Design and Fabrication of a Special Purpose Machine for Eccentric Turning

Project Report 1991-92

Submitted by

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in partial fulfilment of the requirements for the
Award of the Degree of Bachelor of Engineering
in Mechanical Engineering
of Bharathiar University

Department of Mechanical Engineering

Kumaraguru College of Technology

Coimbatore - 641 006

Department of Mechanical Engineering
Kumaraguru College of Technology
Coimbatore-641 006

Certificate

This is to Certify that the report entitled

Design and Fabrication of a Special Purpose Machine for Eccentric Turning

has been Submitted by

Mr. ....

in partial fulfilment for the award of Bachelor of Engineering in the Mechanical Engineering branch of the Bharathiar University, Coimbatore-641 046 during the academic year 1991-92.

....
Guide

....
Head of the Department

Certified that the candidate was Examined by us in the Project Work Viva - Voce Examination held on .... and the University Register Number was ....

....
Internal Examiner

....
External Examiner

PREMIER INSTRUMENTS & CONTROLS LIMITED

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PIC/HRD/CER/ 28 Mar 1992

CERTIFICATE

This is to certify that Mr F Ansarul.Huq student of Kumaraguru College of Technology did his Project Work "Special Purpose machine for Eccentric turning" at Premier Instruments and Controls Ltd between 18.8.1991 and 28.2.1992.

During this period he was attached to the Machine Tools Division. His attendance and conduct were good.

For Premier Instruments & Controls Ltd.,

M. Lakshmanan
Executive - H R D

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SYNOPSIS

The primary aim of this project is to design and fabricate a special purpose machine to machine profiled shape in the control shaft of the oil pumps used in vehicles like TVS Suzuki, Kawasaki Bajaj.

Suitable fixtures are used to hold the work piece between the centres of the lathe, the hydraulic tail stock arrangement ensures the proper clamping of the work piece quickly, thus reducing the loading time.

The master carrier unit is mounted on the rear side of the lathe body, consists of cam shaft mounted parallel to the axis of the lathe. Cams with profile surfaces to the copied on the work piece are also mounted on one end of the shaft. The power is transmitted to the cam shaft from the head stock by means of chain and sprocket arrangement without any speed reduction.

A hydraulic copying attachment with a milling head is mounted on the rear side of the lathe. The attachement is provided with swivel base to fix at a suitable angle depending upon the profile to be copied.

The work piece is rotated considerably at a very low speed, the chain and sprocket arrangement transmit the power with maximum efficiency. Simultaneously the stylus of the copying attachment traces the profile of the cam which is copied in the work piece. The advantage of this special purpose machine over the other types is that the magnitude of the force acting upon the tracing stylus which controls the valve, is very small. Profile copied is of high accuracy and machining time is very lesss.

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1. PRODUCT PROFILE

1.1. INTRODUCTION :

The products are control shafts of the oil pump used in the TVS Suzuki and Bajaj vehicles. These oil pumps are also called as crank case injection pump, have a major role in the engine operation since the lubrication to the crank case and there by the crank shaft, bearings, pins, piston, cylinder bore are lubricated only by its means. If the pump fails to work properly it will cause major effects in starting, idling, running and if it fails to work permanently the engine will get seized and the entire function will go off.

1.2. WORKING PRINCIPLE :-

The working principle is as follows. There is a oil passage in the pump body itself connecting the oil tank and the engine crank case. The pressure of the oil is increased between the body and the plunger at once engine is started. The engine driven shaft gives power to a worm wheel which is engaged permanently with the worm on the plunger. As the helical slot on the plunger while rotating, intermittently supply the oil to the engine in higher pressure which has been obtained by the reduction in the area between the plunger and body, the delivery occurs when the slot controls the flow of oil to the engine according to the engine speed.

Its end is fitted with a slide which is having connection with the throttle cable and the shaft having cam shaped portions on it. During the throttle operation the slide actuates the control shaft, the cam inturn regulates the linear motion, ((ie) it will cause the plunger to move down and thus causes more delivery and after releasing the plunger will return back and normal delivery continues). Thus at higher speeds more oil delivery and at lower speeds at normal delivery has been obtained with the help of the control shaft.

CALIBERATION :

The oil pump caliberation is made to check whether the pump supplies the necessary amount of oil or not. The caliberation is made such that the pump should delivery about 1.5 ml at an engine speed of 2000 rpm and the oil pump at fully opened position for a time duration of 2 minutes. Normally one litre of oil will be consumed by the engine for 1500 kms of normal running condition.

2. CURRENT METHOD

2.1. ECCENTRIC TURNING :-

The component is now produced by eccentric turning using ordinary lathe. As the work piece is very small it cannot be directly fixed between the centres of the lathe. So the work piece is eccentrically located by using suitable fixtures. The work piece is located with required off centre such that the required profile shape could be obtained by turning operation. It is tedious to mark the cff centre for each and every work piece. So suitable fixtures are used for different work pieces. This fixtures are attached to Head stock and tails stock of the lathe. Now the component is fixed easily between the centres eccentrically as shown in figure 2.1. Then turning operation is done for a suitable length to get the profile shape. Then the flat surface is obtained by performing milling operation. This method has many disadvantages.

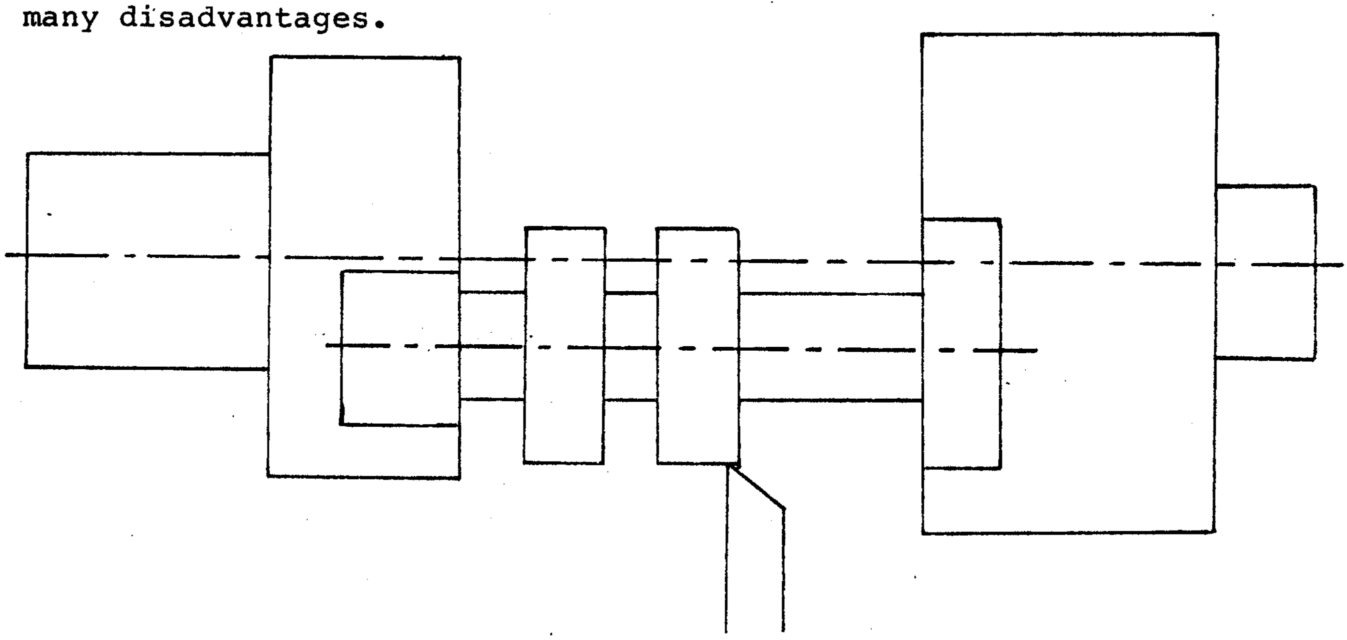


FIG 2.1

The disadvantages are

i. The operations are not done uniformly and effectively to attain better accuracy and finish.

ii. The handling operations, processing operations for the work pieces are done manually so more time is taken to finish the operation.

iii. In this method, single point tool is used, which lack in accuracy and takes more time. In the proposed method, milling cutter is used which complete the job quickly with better finish.

