%.
 The Si content is about 0.05-0.1%.
 The Mn content is about 0.05-0.1%.
 The P content is about 0.01-0.05%.
 The S content is about 0.01-0.05%.

Cast Iron

Pig iron is melted in a ladle and then poured into a mold.
 The C content is about 2-4%.
 The Si content is about 0.5-1%.
 The Mn content is about 0.5-1%.
 The P content is about 0.01-0.05%.
 The S content is about 0.01-0.05%.

Cast iron is divided into two types:
 1. White cast iron: C content is about 2-4%.
 2. Grey cast iron: C content is about 2-4%.

Steel

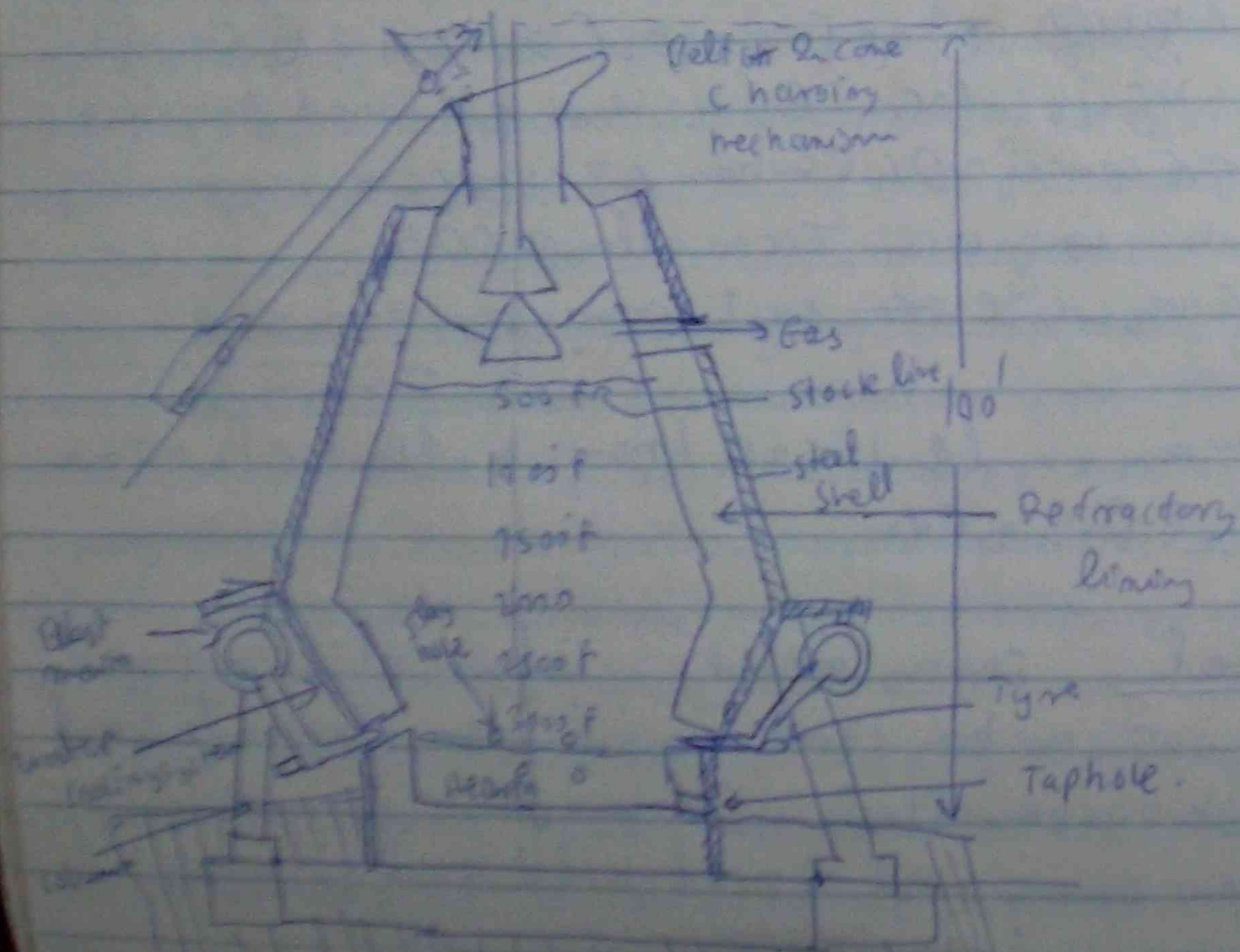
Steel is made by heating pig iron in a basic oxygen furnace.
 The C content is reduced to about 0.1-0.2%.
 The Si content is about 0.05-0.1%.
 The Mn content is about 0.05-0.1%.
 The P content is about 0.01-0.05%.
 The S content is about 0.01-0.05%.

Low carbon steel or Dead mild steel is mild steel with 0.25% carbon and 0.005% phosphorus. It contains carbon, silicon, manganese, sulphur and phosphorus.

It is an alloy of iron with carbon and other elements.

Production of Pig Iron

(Blast Furnace)



Pig Iron is a product of Blast Furnace. It is a mixture of Iron ore, coke, limestone and other materials. It is produced by smelting the iron ore in a blast furnace. The blast furnace is a vertical steel shell lined with refractory materials. It is heated by a gas produced from coke. The gas is used to heat the iron ore and to reduce the iron ore to iron. The iron is then cast into pig iron.

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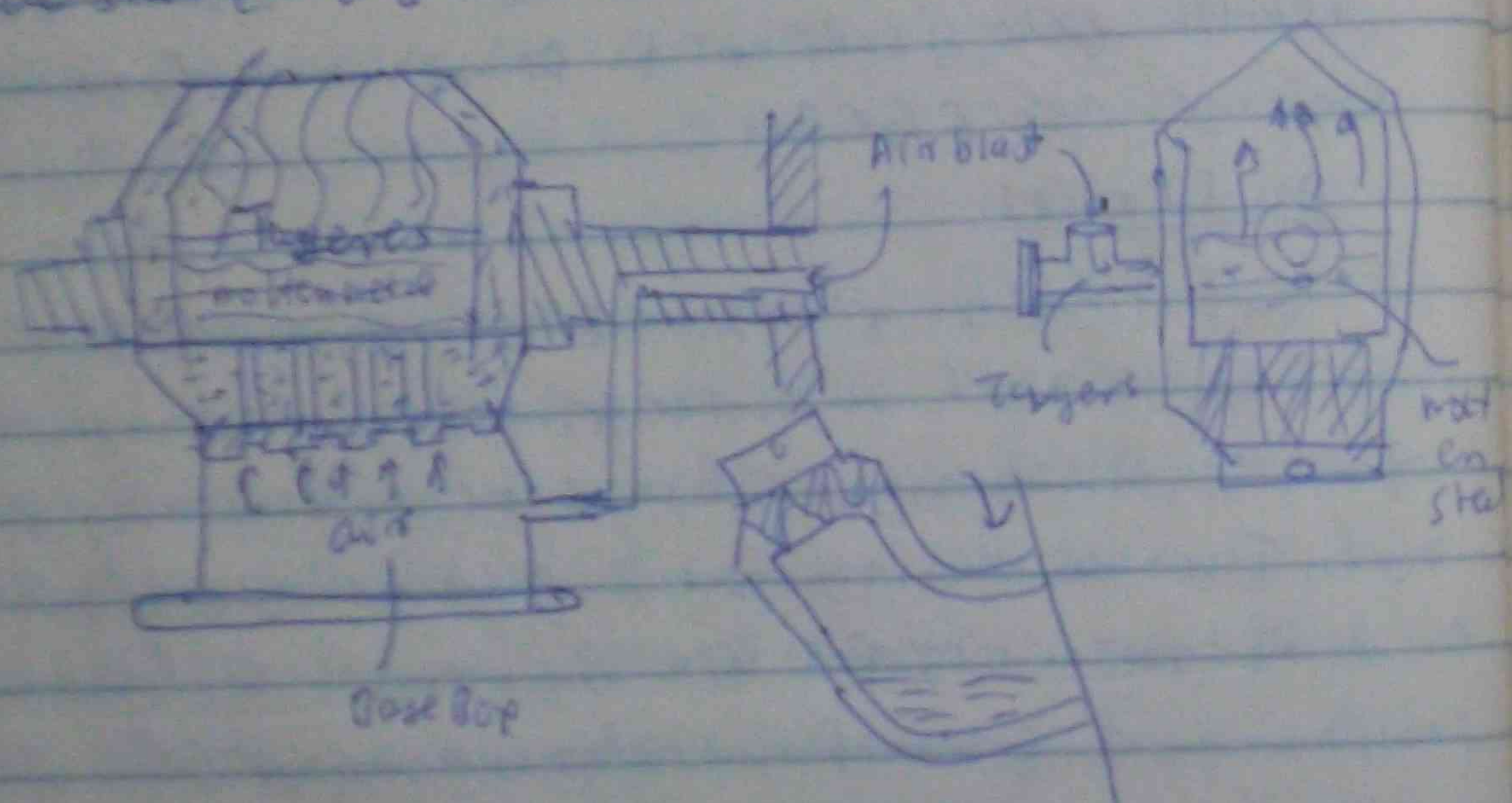
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Phosphorus sulphur & reaction of phosphate

Calcium sulphate is often used as a lining material for the basic process. It is a very refractory material and is not attacked by the molten metal. It is also a good insulator and helps to maintain the temperature of the furnace. The basic process is used for the production of high grade steel from pig iron. It is a very important process in the steel industry.

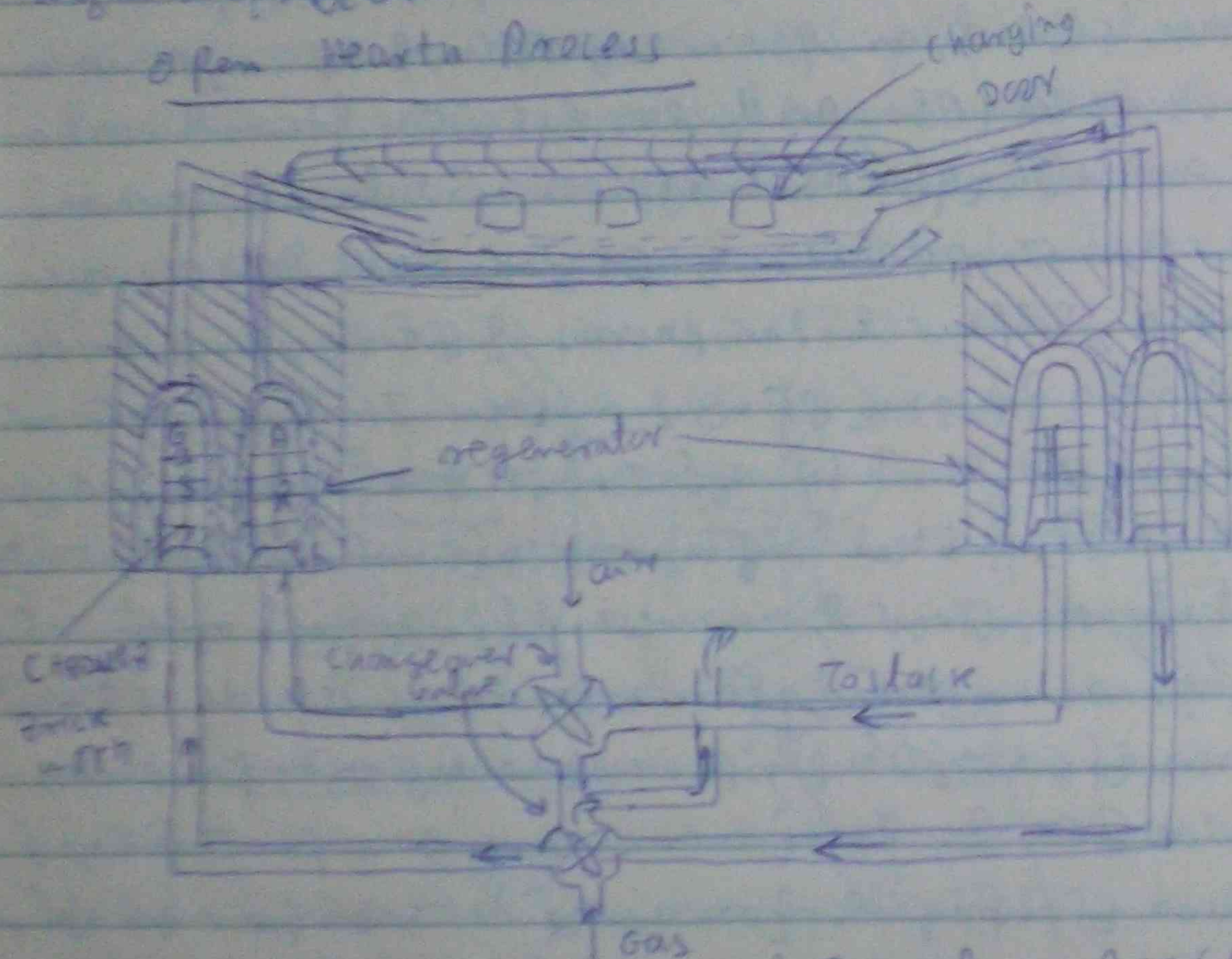


Bessemer process

The Bessemer process is a method of producing steel from pig iron. It is a very important process in the steel industry. The process involves the use of a Bessemer converter, which is a large vessel that can be tilted. The converter is lined with a refractory material, such as calcium sulphate. The pig iron is poured into the converter, and then air is blown through the converter. This process oxidizes the impurities in the pig iron, and the resulting steel is then poured into a mold to form a cast.

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line pipe steel made and refined in the open hearth process



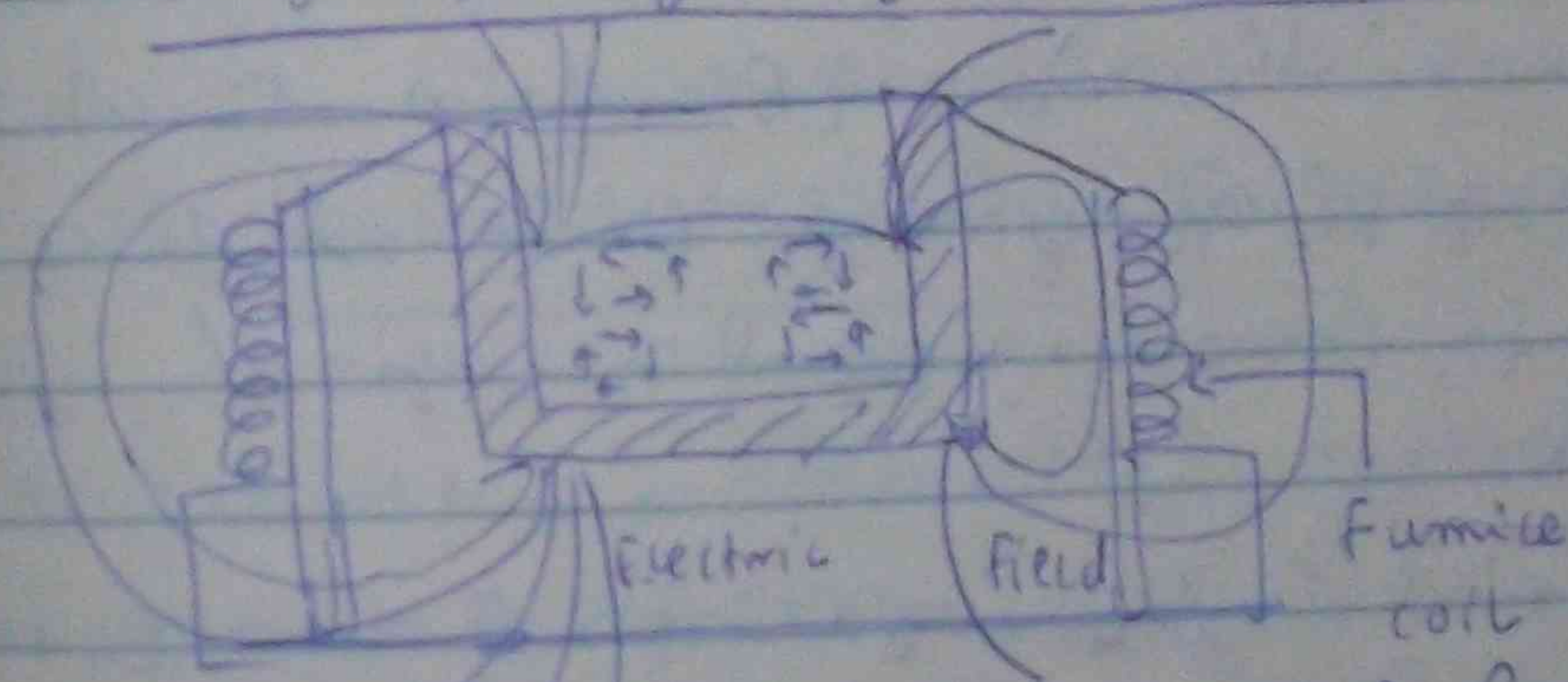
of steel made in the open hearth process. The furnace is made of steel and is used for refining steel. The process involves charging the furnace with scrap steel and molten iron. The furnace is then heated to melt the scrap and refine the metal. The refined metal is then poured into a ladle and cast into a mold.

531
The open hearth process is a method of refining steel. It involves charging the furnace with scrap steel and molten iron. The furnace is then heated to melt the scrap and refine the metal. The refined metal is then poured into a ladle and cast into a mold. The process is used for producing high quality steel for various applications.

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[illegible]

High frequency Induction process



Electric Induction furnace for softening low freq;
non ferrous metal and alloys for high freq;
induction furnace for refractory crucible of
water cool coil for various types
current for various types of crucible for
steel scrap for electric magnetic field
for various types of magnetic stirring
induction furnace for special alloy steel
high quality steel for various types of
steel for various types of steel

(உயர்தர உலக: 161161 - 206101)

August $\rightarrow 8 \rightarrow$ உயர்தர உலக உயர்தர உலக
August $\rightarrow 8 \rightarrow$ உயர்தர உலக உயர்தர உலக

Sept: $\rightarrow 8 \rightarrow$ உயர்தர உலக உயர்தர உலக
Properties - ultimate Tensile strength 30 ton/in
Elongation 20% reduction 50%

2.4 - mild casting for long life: 2.4% C, 0.3% Si, 0.03% S
Carbon 0.3% Si 0.3% S - 0.3% P = 0.02

ultimate tensile strength 30 ton/in, Elongation 60%
used for 161161 mm. Temperature 161161

properties for 161161

2.4% C, 0.3% Si, 0.03% S
weight Shallow cold chisel, rod of tensile strength
4 ton/in 161161

② Medium Carbon Steel

medium, high strength, 161161, 161161, 161161

C = 0.3% Si = 0.3% S = 0.03% P = 0.02
used for 2 ton/in, ultimate tensile strength 30 ton/in
Elongation 20% Tensile 50%

2.4 High strength & ductility, low carbon steel
Axle, connecting rod, crankshaft, engine
used for 161161

High carbon steel

Strength hardness, wear resistance 161161
Ductility weldability & machinability 2.4%
C = 0.7% Si = 0.3% S = 0.03% P = 0.03%

Properties

Yield pt. 2 ton/in
ultimate Tensile strength 30 ton/in
Elongation 20% Tensile 14 ft-lb

2.4 Quench and Temper 161161 2.4% C

Spring steel coil spring, lead spring 2.4% C

used for C \rightarrow 0.5% \rightarrow 0.8%
2 \rightarrow C \rightarrow 1.0% oil quenched, tempering
used for 161161

Answer
c. 152 - 22 = 130. Gl. class is only 1/2 of boys and 2/3 of girls.

William Cutler

unsaturated sulfur phosphorus

carving stone & wood

Place de la Chapelle, Paris
1888

0.9 → 1% carbon - Axes, pocket knives, wire

bit, centre punches, crossind

Saw wire cutter, hot punches

and hollow drill steel.

Ball pen hammer chipping

Chisel, shear blade, machinist

chisel, wood chisel, leather

cutting dies, drills, and

punches wood saws vice jaws

band saw, mason's chisel

carpenter's hammer & nails

shear patch bay, cold

Set Lawrence.

Col d heading, Bol + die

drill & mining drills, small lathe centre & chucks.

Tool steels are made of high carbon & alloy steels. They are used for making tools like drills, reamers, taps, etc. Carbon tool steel is made of 0.5% to 1.5% carbon. Alloy tool steel contains alloying elements like chromium, nickel, molybdenum, etc. along with carbon.

Alloy Steels

Reasons of alloying

1. To improve the mechanical properties of steel.
2. To improve the hardenability of steel.
3. To improve the wear resistance of steel.
4. To improve the corrosion resistance of steel.
5. To improve the machinability of steel.
6. To improve the formability of steel.
7. To improve the weldability of steel.
8. To improve the strength of steel.
9. To improve the toughness of steel.
10. To improve the fatigue resistance of steel.

For the purpose of martensite transformation, the steel must be cooled rapidly. The rate of cooling is determined by the alloying elements. Alloying elements like chromium, nickel, molybdenum, etc. increase the hardenability of steel. This means that the steel can be hardened by cooling it in oil or water instead of having to be cooled in a salt bath.

Alloying elements also affect the mechanical properties of steel. For example, chromium increases the strength and hardness of steel. Nickel improves the toughness of steel. Molybdenum increases the strength and hardness of steel at high temperatures.

(B) Alloying element

1. Aluminium - Carbide former, it is used for deoxidising steel. It also improves the mechanical properties of steel.

2. Chromium - Carbide former, it improves the hardenability of steel. It also improves the strength and hardness of steel. Chromium is also used for corrosion resistance.

3. Nickel - It improves the toughness of steel. It also improves the strength and hardness of steel. Nickel is also used for corrosion resistance.

nickel

Strong carbide former heat treatment res.
Hardenability, mech. properties.
Grain size, mech. properties.

nickel

Mild carbide former heat treatment res.
Hardenability, mech. properties.
Grain size, mech. properties.

phosphorus

Grain size, mech. properties.

silicon

Carbide former heat treatment res.
Hardenability, mech. properties.
Grain size, mech. properties.

aluminum

Grain size, mech. properties.

Free machining
Steel

Tungsten

Strong carbide former heat treatment
Hardenability, mech. properties.
Grain size, mech. properties.

vanadium

Very strong carbide former heat treatment
Hardenability, mech. properties.
Grain size, mech. properties.
Structure.

Q. Composition, Properties, Heat treatment and application of constructional steel (i.e. steel used for manufacture of machine parts).

32

—

10

corrosion resistance chromium 10% composition
mild: 0.05% C: stain less steel 20% Cr 0.05% C
gives film 20% Cr 0.05% C

Heat treatable steel

Pr. 600. 61 61°C Heat treatment 1 year 40000

(a) Low Carbon (C → 0.14%, Mn 0.19%)
C → 0.15%, Si → 0.35%, Mn → 0.5%, mm → 3%, Cr 12%
used for 2nd & 3rd stage of 3rd & 4th stage of forging, cold work
ing, machining of 4th stage

Heat treatment — Hot drawing temp: $950 \rightarrow 1000^\circ\text{C}$, Air or oil quench

Tempering \rightarrow 750°C
 2nd: 6th \rightarrow 629°C up. 2nd or 2rd. 629 & 768-2 times,
 on 768-2 times 2nd or 2rd.

⑥ medium carbon steel 12 → 14%, C in iron type.

C → 0.3%, Si 0.35%, Mn 0.5%, mm. 32 (or 127).
360, 370, 380, 390, 400, 410, 420, 430, 440, 450, 460, 470, 480, 490, 500, 510, 520, 530, 540, 550, 560, 570, 580, 590, 600, 610, 620, 630, 640, 650, 660, 670, 680, 690, 700, 710, 720, 730, 740, 750, 760, 770, 780, 790, 800, 810, 820, 830, 840, 850, 860, 870, 880, 890, 900, 910, 920, 930, 940, 950, 960, 970, 980, 990, 1000, 1010, 1020, 1030, 1040, 1050, 1060, 1070, 1080, 1090, 1100, 1110, 1120, 1130, 1140, 1150, 1160, 1170, 1180, 1190, 1200, 1210, 1220, 1230, 1240, 1250, 1260, 1270, 1280, 1290, 1300, 1310, 1320, 1330, 1340, 1350, 1360, 1370, 1380, 1390, 1400, 1410, 1420, 1430, 1440, 1450, 1460, 1470, 1480, 1490, 1500, 1510, 1520, 1530, 1540, 1550, 1560, 1570, 1580, 1590, 1600, 1610, 1620, 1630, 1640, 1650, 1660, 1670, 1680, 1690, 1700, 1710, 1720, 1730, 1740, 1750, 1760, 1770, 1780, 1790, 1800, 1810, 1820, 1830, 1840, 1850, 1860, 1870, 1880, 1890, 1900, 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1980, 1990, 2000, 2010, 2020, 2030, 2040, 2050, 2060, 2070, 2080, 2090, 2100, 2110, 2120, 2130, 2140, 2150, 2160, 2170, 2180, 2190, 2200, 2210, 2220, 2230, 2240, 2250, 2260, 2270, 2280, 2290, 2300, 2310, 2320, 2330, 2340, 2350, 2360, 2370, 2380, 2390, 2400, 2410, 2420, 2430, 2440, 2450, 2460, 2470, 2480, 2490, 2500, 2510, 2520, 2530, 2540, 2550, 2560, 2570, 2580, 2590, 2600, 2610, 2620, 2630, 2640, 2650, 2660, 2670, 2680, 2690, 2700, 2710, 2720, 2730, 2740, 2750, 2760, 2770, 2780, 2790, 2800, 2810, 2820, 2830, 2840, 2850, 2860, 2870, 2880, 2890, 2900, 2910, 2920, 2930, 2940, 2950, 2960, 2970, 2980, 2990, 3000, 3010, 3020, 3030, 3040, 3050, 3060, 3070, 3080, 3090, 3100, 3110, 3120, 3130, 3140, 3150, 3160, 3170, 3180, 3190, 3200, 3210, 3220, 3230, 3240, 3250, 3260, 3270, 3280, 3290, 3300, 3310, 3320, 3330, 3340, 3350, 3360, 3370, 3380, 3390, 3400, 3410, 3420, 3430, 3440, 3450, 3460, 3470, 3480, 3490, 3500, 3510, 3520, 3530, 3540, 3550, 3560, 3570, 3580, 3590, 3600, 3610, 3620, 3630, 3640, 3650, 3660, 3670, 3680, 3690, 3700, 3710, 3720, 3730, 3740, 3750, 3760, 3770, 3780, 3790, 3800, 3810, 3820, 3830, 3840, 3850, 3860, 3870, 3880, 3890, 3900, 3910, 3920, 3930, 3940, 3950, 3960, 3970, 3980, 3990, 4000, 4010, 4020, 4030, 4040, 4050, 4060, 4070, 4080, 4090, 4100, 4110, 4120, 4130, 4140, 4150, 4160, 4170, 4180, 4190, 4200, 4210, 4220, 4230, 4240, 4250, 4260, 4270, 4280, 4290, 4300, 4310, 4320, 4330, 4340, 4350, 4360, 4370, 4380, 4390, 4400, 4410, 4420, 4430, 4440, 4450, 4460, 4470, 4480, 4490, 4500, 4510, 4520, 4530, 4540, 4550, 4560, 4570, 4580, 4590, 4600, 4610, 4620, 4630, 4640, 4650, 4660, 4670, 4680, 4690, 4700, 4710, 4720, 4730, 4740, 4750, 4760, 4770, 4780, 4790, 4800, 4810, 4820, 4830, 4840, 4850, 4860, 4870, 4880, 4890, 4900, 4910, 4920, 4930, 4940, 4950, 4960, 4970, 4980, 4990, 5000, 5010, 5020, 5030, 5040, 5050, 5060, 5070, 5080, 5090, 5100, 5110, 5120, 5130, 5140, 5150, 5160, 5170, 5180, 5190, 5200, 5210, 5220, 5230, 5240, 5250, 5260, 5270, 5280, 5290, 5300, 5310, 5320, 5330, 5340, 5350, 5360, 5370, 5380, 5390, 5400, 5410, 5420, 5430, 5440, 5450, 5460, 5470, 5480, 5490, 5500, 5510, 5520, 5530, 5540, 5550, 5560, 5570, 5580, 5590, 5600, 5610, 5620, 5630, 5640, 5650, 5660, 5670, 5680, 5690, 5700, 5710, 5720, 5730, 5740, 5750, 5760, 5770, 5780, 5790, 5800, 5810, 5820, 5830, 5840, 5850, 5860, 5870, 5880, 5890, 5900, 5910, 5920, 5930, 5940, 5950, 5960, 5970, 5980, 5990, 6000, 6010, 6020, 6030, 6040, 6050, 6060, 6070, 6080, 6090, 6100, 6110, 6120, 6130, 6140, 6150, 6160, 6170, 6180, 6190, 6200, 6210, 6220, 6230, 6240, 6250, 6260, 6270, 6280, 6290, 6300, 6310, 6320, 6330, 6340, 6350, 6360, 6370, 6380, 6390, 6400, 6410, 6420, 6430, 6440, 6450, 6460, 6470, 6480, 6490, 6500, 6510, 6520, 6530, 6540, 6550, 6560, 6570, 6580, 6590, 6600, 6610, 6620, 6630, 6640, 6650, 6660, 6670, 6680, 6690, 6700, 6710, 6720, 6730, 6740, 6750, 6760, 6770, 6780, 6790, 6800, 6810, 6820, 6830, 6840, 6850, 6860, 6870, 6880, 6890, 6900, 6910, 6920, 6930, 6940, 6950, 6960, 6970, 6980, 6990, 7000, 7010, 7020, 7030, 7040, 7050, 7060, 7070, 7080, 7090, 7100, 7110, 7120, 7130, 7140, 7150, 7160, 7170, 7180, 7190, 7200, 7210, 7220, 72

Heat treatment Hardening temp: $950 \rightarrow 1000^\circ\text{C}$
Quenching water or air.

Tempering Temp. $\rightarrow 150^{\circ}\text{C} \rightarrow 250^{\circ}\text{C}$
2500 no. of: low. of: 1000 of: 2500
 Barren of:

Burn

(18) Cr: 2% Ni type

C = 1.8%, Si = 0.35%, Mn = 0.2%, Ni = 2%, Cr = 18%,
Electrolytic composition of steel

Heat treatment → Hardening temperature 950-1000°C
Quenching oil or air, Tempering 150-250°C
Non-Heat treatable Austenitic stainless steels

Heat treatment of cold working of steel
Strength: 600 MPa

(18) Cr: 8% Ni type
C = 1.7%, Si = 0.2%, Mn = 0.2%, Ni = 8%, Cr = 18%
Spinning, rolling, forging, welding of steel
Use of steel in form of pipe, sheet, etc.

Heat resistant steel

Use of steel in form of pipe, sheet, etc.
Oxidation and scaling at high temperature
Corrosion resistance in various media
Use of steel in form of pipe, sheet, etc.

Self
Silicon-iron steel → C = 0.45%, Si = 3.5%,
Mn = 0.5%, Cr = 8%
Use of steel in form of pipe, sheet, etc.
Use of steel in form of pipe, sheet, etc.

Heat treatment → Hardening temp = 950°C, Quenching oil
Tempering 650°C

Non-Heat treatable steel

(a) Ni-Cr steel (18% Cr, 8% Ni)
Use of steel in form of pipe, sheet, etc.
(b) 25% Cr, 20% Ni
C = 1.6%, Si = 1.7%, Mn = 1.2%, Ni = 20%, Cr = 25%

Use of steel in form of pipe, sheet, etc.
Use of steel in form of pipe, sheet, etc.
Use of steel in form of pipe, sheet, etc.

Nickel-Tungsten steel
13% Cr, 13% Ni, 3% Tungsten

Use of steel in form of pipe, sheet, etc.
(c) 24% Cr, 12% Ni, 3% Tungsten steel
C = 1.5%, Si = 1.6%, Cr = 32%, Mn = 0.5%,
Ni = 12%, Tungsten 3%

Use of steel in form of pipe, sheet, etc.
Use of steel in form of pipe, sheet, etc.
Use of steel in form of pipe, sheet, etc.

Use of steel in form of pipe, sheet, etc.
Use of steel in form of pipe, sheet, etc.

Toughness - strength + ductility + shock resist.
resist: & softening temp. - Tungsten, 3000°C
mechanical properties - ...

1. Plain Carbon Tool Steel
1.1 % Carbon (Type), C = 1.1%, Mn = 0.3%, Forge
400 → 1050°C, 2500 psi, 200°C, 200°C, 1
normalize 350 → 400, hardness 2-310 Rockwell
Anneal Rockwell anneal at 700 → 800°C, 1000 psi.
Prime tempering at 200 → 300°C | Tempering 105 → 190°C
50-60 Rockwell hardness 60, 60
2. Al- Drill, tap, die, stamps, reamer, planing
die, knurl

6. non alloy plain carbon steel :- (1) Low carbon steel :-
 (0.05 to 0.25% C)
 (2) Medium carbon steel :- (0.25 to 0.5% C)
 (3) High carbon steel :- (0.5 to 0.8% C)
 7. Alloy steel :- (1) Low alloy steel :- (0.05 to 0.25% C)
 (2) High alloy steel :- (0.25 to 0.5% C)
 (3) Non alloy steel :- (0.5 to 0.8% C)

Non deforming die
 Σ non deforming steel, C = .97, mm 21.61
 Normalize 950°C, forge 930°C - 1030°C up to 6"
 Rockwell C hardness after annealing 6-15 rockwell
 Hardening oil quenched at 360°C - 490°C Tempering 150°C
 Annealing oil quenched 350-490°C

Die - Die grs - Planing dies, forming dies,
moulding dies, cutter plate etc.
c) wear resist: - Nondeforming steel
Type, High carbon, High cr. $C = 2.2\%$, Mn 0.37% ,
Cr 1.2% , Vanadium 0.15% ,
anneal at $300 \rightarrow 400^\circ C$, large 1000-1100
after anneal

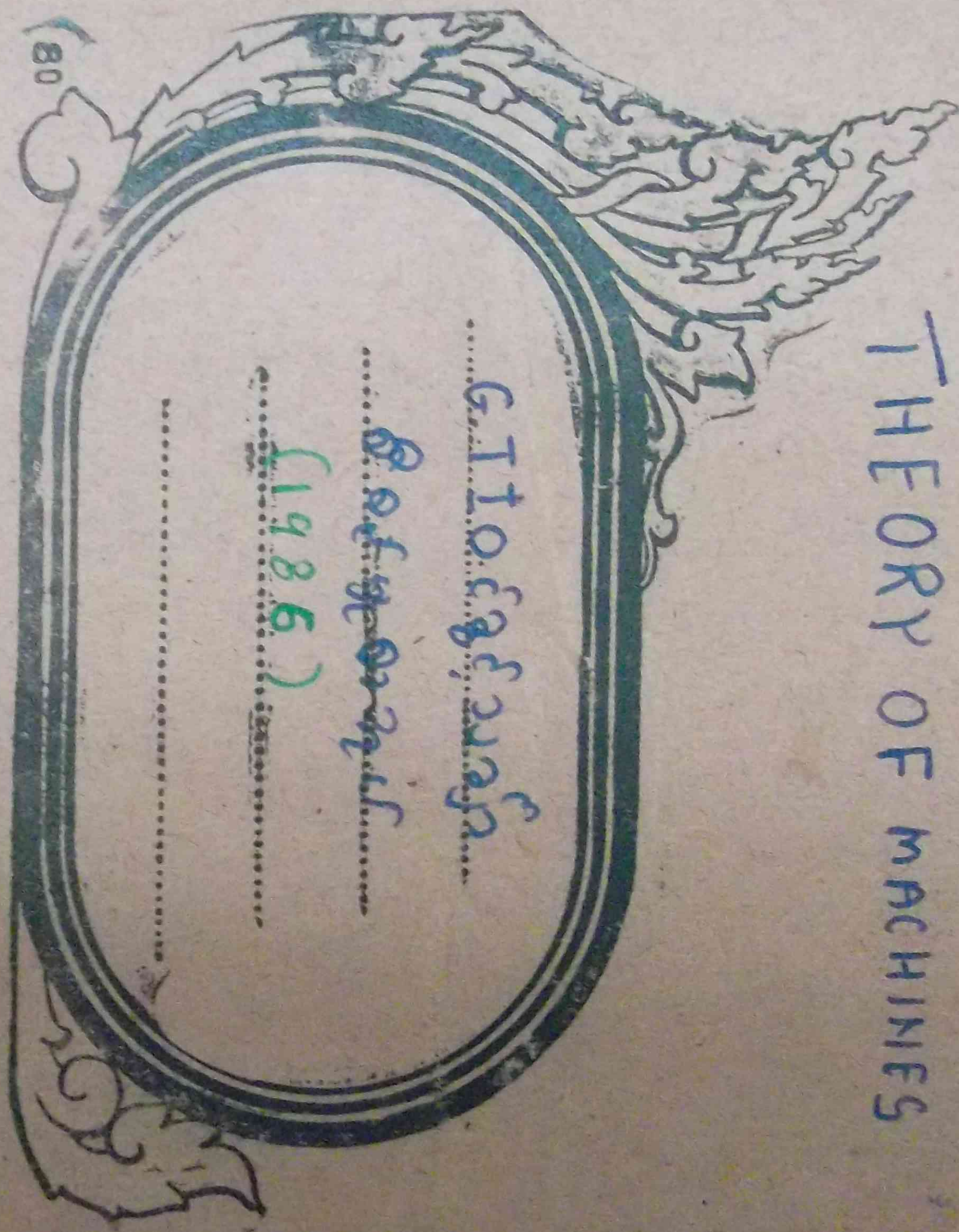
bit,
 (c) not chisel - Tungsten Cr. hot die
 Steel.
 C = .32, Cr 2.3, Tungsten 9.7, Vanadium
 .45.
 Anneal per annealing at 850-870°C.
 Forge 1100-1300°C, 900°C & 2 in hardness after
 annealing 2 in. scale. Heat treating oil quench
 950-970°C, 2 in. - 7 in. per 8 ft. 2 in
 expansion pressure.

Hand field magnese steel C = 1-0.48, mm 11-9147.
Higher ductility than plain alloy. d.f. varies → manufacture
furnace or austenite (A) at 20 deformation / 60%
magnesium alloy, but 10mm diameter casting forming @
point is good.

ප්‍ර 2000 lbs 8 mm

K.N. (1112)

THEORY OF MACHINES



80

Theory Of Machines

(G.T.I mech: Power course)

Volume 2 (b)



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Theory Of Machines

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1. Analysis of velocity, Acceleration and vector
2. Velocities in machines
3. Friction
4. Belt and chain Drives
5. Gear Trains
6. Governors
7. Balancing of weight.

Theory of machines

1) Designing a machine is a process of creating a machine that will perform a specific function. It involves the selection of materials, the design of the machine's components, and the assembly of the machine.

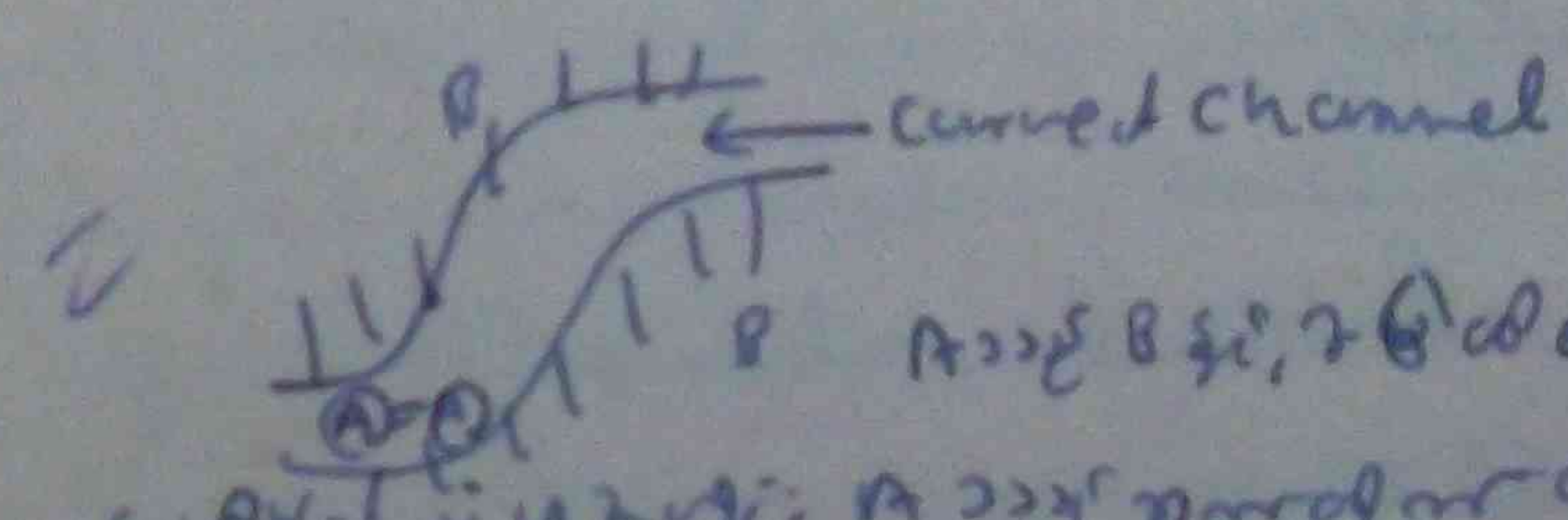
2) The design of a machine is a process of creating a machine that will perform a specific function. It involves the selection of materials, the design of the machine's components, and the assembly of the machine.

3) The design of a machine is a process of creating a machine that will perform a specific function. It involves the selection of materials, the design of the machine's components, and the assembly of the machine.

4) The design of a machine is a process of creating a machine that will perform a specific function. It involves the selection of materials, the design of the machine's components, and the assembly of the machine.

5) The design of a machine is a process of creating a machine that will perform a specific function. It involves the selection of materials, the design of the machine's components, and the assembly of the machine.

machine, frame, pair or kinetic pairs



A curved channel is a type of pair or kinetic pair. It is a mechanism that allows a ball to move along a curved path. The ball is the follower and the curved channel is the guide.

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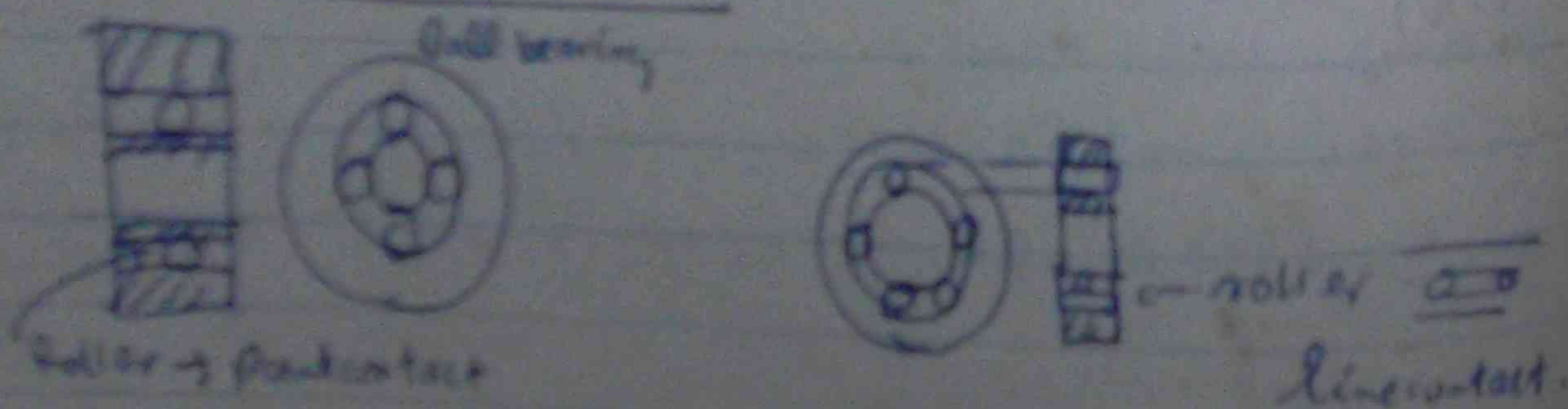
The diagrams illustrate the following types of motion:

- Translation:** A square object with a shaded rectangle inside. An arrow labeled 'v' points to the right above the object.
- Rotation:** A rectangular object with a shaded rectangle inside. A curved arrow labeled 'v' indicates a counter-clockwise circular motion around the center.
- Oscillation:** A curved path with a shaded area in the center. Two curved arrows labeled 'v' point outwards from the center, indicating back-and-forth motion.
- Vibration:** A rectangular object with a shaded rectangle inside. A curved arrow labeled 'v' indicates a circular motion around the center.

Straight translation & rotation.

↳ straight translation

(c) straight translation & rotation for 60°



Find in line pairs of 16 lines A and B in only 46
signature points at a line into 16 B A

motion

motion
 1. motion is the change of position of an object with respect to time.
 2. motion is the change of position of an object with respect to time.
 3. motion is the change of position of an object with respect to time.

(1) Plane motion (2) Helical motion (3) Spherical motion

(1) Plane motion

[illegible]

(i) motion of straight line from translation of piston
cylinder motion of piston motion of translation
of piston

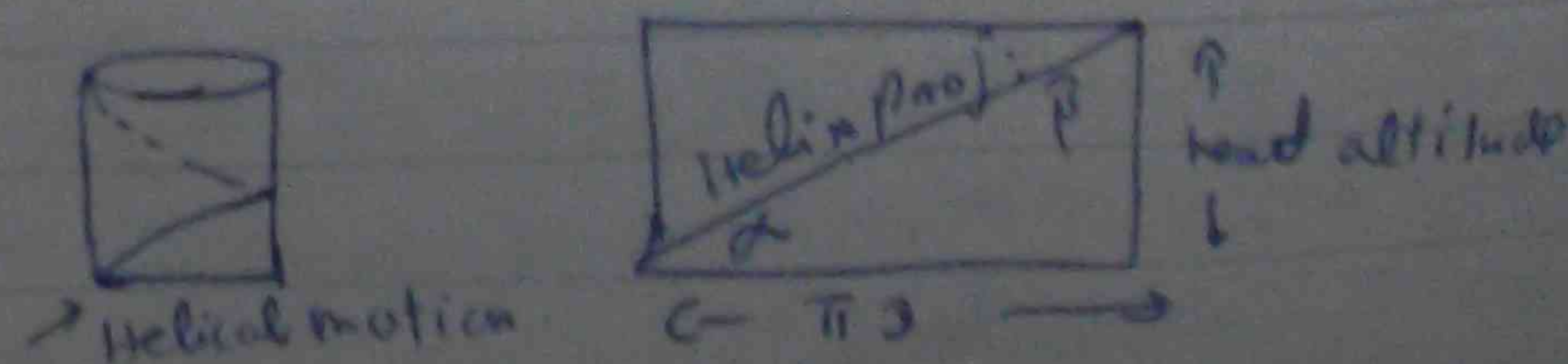
(ii) motion of a particle in a circular path is an example of uniform circular motion.

Translation

2008 - pulley & flywheel of car of mass 1000 kg
 1. motion of rotation of pulley



(2) Helical motion



Helical motion: Helix m, ϕ axis is Helical motion

Surface: ϕ axis

$$\tan \alpha = \frac{\text{lead}}{\pi D} = \frac{l}{\pi D} \quad \left| \quad \tan \phi = \frac{\pi D}{\text{lead}} = \frac{\pi D}{l} \right.$$

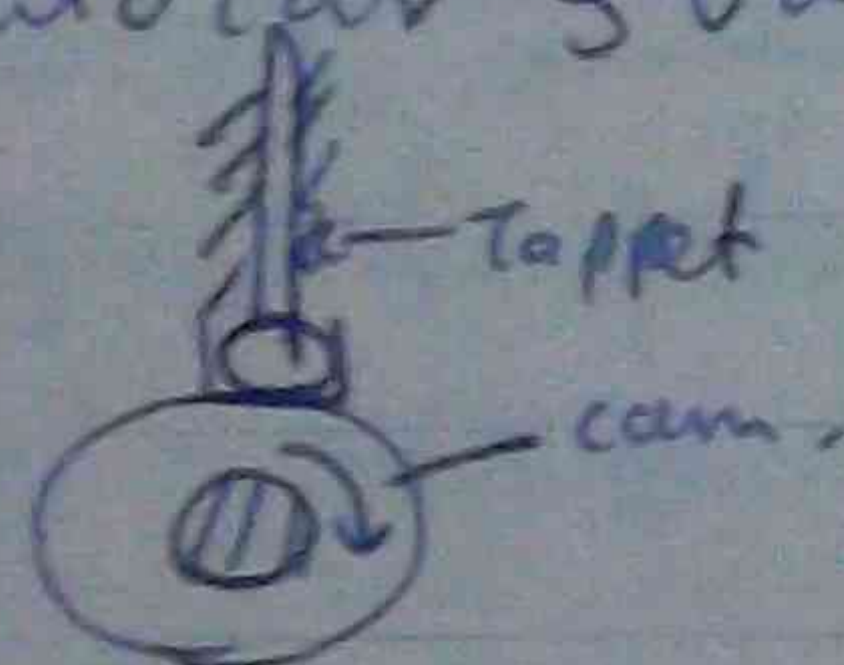
Spherical motion

Point motion: Governor, Flyball, etc. ϕ axis is spherical motion

Intermittent motion

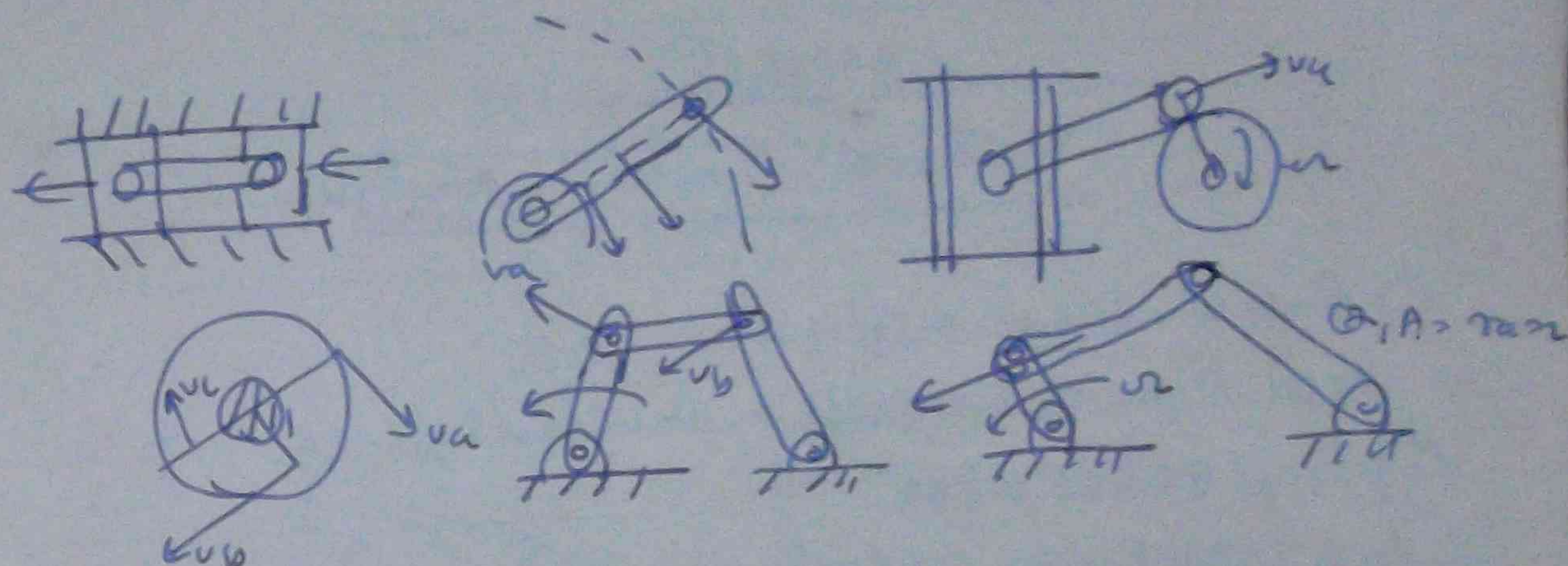
Point motion: Auto car valve tappet, etc. ϕ axis is intermittent motion

Auto car valve tappet: ϕ axis is intermittent motion



Rest: ϕ axis is intermittent motion

Absolute motion: ϕ axis is intermittent motion



6000 rev/min: ϕ axis is intermittent motion

6000 rev/min: ϕ axis is intermittent motion

$$1 \text{ revolution} = 360^\circ = 2\pi \text{ radian}$$

$$1 \text{ radian} = \frac{360}{2\pi} = 57.3^\circ$$

6000 rev/min: ϕ axis is intermittent motion

$$\omega = \frac{\text{angle}}{\text{time}} = \frac{\theta}{t}$$

$$v_a = \omega r$$

$$1 \text{ rev} = 2\pi \text{ rad}$$

$$1 \text{ rev/sec} = 2\pi \text{ rad/sec}$$

$$\begin{aligned} v &= \omega r \\ s &= \theta r \\ a &= \alpha r \end{aligned}$$

$$s = ut + \frac{1}{2}at^2$$

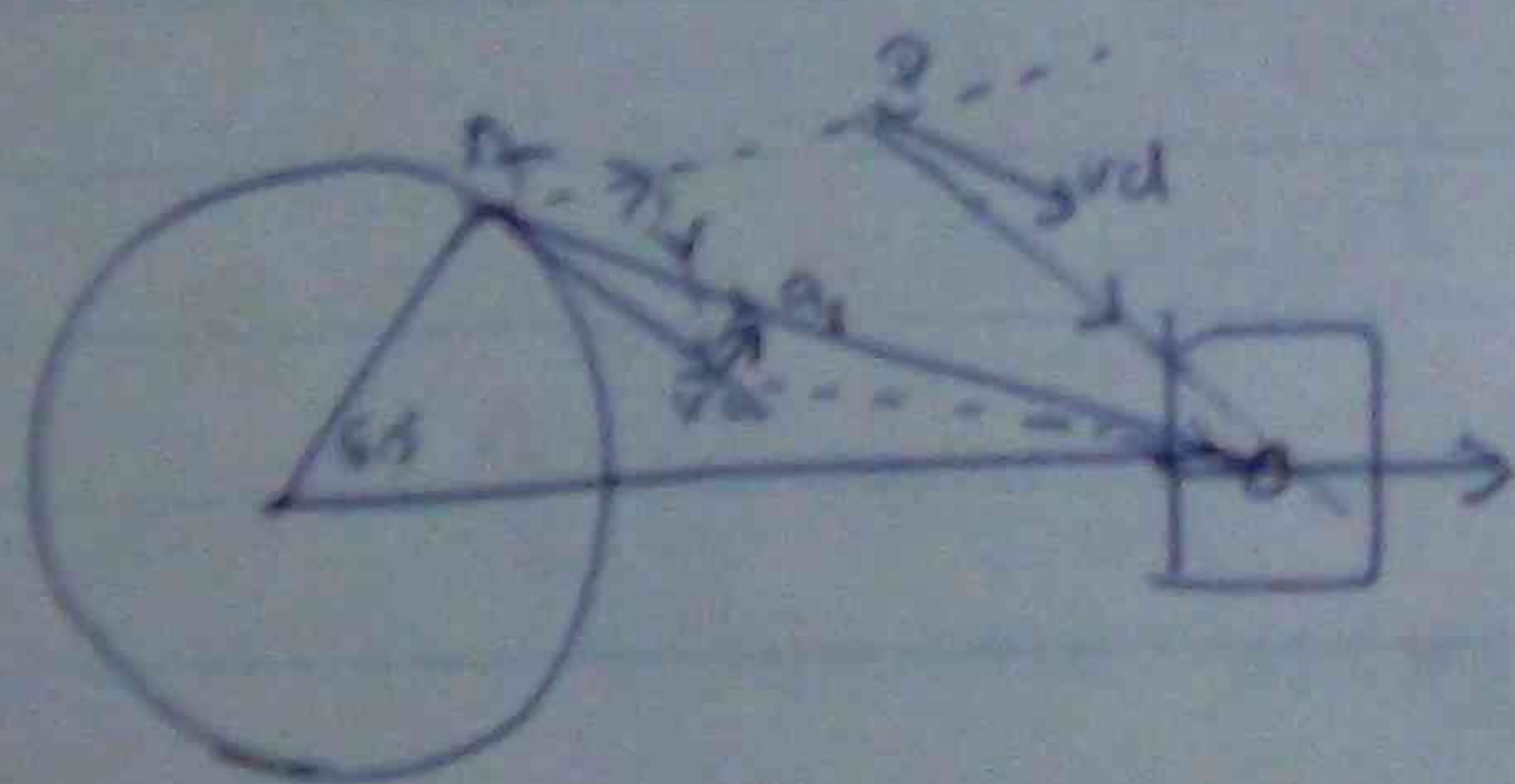
$$\theta = \omega t + \frac{1}{2}\alpha t^2$$

$$\begin{aligned} v^2 &= u^2 + 2as \\ \omega^2 &= \omega_0^2 + 2\alpha\theta \end{aligned}$$

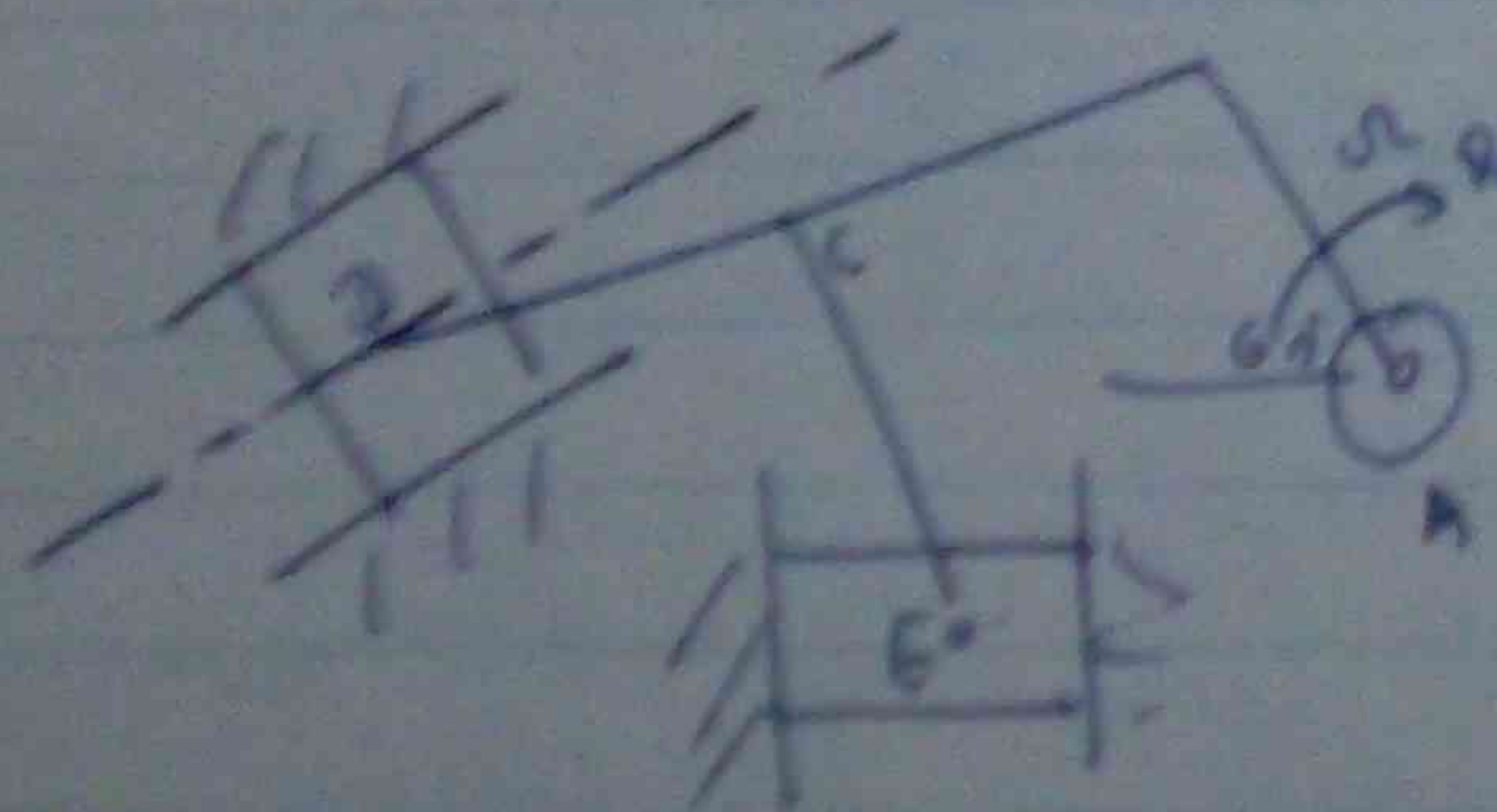
CHAPTER 1

Types of Velocity Analysis

1. Resolution and composition of velocity
2. Instantaneous centers of velocity
3. Relative velocity
4. Relative (relative) velocity



Scale: 1" = 1 ft
Velocity scale: 1" = 2 ft/s

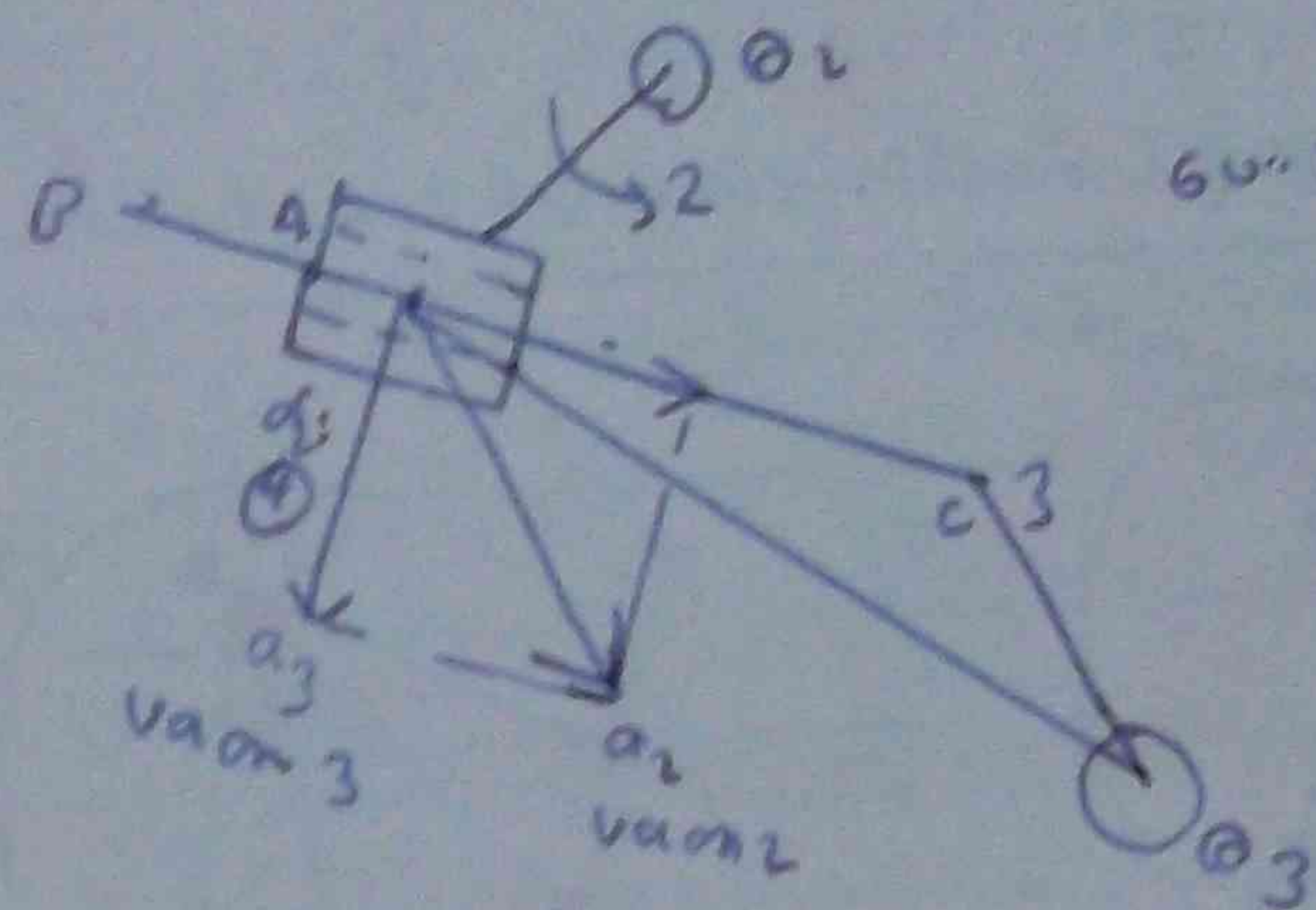


AB = 2 ft, BC = 3 ft
C = 3 ft, E = 2 ft
Velocity of C = $\frac{100}{60} \times 2\pi \times 2 = 20.9$ ft/s

CHAPTER 2 Velocities in machines

Quick Return motion mechanism

Velocity of the slider

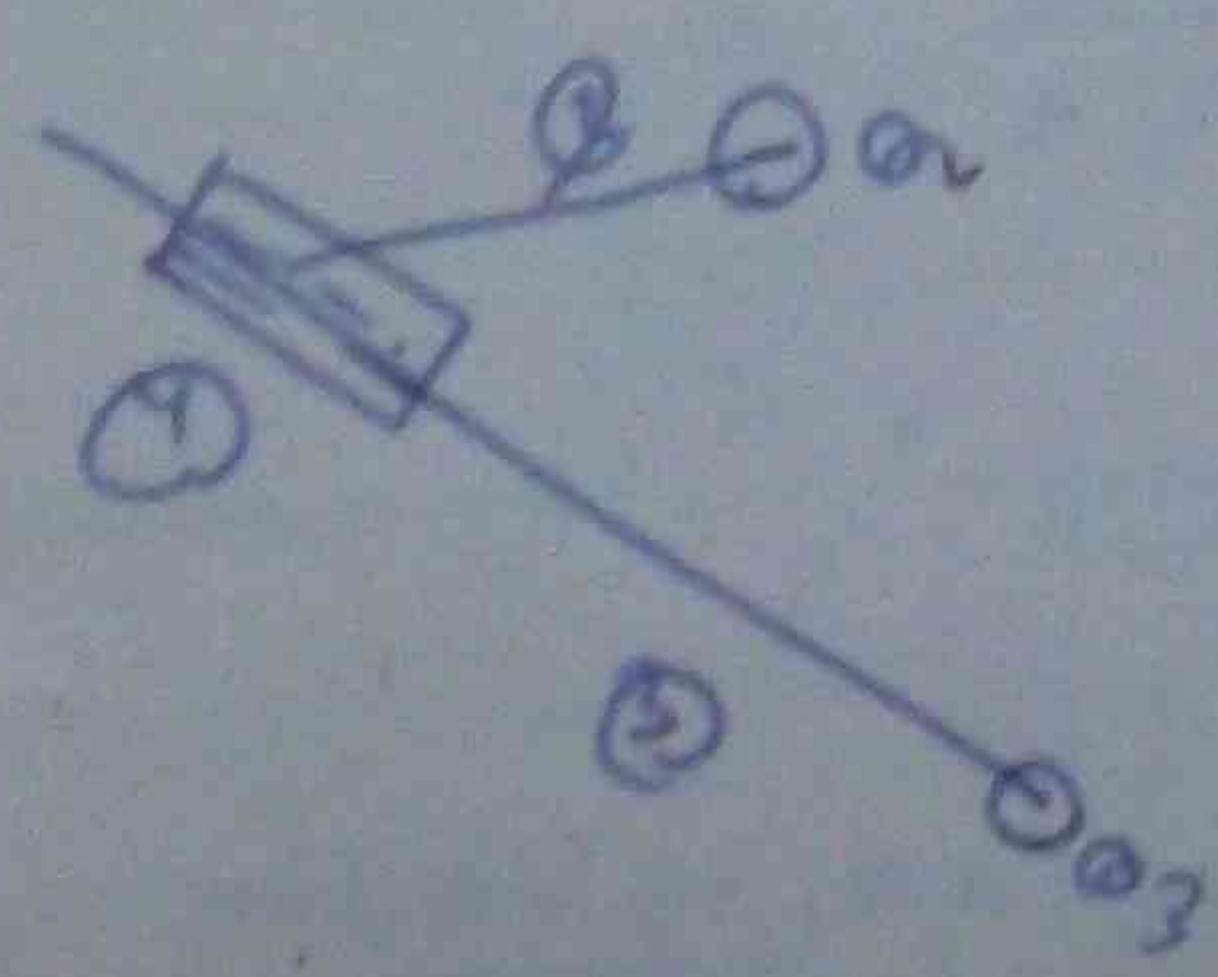


Velocity of the slider
C = 4 ft/s

Velocity of the slider
C = 4 ft/s

Velocity of the slider
C = 4 ft/s

Velocity of the slider
C = 4 ft/s



Velocity of the slider
C = 4 ft/s

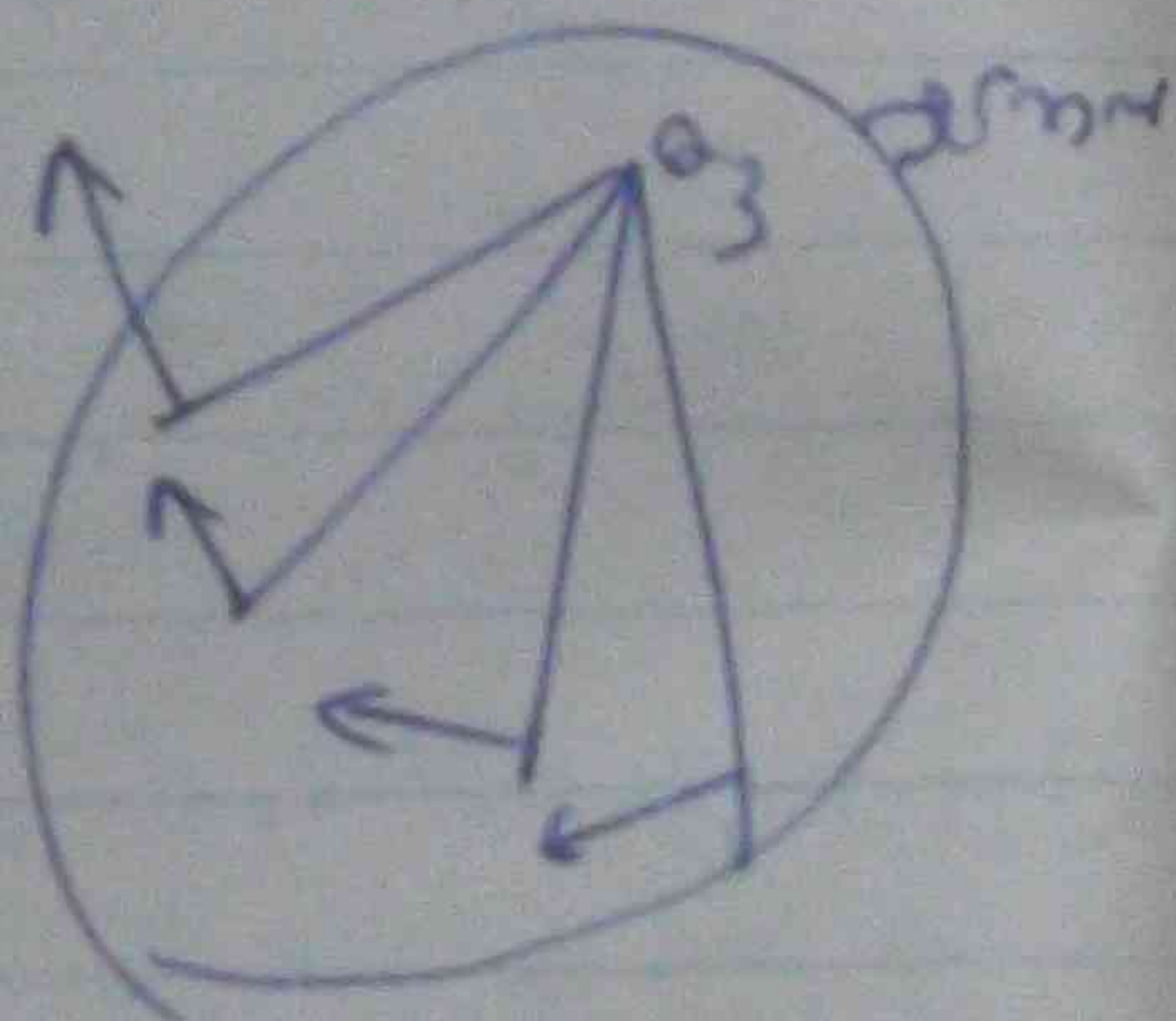
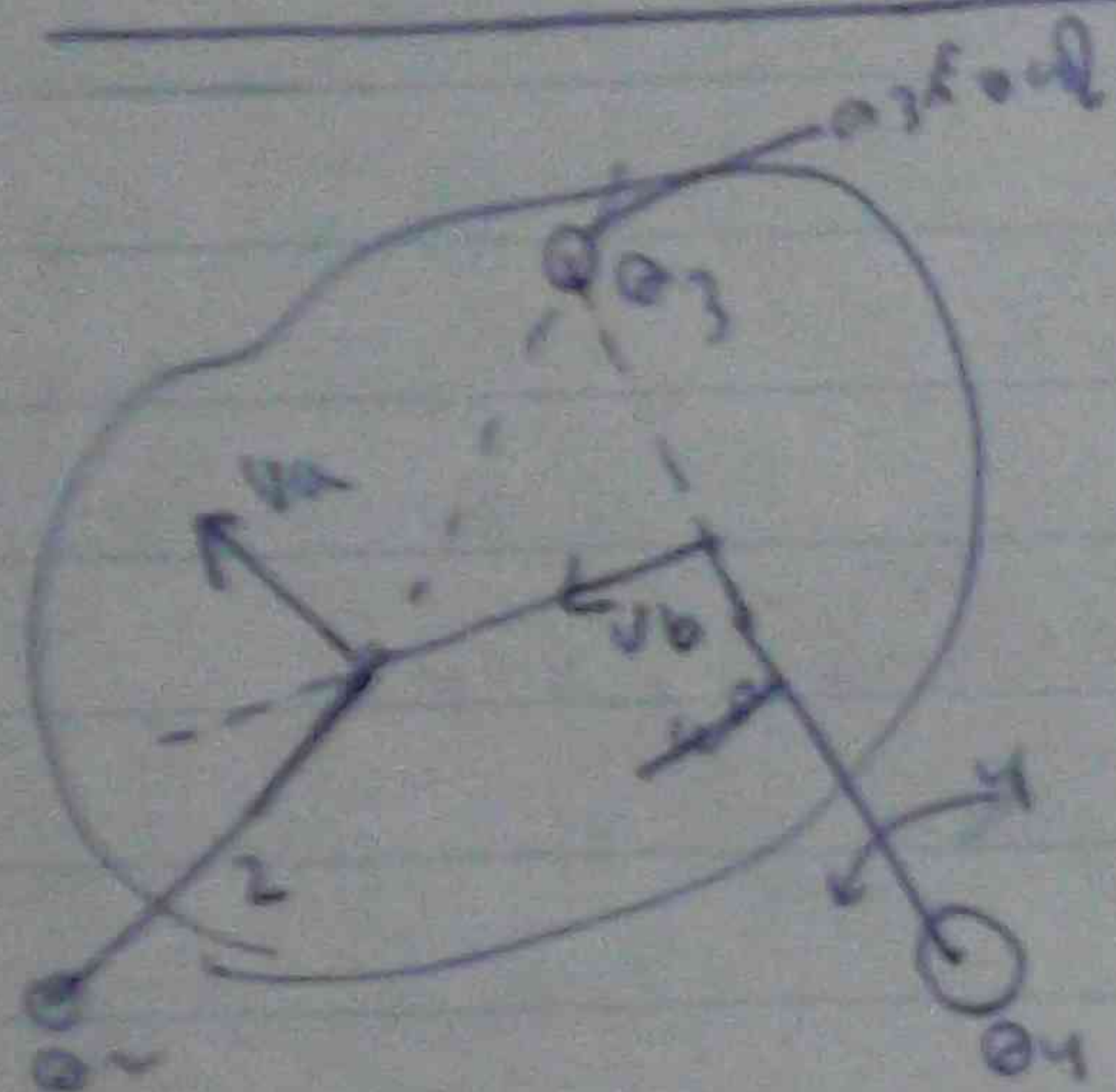
Velocity of the slider
C = 4 ft/s

Velocity of the slider
C = 4 ft/s

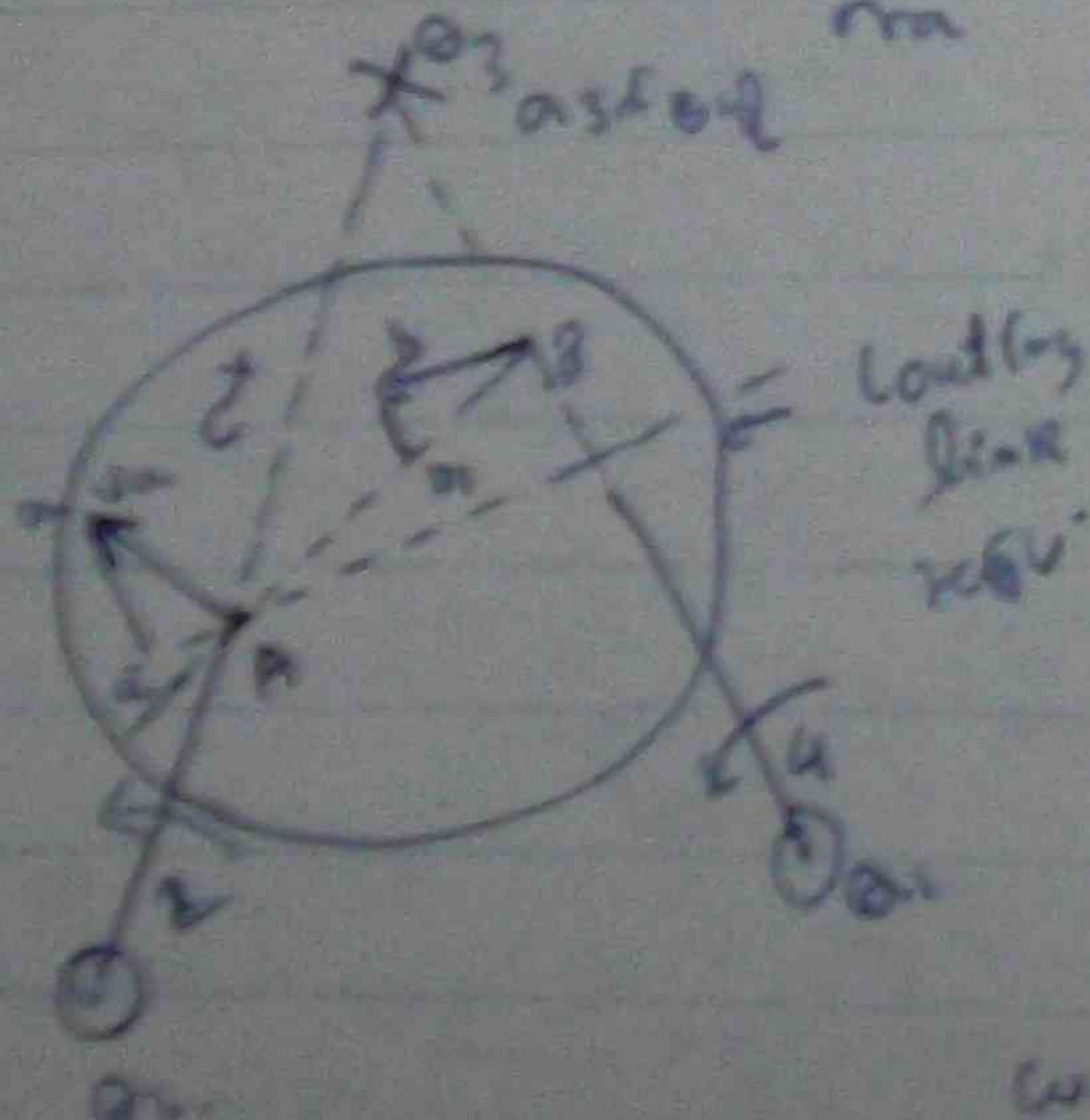
$$u_v = u_{m \cdot O_2}$$

$$u_v = \left(\frac{100 \text{ mm}}{60} \right) \frac{3}{4} \text{ ft/sec}$$

Instantaneous Axis of Velocity



$$v_A = \omega \cdot r_{AO_3}, \quad \frac{v_A}{r_{AO_3}} = \omega = \frac{v_B}{r_{BO_3}} \Rightarrow \omega_2$$



$$\omega_3 = \frac{(a a_1 \rightarrow b b_1) u_v}{AB}$$

$a a_1, b b_1 \perp$ to line of action of u_v

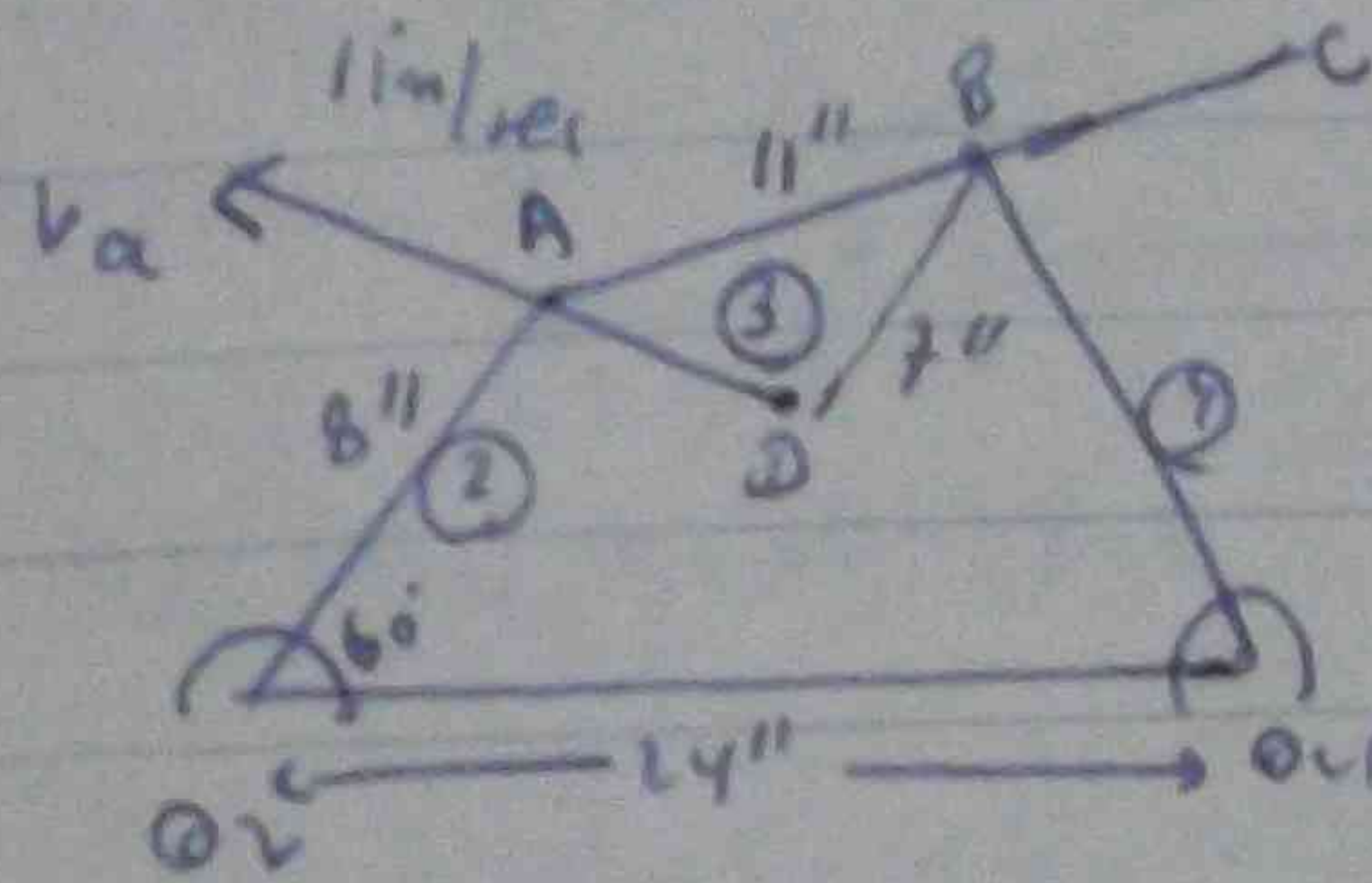
$$\omega_3 = \frac{(a a_1 + b b_1) u_v}{AB}$$

$a a_1, b b_1 \perp$ to line of action of u_v

1) Instantaneous axis of velocity is the axis of velocity at any instant.

2) Instantaneous axis of velocity is the axis of velocity at any instant.