3. NEED TO GO FOR A SPECIAL PURPOSE MACHINE

(i). By using a S.P.M. the operations are done uniformly and effectively which attain better accuracy and finish in these work pieces.

(ii). By using a S.P.M. the operation time for these work pieces is less and there by a large number of pieces can be processed in shorter time.

(iii). Besides these, in a S.P.M. more the handling operations are done automatically. Thus it can be said that the raising of the production as a whole, is deeply indebted to the increasing degree of machine tool automaticity.

(iv). As the level of production is increased, the reduction in unit cost is achieved.

(v). There is less material wastage and rejections through automatic controls.

4. METHOD PROPOSED

4.1. INTRODUCTION :

In this method Hydro copying unit is extensively used in this lathe to cut profile on the work piece to the profile of the cam (or) the master piece. The tool box of the Hydro copying unit is removed and a milling head is attached to it. The work piece is fixed between the centres of the lathe. Cams which resembles the profile to be cut in the work pieces, are mounted on the arms which are fastened to the body of the lathe. The power from the spindle is transmitted to the cam shaft by means of chain and sprocket arrangement. There are four main units in this method they are

i. Power transmission unit

ii. Hydro copying unit

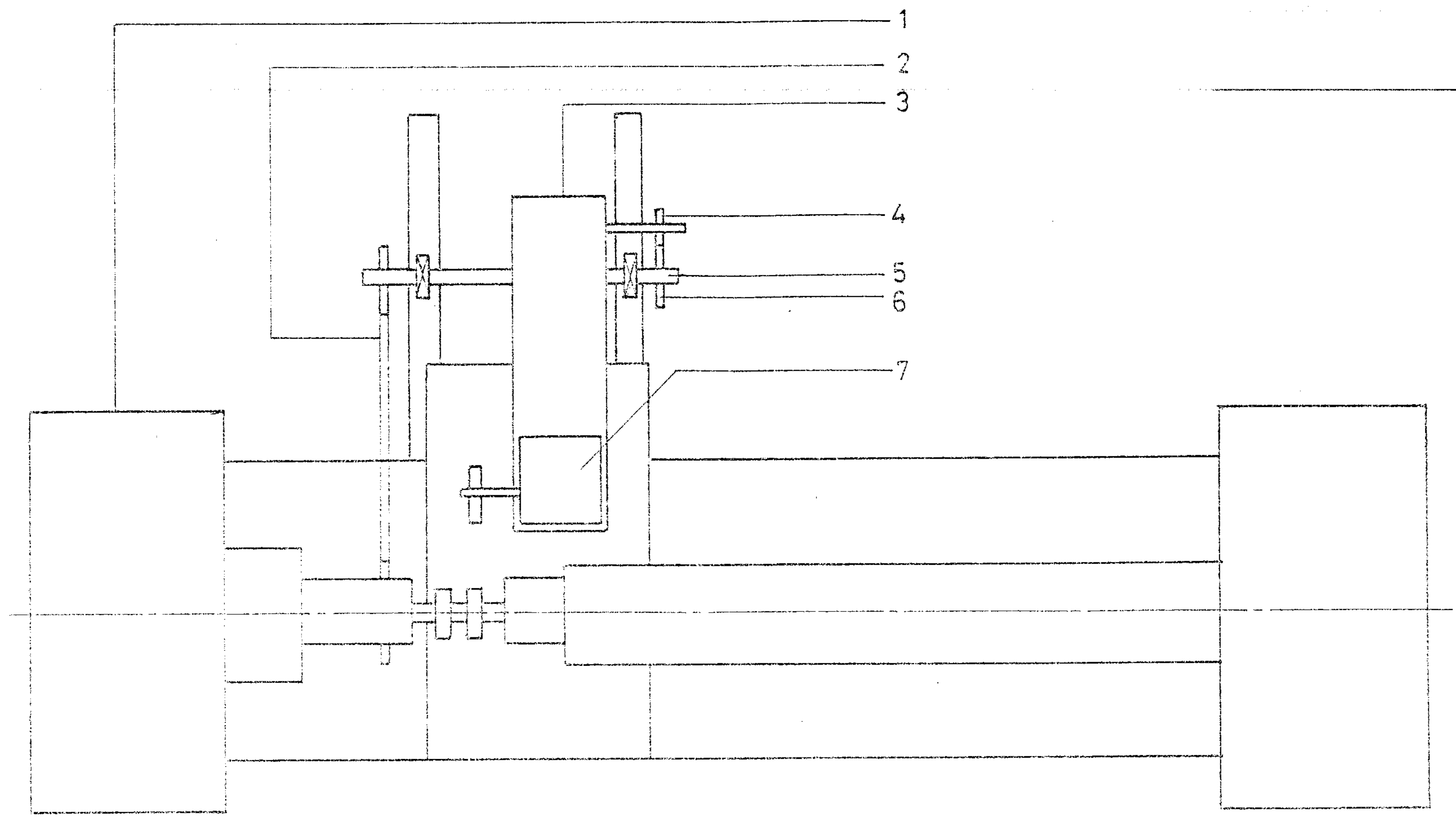
iii. Master carrying unit.

iv. Hydraulic tail stock unit.

4.2. DESCRIPTION AND FUNCTION :

4.2.1. POWER TRANSMISSION UNIT :-

The chain and sprocket arrangement is the power transmission unit. This arrangements transmission ratio is 1:1 ((ie) the cam shaft and the spindle of the lathe rotates at same speed). The work piece is rotated at a very low speed say (1 r.p.m).



1. HEAD STOCK
2. CHAIN DRIVE
3. HYDRAULIC COPYING UNIT
4. STYLUS
5. CAM SHAFT
6. CAM
7. MILLING HEAD
8. HYDRAULIC TAIL STOCK UNIT

4.2.2. HYDRO COPYING UNIT :-

The Hydro copying unit is the main unit in this S.P.M. The Hydro copying unit controls the depth of cut. The stylus of the hydro copying attachment is always kept in contact with the cam by spring pressure on the left hand end of the valve spool. The Milling head which is mounted on the hydro copying attachment is also moved accordingly. For one complete rotaion of the cam the job is completed and the required cam profile is cut on the job.

4.2.3. MASTER CARRYING UNIT :-

This unit consists of the cam shaft and the arms which are mounted to the lathe bed on the rear side. On these arms the shaft is mounted. The cams are mounted on one end of the shaft.

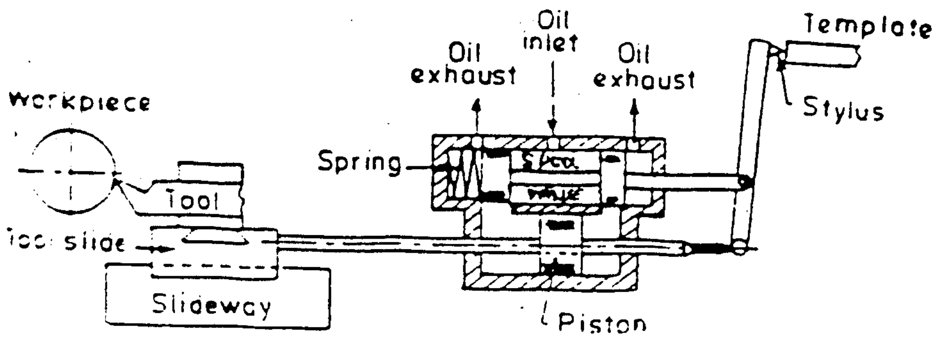
4.2.4. HYDRAULIC TAIL STOCK UNIT :-

The power pack provided in the hydro copying unit is used here. A cylinder is fixed to the extreme end of the tailstock and the cylinder is actuated by means of the pressurized oil in the power pack. The rod end is connected to the fixtures. As the extension stroke is performed, the work piece is clamped and during the retraction stroke the work piece is unclamped.

5. HYDRO COPYING ATTACHMENT

5.1. INTRODUCTION TO HYDRAULIC SYSTEMS :

Hydraulic copying systems can be used to produce the most complex forms. The contact pressure between the stylus and template is very low. hydraulic systems are basically servo motors which magnify a relatively small input power (or) signal for operating the mechanism . It is just like the closed loop control system is which output signal is continuously and automatically modified to suit variations in input signal.



Hydraulic Servo Copying System.

The Fig. No. 5.1 shows the operation of a simple hydraulic copying system.

As the saddle traverse along the bed, the stylus follows the template edge, always being kept in contact by contact pressure on the left hand end of the valve spool. If the stylus moves to the right, then spool will also move to the right, there by allowing the oil to the left of the piston to exhaust and allowing oil into the right of the piston and thus moving it to the left. In this way the tool slide and tool will move to the left reproducing the template shape.

For the design this special purpose machine the "Hydraulic Model 1020" is prefered.

MAKE : DITAMIR HYCON LIMITED

MODEL : HITRACE 1020

This hydraulic tracing unit is extensively used for copy turning. This unit along with a small milling head is used to perform milling opertion. The stylus follows the profile of a master cam which is mounted on the master carrying unit. The same shape is obtained in the work piece. The various parts of this unit is described below.

5.2. DESCRIPTION :-

HITRACE Tracer is suitable normally for rear mounting on Centre Lathe. This arrangement leaves the front tool post of the lathe for normal operations. The Tracer can also be mounted on the front with certain adaptions. The Tracer is provided with Swivel base to fix it at a suitable angle of copying for turning, boring and facing depending on the profile to be copied. Recommended angle of copying is 60 degree for turning and 45 degree for Boaring and Facing generally. But other angles can be tried out depending on the nature of copying and profile.

5.3. TRACING SLIDE UNIT :

Heat-Treated slide with square guideways has been adopted for higher rigidity and bearing area thereby reducing wear under continuos operation. The construction is simple for regular maintenance and occasional repair as may be necessary after long period of use can be easily made at customer's place. The unit is finely ground and finally scraped for smooth operation. For side wear a suitable Gib is provided. This can be adjusted as and when necessary. A stroke adjusting screw is provided to limit the retraction for reducing idle time and a must for boring.

5.4. CYLINDER UNIT :

The Cylinder of Aluminium Alloy with a ground cast iron sleeve which is finely boared and honed to a high surface finish and tolerance for leak proof operation. Piston is provided with metalic sealing rings for a very smooth operation without stick slip.

5.5. RETRACTION AND FINISH CUT UNIT :

This unit is mounted on cylinder and tracer valve. The function of this unit is to bring the tracing slide into operation or withdrawal. The finish cut is to achieve the final dimension desired on the work piece without disturbing either the Tool or Template position. This is provided both on standard and multicut turret model and particularly useful for achieving the desired dimensions on the work piece after the work piece has attained the final shape specially on multicut or roughing operation. This is a very distinct and desirable advantage reducing operational time. The handle provided on this unit is capable of moving up and down for approach or withdrawn of the tracer and right & left for rough and finish cut operation.

5.6. TURRET UNIT :

The Tracer is provided with a six-station-turret to afford multicut by tracer particularly when material removal is high. Six turret screw are provided which can be individually adjusted to suit a particular job. A push Rod Bracket with an adjustable push Rod negotiates each turret screw. Length of projection of turret screw determines the extent of approach of tracing slide or the tool thereby controlling the depth of cut or successive depth of cuts. A bias link is operated by the turret through extension Rod to bring the tracer valve in neutral position thus arresting the motion of tracing slide towards the work piece. This particular feature keeps tracer always sensitive at neutral position and so reduces error lag. On every retraction turret is automatically turns to its next position by a link Cam fitted in Turret Housing.

5.7. TRACER VALVE UNIT :

This Valve is fitted on the Cylinder. In addition to Tracer valve this unit further incorporates design feature which enables the amount of finish-cut to be taken. For this a knob is provided at the end of valve Housing. Clockwise rotation reduces the amount of finish-cut while anticlockwise rotation increases it. No graduation is provided to determine the amount of Tool advancement because of various angle of copying. It is recommended that the amount of tool advancement be actually checked by means of a dial guage.

5.8. MASTER CARRIER :

This Unit is normally fixed on the bed of the Lathe on the rear side. Two Centre carriers for holding the round Master between the centres are provided. Axial adjustment in one, transverse adjustment on both centres are provided. These movements are for adjusting for aligning the Master axis parallel to Lathe axis. The Rail with the Centre Carriers can be moved as a single unit along its length on the bases provided and clamped at desired position.

5.9. POWER PACK UNIT :

This Unit consists of Gear Pump, Suction Filter, High Pressure Filter, Guage Isolator, Relief Valve, Coupling and suitable connection for Houses and air & oil filters. Oil is filled through oil filter until desired level is reached. An oil level indicator is provided for this. It is important that oil should be filled to desired level so that no cavitation should take place or air being drawn into the system. It is also important that the preseure is maintained at 14/16 cm^2 by adjusting the Relief Valve, if necessary.

5.10. GEAR PUMP UNIT :

Normally there should not be any requirement for maintenance. Adequate bearing load capacity is provided to take care of load due to hydraulic pressure of the pump. Only precaution that is required is that Suction Filter must not be clogged for imporper suction leading to cavitation. For this reason also the Tank must be filled at the desired level which must be maintained to prevent air being drawn into system.

5.11. MILLING HEAD UNIT :-

The Milling Head Unit is fixed on the Tracing slide and can be swivelled to a position at 90 degree to the lathe axis to provide the depth of cut. The milling head units specification are.