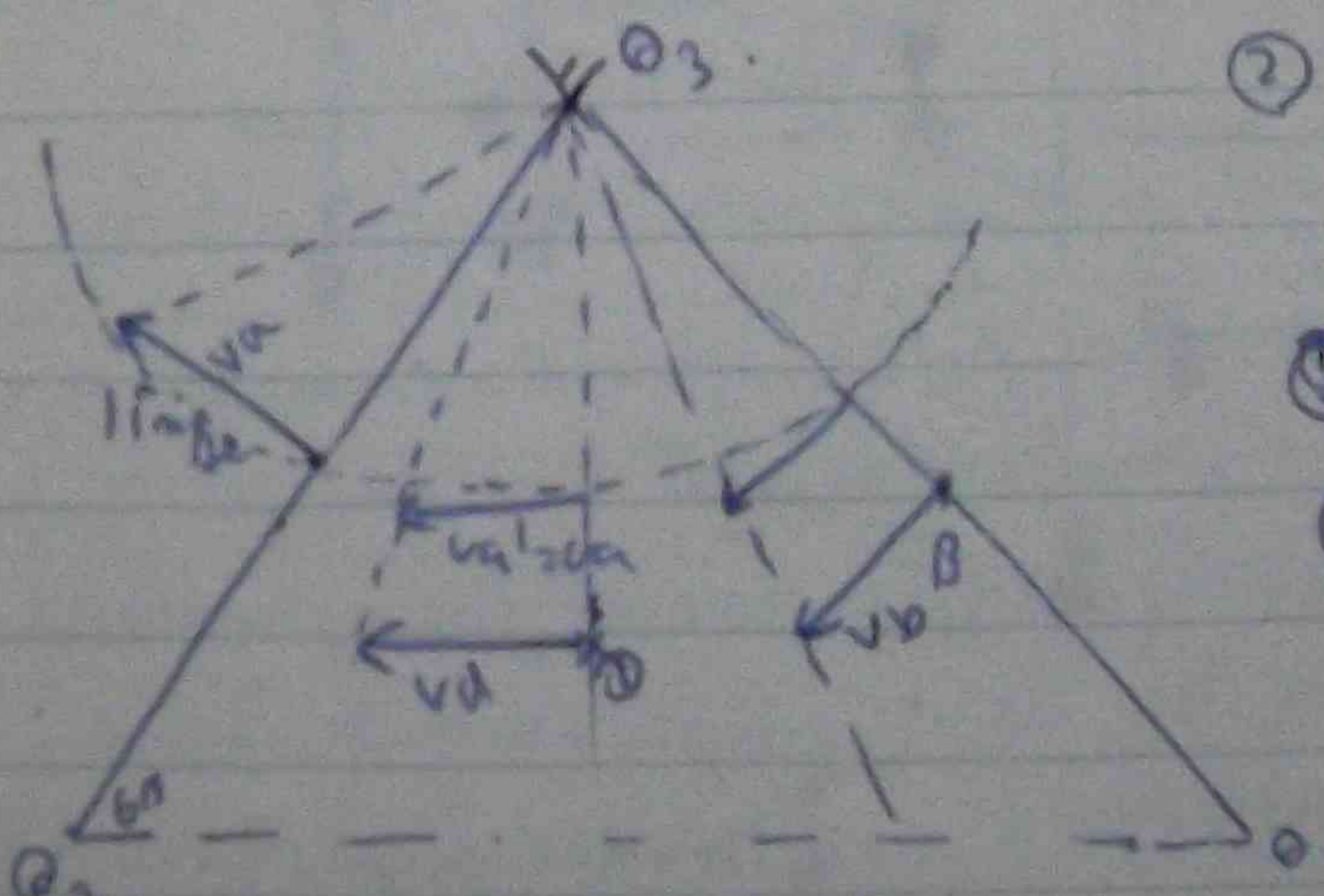
3) Instantaneous axis of velocity is the axis of velocity at any instant.



$$u_v = 1'' = 1 \text{ in/sec}$$

$$u_s = 1'' = 4''$$

1) O_2 is the instantaneous axis of velocity.



2) O_2 is the instantaneous axis of velocity.

3) O_2 is the instantaneous axis of velocity.

4) O_2 is the instantaneous axis of velocity.

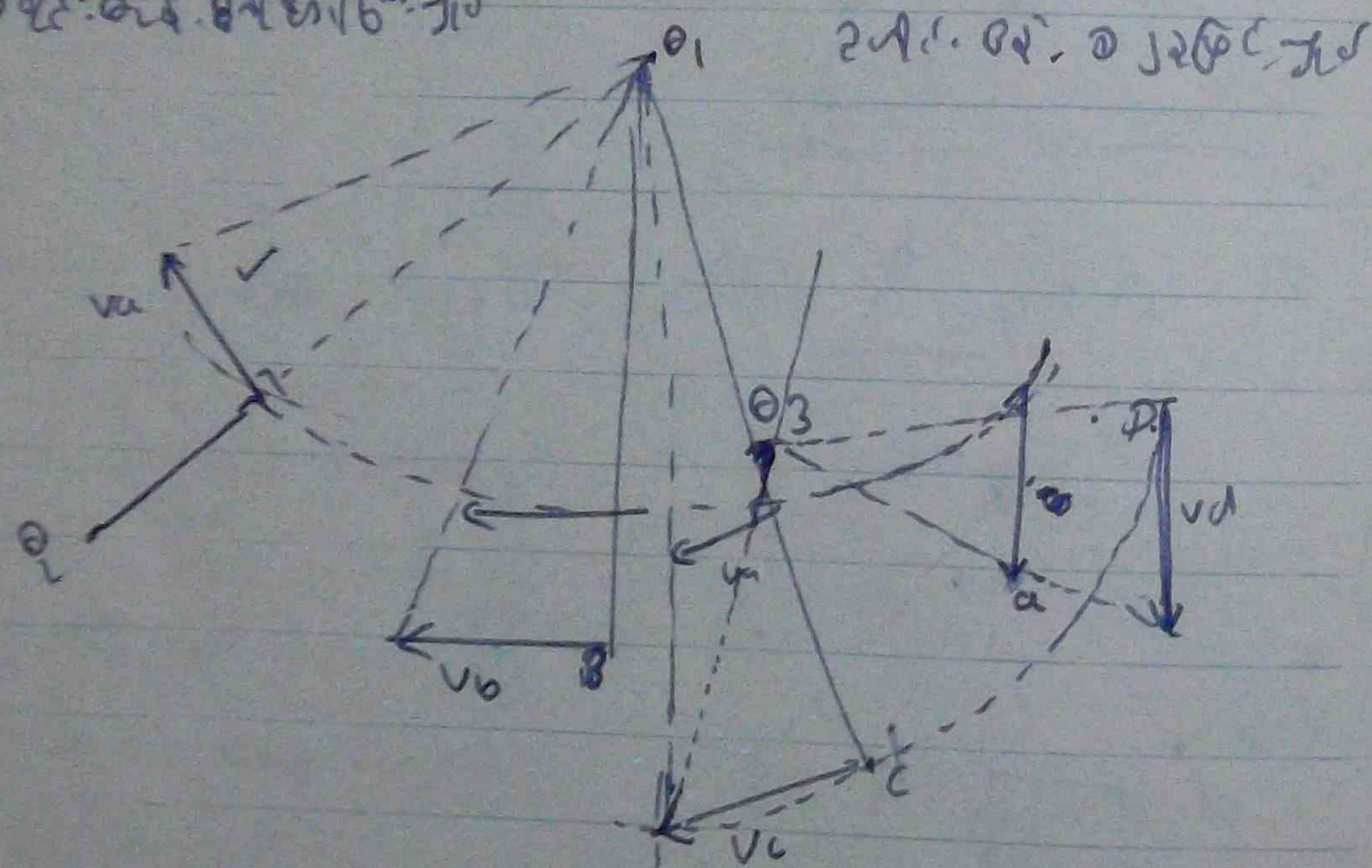
5) O_2 is the instantaneous axis of velocity.

6) O_2 is the instantaneous axis of velocity.

7) O_2 is the instantaneous axis of velocity.


8) O_2 is the instantaneous axis of velocity.

9) O_2 is the instantaneous axis of velocity.



Учитывая, что $30 \rightarrow 2$ и

Mr. Dingler, Ave. 9th & 10th
24: 1/10

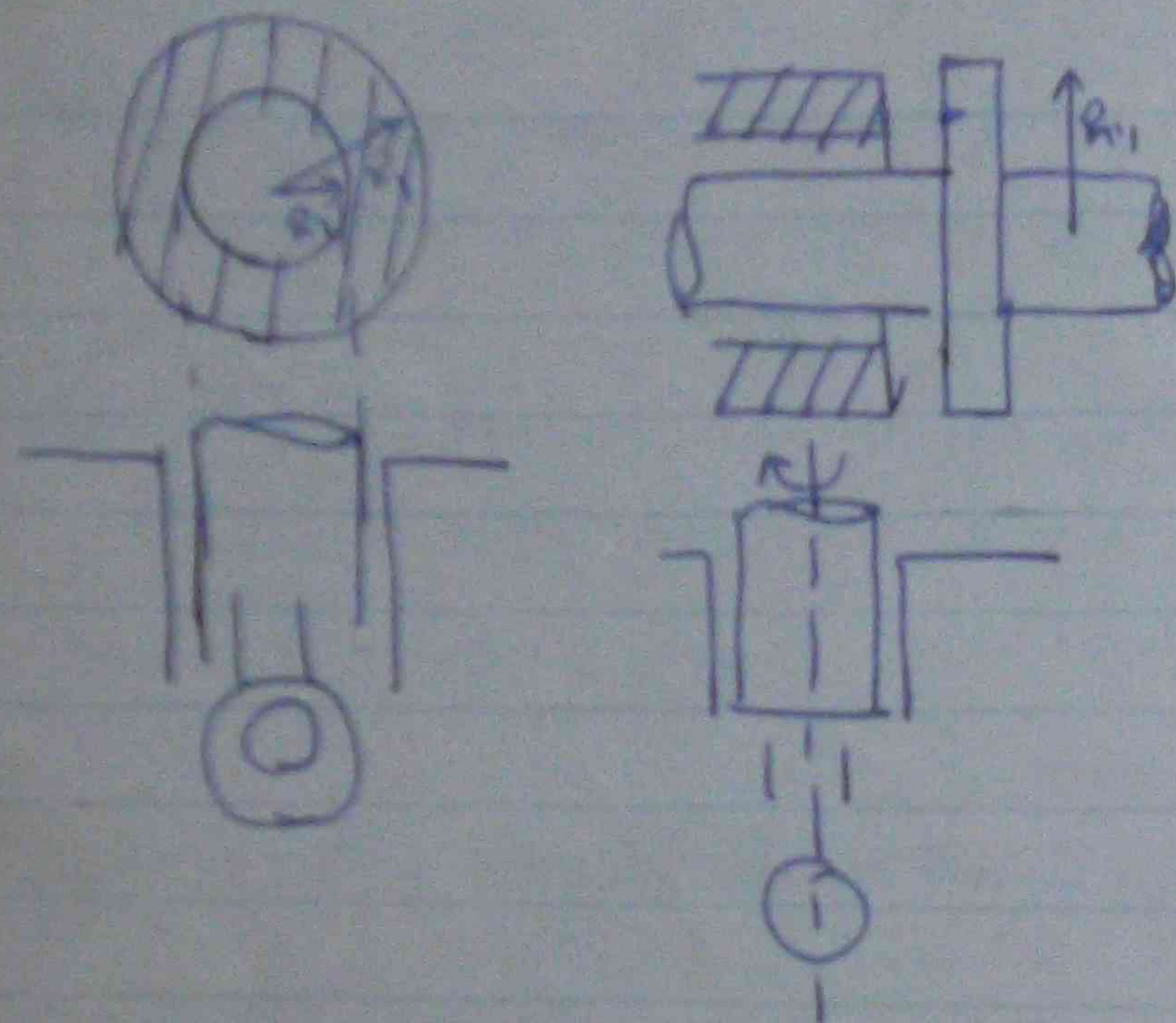
Q3. 

St: $\phi, V_{bi}, n_A, n_D, \phi_0, V_{d0} \dots$

(5) $\frac{1}{2} \log 2 + \frac{1}{2} \log 2 = 1$

Friction

[illegible]



uniform pressure $T = \frac{2}{3} \mu P \frac{R_1^3 - R_2^3}{R_1^2 - R_2^2}$

$R_2 = 0 \text{ (pin)} \rightarrow T = \frac{2}{3} \mu P R_1$

uniform wear

$T = \frac{1}{2} \mu P (R_1 + R_2)$

$T = \frac{1}{2} \mu P R_1$ where $R_2 = 0$

HP. $\frac{2 \pi N T}{12 \times 33000}$

μ = coefficient of friction (avg)
 T = Torque force (lb) of shaft
 P = Intensity of pressure (psi) or (lb/in²)

Pb
 1. A shaft of diameter 16 in is to be fitted into a hub of diameter 16 in. The length of the shaft is 12 in. The intensity of pressure of the shaft is 50 psi. The coefficient of friction is 0.04. The shaft is to be fitted into the hub. The shaft is to be fitted into the hub. The shaft is to be fitted into the hub.

$P = 16 \times 2140 \text{ lb}$ $P = 50 \text{ psi}$ $\mu = 0.04$ $HP = ?$ $N = 1200 \text{ rpm}$

$R_1 = 16''$ $R_2 = 8''$

$R_2 = 16''$ $R_1 = 8''$

Uniform pressure $T = \frac{2}{3} \mu P \frac{R_1^3 - R_2^3}{R_1^2 - R_2^2} = \frac{2}{3} \times 0.04 \times 16 \times 2140 \frac{16^3 - 8^3}{16^2 - 8^2} = 10100 \text{ lb-in}$

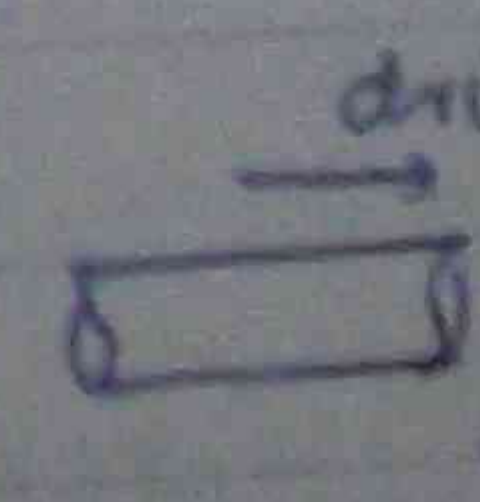
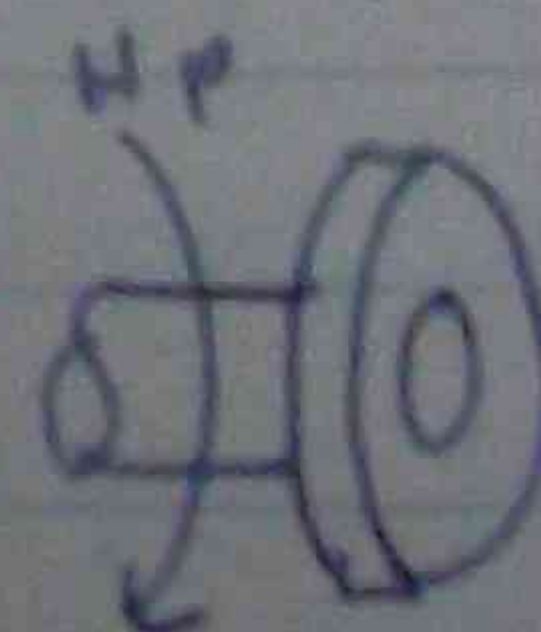
HP. $\frac{2 \pi N T}{12 \times 33000} = \frac{2 \pi \times 1200 \times 10100}{12 \times 33000} = 19.3 \text{ HP}$

$P = P \pi (R_1^2 - R_2^2) m$

$16 \times 2140 = 50 \pi (16^2 - 8^2) m$ $m = 0.15 \approx 9$
 $\therefore \text{collar} = 9 \text{ in}$



$P = P \pi (R_1^2 - R_2^2) m$



driven shaft
 driven shaft
 7000 rpm

driving shaft

driven shaft

Pb. Given: $n = 100 \text{ rpm}$, $\mu = 0.06$, $P = 100 \text{ psi}$, $R_1 = 5 \text{ in}$, $R_2 = 4 \text{ in}$
 Find: Torque T and Power P
 Solution:
 $A = \pi(R_1^2 - R_2^2) = \pi(5^2 - 4^2) = 28.3 \text{ in}^2$
 $F = P \times A = 100 \times 28.3 = 2830 \text{ lbf}$
 $T = \frac{1}{2} \mu F (R_1 + R_2) = \frac{1}{2} \times 0.06 \times 2830 (5 + 4) = 1351 \text{ in lbf}$
 $P = \frac{2\pi T n}{12 \times 33000} = \frac{1351 \times 100}{12 \times 33000} = 0.34 \text{ hp}$

$$P = p \pi (R_1^2 - R_2^2)$$

$$A = \pi(R_1^2 - R_2^2) = \pi(5^2 - 4^2) = 28.3 \text{ in}^2$$

$$F = P \times A = 100 \times 28.3 = 2830 \text{ lbf}$$

$$T = \frac{1}{2} \mu F (R_1 + R_2) = \frac{1}{2} \times 0.06 \times 2830 (5 + 4) = 1351 \text{ in lbf}$$

$$T = \frac{2\pi n \times 12 \times \text{HP}}{33000} = \frac{1351 \times 100 \times 12}{33000} = 0.34 \text{ hp}$$

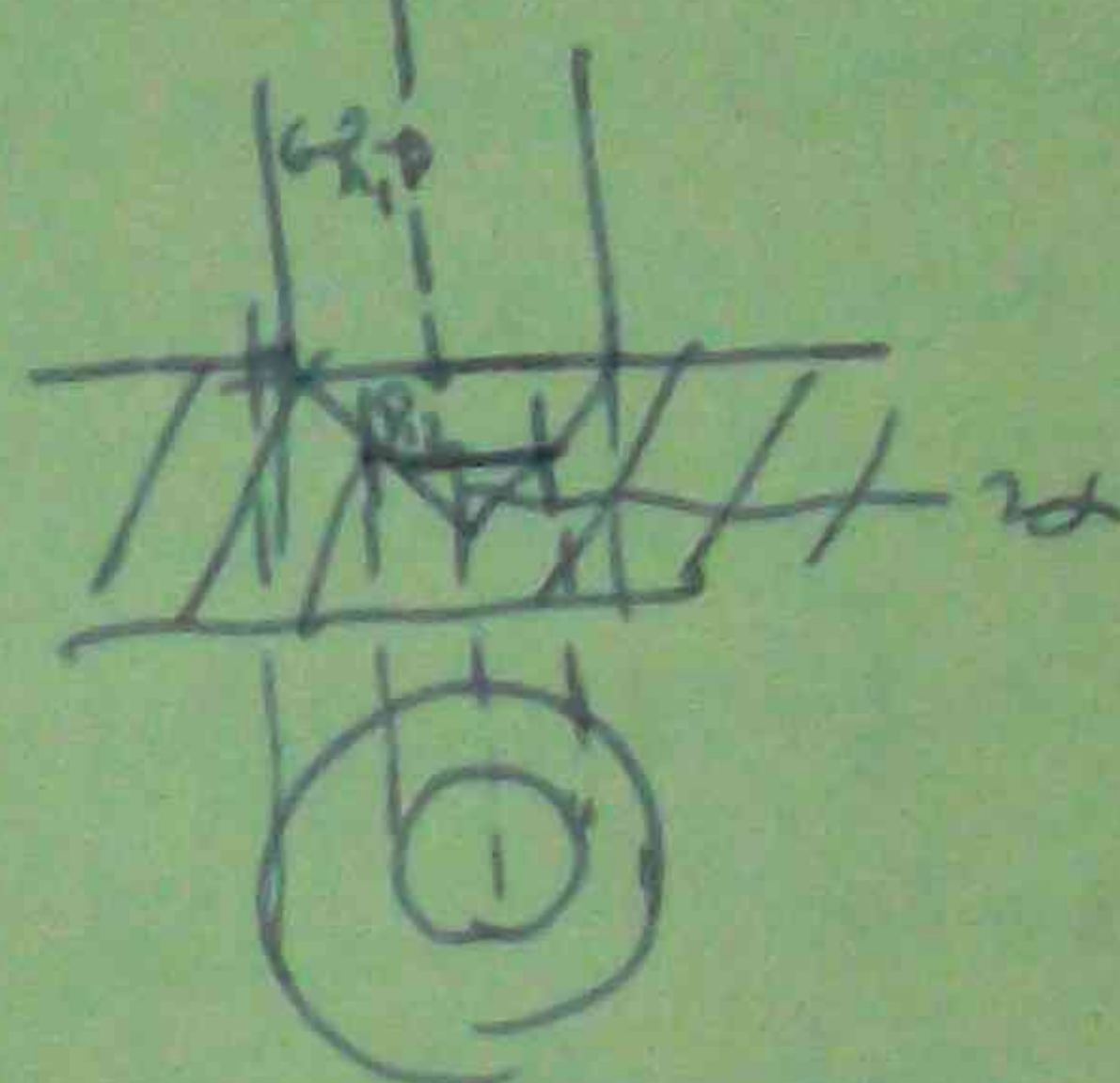
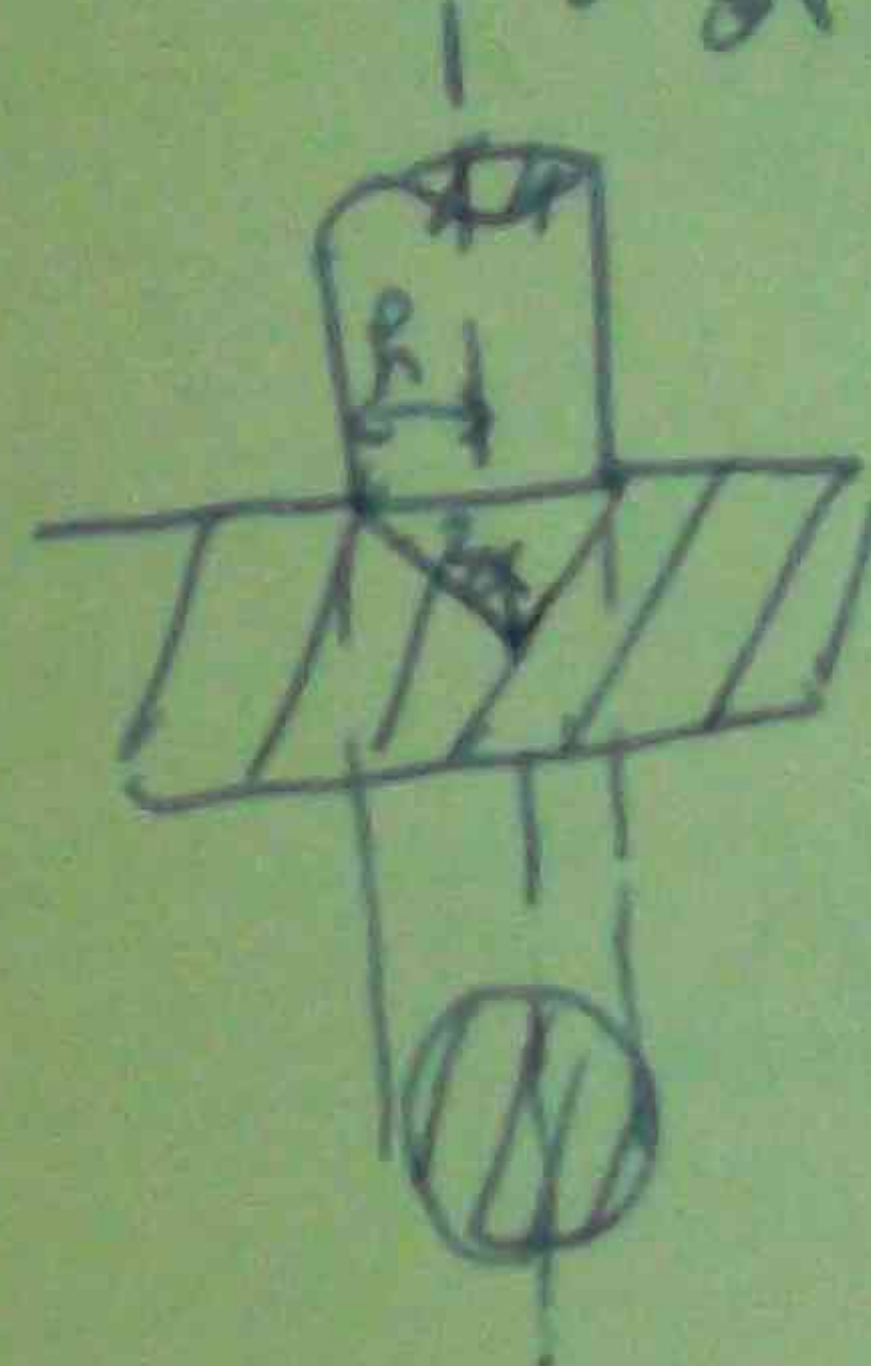
$$\text{Find: } \mu = \frac{1351}{2830} = 0.48$$

Given: (Lubrication plate 112 psi)

Find: Torque T and Power P

Given: $n = 100 \text{ rpm}$ (conical pivot)

Find: Torque T and Power P (conical clutch)



$$T = \frac{1}{2} \mu F (R_1 + R_2) = \frac{1}{2} \times 0.06 \times 2830 (5 + 4) = 1351 \text{ in lbf}$$

Given: $n = 100 \text{ rpm}$, $\mu = 0.06$, $P = 100 \text{ psi}$, $R_1 = 5 \text{ in}$, $R_2 = 4 \text{ in}$

$$T = \frac{1}{2} \mu F (R_1 + R_2) = \frac{1}{2} \times 0.06 \times 2830 (5 + 4) = 1351 \text{ in lbf}$$

$$P = \frac{2\pi T n}{12 \times 33000} = \frac{1351 \times 100 \times 12}{33000} = 0.34 \text{ hp}$$

Find: Torque T and Power P

Pb.

Given: $n = 100 \text{ rpm}$, $\mu = 0.06$, $P = 100 \text{ psi}$, $R_1 = 5 \text{ in}$, $R_2 = 4 \text{ in}$
 Find: Torque T and Power P

Find the power of the beam if the intensity is 1155 W/m²

$$\mu = 0.06, \rho = 50 \text{ PSI}, R_1 = 3R_2$$

$$\rho = 2100 = 2100 \text{ lbs}$$

$$2\lambda = 120, N = 120 \text{ rpm}$$

$$\therefore P = P\pi (R_1^2 - R_2^2)$$

$$2100 = 50\pi [(3R_2)^2 - R_2^2]$$

$$R_2 = 1.84 \text{ in}$$

$$\therefore R_1 = 5.52 \text{ in}$$

$$T = \frac{2}{3} \times \frac{\rho}{\sin \alpha} \left(\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2} \right)$$

$$= \frac{2}{3} \times 0.06 \times 50\pi \left(\frac{R_1^3 - R_2^3}{R_1^2 - R_2^2} \right)$$

$$T = 1865 \text{ in lb}$$

$$HP = \frac{2\pi NT}{12 \times 730} = \frac{120 \times 1865}{63000} = 2.12 \text{ HP}$$

~~Find the power of the beam if the intensity is 1155 W/m²~~

Prob A cylindrical beam of light of diameter 120 mm and length 10 cm is incident on a surface. The intensity of the beam is 1155 W/m². Find the power of the beam. Also find the force exerted by the beam on the surface.

$$R_1 = R_m + \frac{1}{2} \sin \alpha$$

$$R_2 = R_m - \frac{1}{2} \sin \alpha$$

$$T = \frac{1155 \times 33000 \times 12}{2\pi \times 730}$$

$$T = 1155 \text{ in lb}$$

$$\text{Intensity } P = \frac{\rho}{\pi(R_1^2 - R_2^2)}$$

$$\rho = P\pi (R_1^2 - R_2^2)$$

$$= 10\pi (R_1 + R_2)(R_1 - R_2)$$

$$= 10\pi \times 2R_m \sin \alpha$$

$$= 10\pi \times 2R_m \times \frac{7}{2} \times 0.1726$$

$$\therefore \rho = 12\pi R_m$$

$$T = \frac{1}{2} \times \frac{\rho(R_1 + R_2)}{\sin \alpha}$$

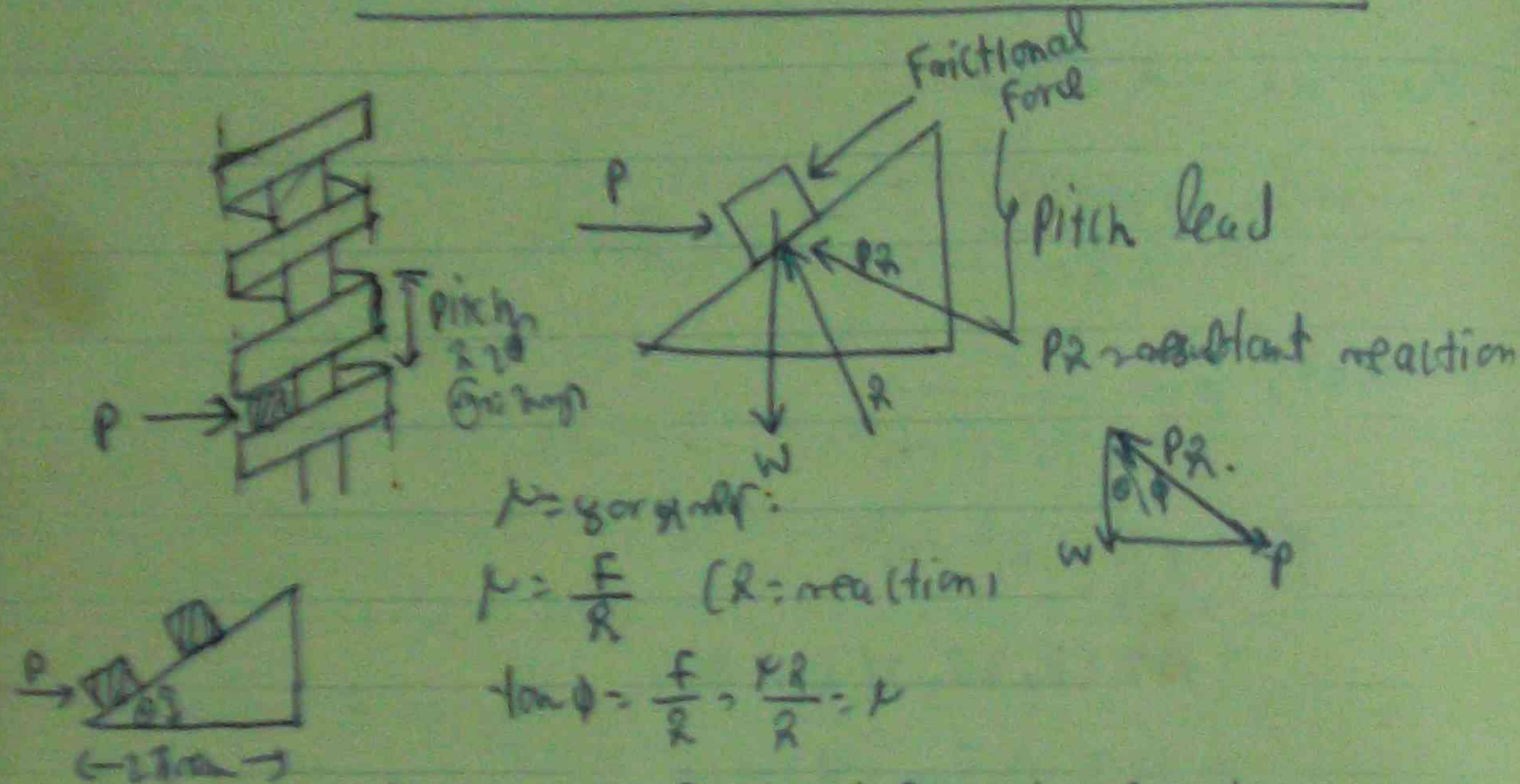
$$1155 = \frac{1}{2} \times 0.25 \times \frac{12\pi R_m \times 2R_m}{0.1726}$$

$$1155 = \frac{0.425 R_m^2}{0.1726}$$

$$R_m = 4.65$$

$$\therefore \text{Diameter} = 9.3 \text{ in}$$

Square screw (6mm dia, 12mm lead)

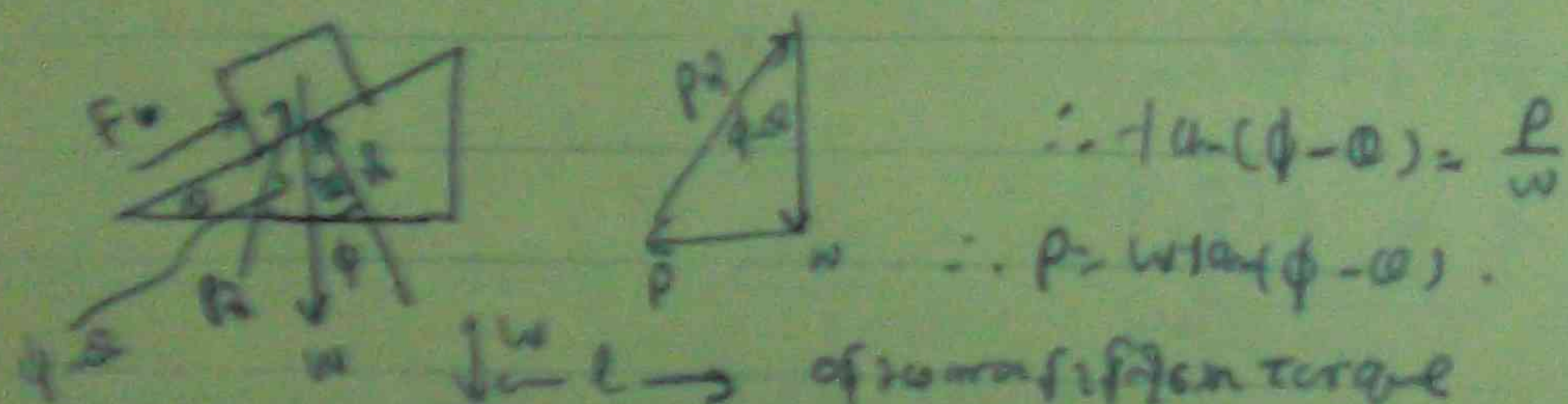


$\mu = \tan \phi$

$$\mu = \frac{F}{R} \quad (R = \text{reaction})$$

$$\tan \phi = \frac{F}{R} = \frac{P R}{R} = \mu$$

$$\tan(\theta + \phi) = \frac{P}{W} \quad \therefore P = W \tan(\theta + \phi)$$



$$\therefore \tan(\phi - \theta) = \frac{P}{W}$$

$$\therefore P = W \tan(\phi - \theta)$$

of transmission torque

$$T = \theta L = W \tan(\theta + \phi) r_m$$

of screw thread torque

$$T = \theta L = W \tan(\phi - \theta) r_m$$

$$\theta = \tan^{-1} \frac{L}{2\pi r_m} \quad \therefore \tan \theta = \frac{L}{2\pi r_m}$$

(pb) A screw of 6mm dia, 12mm lead, 1mm pitch of 1000 lbs weight is to be turned by a screw driver. Find the force P required to turn the screw.

Take $\mu = 0.3$ for the screw. Lead (2mm) Pitch (1mm)

Given: $\mu = 0.3$, $d = 6\text{mm}$, $L = 12\text{mm}$, $W = 1000\text{lbs}$, $P = ?$, $\theta = ?$

$$d = 6\text{mm}, \quad r_m = \frac{1}{2} d = 3\text{mm}, \quad W = 1000\text{lbs}, \quad \mu = 0.3, \quad L = 12\text{mm}$$

$$P = ? \quad \theta = ?$$

For θ : $\tan \theta = \frac{L}{2\pi r_m}$

$$\therefore \theta = 16.7^\circ$$

$$\tan \theta = \frac{L}{2\pi r_m}$$

$$\therefore \tan \phi = \frac{L}{2\pi r_m}$$

$$\tan \phi = \mu = 0.3$$

$$\phi = 16.7^\circ$$

$$\therefore P = W \tan(\phi + \theta) = 1000 \times \tan(16.7^\circ + 16.7^\circ)$$

$$P = \frac{W \tan(\phi + \theta)}{\tan \theta} = \frac{1000 \times \tan(16.7^\circ + 16.7^\circ)}{\tan 16.7^\circ}$$

$$= 55\text{ lbs}$$

(pb) Turn buckle is a device used to adjust the tension of a rope or cable. It consists of a central pin and two end plates. The rope or cable is threaded through the end plates and the central pin. The tension is adjusted by turning the end plates.

Given: $d = 1\text{mm}$, $P = 3\text{mm}$, $L = 1\text{mm}$, $W = 1\text{mm}$, $\mu = 0.15$

Find: P , θ , ϕ , $\tan \theta$, $\tan \phi$, $\tan(\theta + \phi)$

For θ : $\tan \theta = \frac{L}{2\pi r_m}$

$$\therefore \theta = 16.7^\circ$$



$P = \frac{3}{2} \text{ in}$
 $D_m = \frac{3}{2} \text{ in}$ $r_m = \frac{3}{4} \text{ in}$
 $\mu = 0.15$ $W = 2000 \text{ lb}$ $T = ?$

$\tan \phi = \mu = 0.15 \therefore \phi = 8.53^\circ$

$\tan \alpha = \frac{\text{Pitch}}{2\pi r_m} = \frac{3 \times 4}{8 \times 2\pi \times 3} = 0.0726$

$\therefore \tan \alpha = \tan 4.55^\circ \therefore \alpha = 4.55^\circ$

(a) $\text{torque } T = W r_m \tan(\alpha + \phi) \times 2 \quad (T \uparrow, T \uparrow)$
 $= 2000 \times \frac{3}{4} \tan(8.53 + 4.55) \times 2$
 $= 697.2 \text{ in lb.}$

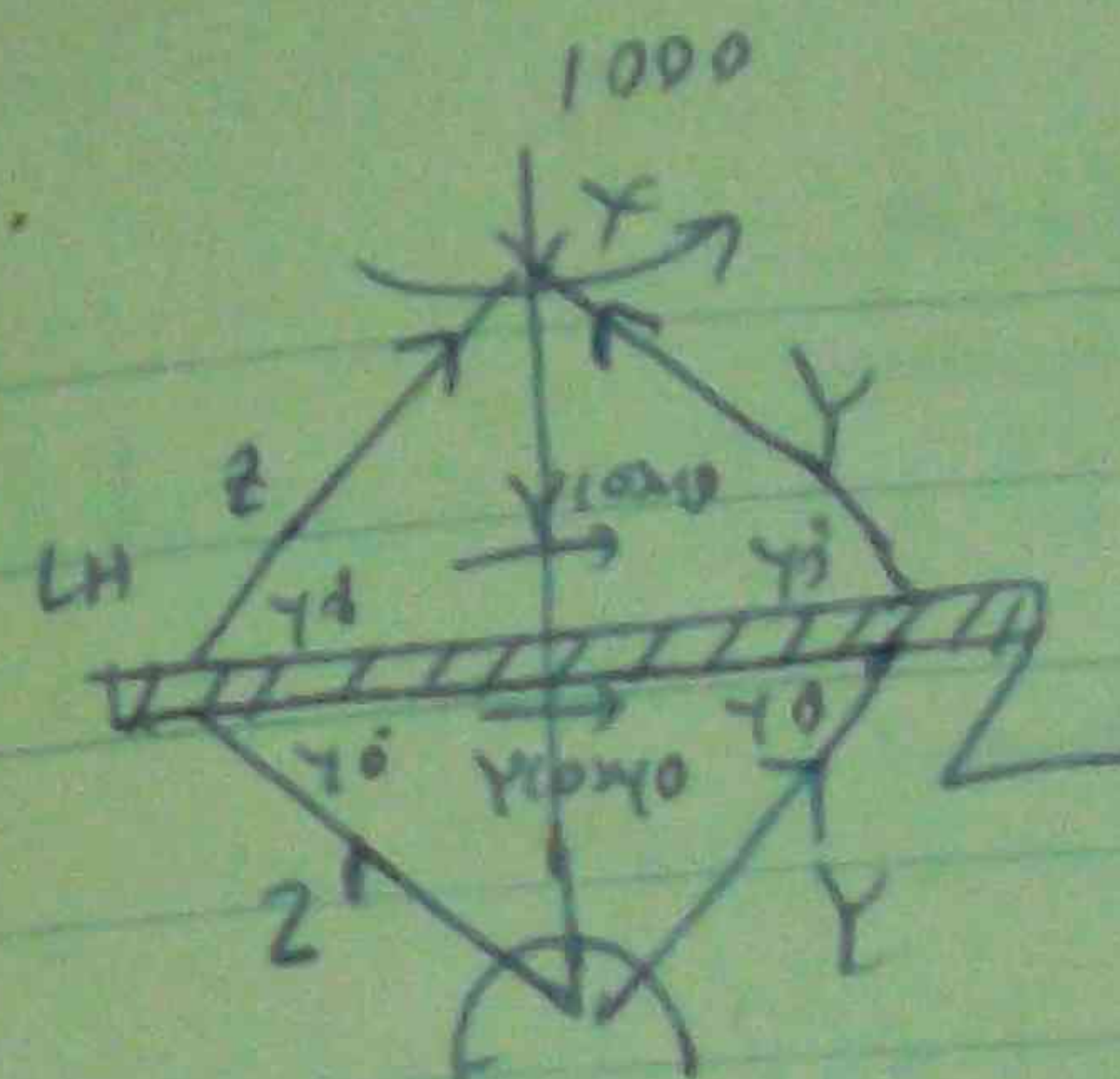
(b) $\text{torque } T = W r_m \tan(\phi - \alpha) \times 2$
 $= 2000 \times \frac{3}{4} \tan(8.53 - 4.55) \times 2$
 $= 209.1 \text{ in lb.}$

efficiency

$\eta = \frac{\tan \alpha}{\tan(\alpha + \phi)}$

(P) Since Jack is self locking screw, one can see
 easily that the lead angle is less than the friction angle
 or $\alpha < \phi$ thus the screw is self locking
 (i.e. T is negative)

$\alpha, \phi, T_{\text{in}}, T_{\text{out}} \text{ (numerical)}$
 $\eta = \frac{\tan \alpha}{\tan(\alpha + \phi)} = \frac{\tan 4.55^\circ}{\tan(4.55 + 8.53)} = 0.316$



$D_m = 1 \frac{1}{4} \text{ in}$ $r_m = \frac{5}{8} \text{ in}$
 $\mu = 0.3$ $\text{lead} = 0.4$
 $1000 \text{ rev } T_{\text{in}} \text{ for } 60^\circ \text{ of}$
 $\phi = 60^\circ$ $\alpha = 4.55^\circ$

$\therefore \text{off } 60^\circ \text{ is } \alpha \text{ for } m. W = 2Y \cos 40^\circ$
 $\frac{\alpha}{\sin \phi} = \frac{Y}{\sin 2} = \frac{2}{\sin \beta}$
 $\frac{Y}{\sin 170} = \frac{1000}{\sin 100} \quad Y = 776 \text{ lb}$