DC	: MOTOR	TYPE	: SHUNT
MODEL	: FLDTIL	CURRENT	: 3.5 AMPS
VOLTS	: 180 A/2001	OUTPUT	: 0.5 H.P
R.P.M	: 4000		

6. DESIGN

6.1. DESIGN OF CAM SHAFT :

Power to be transmitted $P = 1.$ H.P

Speed of the shaft $N = 1$ r.p.m

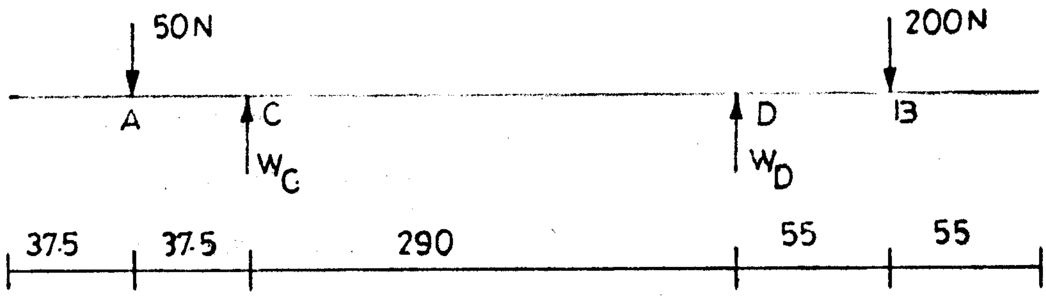
Shear stress of the shaft material $fs = 900\ N/mm^2$

Bending stress of the material $fb = 275\ N/mm^2$

d = diameter of the shaft

T = torque transmitted by the shaft

The loading diagram on the shaft



we know

$$W_c + W_D = 250$$

Now taking moment about c

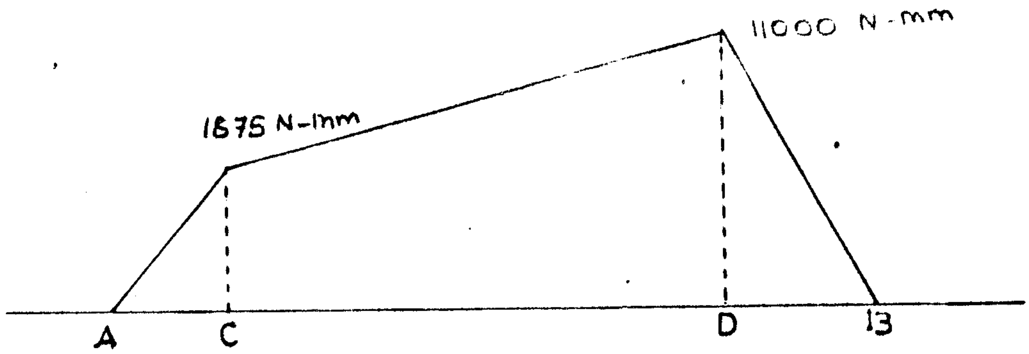
$$-(37.5 \times 50) = W_D \times 290 - (200 \times 345)$$

$$W_D = 231.46\ N$$

Therefor $W_c = 250 - 231.46$

$$W_c = 18.53\ N$$

Bending moment diagram



From the Bending moment diagram it is clear that the maximum bending moment is at D.

Bending moment at D = 11000 N-mm

we know

$$0.09817 \times fb \times d^3 = \text{Bending Moment}$$

$$0.09817 \times 275 \times d^3 = 11000 \text{ N-mm}$$

$$d = 7.43 \text{ mm}$$

Now considering the twisting moment

$$p = \frac{2 \times 3.14 \times N \times T}{60 \times 1000} \text{ kw}$$

$$T = \frac{1.3595 \times 60 \times 1000}{2 \times 3.147 \times 1.2}$$

$$T = 10.81 \times 10^3 \text{ N-m}$$

$$T = 10.81 \times 10^6 \text{ N-mm}$$

we know

$$\frac{3.142}{16} \times fs \times d^3 = T$$

$$\frac{3.142}{16} \times 900 \times d^{3} = 10.81 \times 10^{6} \text{ N-mm}$$

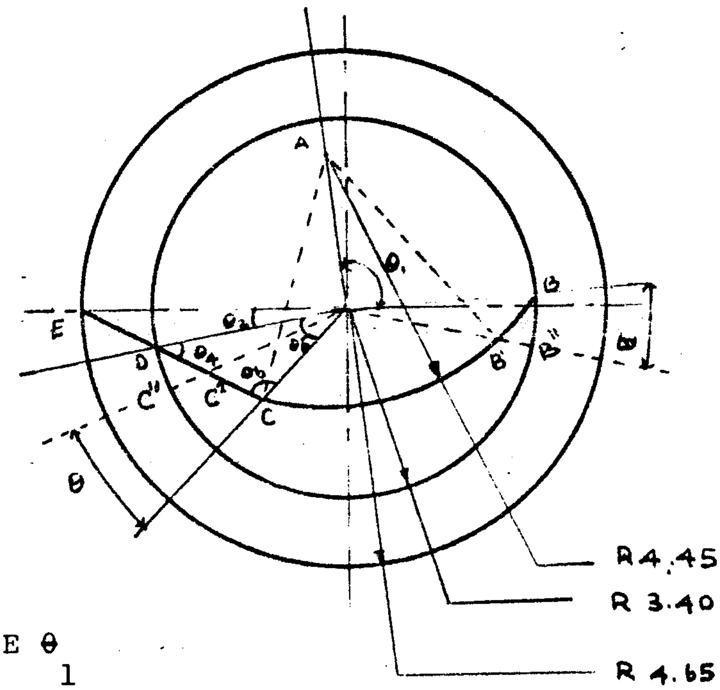
$$d = 39.40 \text{ mm}$$

In considering the twisting moment, the shaft diametter should be 39.40 mm. So for the safe conditions the diameter of the shaft is designed for the maximum diameter.

Therefore

Diameter of the shaft d = 40 mm

6.2. DESIGN OF CAM FOR COMPONENT I :



1. TO FIND ANGLE θ_1

From the triangle oAB

$$\frac{oA}{\sin B} = \frac{oB}{\sin A} = \frac{AB}{\sin \theta_1}$$

$$\frac{AB}{\sin\theta_1} = \frac{oB}{\sin A} \quad \text{(equating)}$$

we get

$$\sin A = \frac{3.40}{4.45} \sin\theta_1$$

$$\sin B = \frac{2.75}{4.45} \sin\theta_1$$

$$B = \sin^{-1} \frac{2.75}{4.45} \sin\theta_1$$

$$A = 180 - (B + \theta_1)$$

$$oB = \frac{4.45}{\sin\theta_1} \sin A$$

$$oB = \frac{4.45}{\sin\theta_1} \sin\{\sin^{-1}(\{\frac{2.75}{4.45}\} \sin\theta_1\} + \theta_1$$

we know

$$oB = 3.40$$

$$\therefore \theta_1 = 92$$

2. TO FIND θ_2, θ_3, θ_4, θ_5 AND θ_6

From triangle OED

$$\frac{3.40}{\sin 26} = \frac{4.658}{\sin\theta_3} = \frac{ED}{\sin\theta_2} \quad \text{(equating)}$$

$$\theta_3 = \frac{4.658 \times \text{Sin } 26}{3.40}$$

$$\theta_3 = 36'54' \text{ (or) } 143'5'$$

$$\theta_3 = 143'$$

$$\therefore \theta_2 = 180 - (143 + 26)$$

$$\theta_2 = 11'$$

From Geometry of fig

$$\therefore \theta_4 = 37'$$

From Triangle ODC

$$\frac{3.40}{\text{Sin } \theta_6} = \frac{2.1}{\text{Sin } \theta_5} = \frac{OC}{\text{Sin } 37}$$