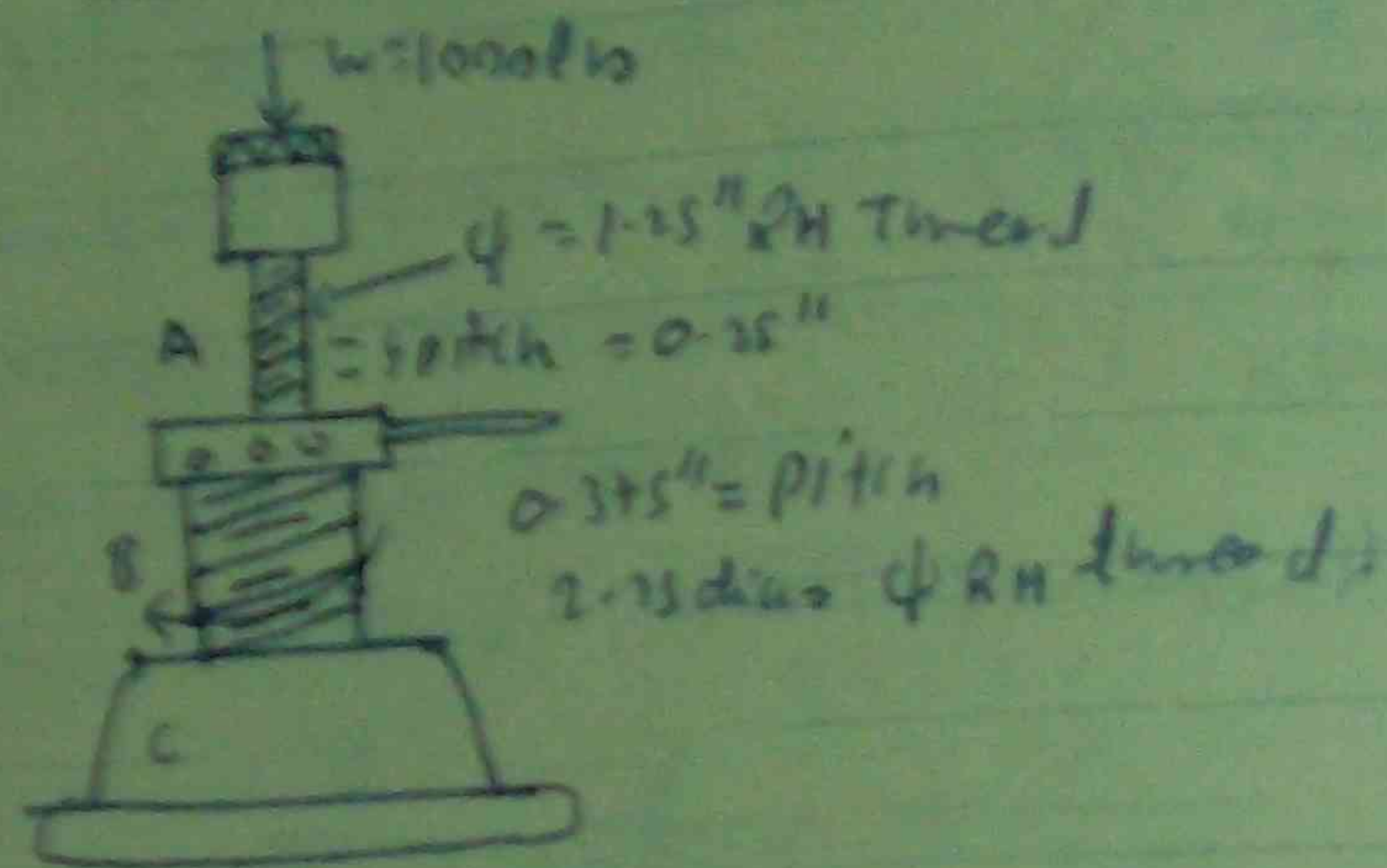
$\therefore \text{off } 60^\circ \text{ is } \alpha \text{ for } m. W = 2Y \cos 40^\circ = 2 \times 776 \times 0.766$
 $= 1190 \text{ lb}$

(a) $\text{torque } T = W r_m \tan(\alpha + \phi) \times 2$
 $= 1190 \times \frac{5}{8} \tan(5.49 + 10.42) \times 2$
 $= 616 \text{ lb-in}$

(b) $\text{torque } T = W r_m \tan(\phi - \alpha) \times 2$
 $= 1190 \times \frac{5}{8} \tan(16.41 - 5.49) \times 2$
 $= 285 \text{ lb-in}$

Differential Screw Jack

10

[illegible]

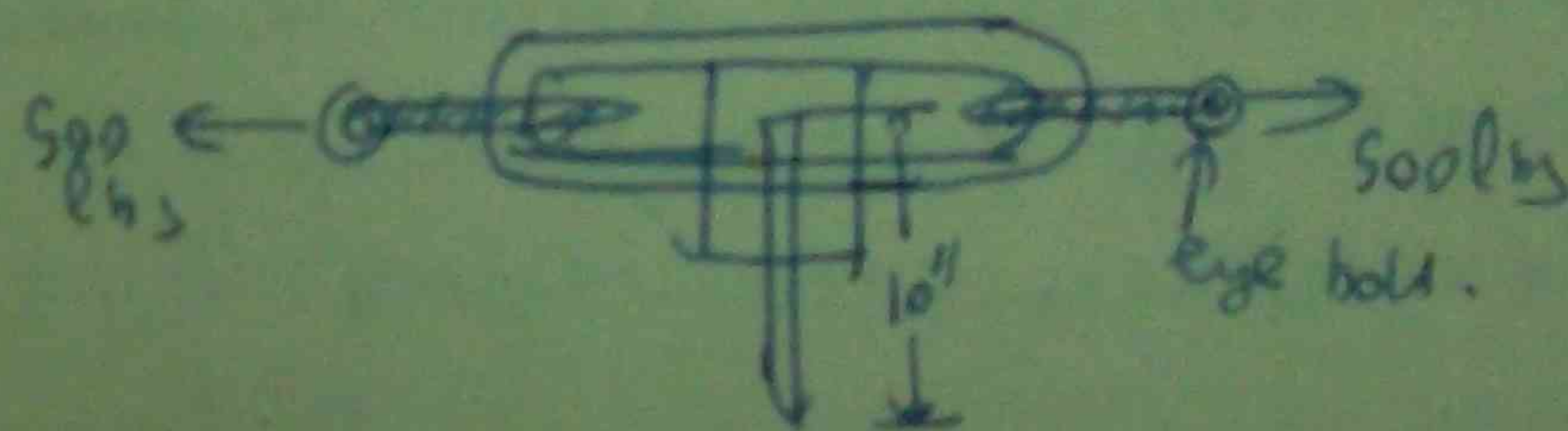
of 2000 was 24.7 -

$$\begin{aligned} \text{Total torque} &= T_A + T_B - W r_B \tan(\theta_B + \phi_B) + W r_A \tan(\phi_A - \theta_A) \\ &= 1000 [1.125 \tan(32' + 832') + 0.625 \tan(832' - 334')] \\ &= 283.6 \text{ lb-in} \end{aligned}$$

of both ends $T_B = W r_B \tan(\phi_B - \alpha_B)$
 $T_A = W r_A \tan(\alpha_A + \phi_A)$

$$\therefore \text{Total torque} > 100 \text{ N} [1.175 + \cos(8.31^\circ - 3.2^\circ) + 0.615 + \cos(3.39^\circ + 8.31^\circ)]$$
$$= 298.2 \text{ lb-in}$$

(p) A turn Buckle carrying single Thread $\phi 10$: 10sq: Thread
 Per inch $\phi 10$ 6 mm $\phi 10$ 2 sq: 10mm $\phi 10$ 1 sq: 10mm
 10mm $\phi 10$ 500 lb $\phi 10$ 10mm $\phi 10$ 10mm $\phi 10$ 10mm
 6.7 lb $\phi 10$ 10mm $\phi 10$ 10mm $\phi 10$ 10mm $\phi 10$ 10mm
 10mm $\phi 10$ 10mm $\phi 10$ 10mm $\phi 10$ 10mm $\phi 10$ 10mm



or: $T = \text{Force} \times \text{distance} = 6.7 \times 10 = 67 \text{ N}$
 $\alpha = \frac{1}{2} \therefore r = \frac{1}{4}$

pitch = 0.1

factor = $\frac{\text{pitch}}{2 \pi r_m} = \frac{0.1}{2 \pi \times \frac{1}{4}} \approx 0.0636$

$\therefore \alpha = 3.34^\circ$

$$T = W \cos \theta \tan(\theta + \phi) \times 2$$

$$G \times 10^2 = 500 \times \frac{1}{2} \tan (\alpha + \phi) \times 2$$

$$\frac{\tan \theta \tan \phi}{1 - \tan \theta \tan \phi} = 0.269 \quad \tan \theta = 0.0636$$

$$\therefore \tan \phi = 0.2049$$

$$\phi = 11.31^\circ$$

2. $\phi = 11.31^\circ$
 $T = W \cos \phi \tan(\phi - \alpha) \times r$
 $\rightarrow Q_L = 500 \times \frac{1}{4} \tan(11.31^\circ - 33^\circ) \times r$
 $\therefore Q = 3.48 \text{ lb}$

[illegible]

$\therefore \text{Reqd. of } f: \text{Max. of } 2, \text{ then } = 1000 + 0.2 \times 20000$
 $= 5000 \text{ lb}$

Collier ~~off~~ \therefore Torque $T_c = \frac{1}{2} F W (R_1 + R_2)$
 $= \frac{1}{2} \times 0.12 \times 5000 \times (\frac{5}{16} + 3.11)$
 $= 1200 \text{ lb-in}$

Screw down Torque $T_s = W \tan(\phi + \psi)$
 $= 5000 \times \frac{3}{4} \times \tan(\phi + \psi)$

$$\tan \alpha = \frac{\text{Pitch}}{2 \pi r m} = \frac{1}{2 \times 2 \pi \times 5} = 0.0637$$

$$\therefore Q = 334$$

$$\tan \psi = \mu = 0.12$$

$$\therefore \phi = 6.51^\circ$$

$$\therefore T_5 = W_{arm} \tan(\theta + \phi_1) = 1150 \times \frac{5}{4} \tan(33.4^\circ + 6.31^\circ)$$

$$= 1160 \text{ lbf}$$

$\therefore \text{Total torque} = 1200 + 1160 = 2360 \text{ lb-in}$

Page 266, eq: 5.8 p. 266

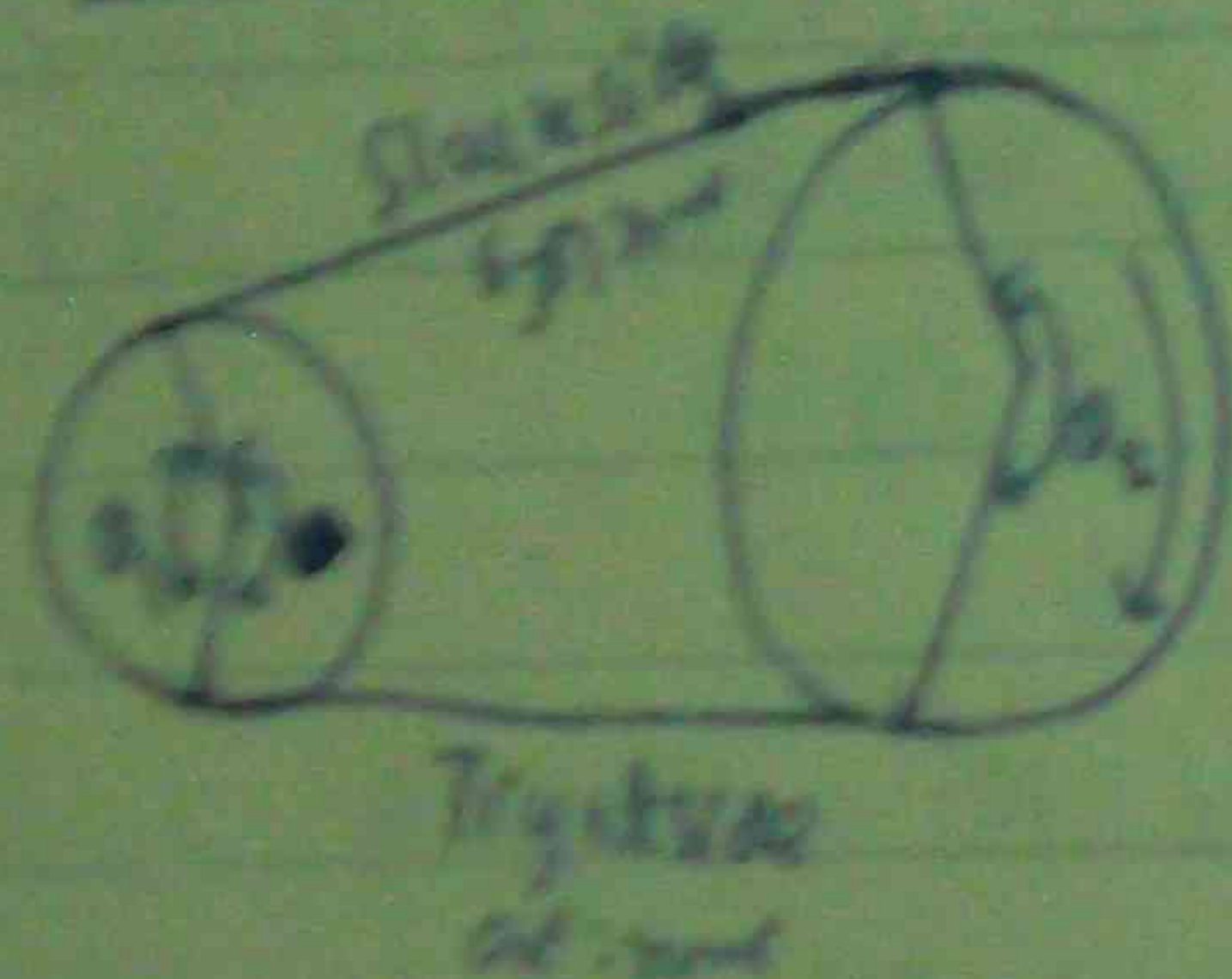
Page 273 E + 1 → 3.

Page 273, 2nd eq: 6.1 → 6.6

Page 273 eq: 6.7 + 6.8 + 6.9 + 6.10

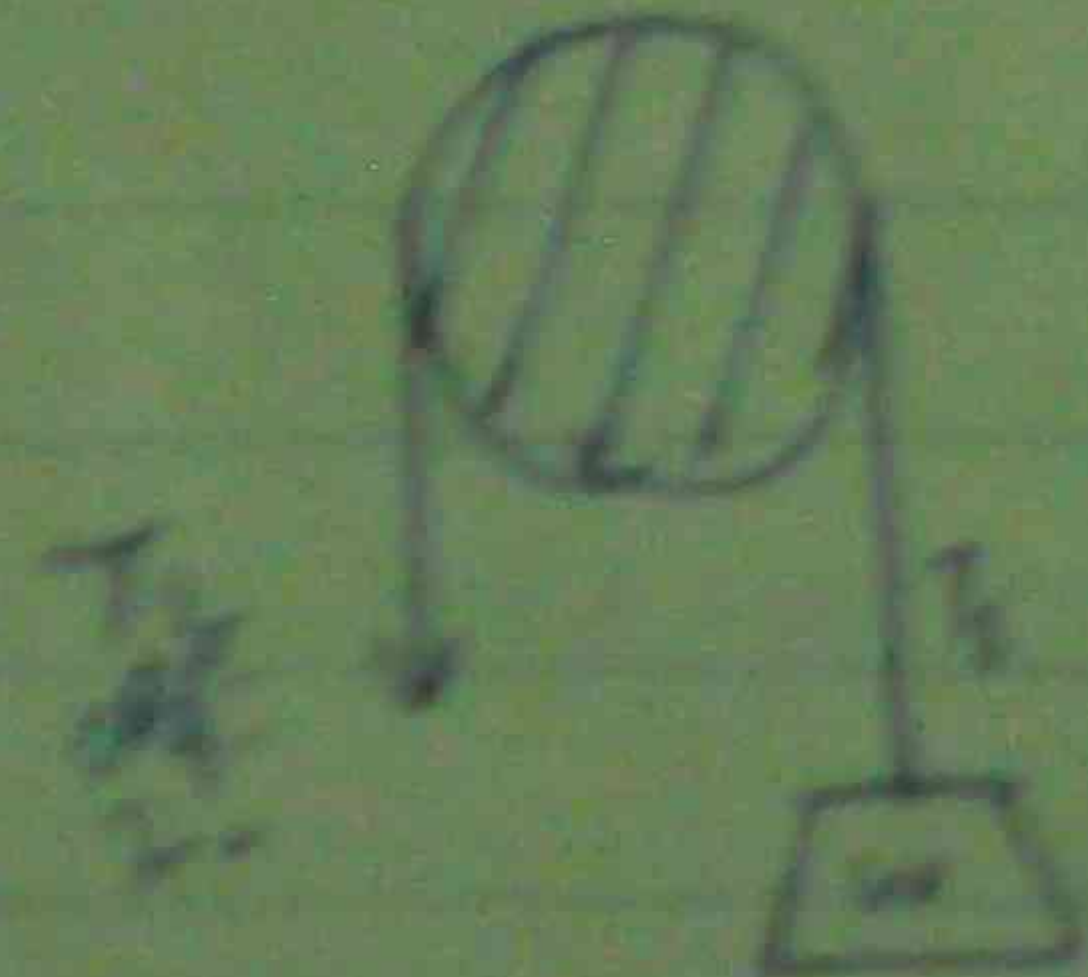
CHAPTER (4)

Chain and Belt Drives



θ_1 and θ_2 are angles of wrap

In radian angles of embrace

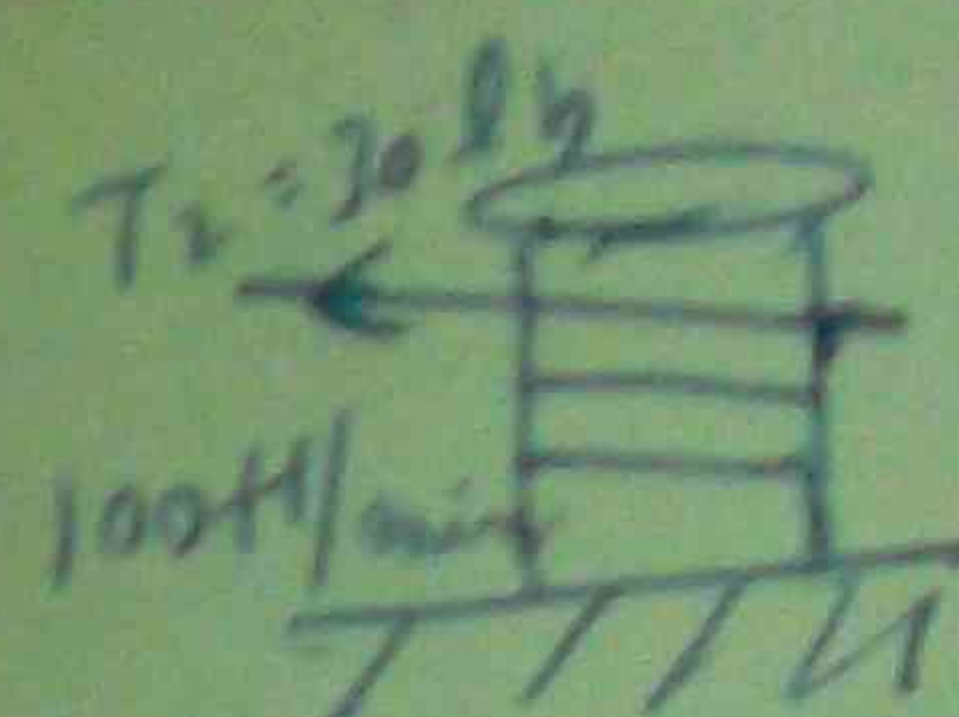


T_1 and T_2 are normal tension

$$\frac{T_1}{T_2} = e^{\mu \theta}$$

μ = coefficient of friction

(P6) A belt drive system (m.p. 2.4) is shown in the figure. The driver pulley has a diameter of 300 mm and the driven pulley has a diameter of 150 mm. The belt is 10 mm thick and the coefficient of friction is 0.3. The belt is wrapped around the pulleys at an angle of 180 degrees. The belt is driven at 1000 rpm. Find the speed of the driven pulley.



$\mu = 0.25$

$T_1 - T_2 = \text{effective}$

tension or normal tension

$$\theta = 2 \pi \text{ rad} \times 3 = 6 \pi \text{ rad}$$

$\mu = 0.25$

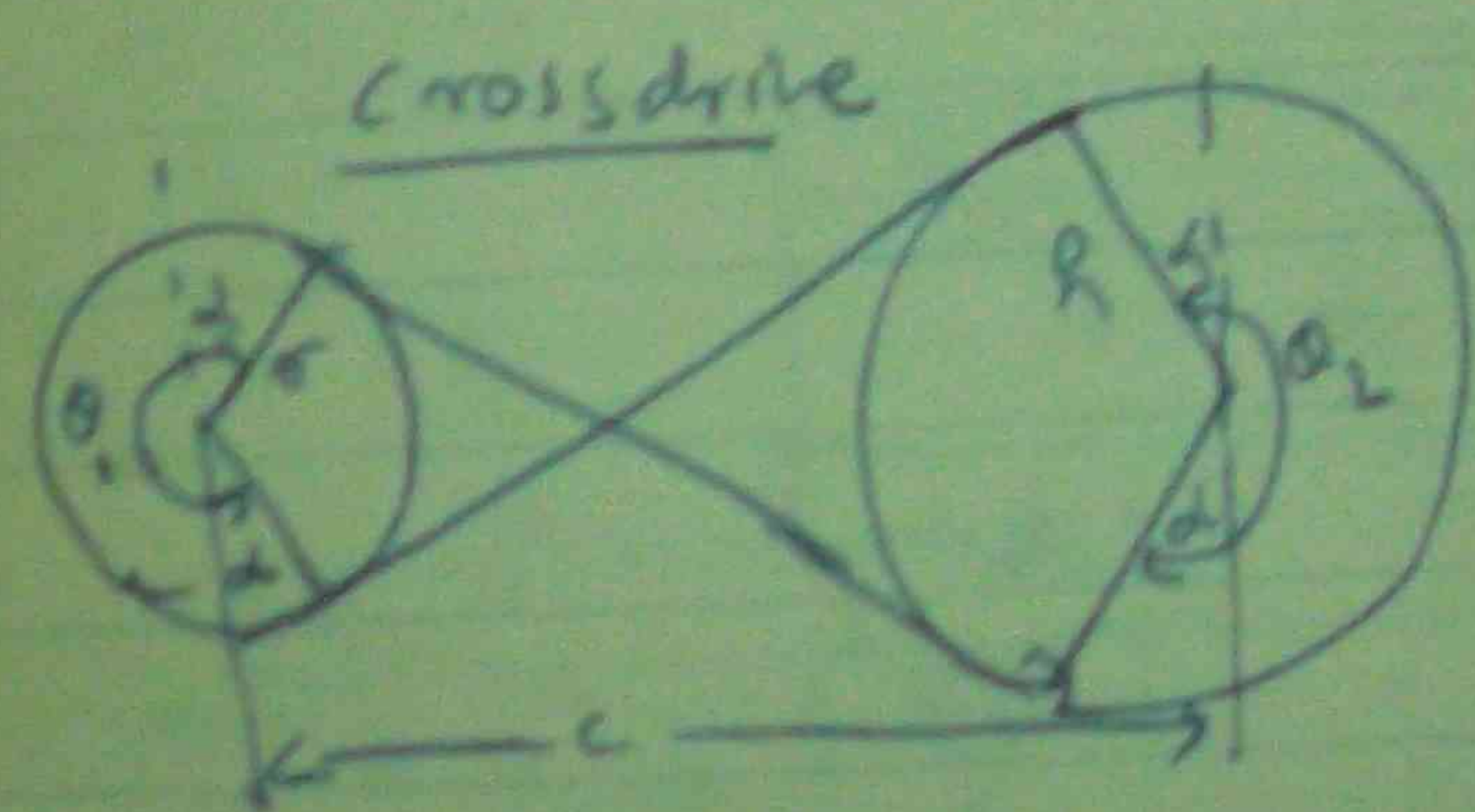
$$T_2 = 30 \text{ lb} \rightarrow \frac{T_1}{T_2} = e^{\mu \theta}$$

$$\therefore T_1 = 30 e^{0.25 \times 6 \pi} = 3330 \text{ lb}$$

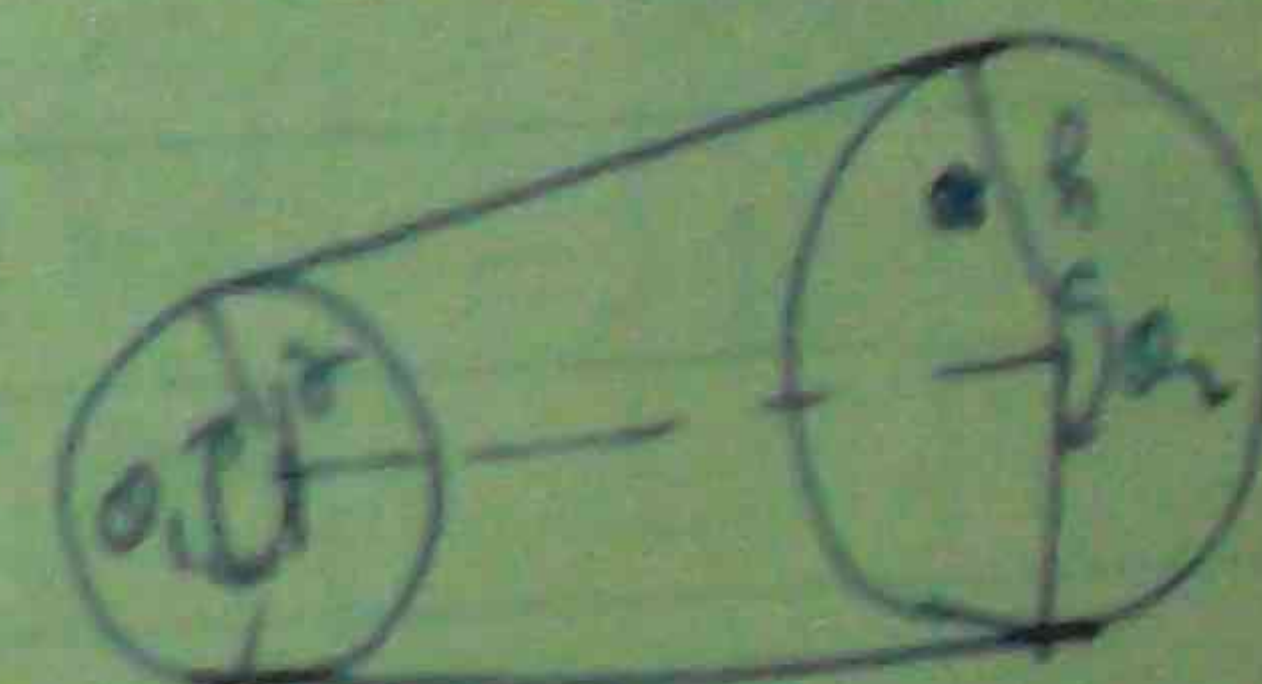
$$HP = \frac{T \times \text{velocity}}{33000} = \frac{(T_1 - T_2) \times v}{33000}$$

$$= \frac{(3330 - 30) \times 192}{33000} = 10 \text{ HP}$$

open drive

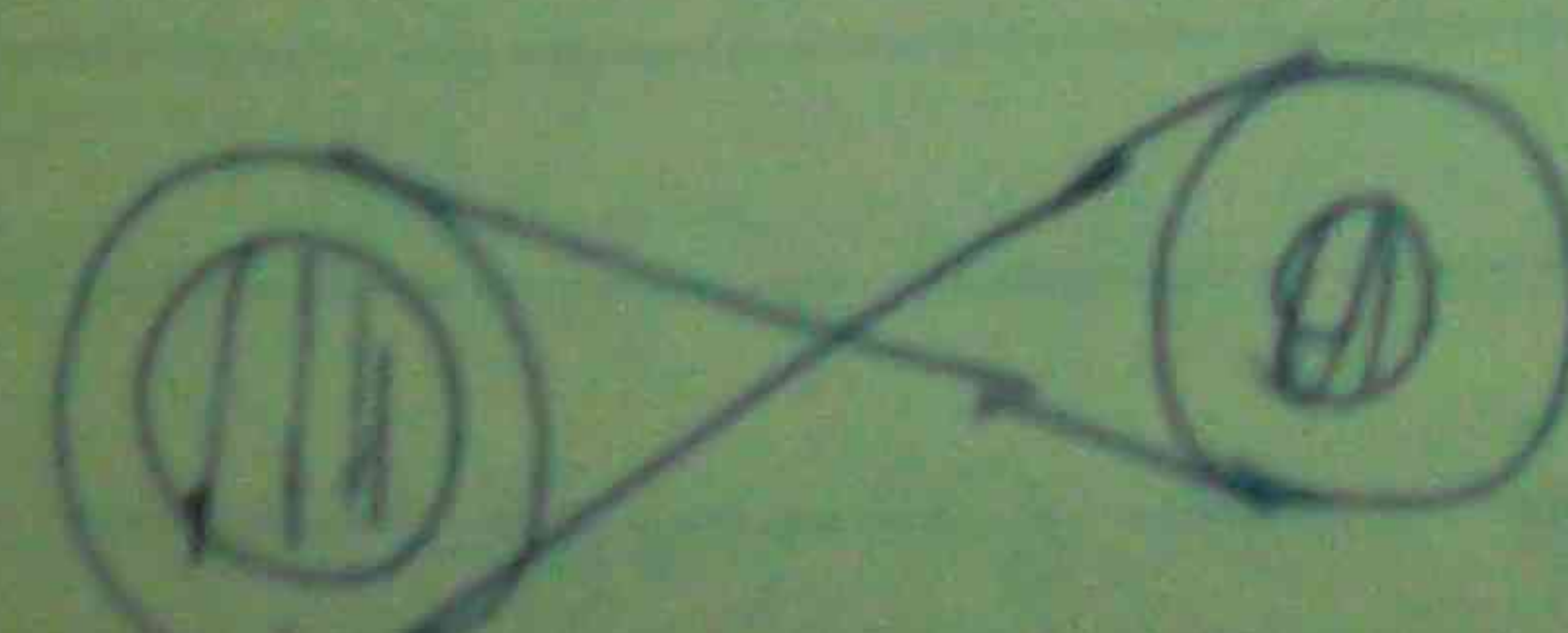


$$\sin \alpha = \frac{R + r}{c} = \frac{D + d}{2c}$$



$$\sin \alpha = \frac{R - r}{c} = \frac{D - d}{2c}$$

(P6)



Eq. 6.6 can be used for the calculation of the angle of wrap. For a belt drive system, the angle of wrap is given by:

or, for a belt drive system, the angle of wrap is given by:

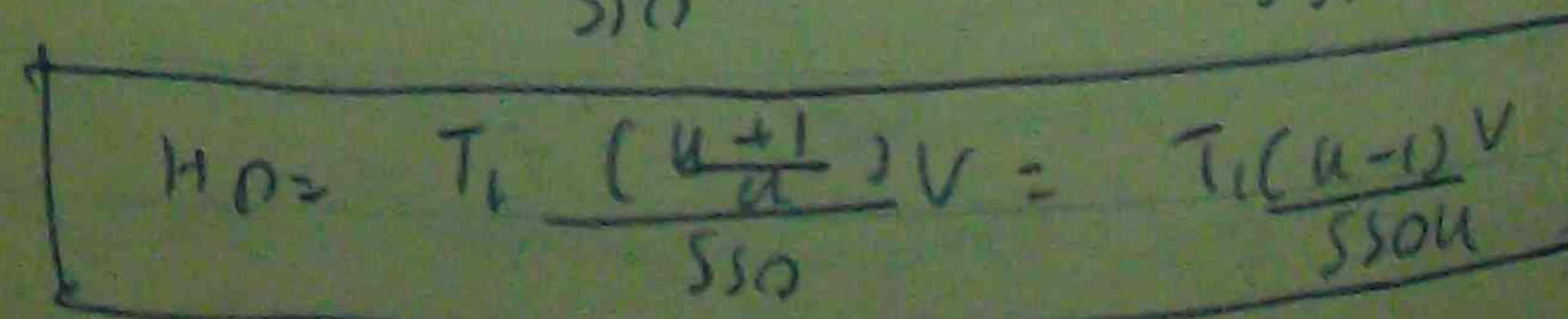
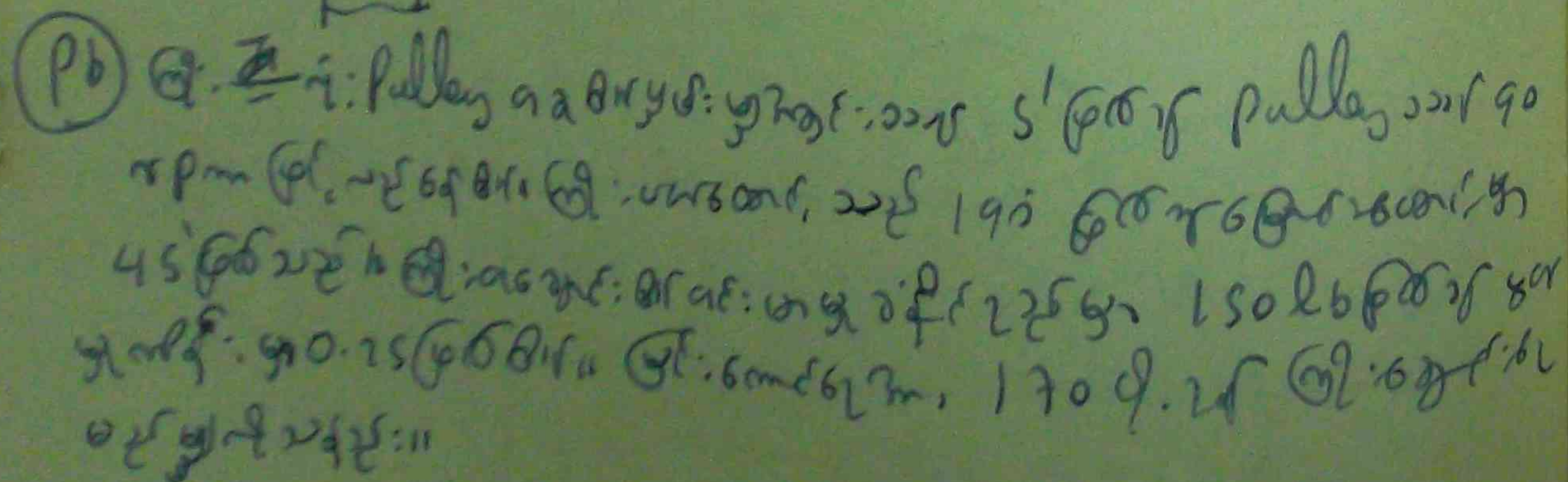
$$D = 1 + \frac{1}{2} + \frac{1}{2} = 2'' \quad d = 1'' \quad c = 6''$$

$$\sin \alpha = \frac{D - d}{2c} = \frac{2 - 1}{2 \times 6} = \frac{1}{12}$$

$\therefore \alpha = 0.25$
 $\alpha = 14.5^\circ$

$$\theta = 2(180 + 2\alpha) = 2(180 + 29) = 418^\circ$$

V600: 80: 100: 120: 140: 160: 180: 200: 220: 240: 260: 280: 300: 320: 340: 360: 380: 400: 420: 440: 460: 480: 500: 520: 540: 560: 580: 600: 620: 640: 660: 680: 700: 720: 740: 760: 780: 800: 820: 840: 860: 880: 900: 920: 940: 960: 980: 1000: 1020: 1040: 1060: 1080: 1100: 1120: 1140: 1160: 1180: 1200: 1220: 1240: 1260: 1280: 1300: 1320: 1340: 1360: 1380: 1400: 1420: 1440: 1460: 1480: 1500: 1520: 1540: 1560: 1580: 1600: 1620: 1640: 1660: 1680: 1700: 1720: 1740: 1760: 1780: 1800: 1820: 1840: 1860: 1880: 1900: 1920: 1940: 1960: 1980: 2000: 2020: 2040: 2060: 2080: 2100: 2120: 2140: 2160: 2180: 2200: 2220: 2240: 2260: 2280: 2300: 2320: 2340: 2360: 2380: 2400: 2420: 2440: 2460: 2480: 2500: 2520: 2540: 2560: 2580: 2600: 2620: 2640: 2660: 2680: 2700: 2720: 2740: 2760: 2780: 2800: 2820: 2840: 2860: 2880: 2900: 2920: 2940: 2960: 2980: 3000: 3020: 3040: 3060: 3080: 3100: 3120: 3140: 3160: 3180: 3200: 3220: 3240: 3260: 3280: 3300: 3320: 3340: 3360: 3380: 3400: 3420: 3440: 3460: 3480: 3500: 3520: 3540: 3560: 3580: 3600: 3620: 3640: 3660: 3680: 3700: 3720: 3740: 3760: 3780: 3800: 3820: 3840: 3860: 3880: 3900: 3920: 3940: 3960: 3980: 4000: 4020: 4040: 4060: 4080: 4100: 4120: 4140: 4160: 4180: 4200: 4220: 4240: 4260: 4280: 4300: 4320: 4340: 4360: 4380: 4400: 4420: 4440: 4460: 4480: 4500: 4520: 4540: 4560: 4580: 4600: 4620: 4640: 4660: 4680: 4700: 4720: 4740: 4760: 4780: 4800: 4820: 4840: 4860: 4880: 4900: 4920: 4940: 4960: 4980: 5000: 5020: 5040: 5060: 5080: 5100: 5120: 5140: 5160: 5180: 5200: 5220: 5240: 5260: 5280: 5300: 5320: 5340: 5360: 5380: 5400: 5420: 5440: 5460: 5480: 5500: 5520: 5540: 5560: 5580: 5600: 5620: 5640: 5660: 5680: 5700: 5720: 5740: 5760: 5780: 5800: 5820: 5840: 5860: 5880: 5900: 5920: 5940: 5960: 5980: 6000: 6020: 6040: 6060: 6080: 6100: 6120: 6140: 6160: 6180: 6200: 6220: 6240: 6260: 6280: 6300: 6320: 6340: 6360: 6380: 6400: 6420: 6440: 6460: 6480: 6500: 6520: 6540: 6560: 6580: 6600: 6620: 6640: 6660: 6680: 6700: 6720: 6740: 6760: 6780: 6800: 6820: 6840: 6860: 6880: 6900: 6920: 6940: 6960: 6980: 7000: 7020: 7040: 7060: 7080: 7100: 7120: 7140: 7160: 7180: 7200: 7220: 7240: 7260: 7280: 7300: 7320: 7340: 7360: 7380: 7400: 7420: 7440: 7460: 7480: 7500: 7520: 7540: 7560: 7580: 7600: 7620: 7640: 7660: 7680: 7700: 7720: 7740: 7760: 7780: 7800: 7820: 7840: 7860: 7880: 7900: 7920: 7940: 7960: 7980: 8000: 8020: 8040: 8060: 8080: 8100: 8120: 8140: 8160: 8180: 8200: 8220: 8240: 8260: 8280: 8300: 8320: 8340: 8360: 8380: 8400: 8420: 8440: 8460: 8480: 8500: 8520: 8540: 8560: 8580: 8600: 8620: 8640: 8660: 8680: 8700: 8720: 8740: 8760: 8780: 8800: 8820: 8840: 8860: 8880: 8900: 8920: 8940: 8960: 8980: 9000: 9020: 9040: 9060: 9080: 9100: 9120: 9140: 9160: 9180: 9200: 9220: 9240: 9260: 9280: 9300: 9320: 9340: 9360: 9380: 9400: 9420: 9440: 9460: 9480: 9500: 9520: 9540: 9560: 9580: 9600: 9620: 9640: 9660: 9680: 9700: 9720: 9740: 9760: 9780: 9800: 9820: 9840: 9860: 9880: 9900: 9920: 9940: 9960: 9980: 10000: 10020: 10040: 10060: 10080: 10100: 10120: 10140: 10160: 10180: 10200: 10220: 10240: 10260: 10280: 10300: 10320: 10340: 10360: 10380: 10400: 10420: 10440: 10460: 10480: 10500: 10520: 10540: 10560: 10580: 10600: 10620: 10640: 10660: 10680: 10700: 10720: 10740: 10760: 10780: 10800: 10820: 10840: 10860: 10880: 10900: 10920: 10940: 10960: 10980: 11000: 11020: 11040: 11060: 11080: 11100: 11120: 11140: 11160: 11180: 11200: 11220: 11240: 11260: 11280: 11300: 11320: 11340: 11360: 11380: 11400: 11420: 11440: 11460: 11480: 11500: 11520: 11540: 11560: 11580: 11600: 11620: 11640: 11660: 11680: 11700: 11720: 11740: 11760: 11780: 11800: 11820: 11840: 11860: 11880: 11900: 11920: 11940: 11960: 11980: 12000: 12020: 12040: 12060: 12080: 12100: 12120: 12140: 12160: 12180: 12200: 12220: 12240: 12260: 12280: 12300: 12320: 12340: 12360: 12380: 12400: 12420: 12440: 12460: 12480: 12500: 12520: 12540: 12560: 12580: 12600: 12620: 12640: 12660: 12680: 12700: 12720: 12740: 12760: 12780: 12800: 12820: 12840: 12860: 12880: 12900: 12920: 12940: 12960: 12980: 13000: 13020: 13040: 13060: 13080: 13100: 13120: 13140: 13160: 13180: 13200: 13220: 13240: 13260: 13280: 133



Q1) cord for an old initial tension of 300 lb. cord: 300 lb. cord
 cord: 1/4" pulley for 165 ft/min. pulley 70 - 100 ft/min. cord: 165 ft/min.
 pulley 165 ft/min. cord: 3600 ft/min. cord: 165 ft/min.
 pulley 165 ft/min. cord: 3600 ft/min. cord: 165 ft/min.
 cord: 165 ft/min. cord: 3600 ft/min. cord: 165 ft/min.

To 500 lb

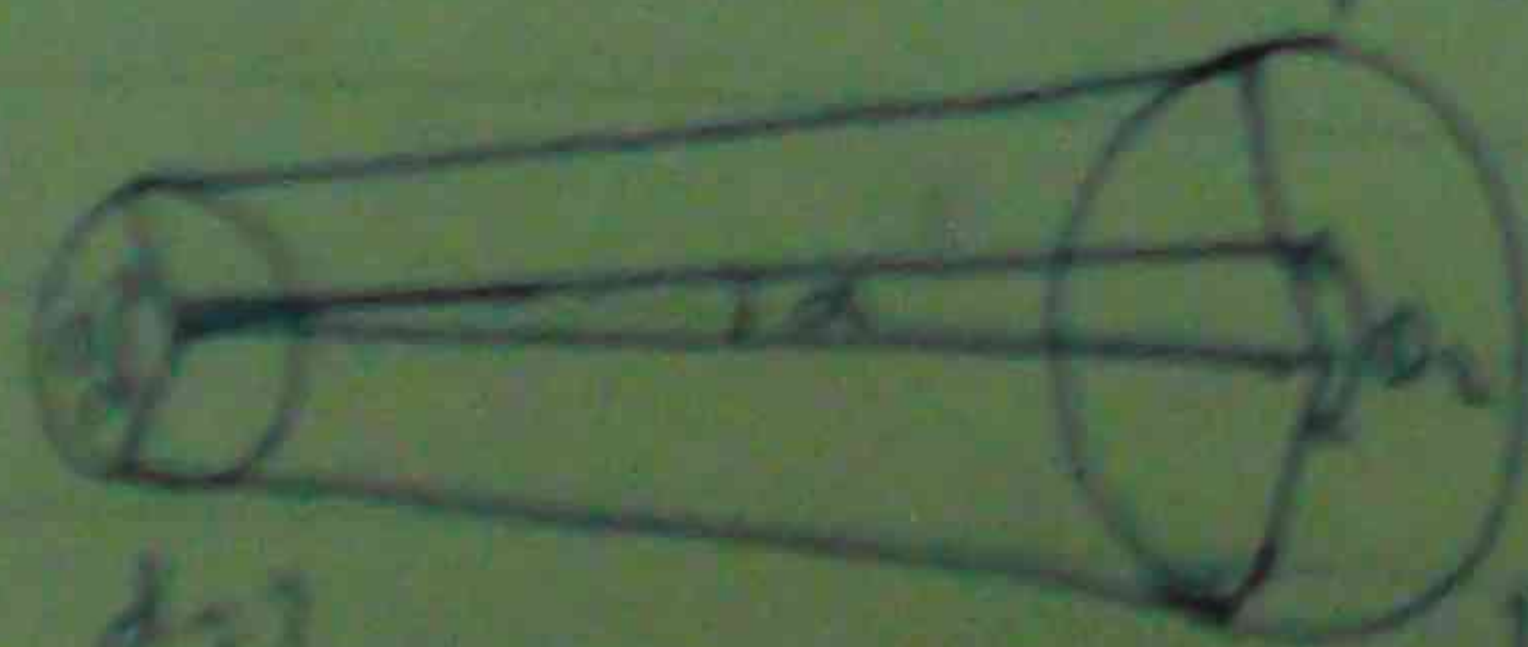
$\mu = 0.3$ $\theta = 165^\circ$ $V = 3600 \text{ ft/min}$
 $\mu = e^{\mu \theta} = e^{0.3 \times 165 \times \pi / 180} = 2.31$

$T_1 = 2 T_0 \times \frac{\mu}{\mu + 1} = 2 \times 300 \times \frac{2.31}{3.31} = 703 \text{ lb}$

$T_2 = \frac{T_1}{\mu} = \frac{703}{2.31} = 297 \text{ lb}$

$HP = \frac{(T_1 - T_2) V}{33000} = \frac{(703 - 297) \times 3600}{33000} = 44.3 \text{ HP}$

Q2) cord for pulley of 24 in. diameter. cord: 120 ft/min.
 cord: 120 ft/min. cord: 120 ft/min. cord: 120 ft/min.
 cord: 120 ft/min. cord: 120 ft/min. cord: 120 ft/min.
 cord: 120 ft/min. cord: 120 ft/min. cord: 120 ft/min.
 cord: 120 ft/min. cord: 120 ft/min. cord: 120 ft/min.



d = 24 in
 b = 1/4 in

$\mu = 0.3$

120 ft/min

$T_{id} = T_1 \theta$

$d = \frac{\pi d n}{T_{id}} = \frac{24 \times 120}{2.31}$

$d = 9.6 \text{ in}$

$\frac{d}{T_{id}} = \frac{9.6}{2.31} = 4.16$

$\theta = 180 - 2 \times 41.3^\circ = 171.24^\circ$

$360^\circ \rightarrow 2\pi$
 $171.24^\circ \rightarrow \frac{171.24^\circ}{360} \times 2\pi$

$\theta \text{ in rad} = 2.99$

$\frac{T_1}{T_2} = e^{\mu \theta} = e^{0.3 \times 2.99} = 2.453$

$\therefore T_1 = 2.453 T_2$

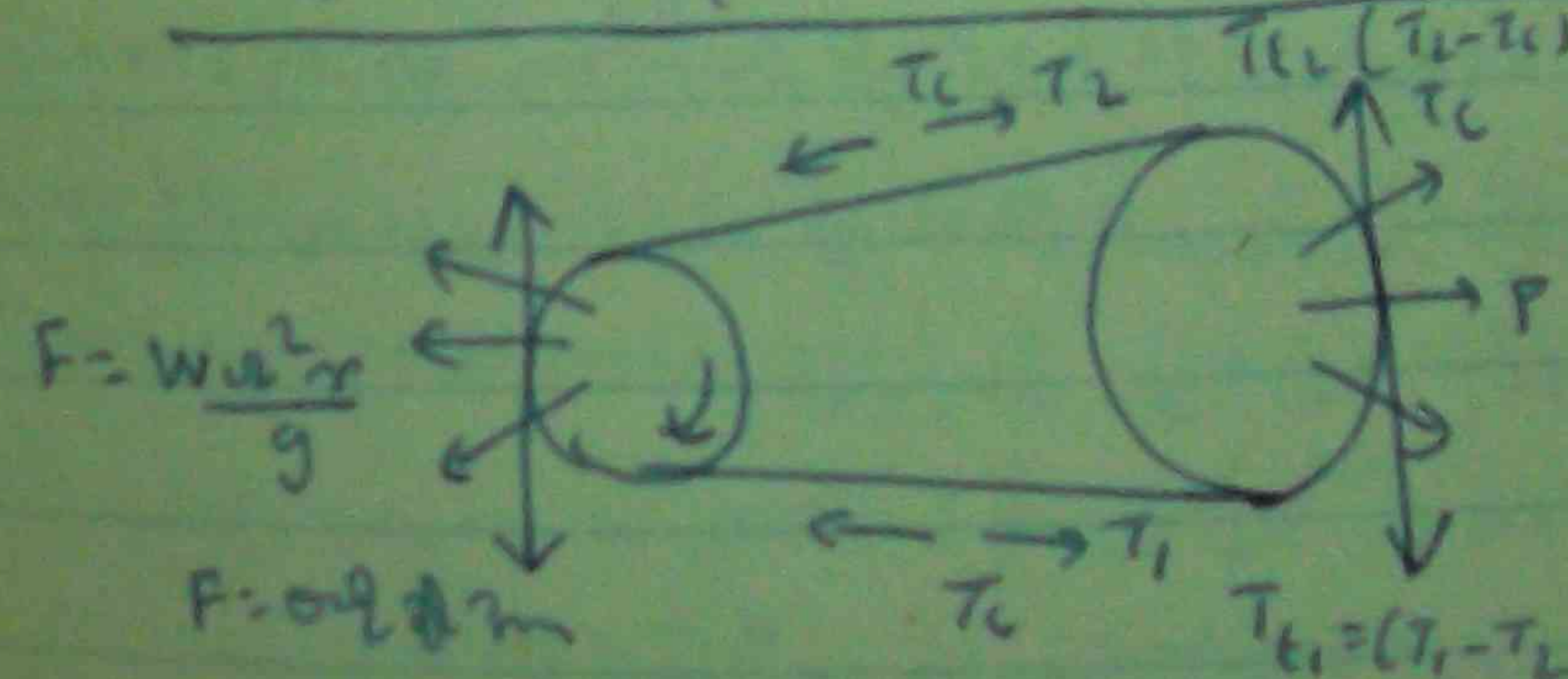
$HP = \frac{(T_1 - T_2) V}{33000} = \frac{(2.453 T_2 - T_2) \times 2\pi \times 120}{33000}$

$\therefore T_2 = \frac{1.453 T_2 \times 2\pi \times 120}{33000}$

$\therefore T_2 = 120.6 \text{ lb}$ $\therefore T_1 = 2.453 \times 120.6 = 296 \text{ lb}$

$\therefore \text{cord: } T_{id} = b = \frac{T_1}{80} = \frac{296}{80} = 3.7 \text{ in}$

cord: 120 ft/min. cord: 120 ft/min. cord: 120 ft/min.



$T_c = \frac{W a^2 r}{g}$

$HP = \frac{(T_1 - T_2) V}{33000}$

$F = \frac{W a^2 r}{g}$

$T_c = \frac{W a^2 r}{g}$

$T_c = 0.0012 \text{ m}$

centrifugal tension

$V = \text{cord: } 120 \text{ ft/min}$

$W = \text{cord: } 120 \text{ ft/min}$

$$\boxed{T_1 = 3T_c} \leftarrow \text{max: power}$$

$$HP_{max} = \left(\frac{u-1}{550u} \right) \left(\frac{2}{3} T_1 \right) \sqrt{\frac{T_1 g}{3W}}$$

$$HP_{max} = \frac{u-1}{550u} 2T_c \sqrt{\frac{T_1 g}{3W}}$$

$$HP = \frac{(1-u)(T_1 - T_c)V}{550} \text{ Required:}$$

HP = $\frac{u-1}{550u} (T_1 u - \frac{Wu^3}{g})$...
 ...
 $V = \sqrt{\frac{T_1 g}{3W}}$

(Pb) 3000 rpm, 1/2" core, 3 ft pulley ...
 25 HP ...
 density of belt 0.035 lb/in³ ...
 stress maximum 350 psi ...

$$Dia = 3 \text{ ft } @ = 165'' \quad \mu = 0.27 \quad \text{density of belt} = 0.035 \text{ lb/in}^3$$

$$\text{Stress max: } > 350 \text{ psi, } t = \frac{1}{4}'' \quad b = ?$$

$$Area = b \times t \quad \text{given } b \text{ and } t$$

$$T_1 = b \times \frac{1}{4} \times 350 \quad \therefore T_1 = 87.5 b \text{ lb}$$

$$u = e^{\mu \alpha} = e^{0.27 \times \frac{165 \pi}{180}} \Rightarrow 2.1761$$

$$\therefore \frac{1}{u} = \frac{1}{2.1761} = 0.46$$

$$T_c = \frac{Wu^2}{g} \quad \therefore W = b \times t \times 12 \times 0.035 \text{ lb/ft} \\ = b \times \frac{1}{4} \times 12 \times 0.035 = 0.105 b \text{ lb/ft}$$

$$\therefore T_c = \frac{0.105 b \pi 2 \times 3000}{32.2} = \frac{0.105 b (4 \times 3 \times 3000)}{32.2 (60)^2}$$

$$\therefore T_c = 7.2 b \quad HP = \frac{(T_1 - T_c)(1 - \frac{1}{u})V}{550}$$

$$\therefore HP = \frac{(87.5b - 7.2b)(1 - 0.46) \times 157}{550}$$

$$b = 6.75 \text{ in}$$

(Pb) 4" x 1/4" core, 120" pulley ...
 ...
 max stress = 200 psi, max HP = ?

$$Area = b \times t = 4 \times \frac{1}{4}'' = 1'' \quad @ = 120'' \quad \mu = 0.3$$

$$\text{max stress} = 200 \text{ psi, max HP} = ?$$

$$T_1 = 4 \times \frac{1}{4} \times 200 = 200 \text{ lb} \quad \therefore T_1 = 3T_c$$

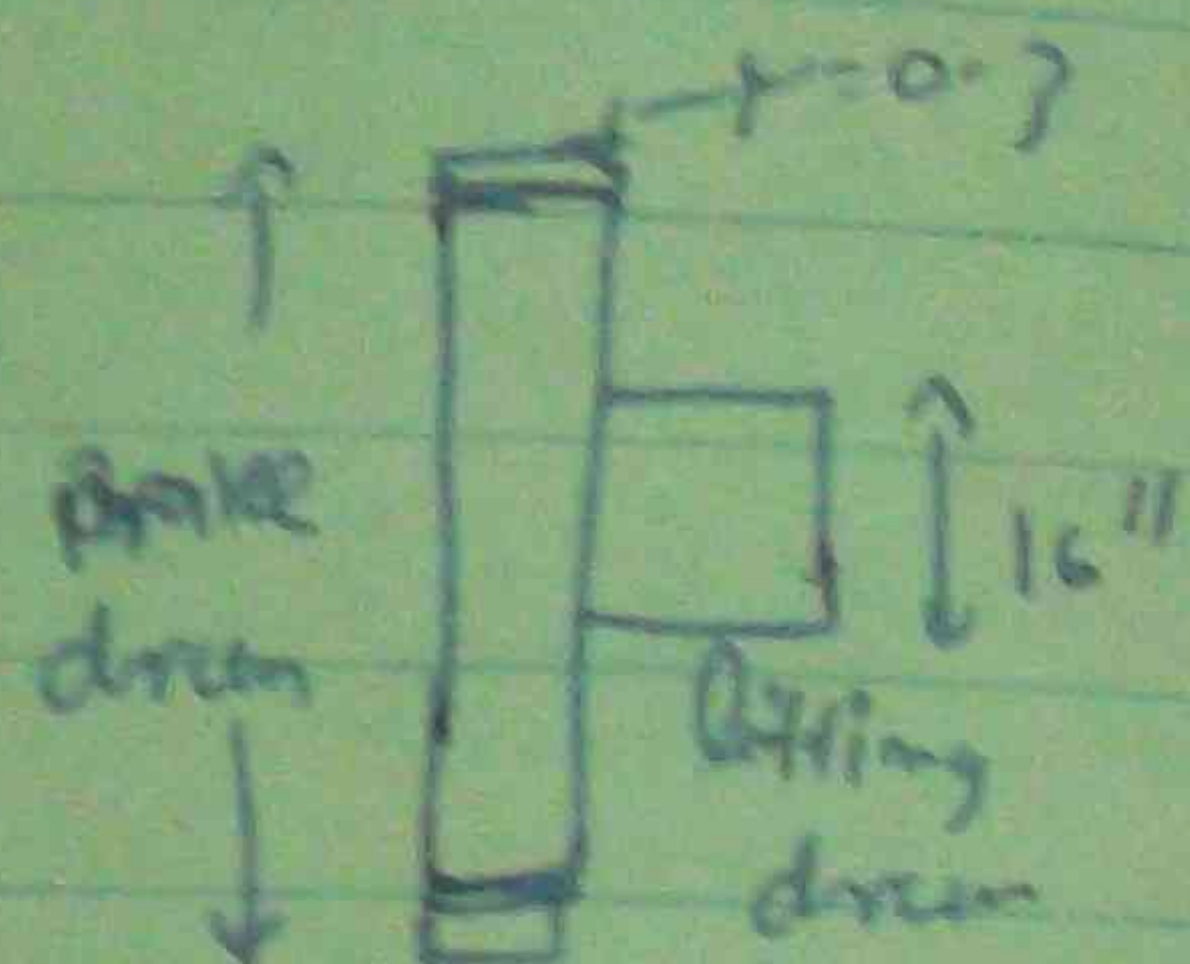
$$\therefore T_c = \frac{1}{3} \times 200 = 66.67 \text{ lb}$$

$$u = e^{\mu \alpha} = e^{0.3 \times \frac{120 \times \pi}{180}} = 1.274$$

$$V = \sqrt{\frac{T_1 g}{3W}} \quad W = 4 \times \frac{1}{4} \times 0.035 \times 12 = 0.42$$

$$\therefore V = \sqrt{\frac{200 \times 32.2}{3 \times 0.42}} = 71.5 \text{ ft/min}$$

$$\therefore \text{max HP} = \frac{2T_c(1 - \frac{1}{u})V}{550} = \frac{2 \times 66.67(1 - \frac{1}{1.274}) \times 71.5}{550} = 8.4 \text{ HP}$$



T-top of
chrom. 700.00
Q. 3 Brake
chrom.
700.00

Wt = of a d down
Gurgler. 82

4 dof gear y-mech: brake drum 16" dia: Gear of 900 lbs
 of 24 teeth: oil self-cool: 24" dia: 1600 rpm: oil film
 brake drum & gear self: $\mu = 0.3$ for oil.

$$\frac{T_1}{T_2} = e^{K\alpha} = e^{0.3 \times \frac{2507}{180}} = e^{1.309} = 3.708$$

$$\therefore T_1 = 3.708 T_v$$

$$[\Sigma m_0 = 0] \quad W_{\text{net}} = [T_1 - T_2] R$$

$$500 \times 16/2 = [3 - 708 T_1 - T_1] \times \frac{24}{2}$$

$$\therefore T_2 = 22206$$

$$\therefore T_1 = 222 \times 3.703 = 822.06$$

$$[\Sigma M_a = 0] \quad T_2 \times 5 \frac{3}{4} + P \times 24 - T_1 \times 1 \frac{1}{2} = 0$$

$$P = 10.37 \text{ lb} //$$

Gear Trains

Driver pinion

Gear

Whole depth

Clearance

radially dedendum distance.

addendum

dedendum

Pitch circle

Addendum circle

Dedendum circle.

circular pitch

gears in mesh



tooth thickness.

[illegible]

(1) Addendum (irre)

Year 2001: design competition circle of 500

Addendum circle

Gear of 20 teeth: 0.5 mm module (root ϕ)
 (3) gear of 20 teeth driven by a 20 teeth driver (1) follow
 the pitch circle (mesh) of the gear pair is 20
 gear pitch point is 20 teeth gear of 20 teeth
 on the pitch circle of 20 teeth

Addendum

Addendum circle of pitch circle 20 teeth: 0.5 mm module
 20 teeth: 0.5 mm module

Addendum addendum of pitch circle 20 teeth: 0.5 mm module radial
 distance 20 teeth: 0.5 mm

Flank pitch circle 20 teeth: 0.5 mm module 20 teeth: 0.5 mm module
 20 teeth: 0.5 mm module

Face - Pitch circle of 20 teeth: 0.5 mm module 20 teeth: 0.5 mm module
 20 teeth: 0.5 mm module

Clearance gear of 20 teeth (mesh) on addendum of
 20 teeth gear of addendum circle of 20 teeth: 0.5 mm module

Tooth thickness (a)

Tooth of pitch circle 20 teeth: arc distance 20 teeth
 of tooth thickness 20 teeth

Space width (b)

Tooth of pitch circle 20 teeth: arc distance 20 teeth
 of space width 20 teeth space width of tooth thickness
 of 20 teeth 20 teeth: 0.5 mm module

Circular pitch (Pc)

Pitch circle of gear 20 teeth: 0.5 mm module
 20 teeth: 0.5 mm module

$$P_c = \frac{\pi D}{T}$$

Diametral pitch (Pd)

gear of 20 teeth: 0.5 mm module pitch circle dia: 0.5 mm
 20 teeth: 0.5 mm module

$$P_d = \frac{T}{D}$$

$$P_c \times P_d = \pi$$

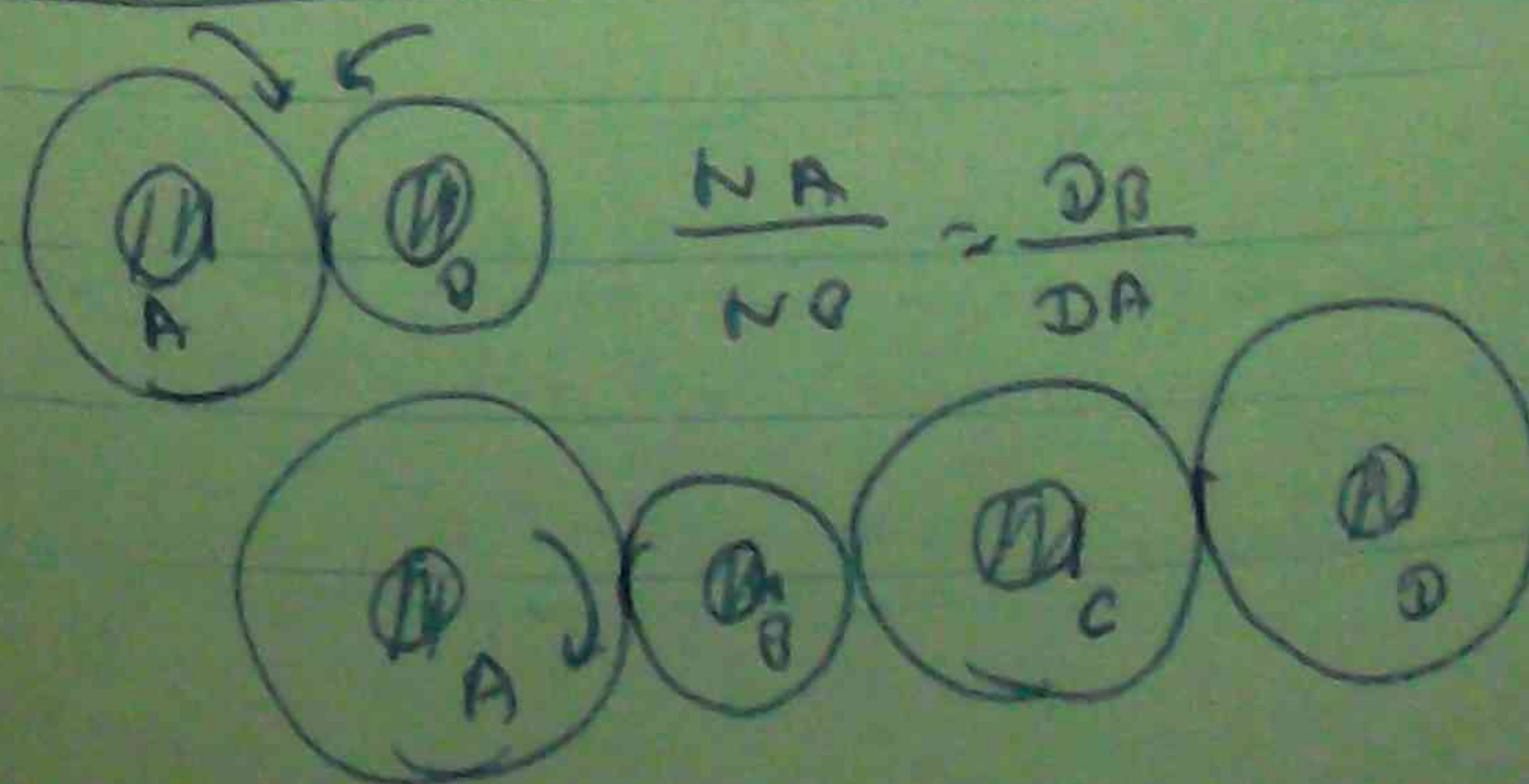
(Ph) 40 teeth: 0.5 mm module gear of circular pitch of 1.57 mm
 40 teeth: 0.5 mm module

$$T = 40 \text{ teeth} \quad D = ?$$

$$P_c = \frac{\pi D}{T} \quad \left| \quad 1.57 = \frac{\pi \times D}{40} \quad \therefore D = 15.9$$

Simple and compound gear trains

Simple gear trains

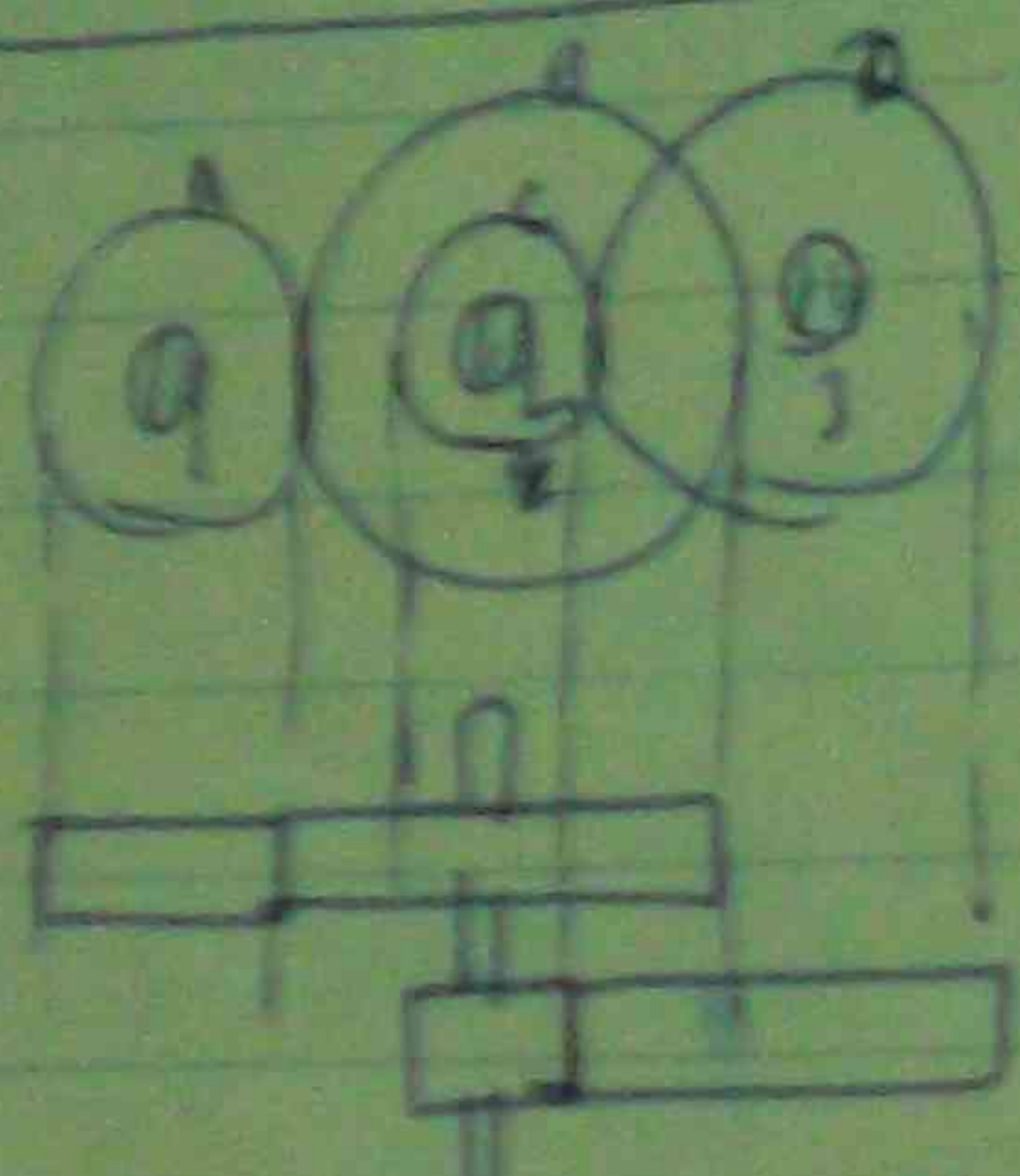


$$\frac{Z_A}{Z_B} = \frac{T_B}{T_A}$$

$$\frac{CA}{CB} = \frac{TA}{TB}$$

NATA - NDTs

low compound glass train


$$\text{ad } f = 1, 2, 3$$

4. 6. 2018. 2018. 5. 11. 2018.

near 2800 cm^{-1} : A compound

தமிழ்நாடு அரசு

1104, 42nd Ave, New York, N.Y. 10018
- 1104, 42nd Ave, New York, N.Y. 10018

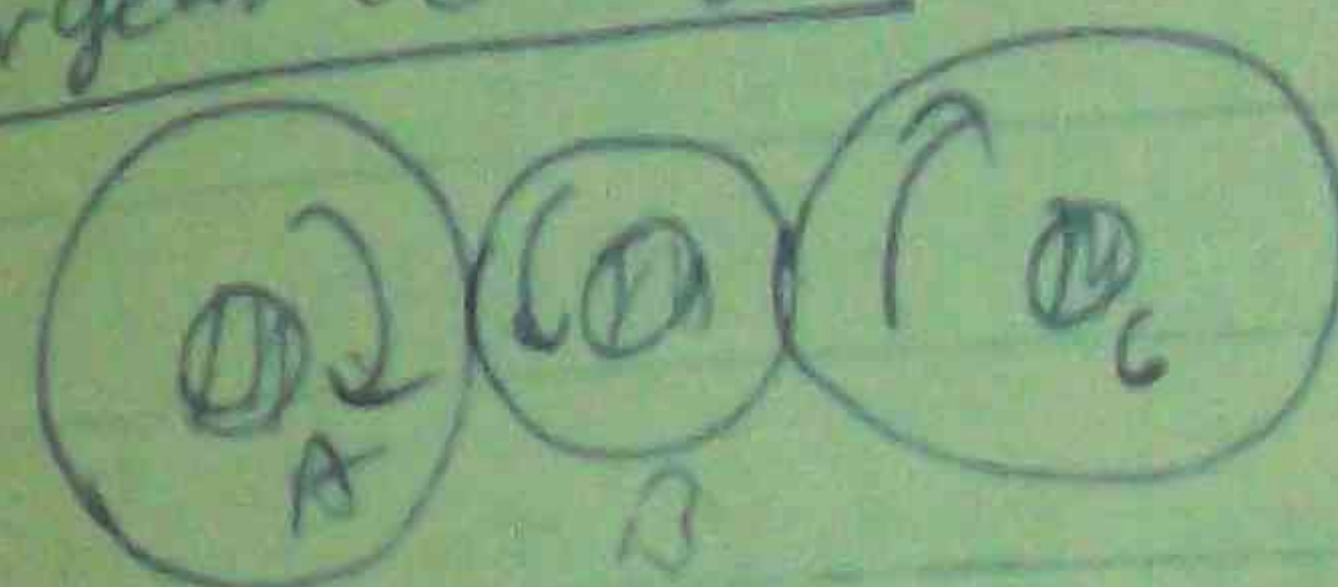
$$\frac{W_B}{W_D} = \frac{T_B}{T_A} \times \frac{T_D}{T_C}$$

$$\frac{Z_3}{Z_4} = \frac{T_A}{T_B} \times \frac{T_C}{T_D}$$

Trans value $e = \frac{n_{p_{\text{not}} + \text{last gear}}}{n_{p_{\text{not}} + 1\text{st gear}}}$

Transfer value = $\frac{\text{total value of 200 units}}{110000}$

Speed ratio = $\frac{1}{\text{Train value}} = \frac{\text{rpm of 1st gear}}{\text{rpm of last gear}}$



driver & follower of 200000

6028

— m. n. 1860 f. 21. 8v

$$\frac{N_A}{N_B} = \frac{T_B}{T_A}, \quad \frac{N_C}{N_D} = \frac{T_C}{T_D}$$

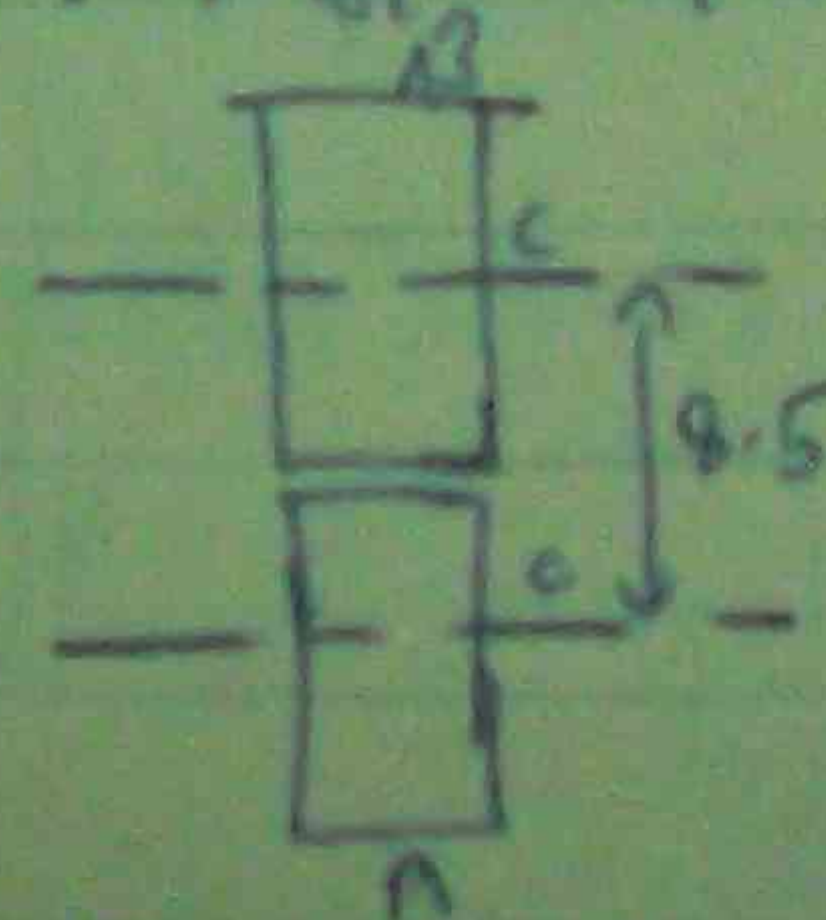
$$\therefore \frac{Z_A}{Z_B} \times \frac{Z_D}{Z_C} = \frac{T_D}{T_A} \times \frac{T_C}{T_B}$$

$$\frac{N_A}{N_C} = \frac{T_C}{T_A}$$

Bo. 11. 09

$$\frac{TA}{NC} = \frac{TA}{TA}$$

speed ratio of gear: $60 \pi \text{ cm} \cdot \text{min}^{-1} : 206 \pi \text{ cm} \cdot \text{min}^{-1}$

[illegible]

$$\frac{2A}{23} = 4$$

$$\frac{2A}{2B} = \frac{TV}{TD}$$

$$CL = \frac{DA + DB}{2}$$

$$C_c = \frac{T_0 + T_D}{2 \rho d}$$

$$\therefore p_d = \frac{I}{9}, \quad D_n = \frac{T_n}{p_d}$$

$$\frac{N_B}{N_A} = \frac{T_B}{T_A} = 4 \quad \therefore T_B = 4T_A$$

$$\frac{T_A + T_B}{2 \times 4} = 8.5 \quad \left| \quad \frac{T_A + 4T_A}{2 \times 4} = 8.5 \right.$$

$$\therefore T_A = 14 \quad T_B = 56 \text{ teeth}$$

Let's find the center distance $C.C. = \frac{D_A + D_B}{2}$

$$C.C. = \frac{14 + 56}{2 \times 4} = \frac{70}{8} \quad \therefore C.C. = 8.75$$

Let's find the center distance $C.C. = \frac{D_A + D_B}{2}$

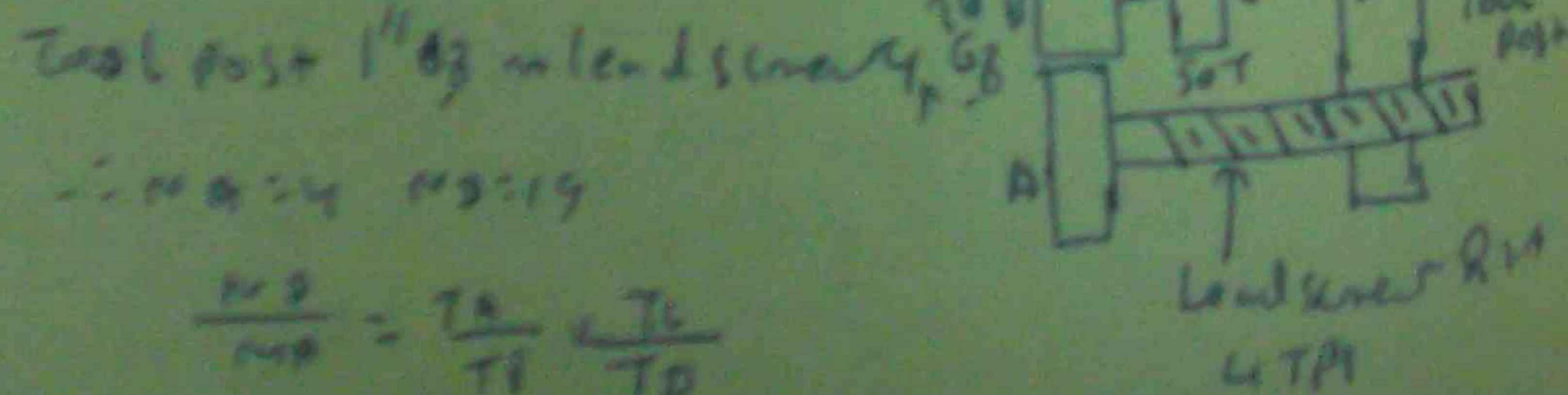
$$\frac{T_A + T_B}{2 \times 4} = 8.5 \quad \left| \quad T_A + T_B = 8.5 \times 2 \times 4 \right.$$

$$14 + T_B = 68 \quad \therefore T_B = 54$$

$$\frac{N_B}{N_A} = \frac{T_B}{T_A} \quad \left| \quad \frac{N_B}{N_A} = \frac{54}{14} \right.$$

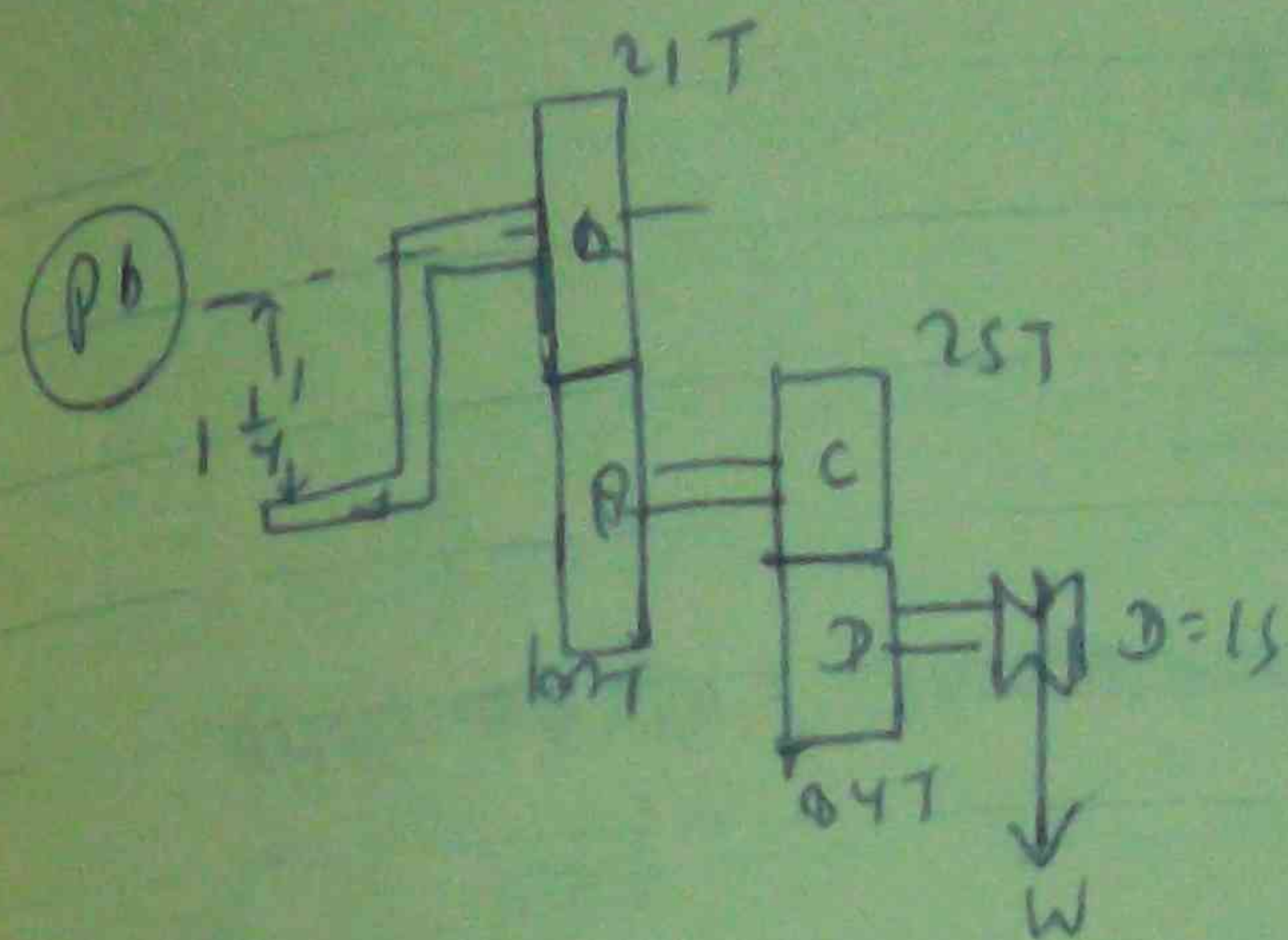
$$\therefore \frac{N_B}{N_A} = 3.857 = 4 \quad \times$$

(Pb) Let's find the center distance of gear
 A gear of 14 teeth and gear B of 56 teeth
 A gear of 14 teeth and gear B of 56 teeth
 14 TP 2 25 78 Tool post 1" 03 84



$$\frac{N_B}{N_A} = \frac{T_A}{T_B} \times \frac{T_C}{T_D}$$

$$\frac{14}{56} = \frac{T_A}{78} \times \frac{50}{40} \quad \therefore T_A = 45 \text{ teeth}$$



Let's find the center distance of gear
 A gear of 21 teeth and gear B of 100 teeth
 A gear of 21 teeth and gear B of 100 teeth
 A gear of 21 teeth and gear B of 100 teeth

$$T_A = 21T \quad \left| \quad T_C = 25T \right. \quad \left| \quad D = 15 \text{ in } N_A = 100 \text{ rpm} \right.$$

$$T_B = 100T \quad \left| \quad T_D = 84T \right. \quad \left| \quad F = 50 \text{ lb } W = ? \right.$$

$$\text{Torque } A \times N_A = \text{Torque } D \times N_D$$

$$\text{Torque } A = F \times \text{distance}$$

$$= 50 \times \frac{1}{4} \times 12$$

$$\therefore T_A = 75 \text{ lb in}$$

$$\frac{N_B}{N_A} = \frac{T_A}{T_B} \times \frac{T_C}{T_D}$$

$$\frac{N_B}{N_A} = \frac{2}{100} \times \frac{75}{84} \quad \therefore N_A = 0.615 \text{ rpm}$$

$$\text{Torque } A \times N_A = \text{Torque } D \times N_D$$

$$50 \times 15 \times 10 = \text{Torque } D \times 0.615$$

$$\therefore \text{Torque } D = 1200 \text{ in lb}$$

$$\therefore \text{Torque } D = W \times R$$

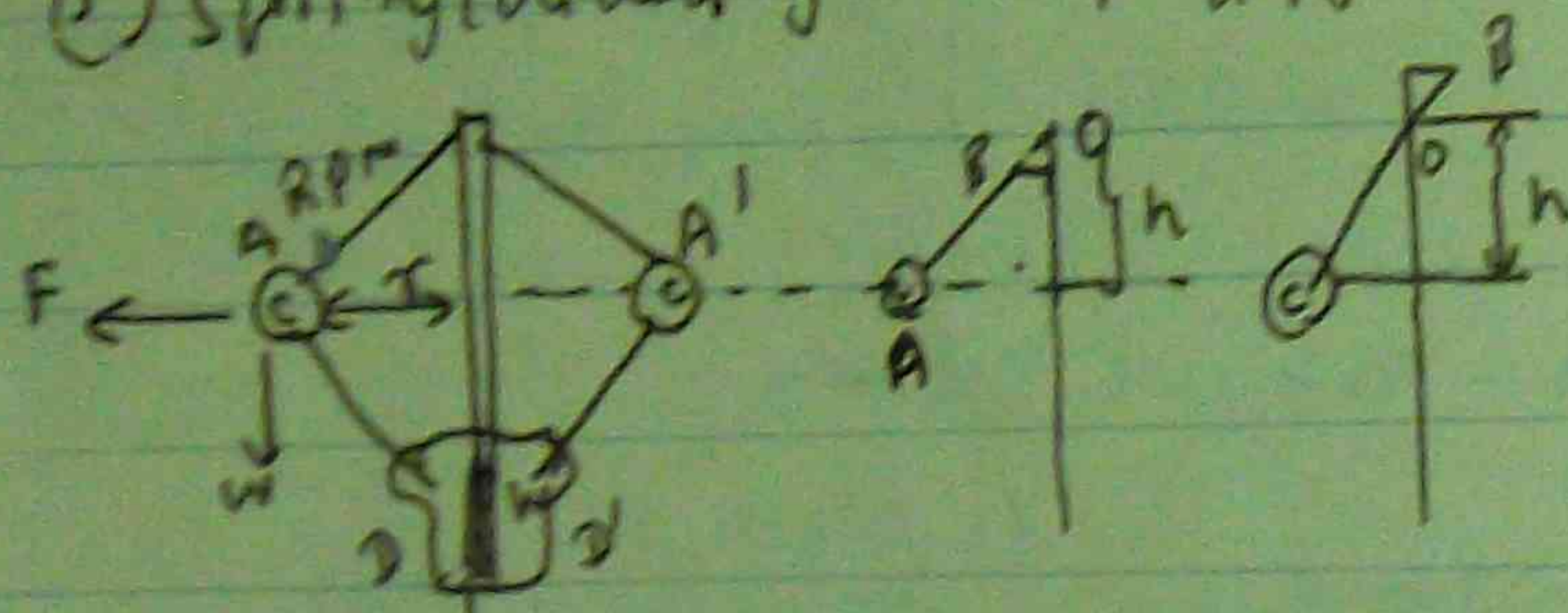
$$W = \frac{1200 \times 2}{15 \times 6} = 1600 \text{ lb}$$

Government

① central government

⑤ loaded at Porter tower

⑤ spring loaded governor with 1500 rpm



simplest centrifugal governor.