$$\frac{3.40}{\text{Sin } \theta_6} = \frac{2.1}{\text{Sin } (180 - 37 - \theta_6)} = \frac{OC}{\text{Sin } 37} \quad \text{(equating)}$$

$$3.40 \text{ Sin } (143 - \theta_6) = 2.1 \text{ Sin } \theta_6$$

$$2.04617 \text{ Cos } \theta_6 + 2.71536 \text{ Sin } \theta_6 = 2.1 \text{ Sin } \theta_6$$

$$\theta_6 = 106'45' \quad \text{or} \quad 36'15'$$

$$\therefore \theta_6 = 36'15'$$

3. EQUATION FOR DEPTH OF CUT FROM B TO C :

$$B'B'' = 3.40 - \frac{4.45}{\text{Sin } (\theta_1 + \theta)} \text{ Sin } \{(\text{Sin}^{-1} \frac{2.75}{4.45} (\text{Sin } (\theta_1 + \theta)) + \theta_1 + \theta\}$$

where

θ_1 = 92'

θ = degree rise

Angle θ	Depth of cut
0	0
88	1.72
136'45'	1.272680

4. EQUATION FOR DEPTH OF CUT FROM C-D :

From triangle OCC

$$\frac{OC}{\sin\theta_4} = \frac{3.4}{\sin\theta_6} = \frac{2.1}{\sin\theta_5}$$

From triangle OCC^1

$$\frac{OC}{\sin\theta_4^1} = \frac{CC^1}{\sin\theta} = \frac{OC^1}{\sin\theta_6} \quad \{OC = 3.4 - 1.272\}$$

$$\frac{OC}{\sin\theta_4^1} = \frac{OC^1}{\sin(106'45')}$$

$$\{\theta_4^1 = 180 - 0 - \theta_6\}$$

$$OC^1 = \frac{CC}{\sin\theta_{41}} \sin(106'45')$$

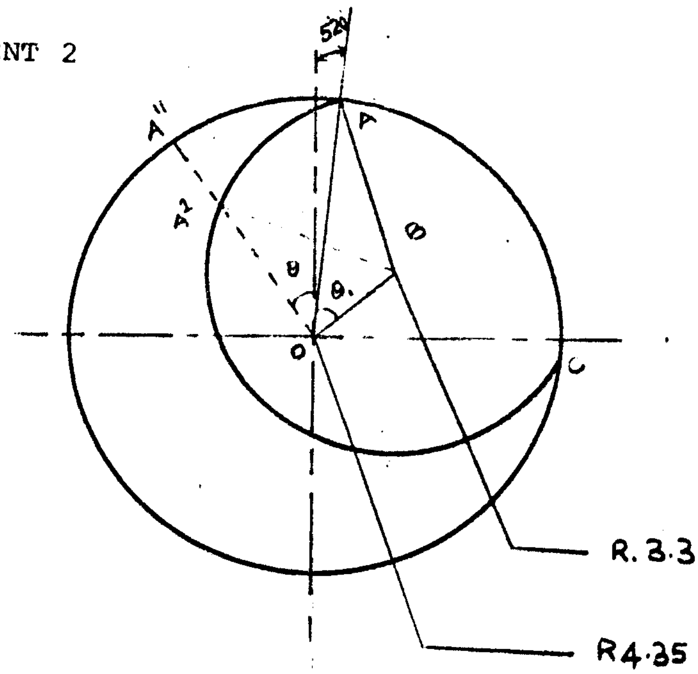
Depth of cut

$$C^1C'' = 3.40 - \frac{2.127319}{\sin(73'15' - \theta)} \sin(106'4)$$

where θ rise in degree

Angle	Depth of cut
0	1.272681
20	0.85765
36'15'	0.0015

6.3. FOR COMPONENT 2



1. TO FIND θ_1 :

From triangle AB

Area = S(S-A)(S-B)(S-C)

A = 4.35 B = 1.85 C = 3.3

S = A + B + C/2

. . Area = 2.8265 mm^2

we know

Area = AB Sins θ_1 /2

$$\theta_1 = \frac{2 \times Area}{A \times B}$$

2. TO FIND THE DEPTH OF CUT FROM A TO C :

$$\frac{A^1 B}{\text{Sin } (\theta + 44'37)} = \frac{CB}{\text{Sin } A^1} = \frac{OA^1}{\text{Sin } B}$$

$$\frac{3.3}{\text{Sin } (\theta + 44'37)} = \frac{1.85}{\text{Sin } A^1}$$

$$A^1 = \text{Sin}^{-1} \{ \frac{1.85}{3.3} \times \text{Sin } (\theta + 45'20) \}$$

$$\therefore B = \{180 - (A^1 \ \theta + 44'37')\}$$

$$\therefore OA^1 = \frac{3.3}{\text{Sin } (\theta + 44'37')} \{\text{Sin } (A^1 \ \theta + 44'37')\}$$

By subsititute the value of A^1 we get

$$OA^1 = \frac{3.3}{\text{Sin } (\theta + 44'37')} \{\text{Sin } \{\text{Sin}^{-1} (\frac{1.85}{3.3} \times \text{Sin } (\theta + 44'20')\} + \theta + 44'37'\}$$

$\therefore$ Depth of cut $A^1A'' = 4.35 - OA^1$

Angle	Depth of cut
0	0
20	0.711535
135	2.90

6.4. CYLINDER :-

Capacity of the cylinder = 5 kgf/cm^2

$D = 60mm$

$d = 30\ mm$

$L = 120\ mm$

$F = P \times A$

$$F = \frac{3.142}{4} D^2 \times 5$$

$$F = \frac{3.142}{4} (6.0)^2 \times 5$$

$F = 141.37$ Kgt

The clamping force needed to clamp the work piece is very much less than the force exerted by the piston. So the cylinder with above dimensions is chosen.

6.5. DESIGN OF CHAIN DRIVE :

Transmission ratio	i	= 1
Power to be transmitted		= 1.3596 k.w.
Speed	N	= 1.2 r.p.m
Centre distance between the sprockets		= 600 mm
Working hours		= 20 hrs/day

i). Transmission ratio i $= \frac{N_1}{N_2} = \frac{Z_2}{Z_1}$, from DDB 7.74

where

Z_1 - Number of teeth in sprocket pinion

Z_2 - Number of teeth in sprocket wheel

N_2 - Speed of sprocket wheel

N_1 - Speed of sprocket pinion

$$\frac{N_1}{N_2} = \frac{Z_2}{Z_1} \quad 1$$

ii). Design H.P. = Rated H.P x K_s , from DDB 7.74

where

K_s (service factor) = K_1 K_2 K_3 K_4 K_5 K_6

K_1 (Load factor) = 1 (constant load)

K_2 (factor of distance regulation) = 1.25 (fixed centre)

K_3 (factore for centre distance of sprockets) = 1.0 (assuemed)

K_4 (factore for the position of the sprockets) = 1.0 (inclined below 60')

K_5 (lubrication factor = 1.5 (periodic)