Ever more

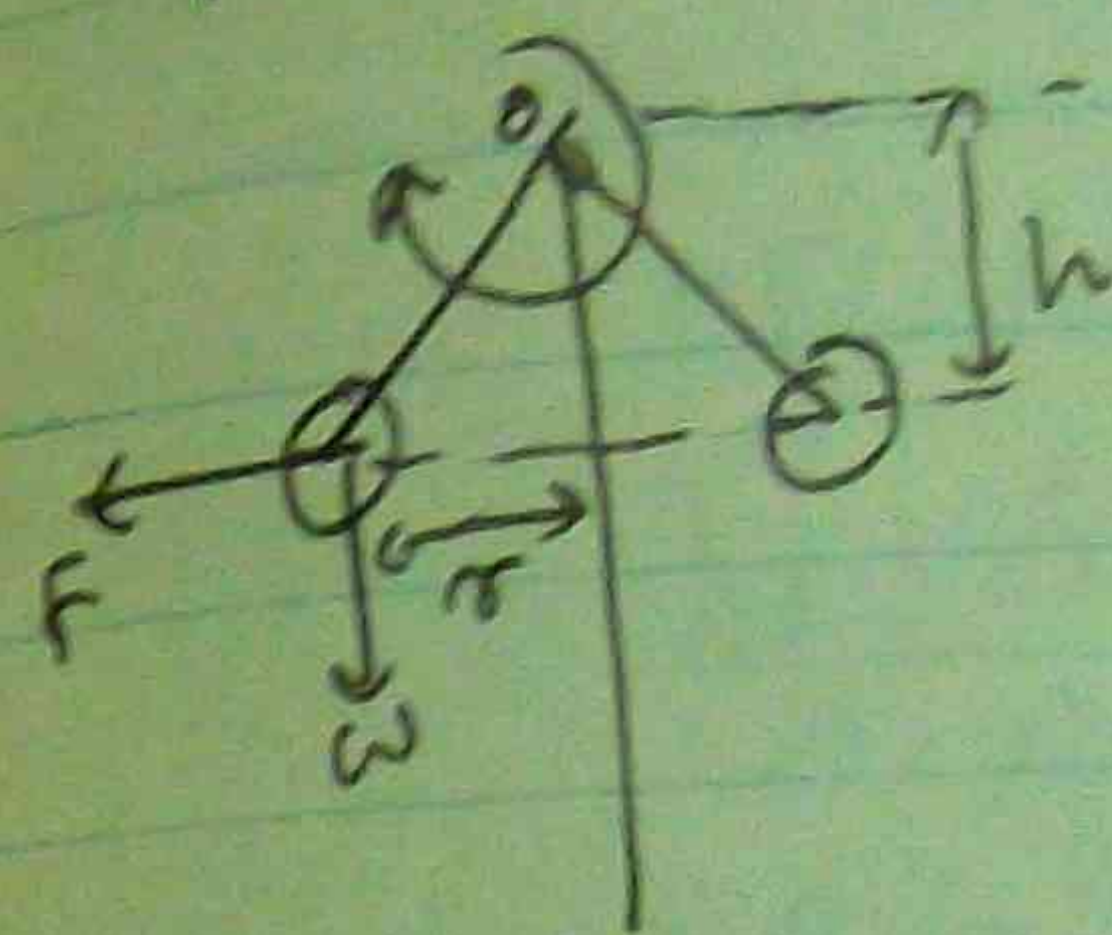
Function of governor.

[illegible]

w = Governor Ball weight

$W = \text{Sleeve weight}$

$r =$ centrifugal force
 $r =$ ball radius.



$$\sum m_0 = 0$$

$$F \times h = \omega \times r$$

$$F = \frac{\omega \times r}{h}$$

$$\frac{\omega r^2 m}{g} = \frac{\omega \times r}{h}$$

$$\omega^2 = \frac{g}{h}$$

$$\Omega = \frac{2\pi N}{60} = \frac{\pi N}{30}$$

$$\therefore n^2 = \frac{\pi^2 N^2}{900}$$

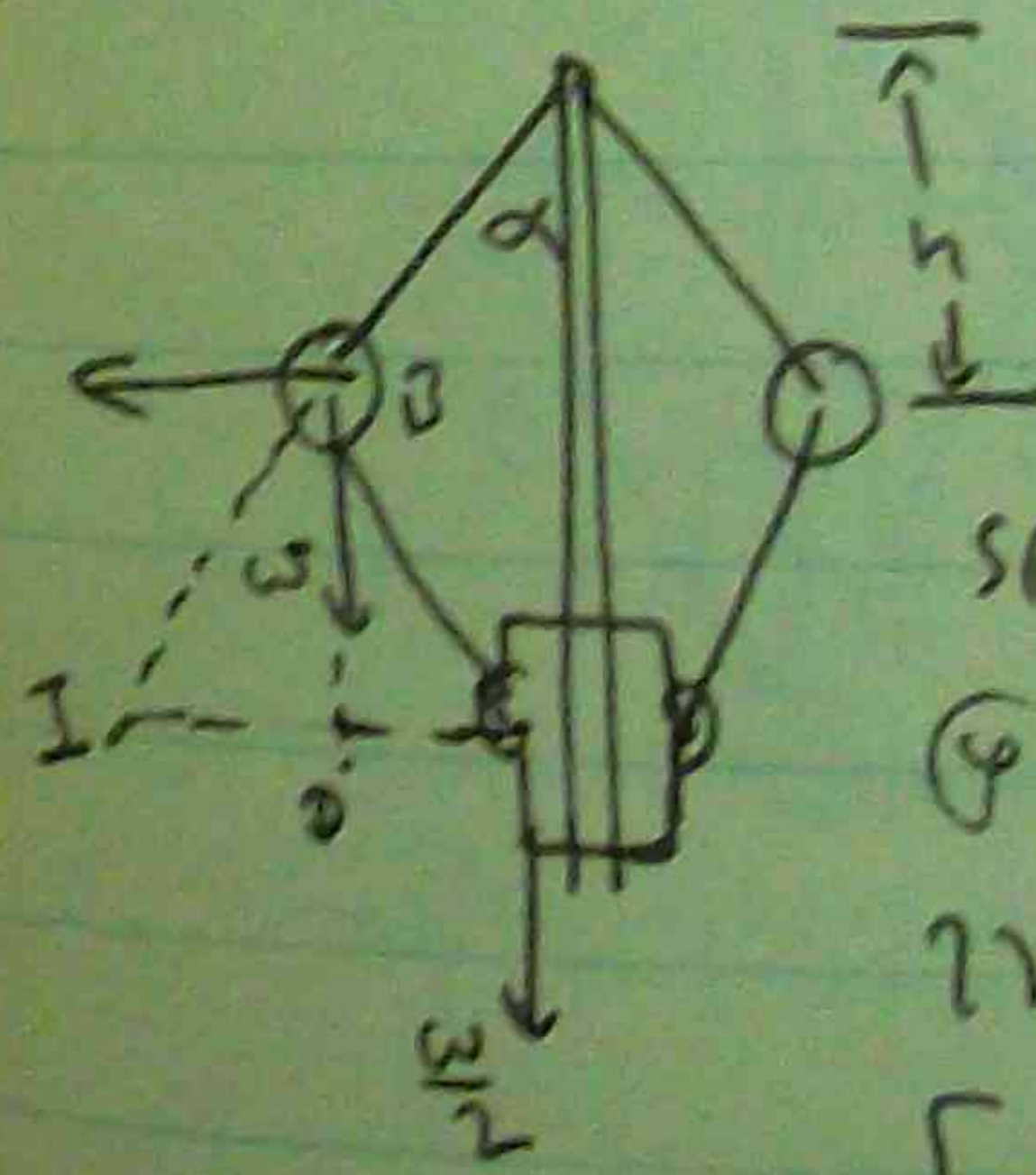
$$\therefore \frac{T_1^2 N^2}{g n} = \frac{g}{n}$$

$$\therefore N^2 = \frac{9009}{712}$$

$$\therefore N^2 = \frac{2936}{9}$$

$$-f h = \frac{2436}{N^2} dt$$

$$h = \frac{35230}{122} \text{ inch.}$$



spindle \rightarrow ১৮০°-এ ঘুরে আসে।
 গভর্নর \rightarrow ১৮০°-এ ঘুরে আসে।
 ১৮০°-এ ঘুরে আসে।
 [EMI = 0.]

$$F = \left\{ \frac{w}{2} (1+u) + w y + w u d \right.$$

$\alpha = \beta, n \geq 1$

$$\therefore \omega^2 = \frac{\left\{ \frac{W}{2}(1+u) + w \right\} \frac{1}{h}}{u}$$

For $u = 1$, sleeve of weight 6 lb and of 4 lb of 2 lb

$$\omega^2 = \frac{9}{u} \quad N^2 = \frac{\frac{W}{2}(1+u) + w}{u} \times \frac{35230}{h}$$

$$\text{For } u = 1 \text{ lb of 6 lb } N^2 = \frac{W+w}{u} \times \frac{35230}{h}$$

(pb) Porter governor with arms of 12" each of 12" radius of gyration. The sleeve of 1 1/2" radius of 150 lb. Ball of 20 lb each. At equilibrium speed of 208 rpm.

sleeve load $w = 150$ lb

Ball load $= w = 20$ lb each

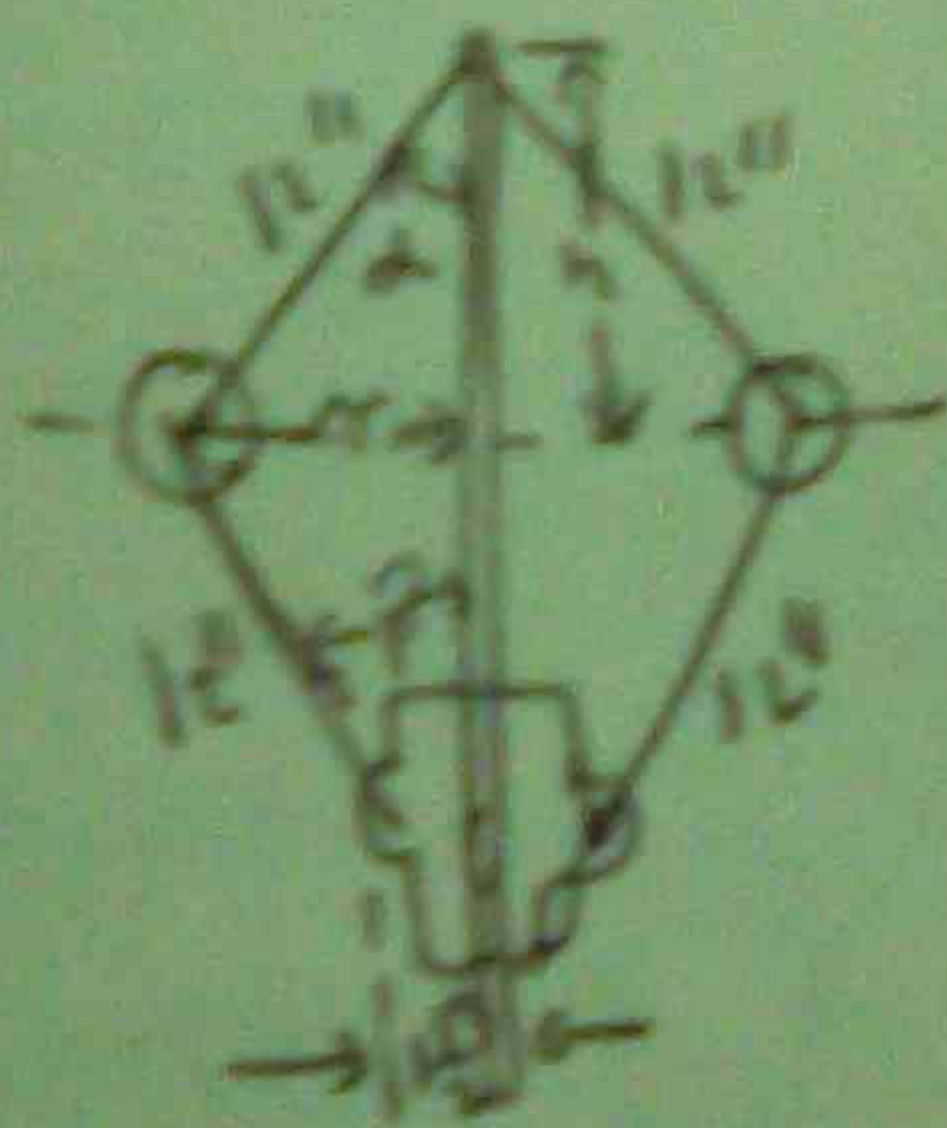
$$\tan \phi = \frac{9}{\sqrt{12^2 - 9^2}} = 1.33$$

$$\tan \theta = \frac{9 - 1.5}{\sqrt{12^2 - (9 - 1.5)^2}} = 0.8$$

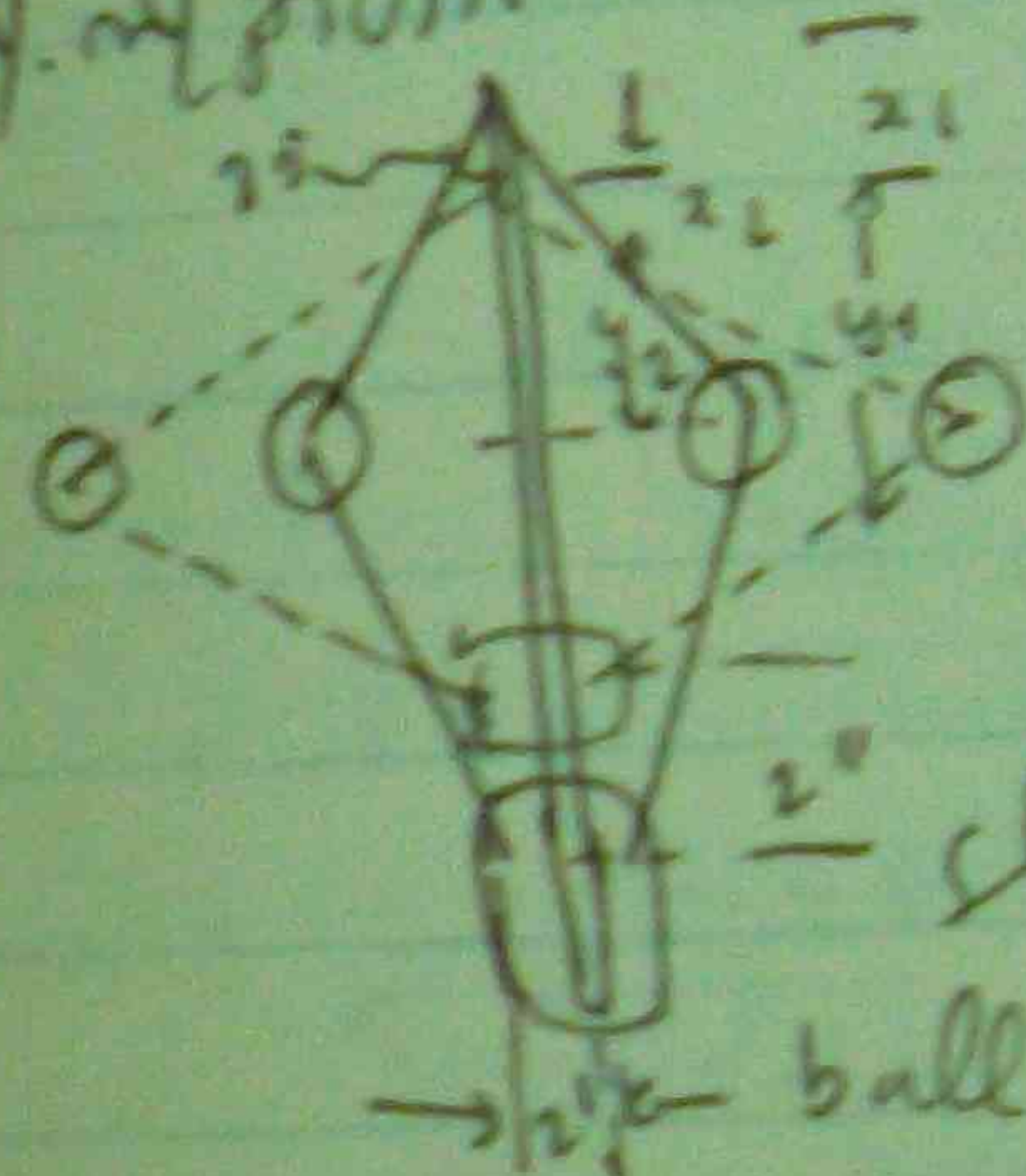
$$u = \frac{\tan \theta}{\tan \phi} = \frac{0.8}{1.33} = 0.606$$

$$N^2 = \frac{\frac{W}{2}(1+u) + w}{u} \times \frac{35230}{h}$$

$$N^2 = \frac{\frac{150}{2}(1+0.606) + 20}{0.606} \times \frac{35230}{7.937} = 191.2 \text{ rpm}$$



(pb) Governor of 12" arms of 12" radius of gyration. The sleeve of 1 1/2" radius of 150 lb. Ball of 20 lb each. At equilibrium speed of 208 rpm.



sleeve load 150 lb

$$h_1 = x_1 + y_1$$

$$= 10.0330 + 2.0670$$

$$h_1 = 12.10$$

sleeve of 2" diameter and 150 lb weight

ball of 20 lb each and 1" diameter

of spindle of 12" radius of gyration

$$\cos \alpha = \frac{10.0330 - 1}{10} = 0.9336$$

$$\therefore \alpha = 4^\circ$$

$$h_2 = x_2 + y_2 = 10.0330 + 2.0670$$

$$= 10.0330 + 2.0670 = 12.10$$

$$N_1^2 = \frac{W+w}{u} \times \frac{35230}{h_1} = \frac{56+4}{u} \times \frac{35230}{12.10}$$

$$N_1 = 208.8 \text{ rpm}$$

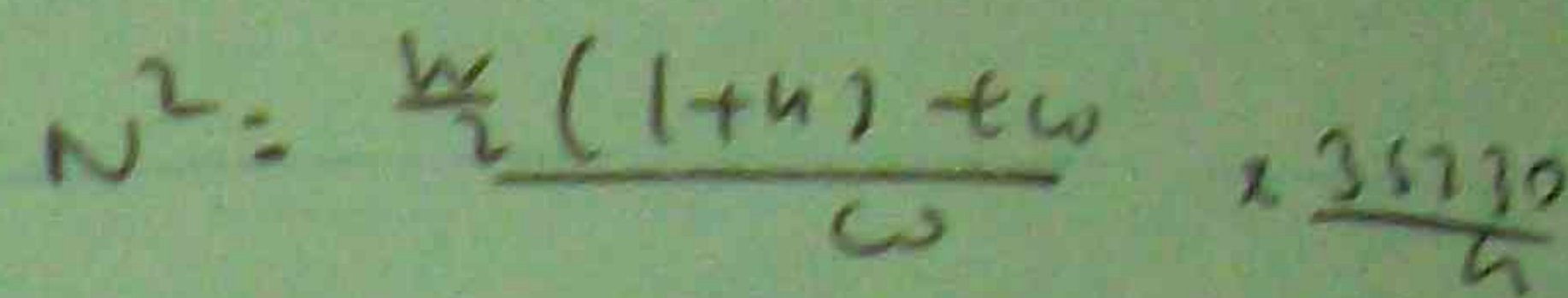
$$N_2^2 = \frac{56+4}{u} \times \frac{35230}{10.04} \Rightarrow N_2 = 229.4 \text{ rpm}$$

ball load = 15 lb $r_1 = 8''$, $r_2 = 10''$

$$\tan \phi_1 = \frac{8}{8.95} = 0.9 \quad \left| \quad \tan \phi_1 = \frac{8-1.5}{\sqrt{12^2 - (8-1.5)^2}} = 0.645 \right.$$

$$n_2 = \frac{w_2(1+u) + w_1}{w_2} = \frac{351.32}{h_1} = \frac{112(1+0.118) + 15}{15} \cdot \frac{352.16}{8.9}$$

$$\therefore N_2 = 204.4 \text{ rpm}$$



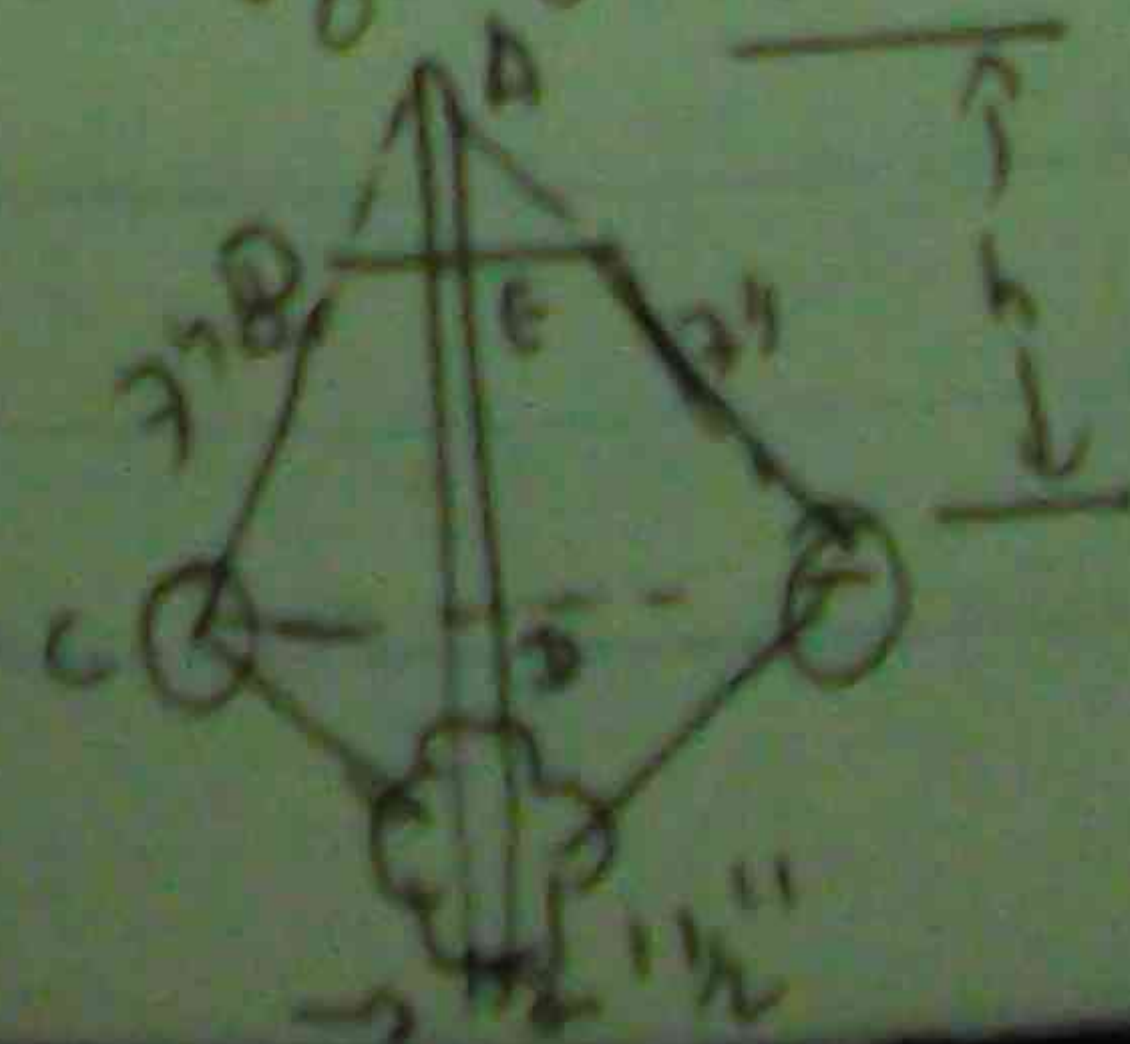
$$u = \frac{+ \sin \beta}{+ \sin \alpha}$$

$$N_2 = \frac{W_2 \pm f(1+K) + W}{W} \times \frac{35230}{h}$$

$$u = 1618 \text{ mm} \quad N2 = \frac{w + f + w}{w} \times \frac{35230}{w}$$

Sr: frictional force "f" ~ ω & velocity sleeve.
 driving torque + f ~ ω & velocity sleeve mm sp.
 sr: ω , sleeve - f ~ ω sp. mm, up or down gear
 equilibrium speed 2 wh: ω & ω

(Pb) Porter Governor 2 1/2" max dia. 7" 3/4" max dia. of B.
 1 1/2" max dia. of A: 2 1/2" Ball of B. 2 1/2" 2.5 lb
 of sleeve max: 4 1/2" 4 1/2" 11" max dia. spindle
 8, 3 1/2" 6" 6" 3" sleeve max dia. 2 1/2" 2 1/2" 2 1/2" 2 1/2"
 5: max dia. of A: 2 1/2" 2 1/2" 2 1/2" 2 1/2" max dia.
 spindle 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2"
 of sleeve max: 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2" 4 1/2"



BE ~ 1 1/2"

$BE = 1\frac{1}{2}$
 $W = 7.5 lb$, $W = 45 lb$

$\alpha = 30^\circ$ amplitude $\rho = 11$

$$\cot 30^\circ = \frac{AB}{BE} \quad \therefore AB = 1.5 \times 2 = 3''$$

$$\therefore AC = AB + BE = 3 + 3 = 10''$$

$$\sin 30^\circ = \frac{CD}{AC} \quad \therefore CD = AC \sin 30^\circ = 10.8 \sin 30^\circ = 5''$$

$$AC^2 = CD^2 + h^2$$

$$10^2 = 5^2 + h^2 \rightarrow h = 8.66''$$

slave governor of Porter governor friction m. of 45 lb
 45 lb

$$N_2 = \frac{W + f + w}{\omega} \times \frac{35230}{h}$$

normal def. of 245 rpm & 255 rpm

$$N_2 = \frac{W + f + w}{\omega} \times \frac{35230}{h}$$

$$(293)^2 = \frac{45 + f + 2.5}{2.5} \times \frac{35230}{8.66}$$

$$f = 1.717 \text{ lb}$$

spindle speed, normal 45 lb of 45 lb of 45 lb of 45 lb
 normal def. of 245 rpm & 255 rpm

$$\sin 45^\circ = \frac{CD}{AC}$$

$$\therefore CD = 10 \times 0.707 = 7.07''$$

$$AC^2 = CD^2 + h^2$$

$$10^2 = (7.071)^2 + h^2 \rightarrow h = 7.07$$

45 lb of 45 lb of 45 lb

$$\text{spindle speed, normal 45 lb of 45 lb of 45 lb of 45 lb} \quad N_1 = \frac{W + f + w}{\omega} \times \frac{35230}{h}$$

$$N_1 = \frac{45 + 1.717 + 2.5}{2.5} \times \frac{35230}{7.07}$$

$$N_1 = 313.19 \text{ rpm}$$

spindle speed, normal 45 lb of 45 lb of 45 lb of 45 lb

$$N_2 = \frac{47.5 - 1.717}{2.5} \times \frac{35230}{7.071}$$

$$N_2 = 302.1 \text{ rpm}$$

(p) Porter governor of sleeve governor of 45 lb of 45 lb of 45 lb of 45 lb
 ball and sleeve of 45 lb of 45 lb of 45 lb of 45 lb
 245 rpm & 255 rpm of 245 rpm & 255 rpm of 245 rpm & 255 rpm

$$W = 45 \text{ lb} \quad \left| \quad N_1 = 255 \text{ rpm (normal def. of 245 rpm)} \right.$$

$$w = 2.5 \text{ lb} \quad \left| \quad N_2 = 245 \text{ rpm (normal def. of 245 rpm)} \right.$$

$$h_1 = h_2 \quad \left| \quad f = ? \right.$$

$$N_1 = \frac{W + f + w}{\omega} \times \frac{35230}{h_1}$$

$$h_1 = \frac{45 + f + 2.5}{2.5} \times \frac{35230}{255^2}$$

$$N_2 = \frac{W - f + w}{\omega} \times \frac{35230}{h_2}$$

$$h_2 = \frac{45 - f + 2.5}{2.5} \times \frac{35230}{245^2}$$

$$h_1 = h_2$$

$$\frac{50 + f}{2.5} \times \frac{35230}{255^2} = \frac{50 - f}{2.5} \times \frac{35230}{245^2}$$

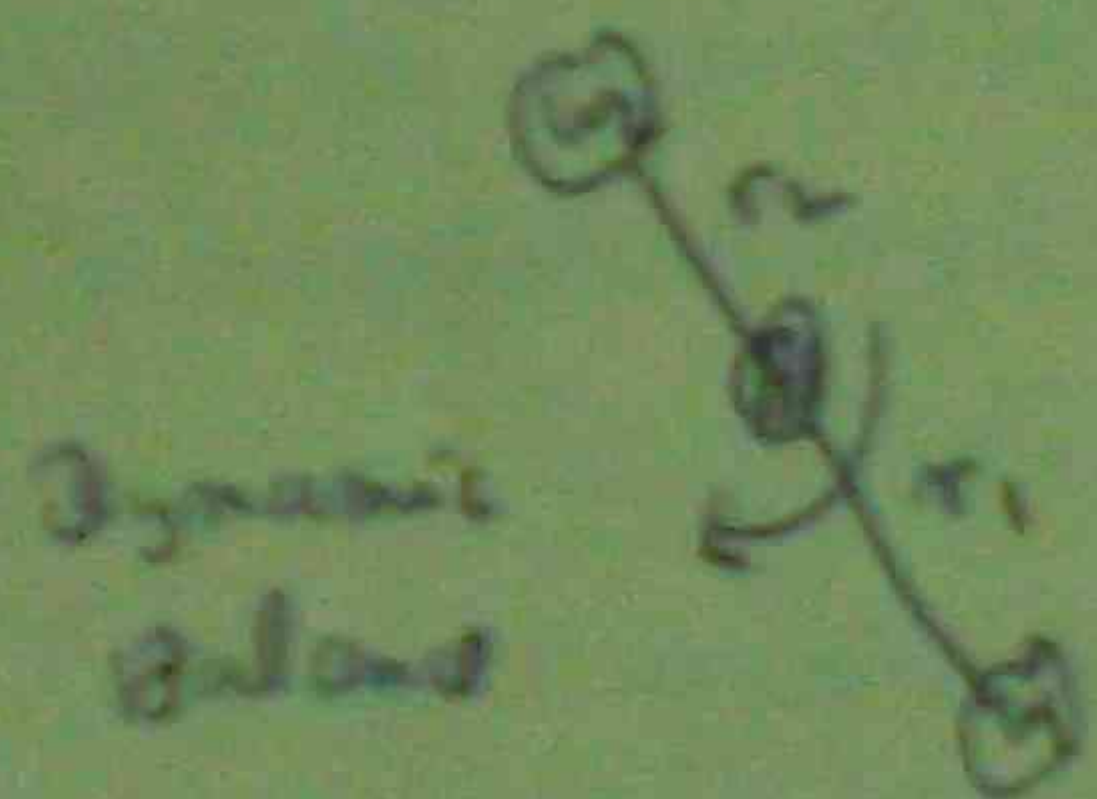
$$f = 1.92 \text{ lb}$$

CHAPTER (7) BALANCING

Single Plane

6160808:

Static Balance Force = $\frac{\omega \omega^2 r}{g}$



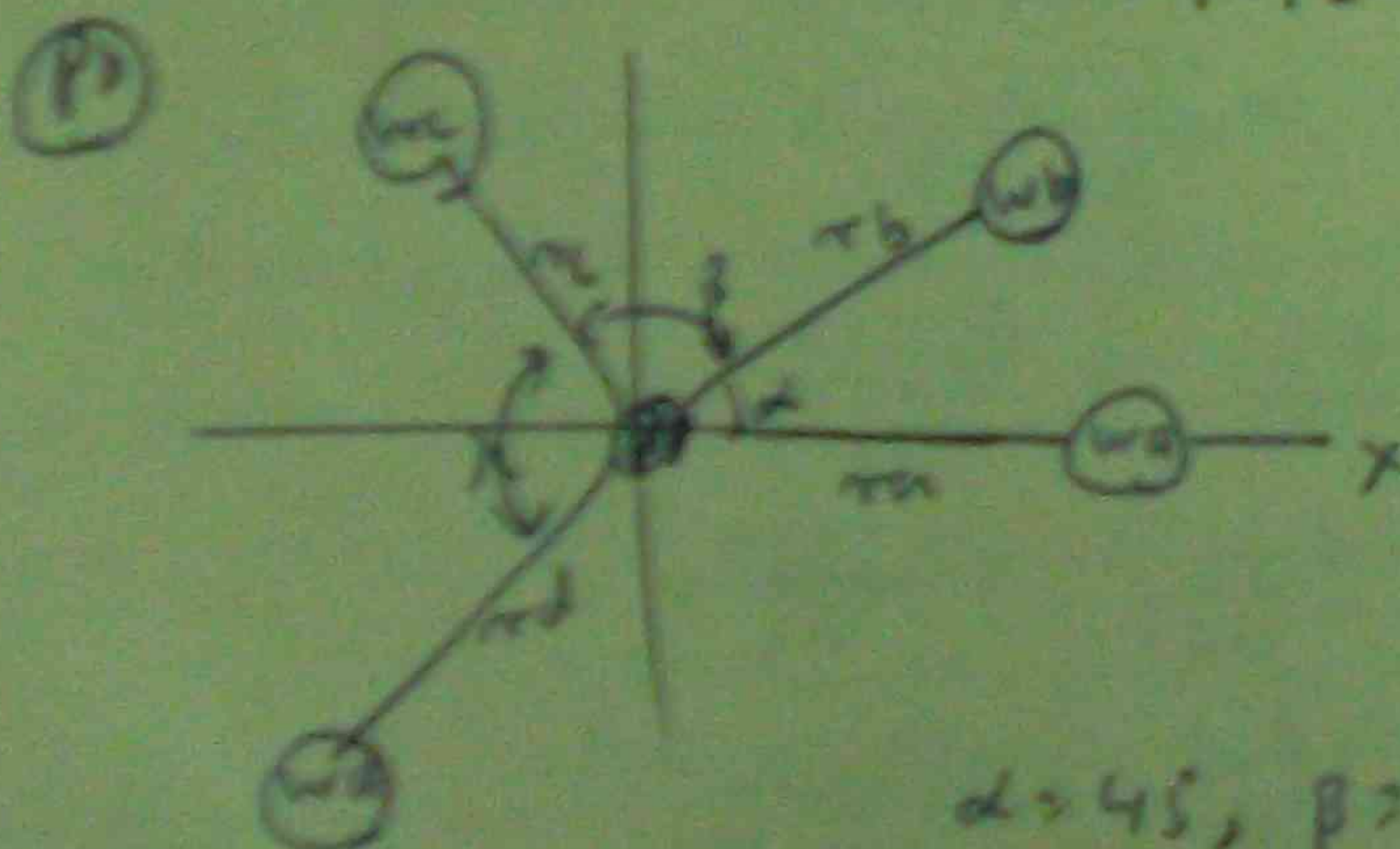
$$F_1 = \frac{W_1}{g} \omega^2 r_1$$

$$F_2 = \frac{W_2}{g} \omega^2 r_2$$

$$F_1 = F_2$$

$$\therefore \frac{W_1}{g} \omega^2 r_1 = \frac{W_2}{g} \omega^2 r_2$$

$$\therefore W_1 r_1 = W_2 r_2$$



$$W_1 = 20 \text{ lb}, r_1 = 9"$$

$$W_2 = 30 \text{ lb}, r_2 = 7"$$

$$W_3 = 240 \text{ lb}, r_3 = 10"$$

$$W_4 = 20 \text{ lb}, r_4 = 12"$$

$$\alpha = 45^\circ, \beta = 75^\circ, \lambda = 135^\circ$$

... ..
... ..