K_6 (Rating factor) = 1.50 (continuous)

from DDB, 7.76 - 7.77

Therefore K_s = 1 x 1.25 x 1.0 x 1.5 x 1.50 x 1.0

K_s = 2.8125

Design H.P. = Rated H.P. x K_s

= 1 x 2.8125

Design H.P. = 2.8125

iii). Number of teeth on sprocket pinion

Z_1 = 30 (Based on i) from DDB 7.74

Z_2 = 1 x 30

Z_2 = 30

iv). Pitch length, P = 9.525 (on the basis of number of teeth on pinion)

From DDB for P = 9.525, the chain is selected

DDB Page No.7.71

The chain number is 06 B - 1 R - 957

The details of the chain are

Pitch length,	P	= 9.525
Roller diameter	Dr	= 6.35 mm
Width between inner plate	W	= 5.90 mm
Pin body diameter	Dp	= 3.28 mm
Plate depth maximum	G	= 8.15 mm
Overall over joint A_1, A_2, A_3		= 16.40 mm
Bearing area		= 0.28 cm^2
Weight per meter		= 0.41 kgf
Braking load mim		= 910 kgf

v). Minimum centre distance

DDB Page No. 7.74

$$600 = a^1 + (30 \text{ to } 50)$$

$$600 = a_1 + 50$$

$$a^1 = \frac{da_1 + da_2}{2} \qquad (1)$$

where

da_1 - tip diameter of sprocket pinion

da_2 - tip diameter of sprocket wheel

$$da = \frac{P}{\tan \frac{180}{Z}} + 0.6\,P$$

we know

$a^1 = 550$ mm - (2)

Now equating (1) and (2) and substituting for da_1 and da_2

we get

$$a^1 = \frac{\left(\frac{P}{\tan \frac{180}{Z_1}} + 0.6\,P\right) + \left(\frac{P}{\tan \frac{180}{Z_2}} + 0.6\,P\right)}{2}$$

$$a^1 = \frac{\left(\frac{P}{\tan \frac{180}{30}} + 0.6\,P\right) + \left(\frac{P}{\tan \frac{180}{30}} + 0.6\,P\right)}{2}$$

$a^1 = P \times 10.114$

$550 = P \times 10.114$

$P = 54.38$ mm

The pitch can be selected up to 54.38 m. So the design is safe.

vi). Pitch Circle diameter

$$da_1 = \frac{P}{\tan \frac{180}{30}} + 0.6\,P$$

$$= \frac{9.525}{\tan 6} + 0.6 \times 9.525$$

$$= 96.339 \text{ mm}$$

$$da_2 = \frac{P}{\tan \frac{180}{30}} + 0.6\,P$$

$$= 96.33 \text{ mm}$$

For our requirements the diameter of the sprocket is selected as 120 mm.

we know

$$da_1 = \frac{P}{\tan \frac{180}{30}} + 0.6\,P$$

$$120 = \frac{9.525}{\tan \frac{180}{Z_1}} + 0.6 \times 9.525$$

$$Z_1 = 38 \text{ teeth}$$

$$Z_2 = 38 \text{ teeth } (\because Z_1 = Z_2)$$

vii). Velocity $$V = \frac{3.142 \times D_1 \quad N}{60 \times 1000}$$

$$= \frac{3.147 \times 120 \times 1.2}{60 \times 1000}$$

$$V_1 = 7.539 \times 10^{-3} \text{ m/sec}$$

Power transmitted cn the basis of allowable bearing stress.

$$N = \frac{Fb \times A \times V}{75 \; K_s} \text{ h.p} \quad \text{where}$$

Fb - bearing stras
A - bearing area
V - Velocity

$$N = \frac{3.5 \times 0.28 \times 7.539 \times 10^{-3}}{75 \times 2.875}$$

$$N = 3.447 \times 10^{-5} \text{ h.p}$$

Since $$N = \frac{Q.V}{75 \; n \; K_s}$$ from DDB 7.77

$$3.447 \times 10^{-5} = \frac{Q \times 7.53 \times 10^{-3}}{75 \times 7 \times 2.875}$$

$$Q = 6.91 \text{ kgf}$$

The load is only 6.36 kgf. The maximum braking load .is 910 kgf. So the design is safe.

Braking stress on the roller :

From DDB 7.77

$$F_b = \frac{\text{Load on the chain}}{\text{Dia of roller x roller width}}$$

$$= \frac{6.91}{6.35 \times 5.90}$$

$$= 0.18425 \text{ kgf/mm}^2$$

Since it is less than the permissible value given in the table the design is safe.

ix). Length of the chain $l_p = 2\,a_p + \frac{Z_1 + Z_2}{2} + \left\{\frac{\frac{Z_1 - Z_2}{2 \times 3.142}}{a_p}\right\}^2$

Where $a_p = \frac{a_o}{P}$

$$= \frac{600}{9.525}$$

$$a_p = 62.992 \text{ pitches}$$

$$l_p = 2 \times 62.992 + \frac{38 + 38}{2}$$

$$l_p = 163.984 \text{ pitches}$$

x). Correct centre distance

$$a = \left\{\frac{e + \sqrt{e^2 - 8\,m}}{4}\right\} P \text{ where}$$

$$e = lp - \frac{Z_1 + Z_2}{2}, \quad m = \left(\frac{Z_2 - Z_1}{2 \times 3.142}\right)^2$$

$$= 165.98 - \frac{38 + 38}{2}$$

$$e = 125.984 \text{ pitches}$$

Therefore $a = \left\{ 125.984 + \frac{(125.984)^2 - 8(o)}{4} \right\} 9.525$

Correct centre distance a = 599.99 mm

xi). Decrement in centre distance for a initial sag.

$$da = \frac{1}{2} \left\{ f - \left(\frac{Z_1 - Z_2}{2 \times 3.142 \times Qp}\right)^2 P \right.$$

where from DDB 7.78

$$f = 0.02\ a$$

$$da = \frac{1}{2} \{ 0.02 \times 599.99 - 0 \}$$

$$da = 6 \text{ mm}$$

Therefore

Decrement in centre distance for a initial sag da = 6 mm

Correct centre distance = a - da

= 599.99 - 6

= 594 mm

xii). Tooth Flank radius re_1 (minimum)

$$= 0.12\ Dr(Z + 2)$$

$$= 0.12 \times 6.35\ (38 + 2)$$

$$re_1 = 30.48\ mm$$

Tooth Flank radius re_2 (maximum)

$$= 0.008\ Dr\ (Z^2 + 180)$$

$$= 0.008 \times 6.35 (38^2 + 180)$$

$$= 82.49\ mm$$

xiii) Tooth width bf_1

$$= 0.93\ W$$

$$= 0.93 \times 5.\ 0$$

$$= 5.487\ mm$$

xiv). Minimum tooth radius r_x

$$= P$$

$$= 9.525\ mm$$

xv). Measuring pin diameter D_P

$$= D_R$$

$$= 6.35\ mm$$

SPECIFICATION OF THE DRIVE

Description	Dimension	Tolerance
1. Centre distance	594 mm	-
2. Type of chain	0 6 B - 1 R - 957	-
3. Number of strands	1	-
4. Pitch of the chain, P	9.525 mm	-
5. Roller diameter, D_R	6.35 mm	-
6. Width of roller, W	5.90 mm	-
7. Length of chain, lp	16 pitches	-
8. Initial sag	6 mm	-
9. Pitch circle diameter of sprocket wheels da_1, da_2	120 mm	h11
10. Tooth Flank radius re_1 (minimum)	30.48 mm	-
11. Tooth Flank radius re_1 (maximum)	82.49 mm	-
12. Tooth width bf_1	5.487 mm	h14
13. Minimum tooth radius r_x	9.525 mm	-
14. Measuring pin diameter D_p	6.35 mm	+ 0.1 - 0.0

6.6. SELECTION OF BEARING :

1. Bearings for the shaft used

Diameter of shaft d = 25 mm

The bearing is selected from standard series 60.