$$H_0 = W_1 r_1 \cos \alpha + W_2 r_2 \cos \beta + W_3 r_3 \cos (\alpha + \beta) + W_4 r_4 \cos (\alpha + \beta + \lambda)$$

$$= 200 \times 9 \times 1 + 30 \times 7 + 240 \times 10 \cos (45 + 75) + 20 \times 12 \cos (45 + 75 + 135)$$

$$= 20163.87$$

$$V_0 = W_1 r_1 \sin \alpha + W_2 r_2 \sin \beta + W_3 r_3 \sin (\alpha + \beta) + W_4 r_4 \sin (\alpha + \beta + \lambda)$$

$$= 20 + 1120 \sin 45 + 2400 \sin (45 + 75) + 3120 \sin (45 + 75 + 135)$$

$$= 2077.47$$

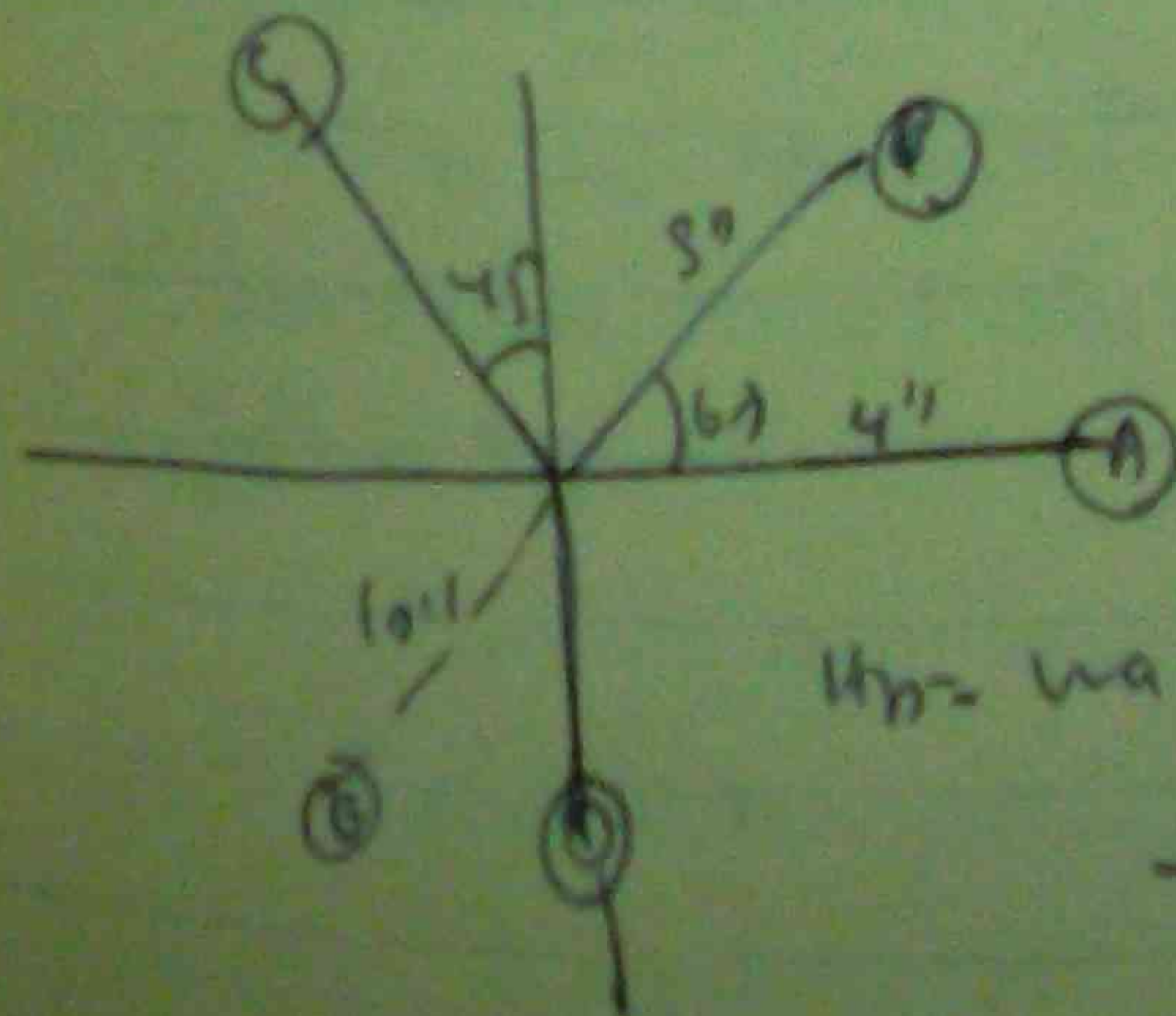
(P1) A, B, C, D, E, F, G, H, I, J, K, L, M, N, O, P, Q, R, S, T, U, V, W, X, Y, Z, AA, AB, AC, AD, AE, AF, AG, AH, AI, AJ, AK, AL, AM, AN, AO, AP, AQ, AR, AS, AT, AU, AV, AW, AX, AY, AZ, BA, BB, BC, BD, BE, BF, BG, BH, BI, BJ, BK, BL, BM, BN, BO, BP, BQ, BR, BS, BT, BU, BV, BW, BX, BY, BZ, CA, CB, CC, CD, CE, CF, CG, CH, CI, CJ, CK, CL, CM, CN, CO, CP, CQ, CR, CS, CT, CU, CV, CW, CX, CY, CZ, DA, DB, DC, DD, DE, DF, DG, DH, DI, DJ, DK, DL, DM, DN, DO, DP, DQ, DR, DS, DT, DU, DV, DW, DX, DY, DZ, EA, EB, EC, ED, EE, EF, EG, EH, EI, EJ, EK, EL, EM, EN, EO, EP, EQ, ER, ES, ET, EU, EV, EW, EX, EY, EZ, FA, FB, FC, FD, FE, FF, FG, FH, FI, FJ, FK, FL, FM, FN, FO, FP, FQ, FR, FS, FT, FU, FV, FW, FX, FY, FZ, GA, GB, GC, GD, GE, GF, GG, GH, GI, GJ, GK, GL, GM, GN, GO, GP, GQ, GR, GS, GT, GU, GV, GW, GX, GY, GZ, HA, HB, HC, HD, HE, HF, HG, HH, HI, HJ, HK, HL, HM, HN, HO, HP, HQ, HR, HS, HT, HU, HV, HW, HX, HY, HZ, IA, IB, IC, ID, IE, IF, IG, IH, II, IJ, IK, IL, IM, IN, IO, IP, IQ, IR, IS, IT, IU, 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LR, LS, LT, LU, LV, LW, LX, LY, LZ, MA, MB, MC, MD, ME, MF, MG, MH, MI, MJ, MK, ML, MM, MN, MO, MP, MQ, MR, MS, MT, MU, MV, MW, MX, MY, MZ, NA, NB, NC, ND, NE, NF, NG, NH, NI, NJ, NK, NL, NM, NN, NO, NP, NQ, NR, NS, NT, NU, NV, NW, NX, NY, NZ, OA, OB, OC, OD, OE, OF, OG, OH, OI, OJ, OK, OL, OM, ON, OO, OP, OQ, OR, OS, OT, OU, OV, OW, OX, OY, OZ, PA, PB, PC, PD, PE, PF, PG, PH, PI, PJ, PK, PL, PM, PN, PO, PP, PQ, PR, PS, PT, PU, PV, PW, PX, PY, PZ, QA, QB, QC, QD, QE, QF, QG, QH, QI, QJ, QK, QL, QM, QN, QO, QP, QQ, QR, QS, QT, QU, QV, QW, QX, QY, QZ, RA, RB, RC, RD, RE, RF, RG, RH, RI, RJ, RK, RL, RM, RN, RO, RP, RQ, RR, RS, RT, RU, RV, RW, RX, RY, RZ, SA, SB, SC, SD, SE, SF, SG, SH, SI, SJ, SK, SL, SM, SN, SO, SP, SQ, SR, SS, ST, SU, SV, SW, SX, SY, SZ, TA, TB, TC, TD, TE, TF, TG, TH, TI, TJ, TK, TL, TM, TN, TO, TP, TQ, TR, TS, TT, TU, TV, TW, TX, TY, TZ, UA, UB, UC, UD, UE, UF, UG, UH, UI, UJ, UK, UL, UM, UN, UO, UP, UQ, UR, US, UT, UU, UV, UW, UX, UY, UZ, VA, VB, VC, VD, VE, VF, VG, VH, VI, VJ, VK, VL, VM, VN, VO, VP, VQ, VR, VS, VT, VU, VV, VW, VX, VY, VZ, WA, WB, WC, WD, WE, WF, WG, WH, WI, WJ, WK, WL, WM, WN, WO, WP, WQ, WR, WS, WT, WU, WV, WW, WX, WY, WZ, XA, XB, XC, XD, XE, XF, XG, XH, XI, XJ, XK, XL, XM, XN, XO, XP, XQ, XR, XS, XT, XU, XV, XW, XX, XY, XZ, YA, YB, YC, YD, YE, YF, YG, YH, YI, YJ, YK, YL, YM, YN, YO, YP, YQ, YR, YS, YT, YU, YV, YW, YX, YY, YZ, ZA, ZB, ZC, ZD, ZE, ZF, ZG, ZH, ZI, ZJ, ZK, ZL, ZM, ZN, ZO, ZP, ZQ, ZR, ZS, ZT, ZU, ZV, ZW, ZX, ZY, ZZ

$$W_1 = 11 \text{ lb}, r_1 = 4"$$

$$W_2 = 10 \text{ lb}, r_2 = 5"$$

$$W_3 = 10 \text{ lb}, r_3 = 6"$$

$$W_4 = 15 \text{ lb}, r_4 = 3"$$



$$H_0 = W_1 r_1 \cos \alpha + W_2 r_2 \cos \beta + W_3 r_3 \cos \gamma + W_4 r_4 \cos \delta$$

$$= -3.5 \text{ lb}$$

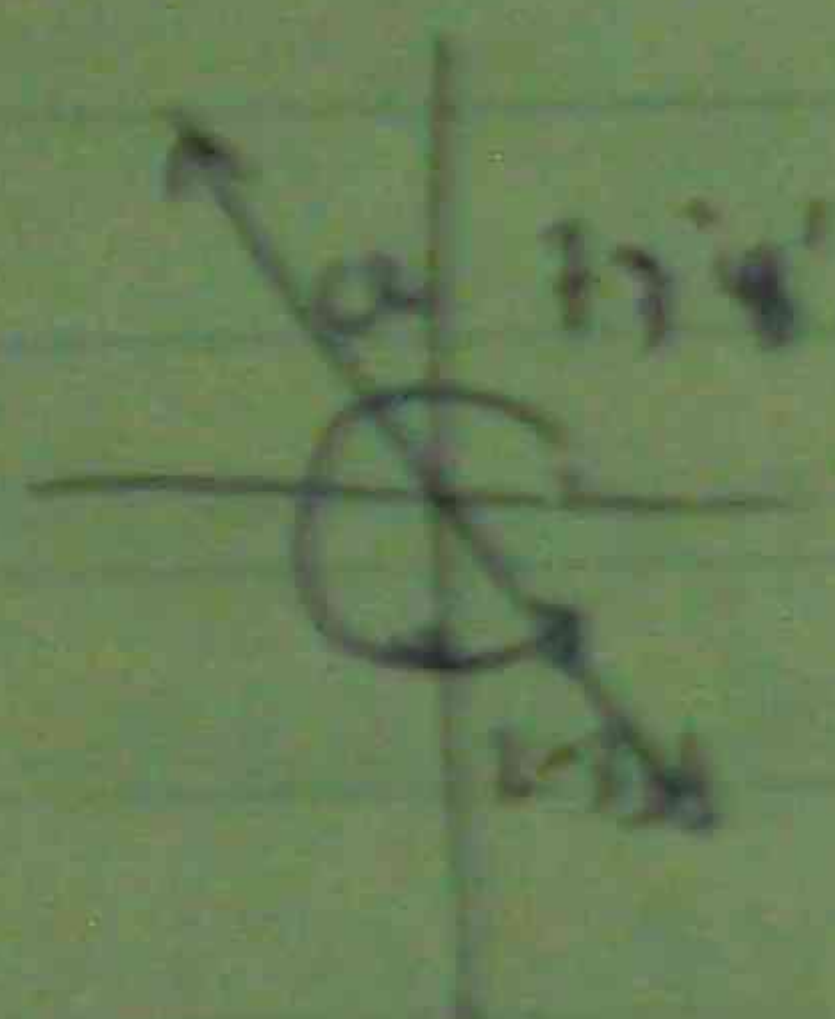
$$V_0 = w_0 r_0 \sin \theta + w_b r_b \sin \theta + w_c r_c \sin \theta - w_d r_d \sin \theta$$

$$= 74.3 \text{ lb}$$

$$R = \sqrt{V_0^2 + H_0^2} = 74.9 \text{ lb}$$

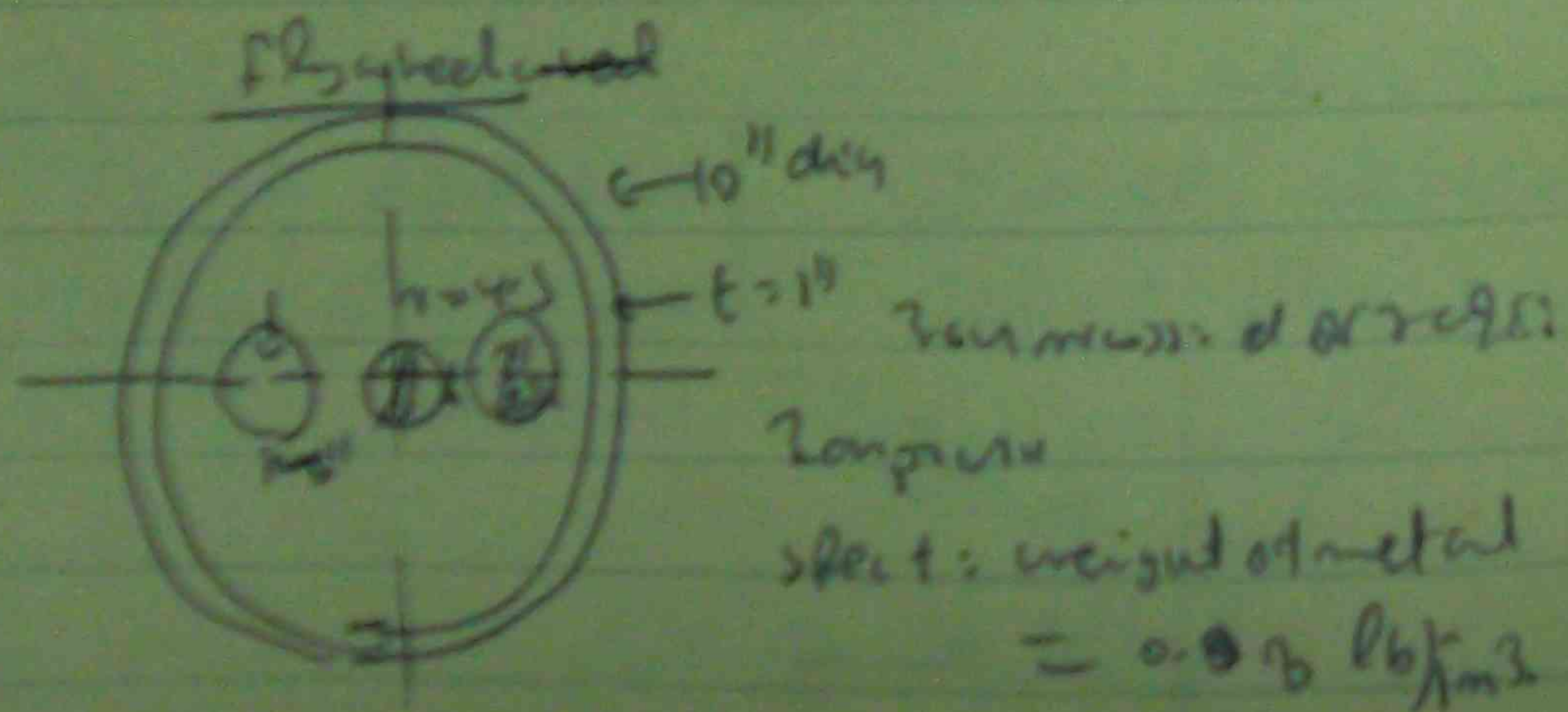
$$w_{\text{steel}} = 74.9$$

$$\therefore w_e = \frac{74.9}{10} = 7.49 \text{ lb}$$



$$\tan \theta = \frac{7.5}{99.7} = 3.351$$

$$\theta = 17.8 + 3.351 = 21.151 \text{ degrees}$$



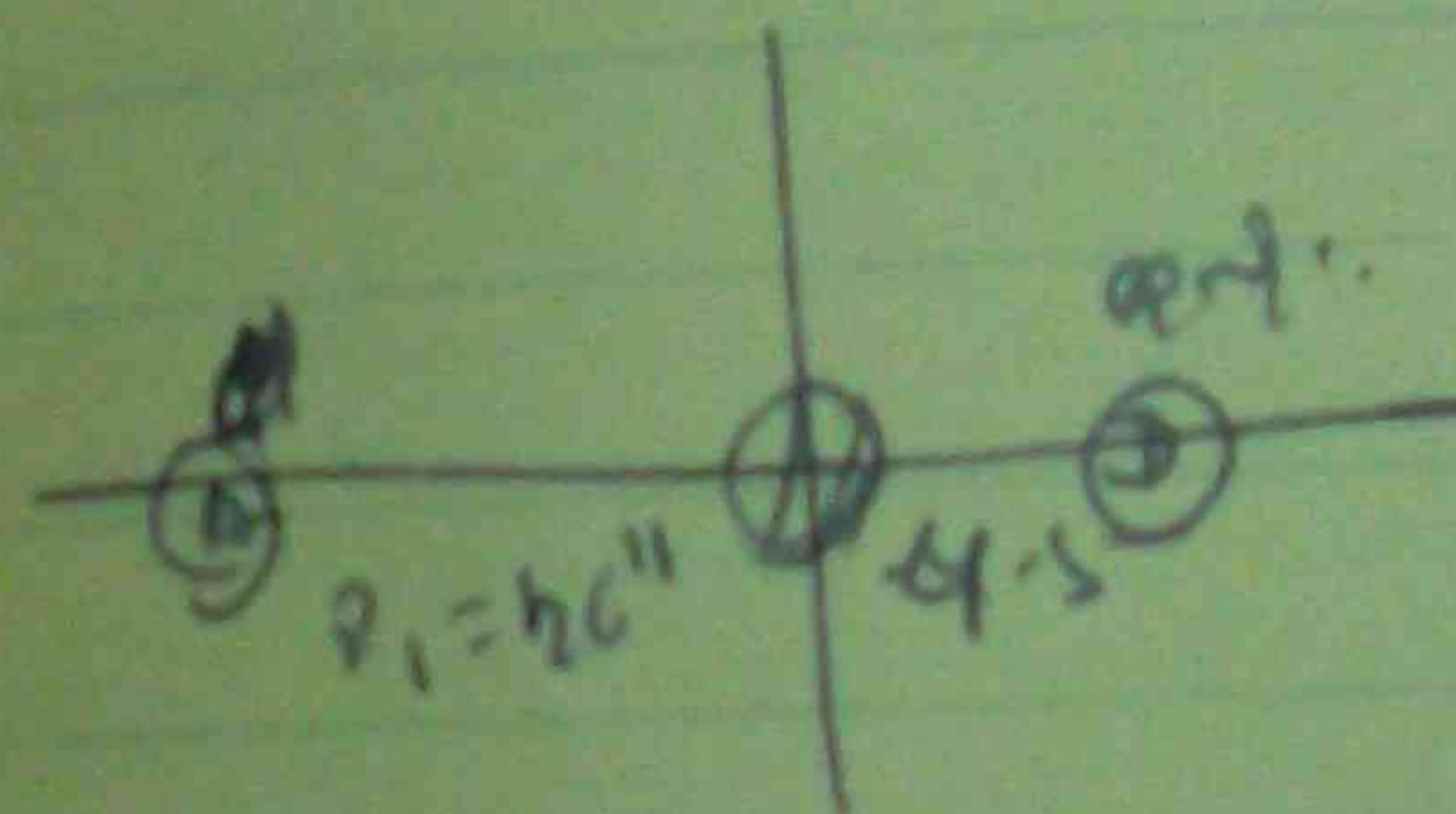
2" dia: 8000 lb/in^3

$$w_1 r_1 = w_2 r_2$$

$$d_1^2 r_1 = d_2^2 r_2$$

$$\therefore 3^2 \times 4.5 = d_2^2 \times 6$$

$$\frac{9 \times 4.5}{6} = d_2^2 \quad \therefore d_2 = 2.6 \text{ inches}$$



$$\frac{4}{3} \pi r_1^3 \times w_{\text{steel}} = w_1$$

$$\frac{4}{3} \pi r_2^3 \times w_{\text{steel}} = w_2$$

$$w_1 r_1 = w_2 r_2$$

$$\frac{4}{3} \pi r_1^3 \times w_{\text{steel}} \times r_1 = \frac{4}{3} \pi r_2^3 \times w_{\text{steel}} \times r_2$$

$$r_1^3 = r_2^3 \times r_2$$

$$r_1^3 = 6, \quad = (3.1)^3 \times 4.5$$

$$r_1^3 = 2.53 \quad \therefore r_1 = 1.36 \text{ inches}$$

5

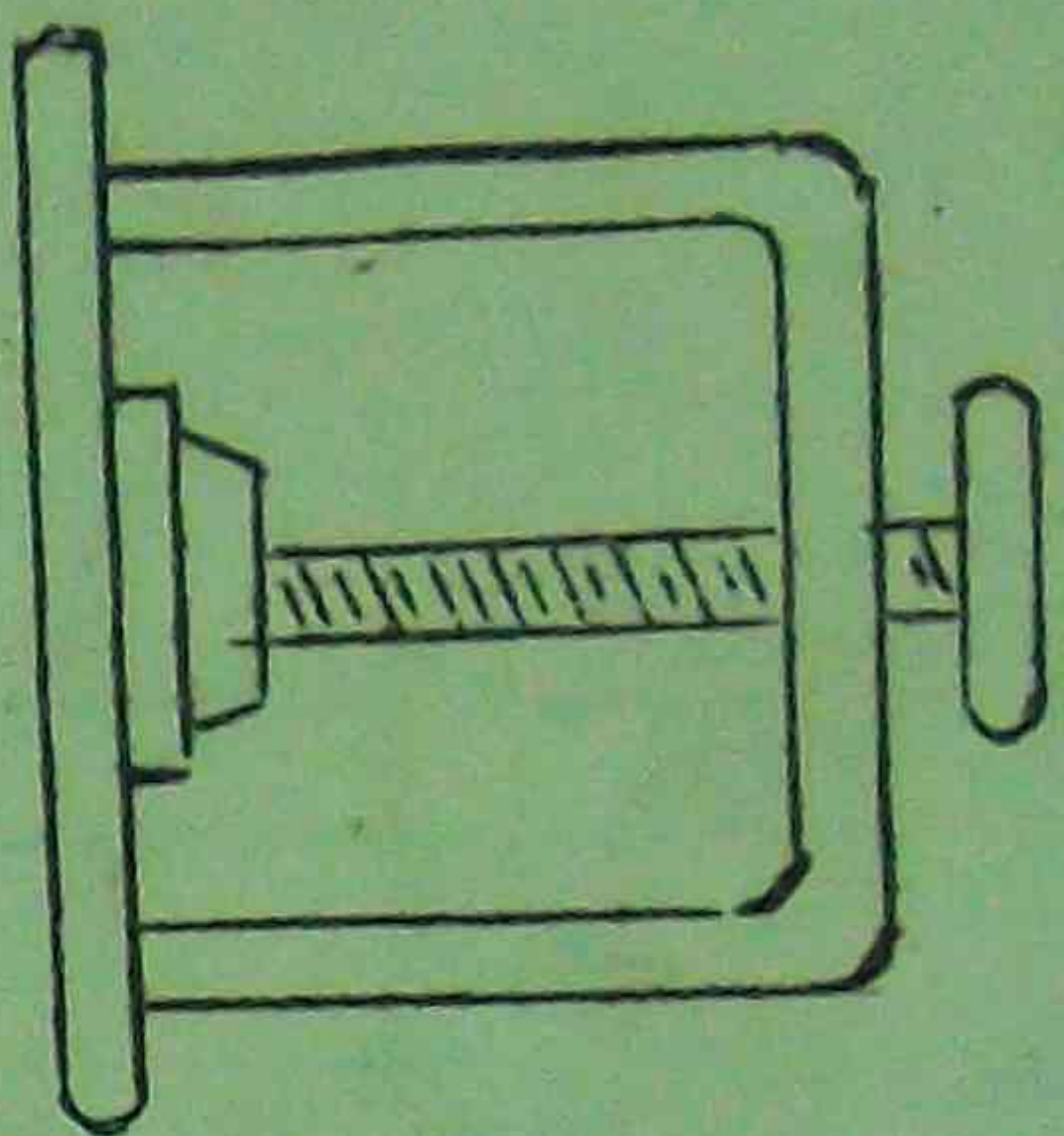
[illegible]

ဒုတိယနှစ်ဝက်များ၌ ရင်နှိယာသင်တန်း

၁-၄-၀၀
၁၄:၀၀နာရီ
၁၅:၀၀နာရီ

THEORY OF MACHINES.

(၆) ပုဒ်ဖြေဆိုပါ။



၃၂၂ 2000 lbs ကို အားထုတ်လိုသော ၁၀၀၀ lb Press ၏
 လေးထောင့်ဝက်ဆူရပ်၏ ပျက်စီးမှုအချင်းမှာ 2 in နှစ်ဝရပ်
 $Lead = 1 \text{ in}$ ဖြစ်သည်။ ဝက်ဆူရပ် ၁၂ ပုံငါးပါး $U = 0.316$
 ဖြစ်လျှင် လက်ကိုင်အား Torque or turning moment,
 $T \text{ or } M \text{ lb-ft}$ မည်မျှလိုမည်နည်း။ (ဤအခြားနေ
 ၇၁ တွင် ပွတ်မှုကိန်းသည် ၀.၁၁ ရန်မရှိ။)

၂။ ဗဟုချင်ပြားကလတ်အမျိုးအဝားကလတ်တင် ခုယည် 3600 rpm. နှုန်းဖြင့်လည်ပတ်နေဝှဲမြင်း ကောင့် ဂျေအား 100 H.P ဖွက်ရန်လိုလေသည်။ ကလတ်ပြား၏အစွင်းအချင်းဝက်သည် ယင်း၏အပြင်အချင်းဝက်၏ 0.8 ဆဖြစ်သည်။ အပြင်အချင်းဝက်သည် 5 in ဖြစ်၏။ $V = 0.07$ ဖြစ်၍၊ ဝင်ရိုး ဖြောင့်၊ စီအားသည် 20 lb/in² ဖြစ်သော်လည်းကောင်း၊ အဂျေအဖွက်ကို ၇၁ ပါ။

၃။ ပတ်ကြီး တစ်ခုကိုတစ်ဆင့် ၃၁၆၆။ ပတ်ကြီး ၁ in ကျယ်လျှင် ထိရောက်သောတင်း
 မာမှုမှာ 40 lbs. ဖုယတ်မှတ်ထားသည်။ ပတ်ကြီး ဆယ့်ဆယ့် ၁၆ in ဖြစ်၍၊ ပတ်ခေါက်
 မှာ 160° ရှိပြီး $U = 0.3$ ဖြစ်သည်။ ပတ်ကြီး ချိတ်တင်း ဘက်တင်း မာမှုအပေါ်တွင်
 ရှိသော Max. Stress ကိုရှာပါ။

၄။ ၇၇ ပေါင်းအလေးချိန်ကပ်ဘဲလေးသည့်ဝက်သေတ္တာကပ်ကုံးကိုအမြင့် ၃၂၅ ရှိသည့်ကားဖော်မှချရသည့်အထုံးပြသောကပ်ကုံးတောင်၏အလျားမှာ ၁၀၀ ရှည်၏။ သေတ္တာကိုမြေပြင်သို့ချရသည့်အထုံးပြသော ၄ -

(က) ကြီးကိုကုန်းဘောင်နှင့်အပြိုင်အမျှ

(၁) ဆွဲဆားကို ပြေပြောင်နှင့်အပြိုင် ဝှက်ထုတ်လျှင် - ဝှက်ဆား မည်မျှဝိဆည်း ပြုရမည်နည်း ၊ ဝှက်ကုန်း = ၀.၄ ။

၅။ (က) မော်တော်ကား တစ်စီး သည် ၁၂၀ mph ဖြင့် မောင်းနှင်ရင်း ဖိအားစွမ်းအင် (Kinetic Energy) ၄၁ ၀၁၆၀၀ ft-lb ရှိမည်။ အမြန်နှုန်းကို ၄၆၀ fpm သို့မဟုတ် ၁၂၀ mph ဖြင့် မောင်းနှင်နေသော အားသက်သာမှု (thrust) ကို ၁၂၀၀၀ lb ရှိမည်။

အမည်အားဖြင့်

အမည်အားဖြင့်

၁။ ဖိလပ်ပိုင်စ်

၂။ အိမ်

၃။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

၄။ အိမ်အတွင်း အိမ်အတွင်း

၅။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

၆။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

၇။ Safety valve

၈။ Salinometer

၉။ ဖိလပ်ပိုင်စ် (draught)

၁၀။ အိမ်အတွင်း

၁၁။ ဖိလပ်ပိုင်စ်

၁၂။ Flash point & Firing point

၁၃။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

၁၄။ ဖိလပ်ပိုင်စ် အိမ်အတွင်း အိမ်အတွင်း

အမည်အားဖြင့်

၁၅။ ဖိလပ်ပိုင်စ် အိမ်အတွင်း အိမ်အတွင်း

၁၆။ ဖိလပ်ပိုင်စ် အိမ်အတွင်း အိမ်အတွင်း

၁၇။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

၁၈။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

၁၉။ Furnace Fuel oil pump

၂၀။ Air pump

၂၁။ main pump

၂၂။ Boiler Donkey pump

၂၃။ Bilge pump

၂၄။ Ballast Pump (or) Deke Donkey pump

၂၅။ Fan Engine -

၂၆။ circulating Engine

၂၇။ Lighting Engine

၂၈။ windlass Engine

၂၉။ Steering Engine

၃၀။ Shuttle valve

၃၁။ Shuttle valve operation

၃၂။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

၃၃။ ဝါးစိန် (valve setting)

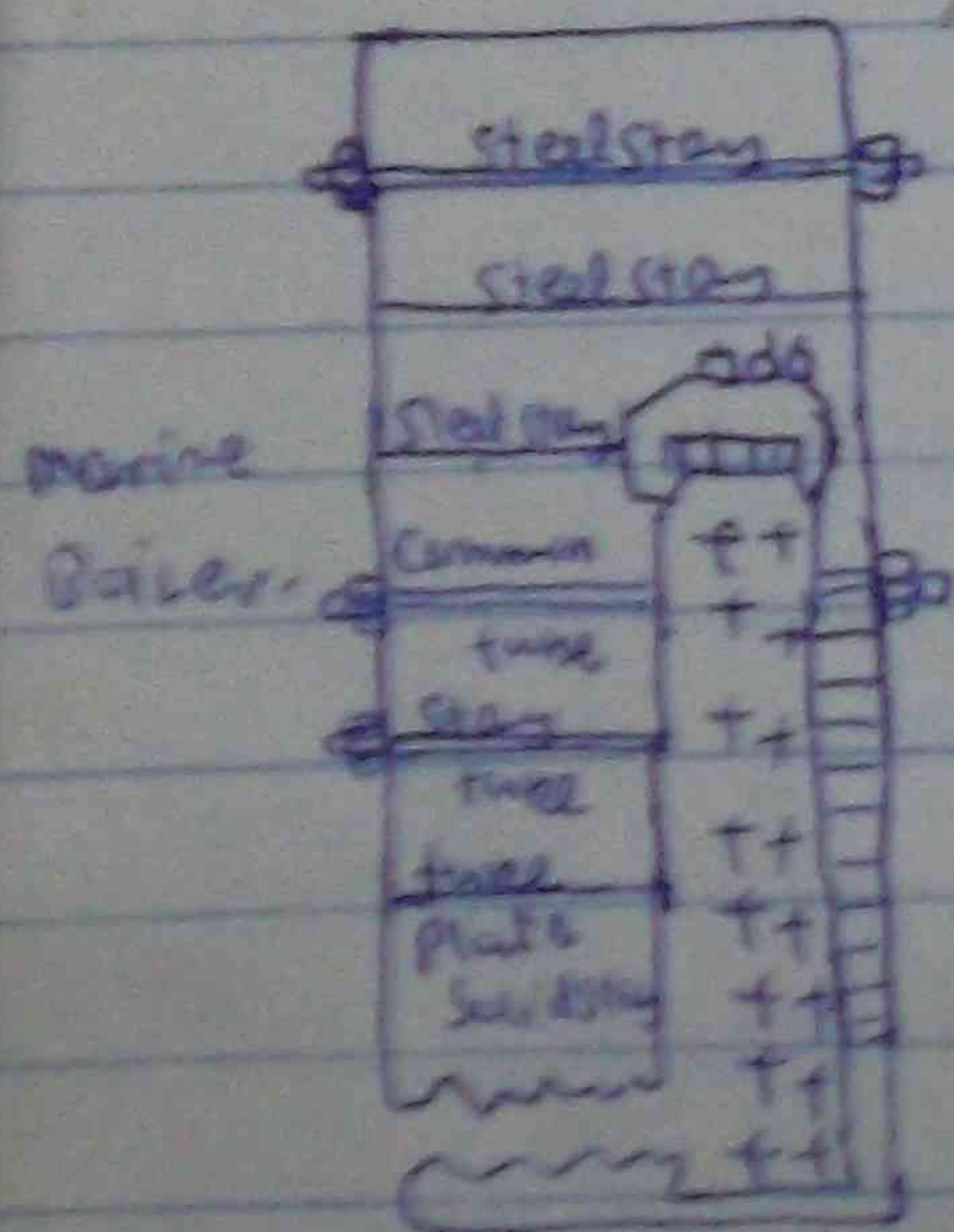
၃၄။ Horse power

၃၅။ အိမ်အတွင်း အိမ်အတွင်း အိမ်အတွင်း

016168-ly Gdswm

[illegible]

2/20/20

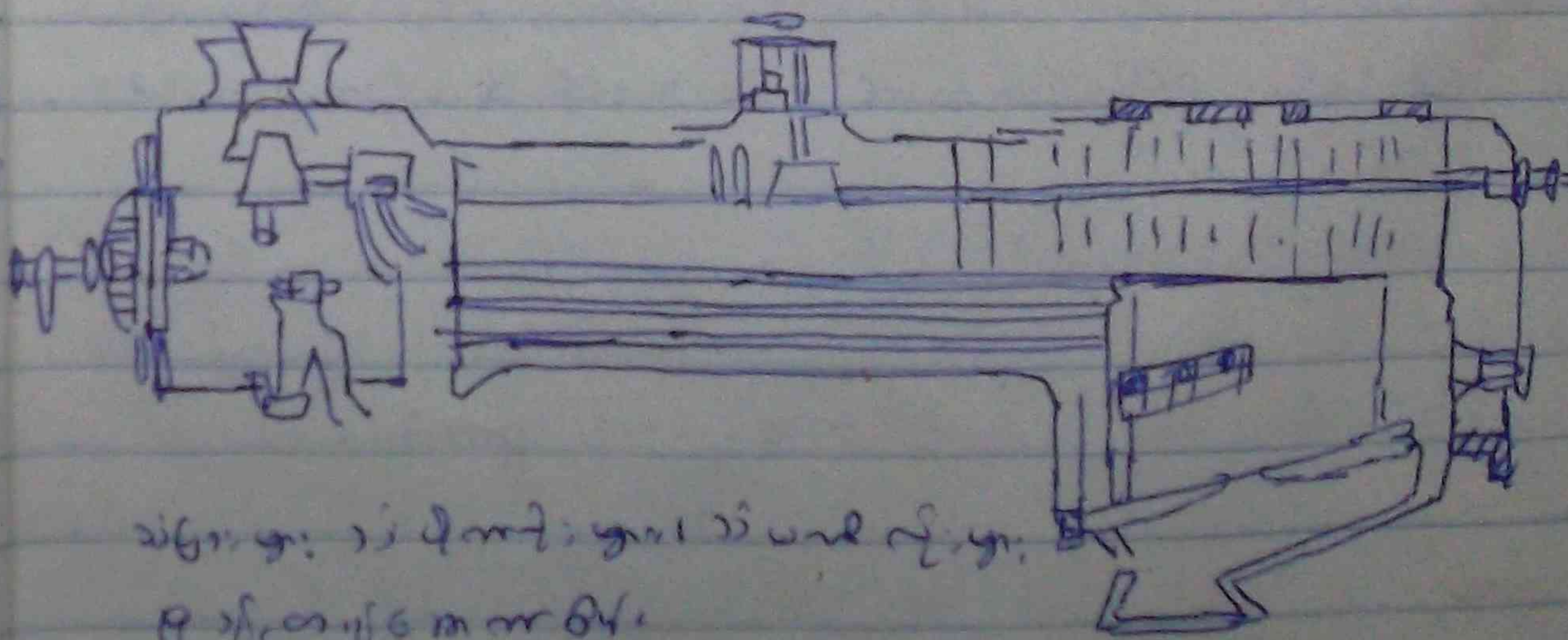
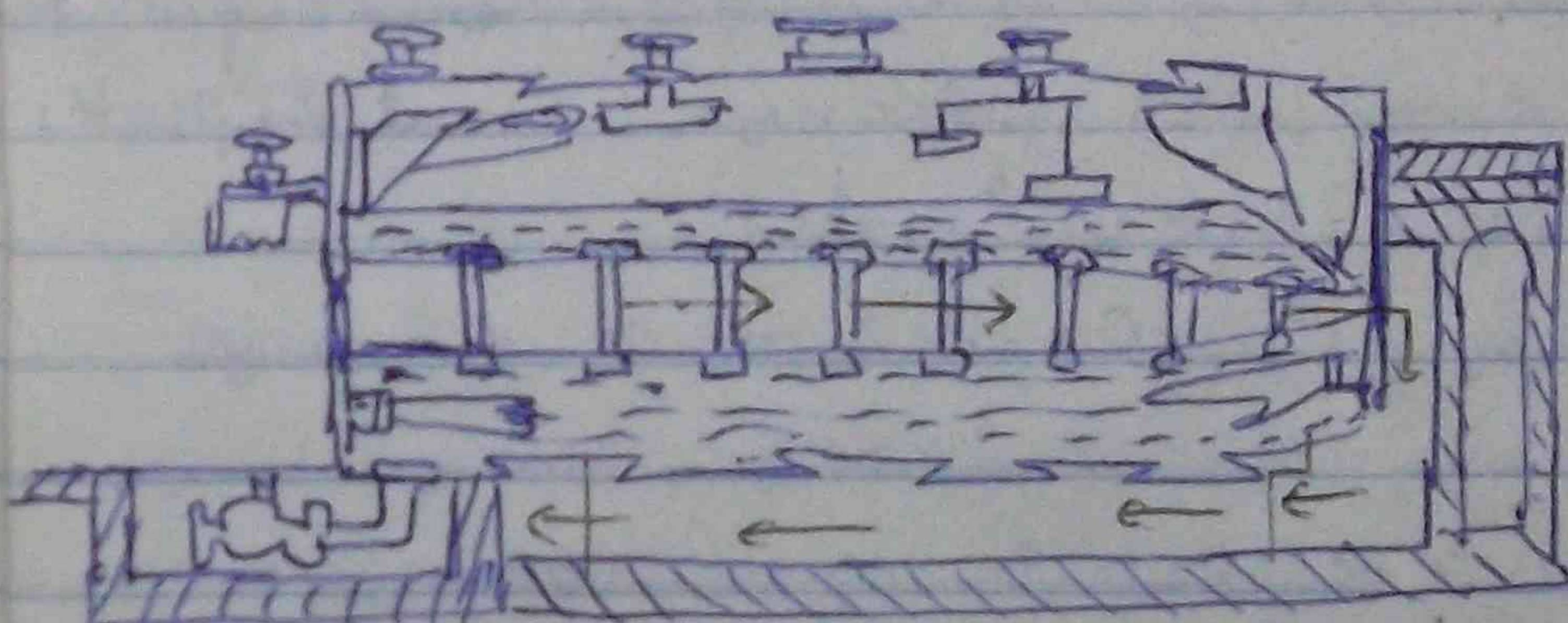


P. of combustion \rightarrow (Furnace) or (Flue)
 P. of combustion: surface of gas and
 of combustion (P. of combustion
 (number) P. of combustion: surface of
 of combustion: surface of pipe (tube) (smoke tube)
 P. of combustion: surface of gas and
 of combustion: surface of gas and

1. 21 жерлер: 3488 жер, 0000

S. of furnace combustion chamber (P_1 and T_1) or at junction
 of P. 60 surface & S. of gas side smoke tube at port of combustion
 S. of gas side radiation, conduction & conv. S. of G. 2 of air.
 m d r II

9/ marine boiler (marine boiler)



১৯৭৭: ১১ ডিসেম্বর: গুলি ও বন্দুকের গুলি
 ও ১৯৭৭: ১১ ডিসেম্বর: গুলি ও বন্দুকের গুলি

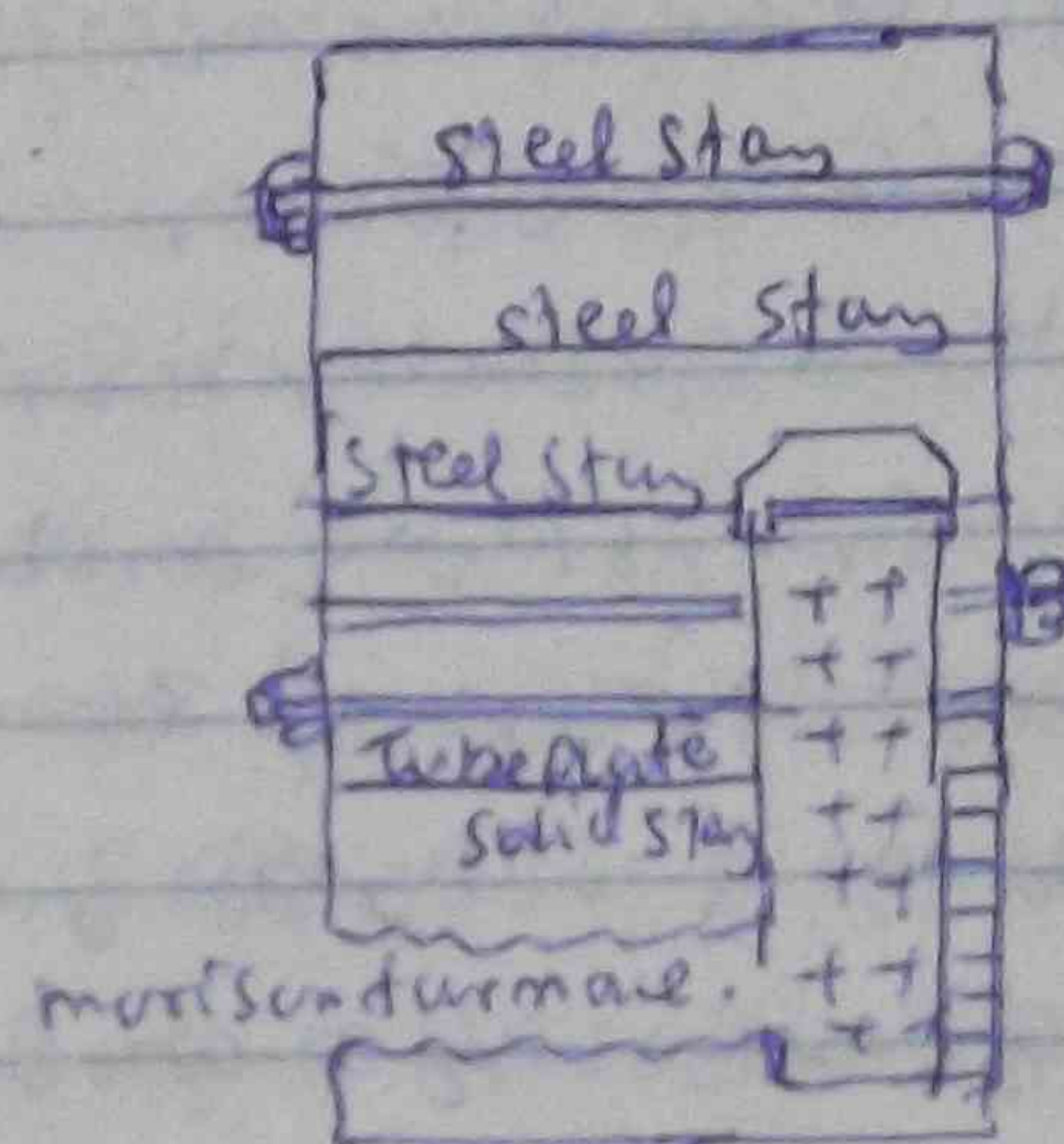
Diagram of boiler (1) stationary boiler
(2) portable boiler (locomotive boiler) (3) marine boiler of boiler
Diagram of boiler (1) smoke tube (2) water tube
fire tube boiler of boiler

2) 3. Boilers are of 2 types i.e. horizontal & vertical. marine boiler
 are of vertical type. All are (spiral) & of (steel)
 3) 4. 2 types: (1) shell & (2) cylindrical. (3) of con. st.
 (1) 2 types: (1) shell (2) cylindrical. (3) of con. st.
 (3) cylindrical: (Back end plate)

[illegible]

Rivet & Snap head 3/4, 1/2, 3/8, 1/4, 3/16, 1/8, 1/16, 1/32, 1/64, 1/128, 1/256, 1/512, 1/1024, 1/2048, 1/4096, 1/8192, 1/16384, 1/32768, 1/65536, 1/131072, 1/262144, 1/524288, 1/1048576, 1/2097152, 1/4194304, 1/8388608, 1/16777216, 1/33554432, 1/67108864, 1/134217728, 1/268435456, 1/536870912, 1/1073741824, 1/2147483648, 1/4294967296, 1/8589934592, 1/17179869184, 1/34359738368, 1/68719476736, 1/137438953472, 1/274877906944, 1/549755813888, 1/1099511627776, 1/2199023255552, 1/4398046511104, 1/8796093022208, 1/17592186044416, 1/35184372088832, 1/70368744177664, 1/140737488355328, 1/281474976710656, 1/562949953421312, 1/1125899906842624, 1/2251799813685248, 1/4503599627370496, 1/9007199254740992, 1/18014398509481984, 1/36028797018963968, 1/72057594037927936, 1/144115188075855872, 1/288230376151711744, 1/576460752303423488, 1/1152921504606846976, 1/2305843009213693952, 1/4611686018427387904, 1/9223372036854775808, 1/18446744073709551616, 1/36893488147419103232, 1/73786976294838206464, 1/147573952589676412928, 1/295147905179352825856, 1/590295810358705651712, 1/1180591620717411303424, 1/2361183241434822606848, 1/4722366482869645213696, 1/9444732965739290427392, 1/18889465931478580854784, 1/37778931862957161709568, 1/75557863725914323419136, 1/151115727451828646838272, 1/302231454903657293676544, 1/604462909807314587353088, 1/1208925819614629174706176, 1/2417851639229258349412352, 1/4835703278458516698824704, 1/9671406556917033397649408, 1/19342813113834066795298816, 1/38685626227668133590597632, 1/77371252455336267181195264, 1/154742504910672534362390528, 1/309485009821345068724781056, 1/618970019642690137449562112, 1/1237940039285380274899124224, 1/2475880078570760549798248448, 1/4951760157141521099596496896, 1/9903520314283042199192993792, 1/19807040628566084398385987584, 1/39614081257132168796771975168, 1/79228162514264337593543950336, 1/158456325028528675187087900672, 1/316912650057057350374175801344, 1/633825300114114700748351602688, 1/1267650600228229401496703205376, 1/2535301200456458802993406410752, 1/5070602400912917605986812821504, 1/10141204801825835211973625643008, 1/20282409603651670423947251286016, 1/40564819207303340847894502572032, 1/81129638414606681695789005144064, 1/162259276829213363391578010288128, 1/324518553658426726783156020576256, 1/649037107316853453566312041152512, 1/1298074214633706907132624082305024, 1/2596148429267413814265248164610048, 1/5192296858534827628530496329220096, 1/10384593717069655257060992658440192, 1/20769187434139310514121985316880384, 1/41538374868278621028243970633760768, 1/83076749736557242056487941267521536, 1/166153499473114484112975882535043072, 1/332306998946228968225951765070086144, 1/664613997892457936451903530140172288, 1/1329227995784915872903807060280344576, 1/2658455991569831745807614120560689152, 1/5316911983139663491615228241121378304, 1/10633823966279326983230456482242756608, 1/21267647932558653966460912964485513216, 1/42535295865117307932921825928971026432, 1/85070591730234615865843651857942052864, 1/170141183460469231731687303715884105728, 1/340282366920938463463374607431768211456, 1/680564733841876926926749214863536422912, 1/1361129467683753853853498429727072845824, 1/2722258935367507707706996859454145691648, 1/5444517870735015415413993718908291383296, 1/10889035741470030830827987437816582766592, 1/21778071482940061661655974875633165533184, 1/43556142965880123323311949751266331066368, 1/87112285931760246646623899502532662132736, 1/174224571863520493293247799005065324265472, 1/348449143727040986586495598010130648530944, 1/696898287454081973172991196020261297061888, 1/1393796574908163946345982392040522594123776, 1/2787593149816327892691964784081045188247552, 1/5575186299632655785383929568162090376495104, 1/11150372599265311570767859136324180752990208, 1/22300745198530623141535718272648361505980416, 1/44601490397061246283071436545296723011960832, 1/89202980794122492566142873090593446023921664, 1/178405961588244985132285746181186892047843328, 1/356811923176489970264571492362373784095686656, 1/713623846352979940529142984724747568191373312, 1/1427247692705959881058285969449495

9) $\frac{1}{x^2} = x^{-2}$ எனில் $\frac{d}{dx} x^{-2}$ காண்க.