DDB 4.12

Bearing number (SKF) = 6005

Diameter of bearing held, d = 25 mm

Outer diameter of top race, D = 47 mm

Thickness, B = 12 mm

Abutment diameter for bottom race = 28 mm

Abutment diameter for top race = 44 mm

Static load carrying capacity = 520 kgf

Dynamic load carrying capacity = 780 kgf

2. Bearing for the work holding fixture

Diameter of shaft d = 9.8 mm

The bearing is selected from standard series 60.

DDB 4.12

Bearing number (SKF) = 6000

Diameter of bearing hole, d = 10 mm

Outer diameter of top race, D = 26 mm

Thickness, B = 8 mm

Abutment diameter for bottom race D_1 = 12 mm

Abutment diameter for top race D_2 = 24 mm

Static load carrying capacity = 190 kgf

Dynamic load carrying capacity = 360 kgf

6.7. SELECTION OF MILLING CUTTER :

Side and face milling is selected since it is designed to produce a specific shape of the work piece. It may be noted that it has teeth on the circumferential surface and as well as on both the sides.

For our requirement the cutter dia is selected as 110 mm

Other details (for tough materials and Doun milling)

DDB 12.30

Number of teeth = 22

Primary clearance angle = 8'

Positive radial angle = 14'

Helix angle = 12'

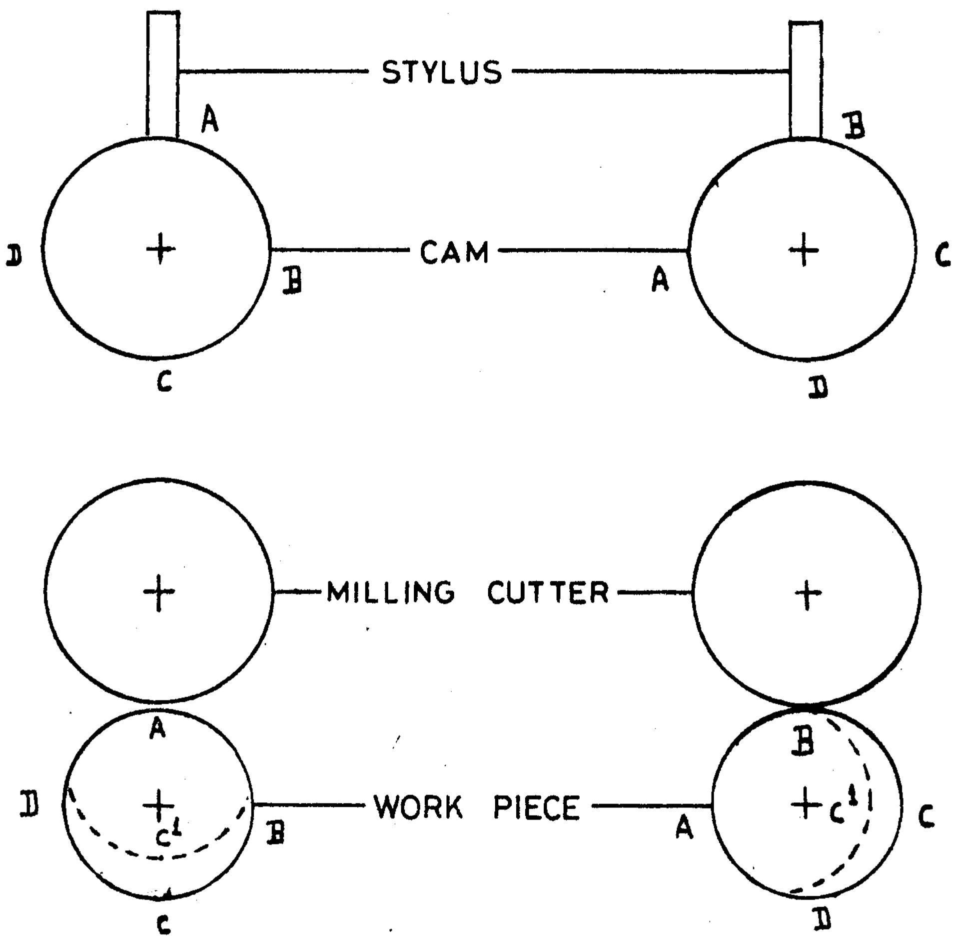
Cutter material = plain H.S.S

6.8. LATHE SPECIFICATIONS :-

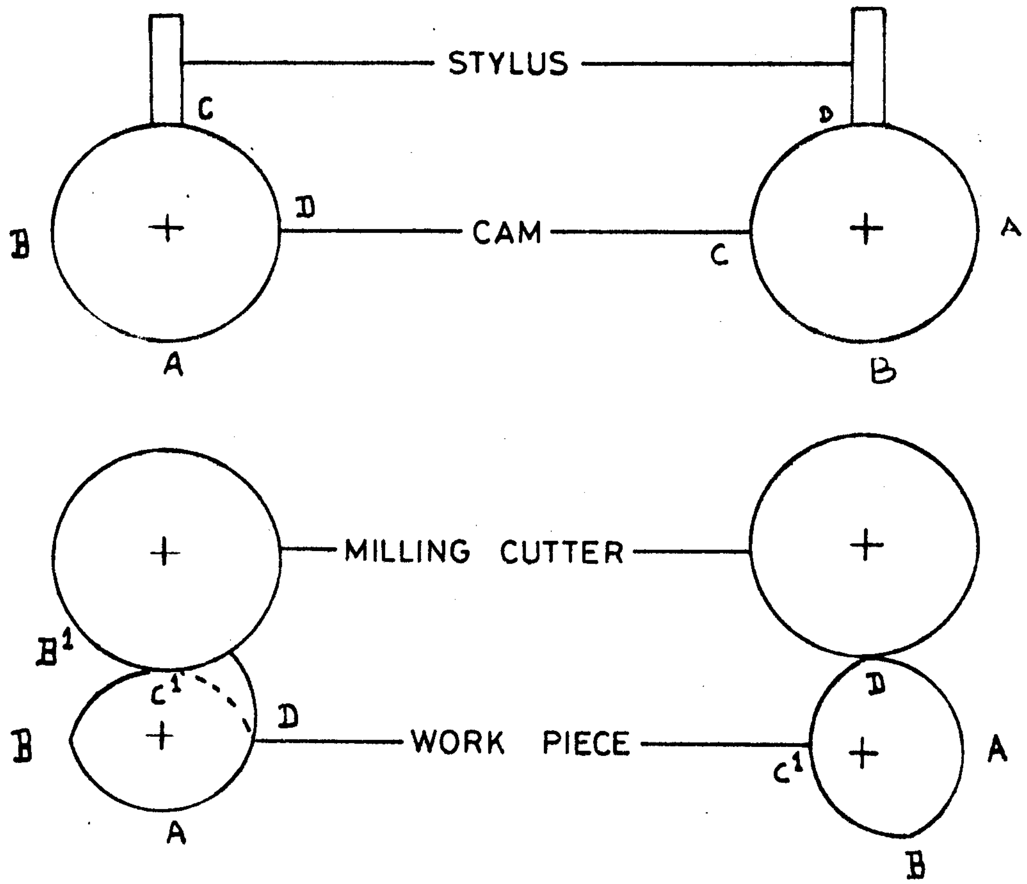
1.	Height of centres	: 1000 mm
2.	Type bed	: Gap type
3.	Distance between the centres	: 800 mm
4.	Width of the bed	: 270 mm
5.	Main drive motor power	: 1 H.P
6.	Range of speed	: 1 to 1200 rpm

7. WORKING CYCLE

For one complete rotation of the cam, the work piece is machined and the product is finished. So the working cycle can be represented by means of block diagrams.