[illegible]

ex. 1000 = 60.20 ft of smoke tube for 1.5 m of plain tube
 ex. 1000 = 60.20 ft of smoke tube for 1.5 m of plain tube
 ex. 1000 = 60.20 ft of smoke tube for 1.5 m of plain tube

[illegible]

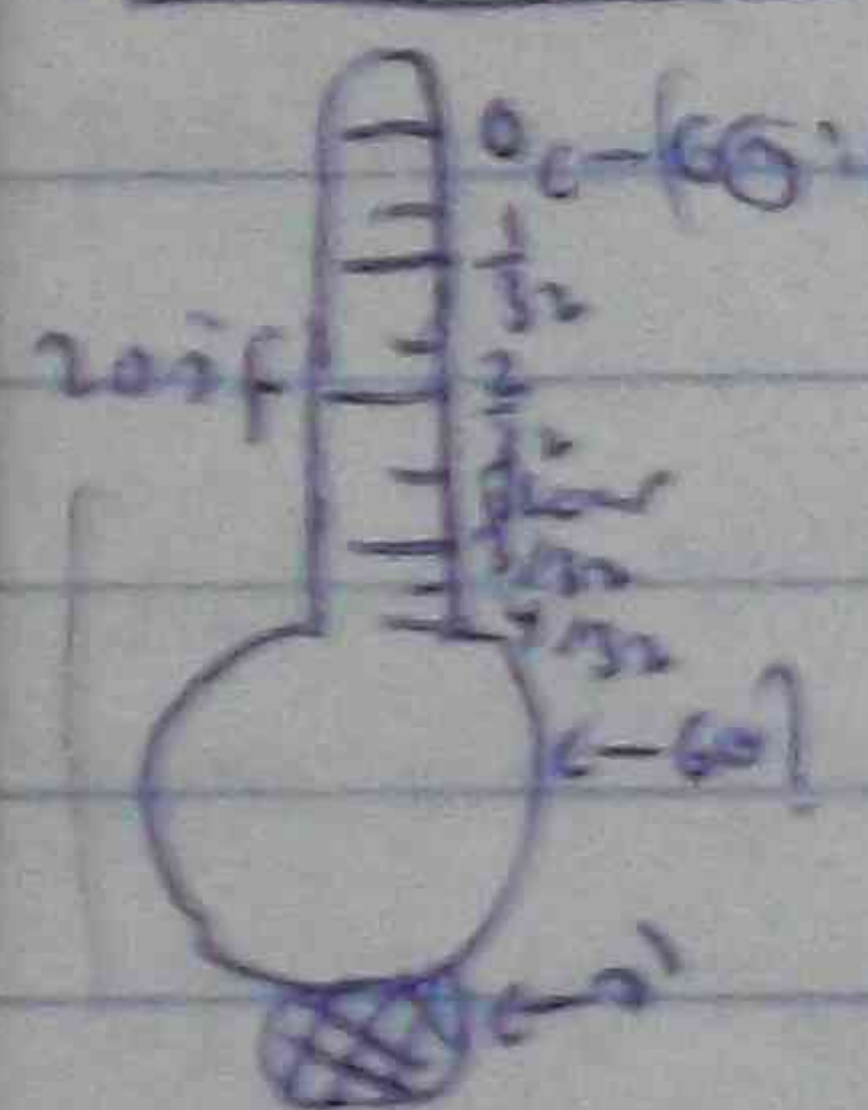
Stangtube plain tube connecting: cover plate & inner 2 parts
of 2nd & 3rd covers: Oil of oil. cylinder & 1st combustion chamber
tube plug: 2nd & 3rd covers: Oil roller 1st, 2nd, 3rd
oil, 1st, 2nd, 3rd & 4th roller 1st, 2nd, 3rd, 4th

(1) D. of gas (2) cylinder diameter (3) height
of piston (4) S.C. combustion chamber plug (5) orifice
dia.

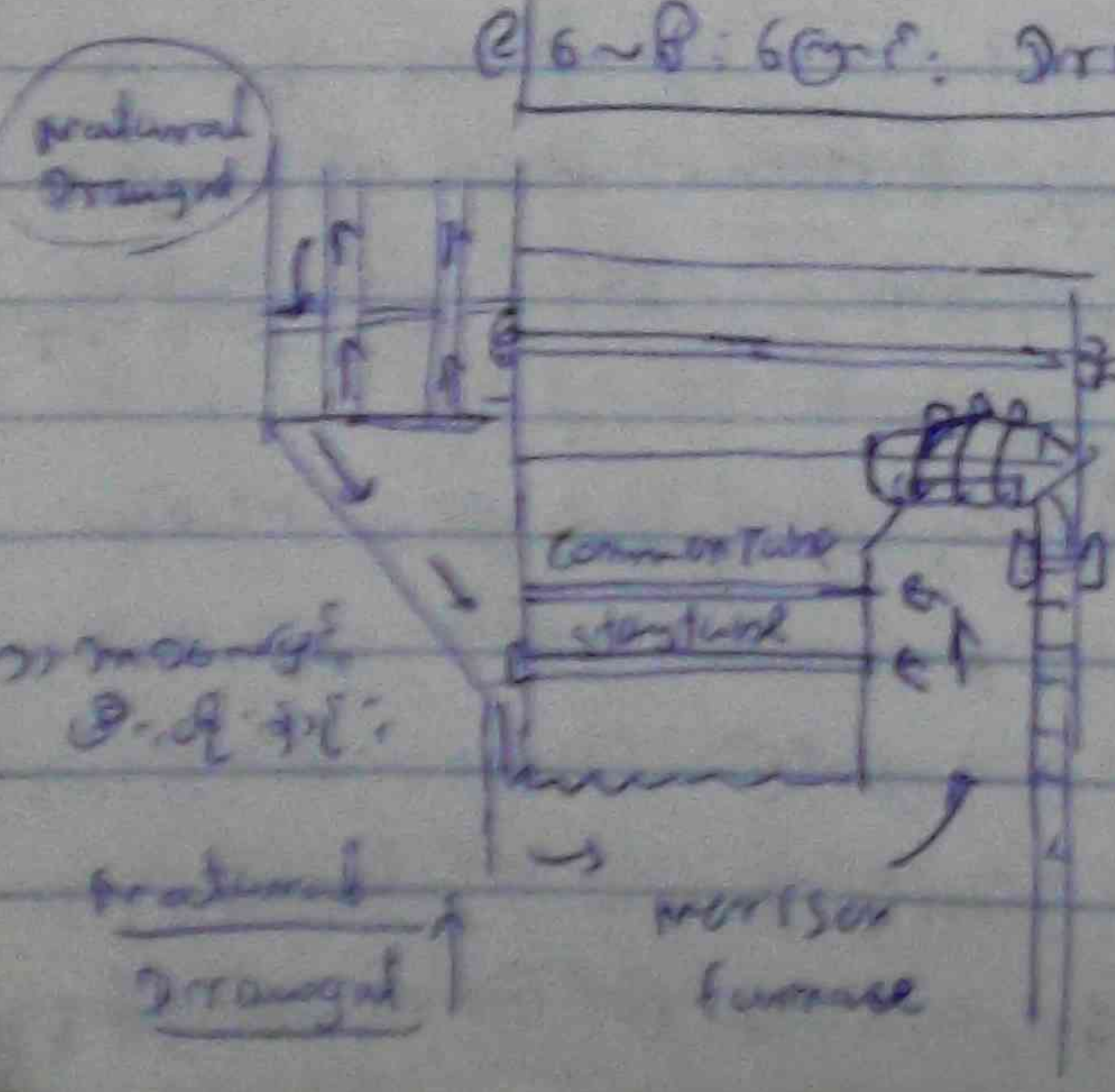
Circulator
 1. It is a device which is used to circulate the heat transfer fluid in a closed loop.
 2. It is used in a variety of applications such as heating and cooling systems, industrial processes, and power generation.

Flue of the engine is for combustion chamber
of the engine single rivetted lap joint commonly
of the rivet of a common standard of the rivet
same rivet of the rivet of the rivet of the rivet
of the rivet of the rivet of the rivet of the rivet

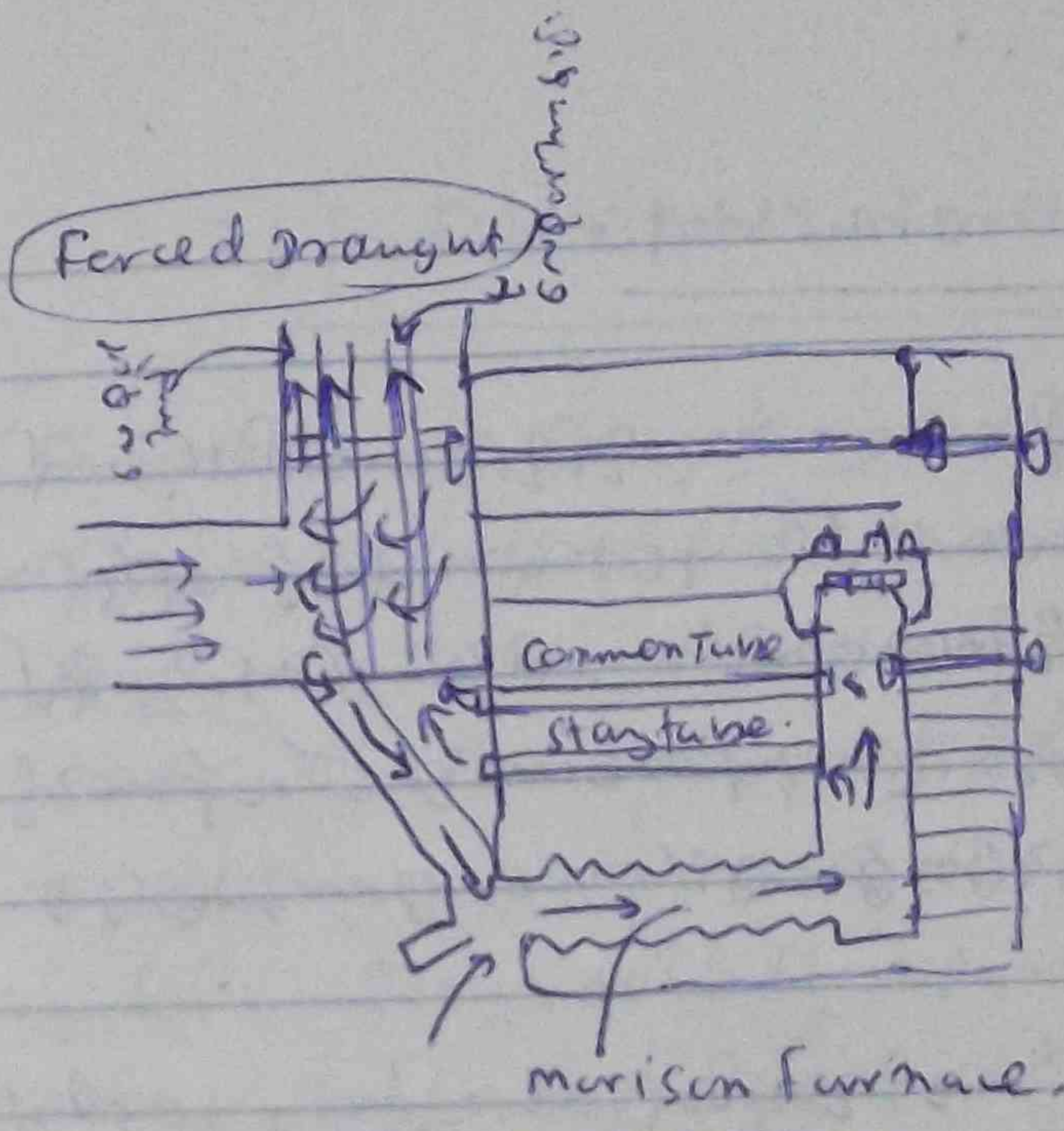
Horizontal boiler is a boiler in which the boiler tube is horizontal. It is used for generating steam. It is a type of boiler in which the boiler tube is horizontal. It is a type of boiler in which the boiler tube is horizontal.



A horizontal boiler is a boiler in which the boiler tube is horizontal. It is used for generating steam. It is a type of boiler in which the boiler tube is horizontal. It is a type of boiler in which the boiler tube is horizontal.



A horizontal boiler is a boiler in which the boiler tube is horizontal. It is used for generating steam. It is a type of boiler in which the boiler tube is horizontal. It is a type of boiler in which the boiler tube is horizontal.



A horizontal boiler is a boiler in which the boiler tube is horizontal. It is used for generating steam. It is a type of boiler in which the boiler tube is horizontal. It is a type of boiler in which the boiler tube is horizontal.

Induced draught



A horizontal boiler is a boiler in which the boiler tube is horizontal. It is used for generating steam. It is a type of boiler in which the boiler tube is horizontal. It is a type of boiler in which the boiler tube is horizontal.

13/ Diagram of the engine

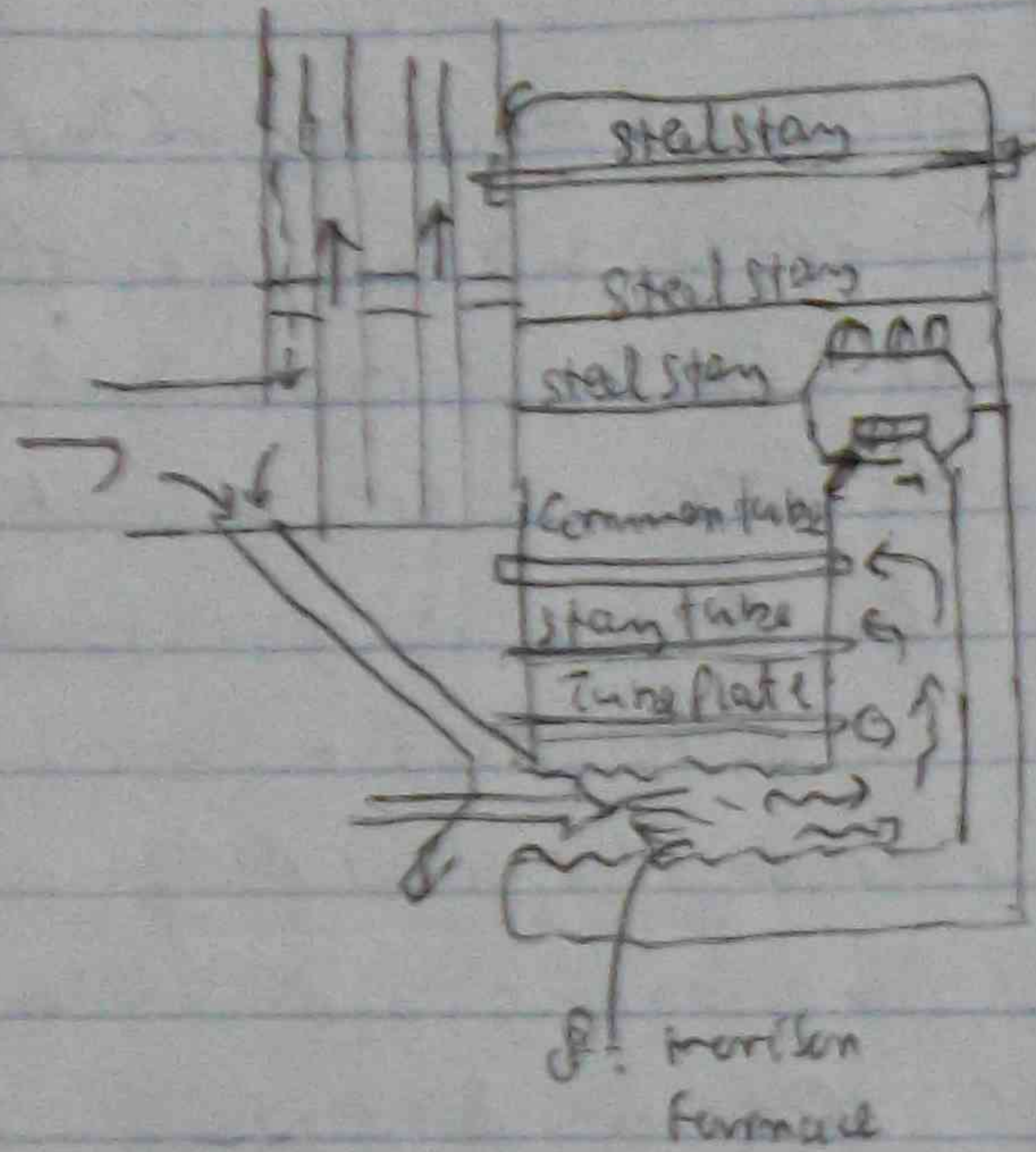


Diagram of the engine
 showing the combustion
 chamber and the piston
 and crankshaft mechanism.
 The diagram illustrates the
 main components of the
 engine, including the cylinder,
 piston, and crankshaft.

14/ Diagram of the engine

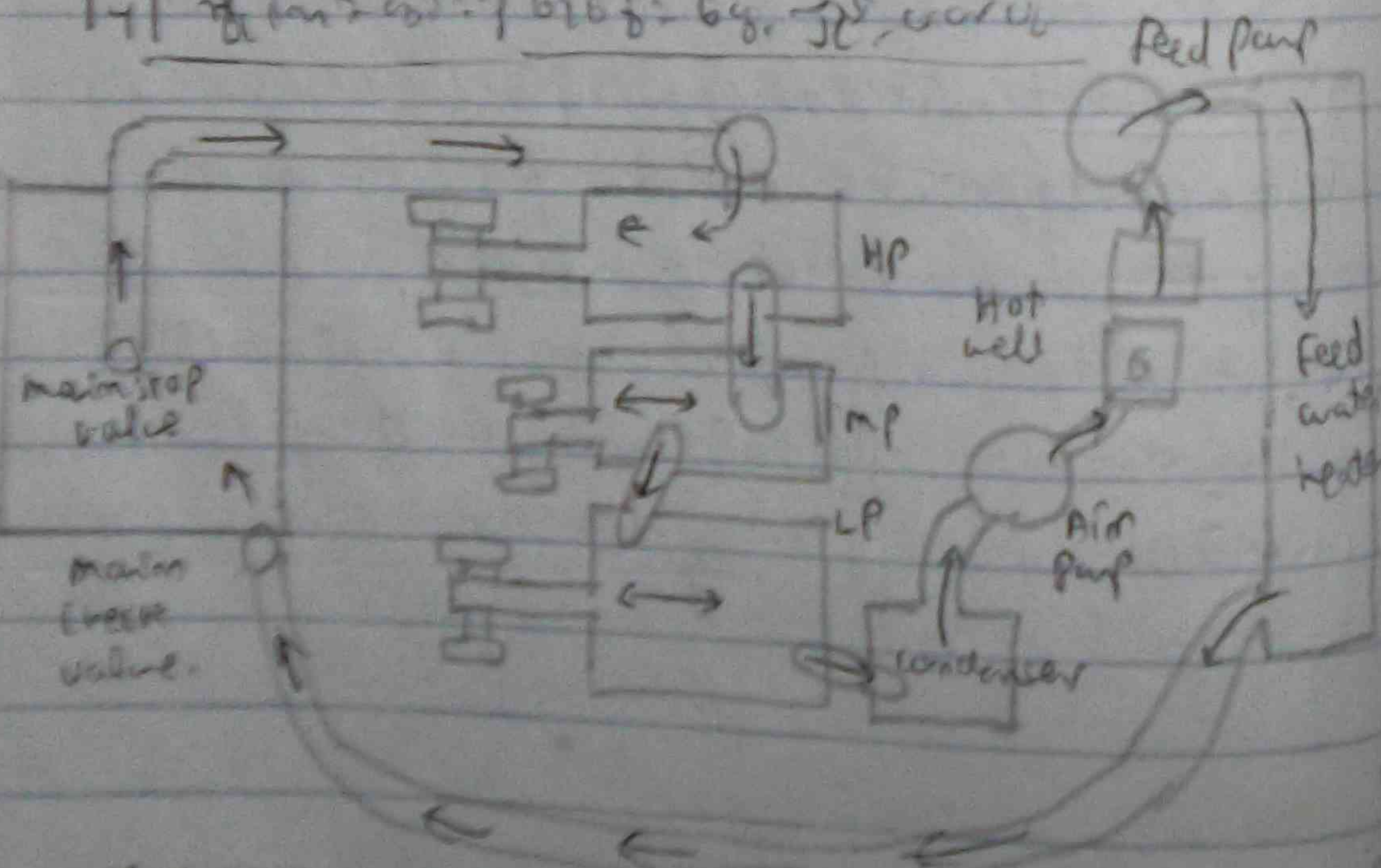
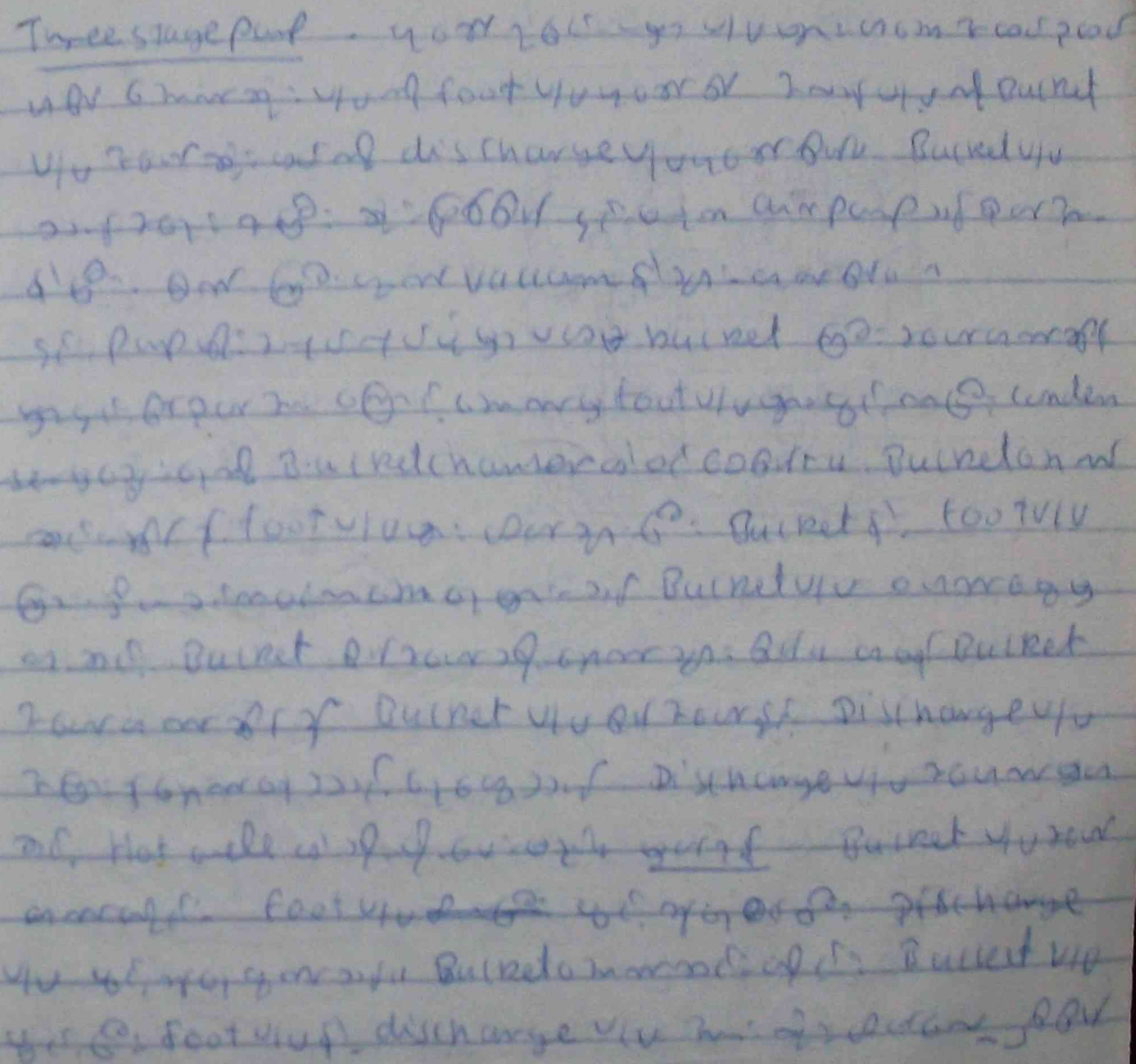


Diagram of the engine
 showing the main components
 and the flow of steam and
 water through the system.

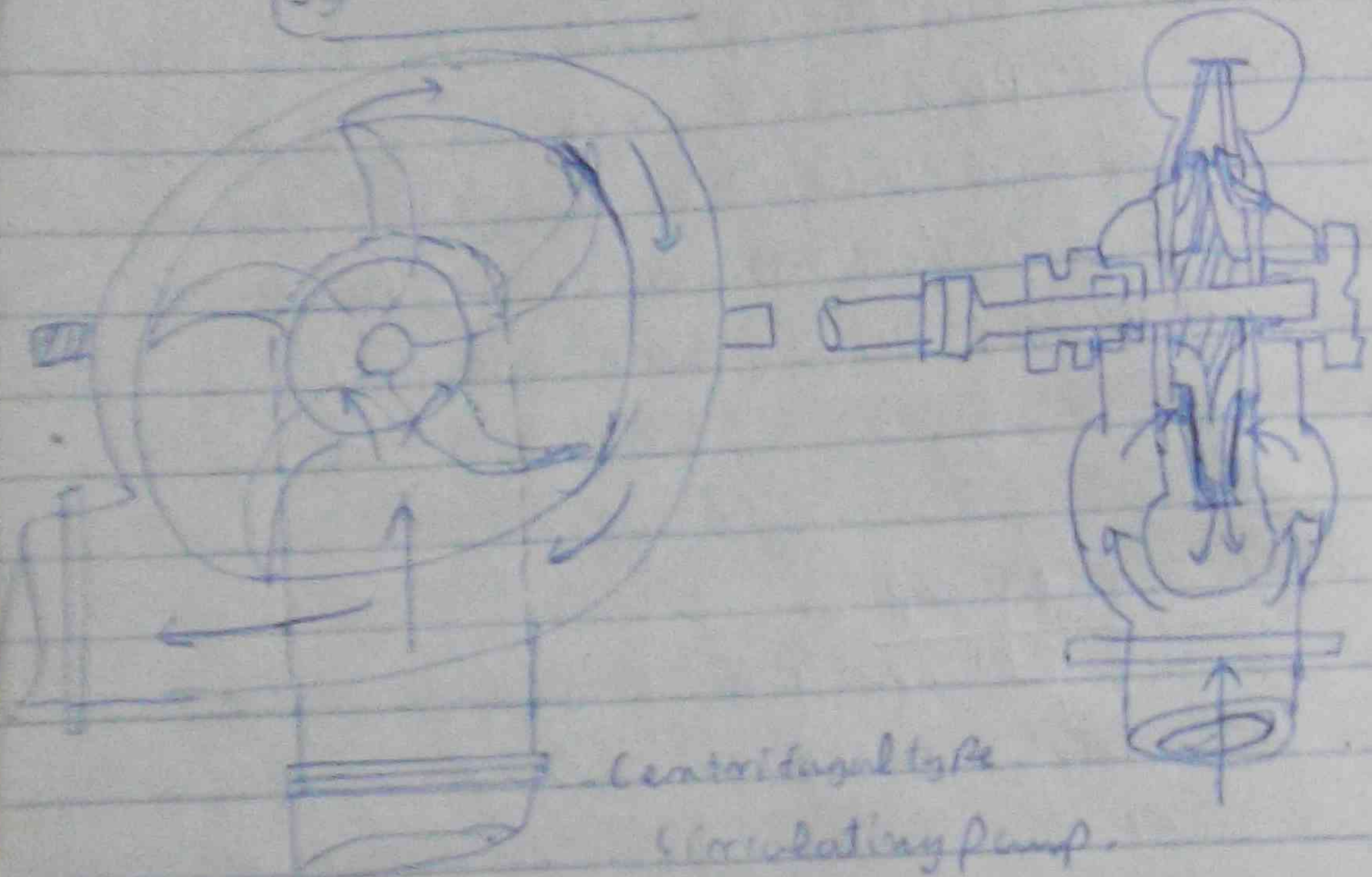
Diagram of the engine
 showing the main components
 and the flow of steam and
 water through the system.
 The diagram illustrates the
 main components of the
 engine, including the cylinder,
 piston, and crankshaft.
 The diagram shows the flow
 of steam and water through
 the system, including the
 condenser, air pump, hot
 well, and feed water heater.
 The diagram also shows the
 main stop valve and main
 check valve.

The first of these is the fact that the
 cylinder is not a perfect cylinder but
 is a cylinder with a slightly irregular
 surface. This is due to the fact that the
 cylinder is not perfectly round but has
 a slight irregularity in its shape. This
 irregularity is due to the fact that the
 cylinder is not perfectly round but has
 a slight irregularity in its shape. This
 irregularity is due to the fact that the
 cylinder is not perfectly round but has
 a slight irregularity in its shape.

[illegible][illegible][illegible]

[illegible]

11) Fan Engine



Centrifugal type
Circulating pump.

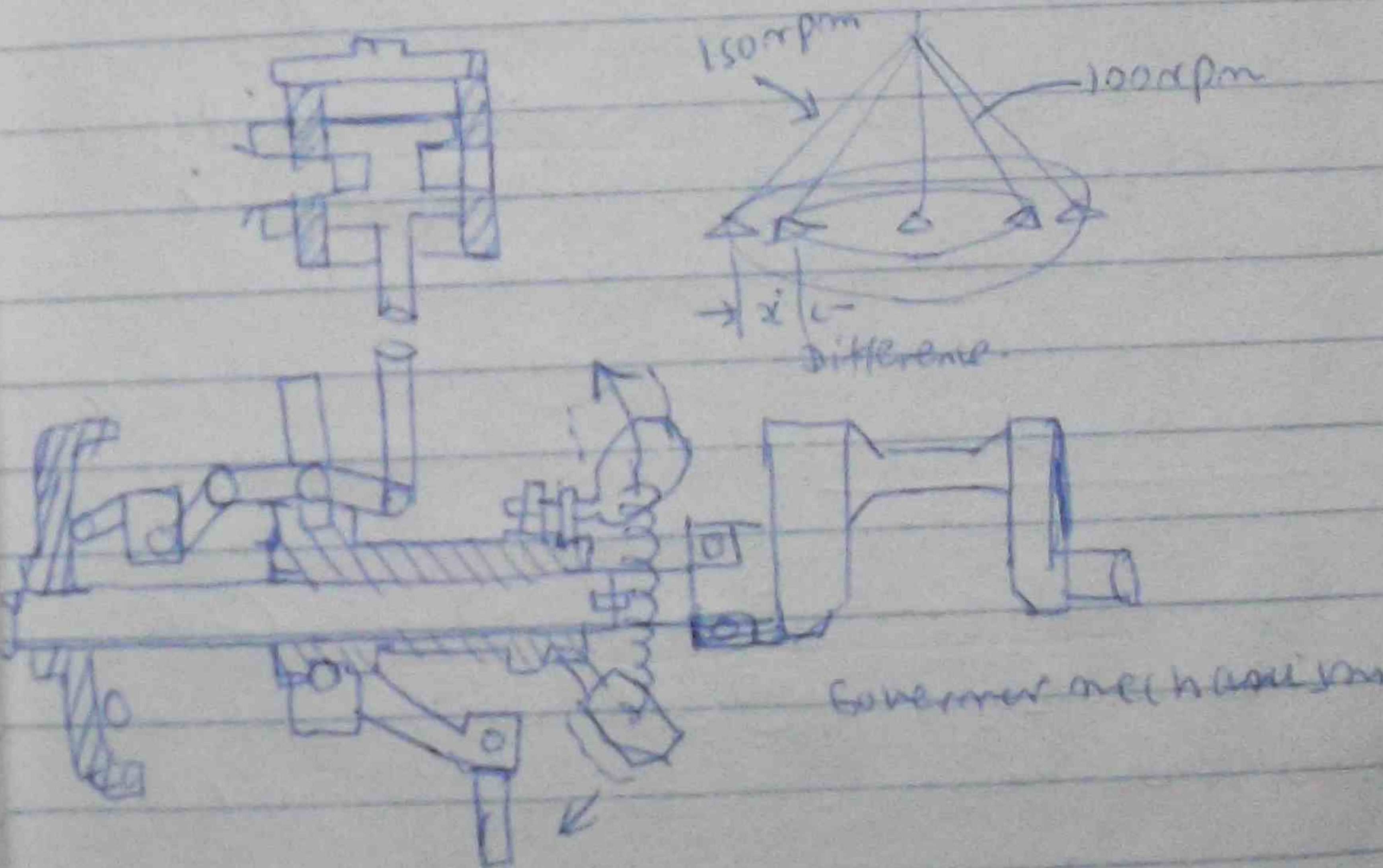
Water is drawn from the reservoir and forced into the pump. The pump is driven by the engine. The water is then forced into the radiator where it is cooled. The cooled water then flows back into the reservoir.

12) Circulating Engine

The water is drawn from the reservoir and forced into the pump. The pump is driven by the engine. The water is then forced into the radiator where it is cooled. The cooled water then flows back into the reservoir.

Water is drawn from the reservoir and forced into the pump. The pump is driven by the engine. The water is then forced into the radiator where it is cooled. The cooled water then flows back into the reservoir.

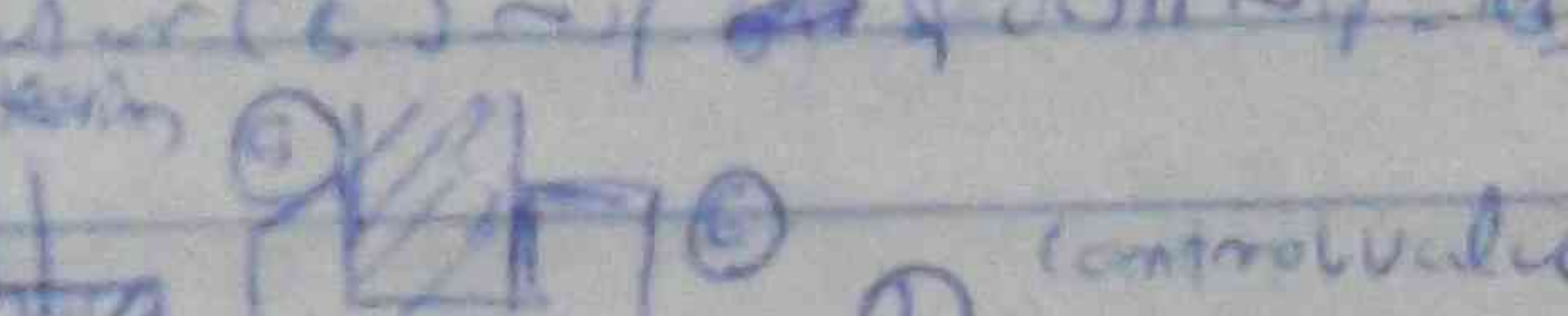
13) Lighting Engine



Governor mechanism

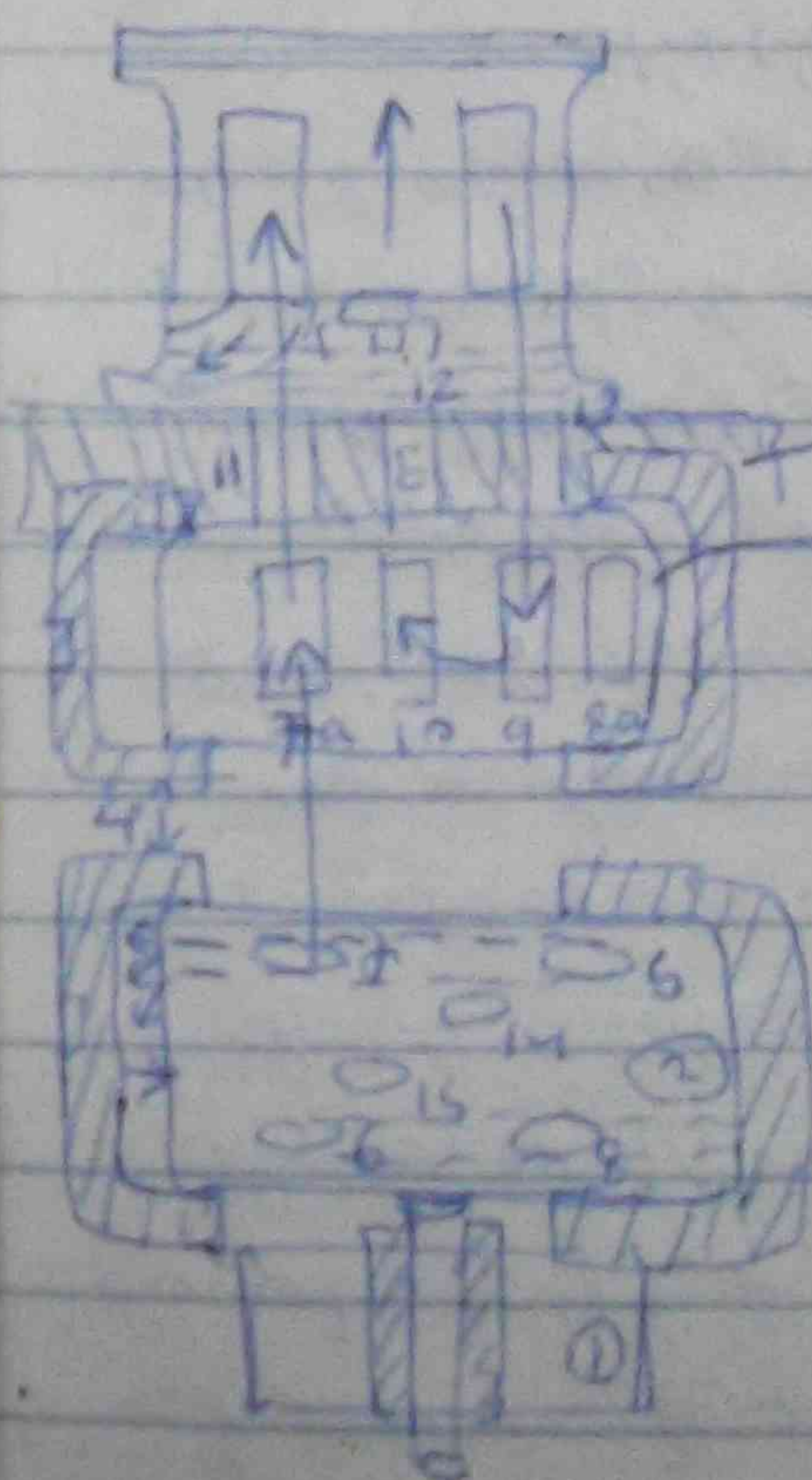
The water is drawn from the reservoir and forced into the pump. The pump is driven by the engine. The water is then forced into the radiator where it is cooled. The cooled water then flows back into the reservoir.

(10) steering Engine -



1. $\frac{1}{2}$ of the total weight of the sample is made up of the following components:

②② small value

[illegible][illegible]

The first of these is the fact that the
 piston is not at the bottom of the
 cylinder when the valve is open. This
 is due to the fact that the piston
 is not at the bottom of the cylinder
 when the valve is open. This is due
 to the fact that the piston is not
 at the bottom of the cylinder when
 the valve is open. This is due to
 the fact that the piston is not at
 the bottom of the cylinder when the
 valve is open. This is due to the
 fact that the piston is not at the
 bottom of the cylinder when the valve
 is open. This is due to the fact that
 the piston is not at the bottom of
 the cylinder when the valve is open.

[illegible]

A hand-drawn schematic diagram of a mechanical assembly, likely a pump or engine component, with numbered parts 1 through 21. The diagram is drawn on lined paper. The assembly consists of a central vertical shaft (18) passing through a housing. At the top, there is a cover (1) with a central opening (4) and a side opening (5). A piston (11) is connected to the shaft via a connecting rod (12). The piston is shown in two positions, with arrows indicating its movement. The housing (3) has a central cavity (4) and a side cavity (5). The bottom of the housing is connected to a base (21) via a flange (19). A vertical rod (20) is attached to the side of the housing. The diagram is labeled with numbers 1 through 21, corresponding to the numbered parts in the list.

My Teacher

System control Pillen

1. The first part of the paper is a general introduction to the subject of the paper. It discusses the importance of the subject and the need for a systematic approach to its study.

Crosshead pitman rod mechanism: for converting
rotary motion into reciprocating motion

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