As the styluis is at the point A on the cam, there is no machining in the work piece. The cam rotates. When the poinmt B touches the stylus, the milling cutter is forwarded and the machining takes place. A-B is the ideal cycle there is no machining during this cycle.



As the point C in the cam touches the stylus the machining is done in the work piece. The milling cutter machines the profile, which the stylus follows on the cam.

The material removed in $B C^{1} B^{1}$ as shown in the fig. Thus the machining is continued till the point D is reached. The portion D-A is also ideal cycle in which machining does not takes place. After completion of the one full rotation of the cam the job is produced. Again another wor piece is fitted and the same procedure is continued. Thus the required job is done on this S.P.M.

8. COST ANALYSIS

8.1. MATERIAL COST :

COMPONENTS	QTY	COST/UNIT	TOTAL COST
1. Hydro copying attachment			
Model :1020			
Make :PITAMBR HYCON LTD.	1	54,000	54,000.00
2. Lathe Medium duty	1	30,000	30,000.00
3. Milling head	1	2,500	2,500.00
4. Cylinder	1	300	300.00
5. Mechanically operated			
Two way valve	1	350	350.00
6. Milling cutter	1	750	750.00
			87,900.00

8.2. MACHINING COST

S.No.	Partname	Qty	Mat	Drg size	Wt kg	Cost of mat. Rs.	M/c opn.	M/c time	M/c Cost/ hr.	Total Cost
1.	Shaft	1	C55 Cr 75	40 x 395	3.5	105	Turning	60	20.00	125.00
							Milling			
2.	Cams	2	C-55	100 x 10	2	90	Wire-cutting	180	1500.00	3090.00
3.	Work holding fixture	3	M.S	-	4.5	90	Turning	60	20.00	115.00
							Boring	30	38.00	17.50
							Milling	60	45.00	45.00
							Drilling	10	25.00	2.50
4.	Tail stock	-	-	-	-	-	Boring	30	40.00	20.00
5.	Sprocket	2	C-30	-	1	30	Boring	20	35.00	37.00
							Milling	90	45.00	67.50
								Total cost		3537.50

8.3. ASSEMBLING COST :

Labour Cost : 450.00

8.4. OPERATION CHART FOR CONTROL SHAFT USING S.P.M.

Component : I - Control Shaft   No of pieces/product : 1

Component : II - Control Shaft

Drg No. :   Batch size : 100

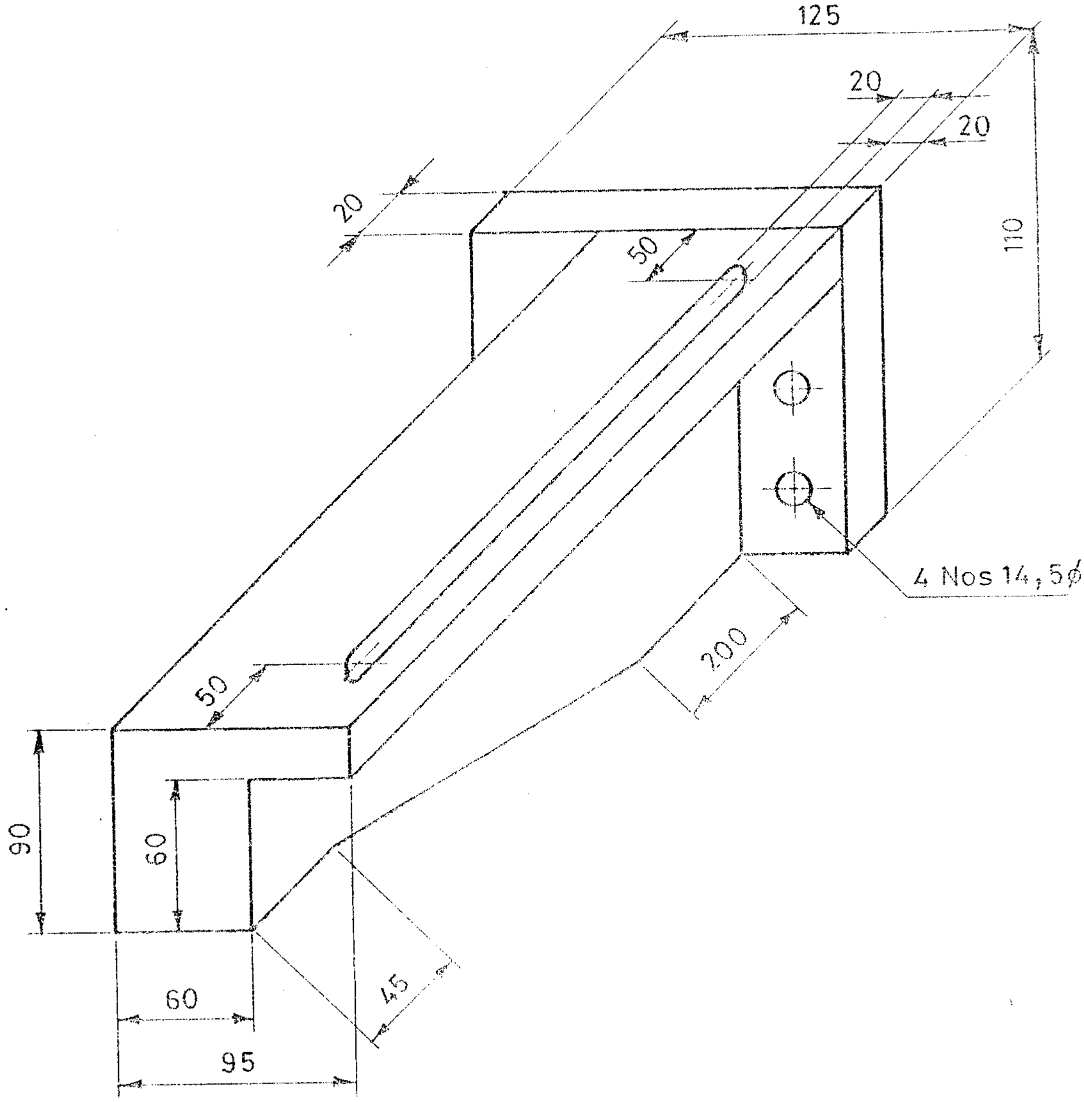
Material : En. 353   No. of shift : 3

Particulars	Operation	Jigs & Fixtures	Setup time/min	M/c/ time in min	Std time min
Component I	Milling	3,6	45	1	165
Component II	Milling	4,6	45	1	165

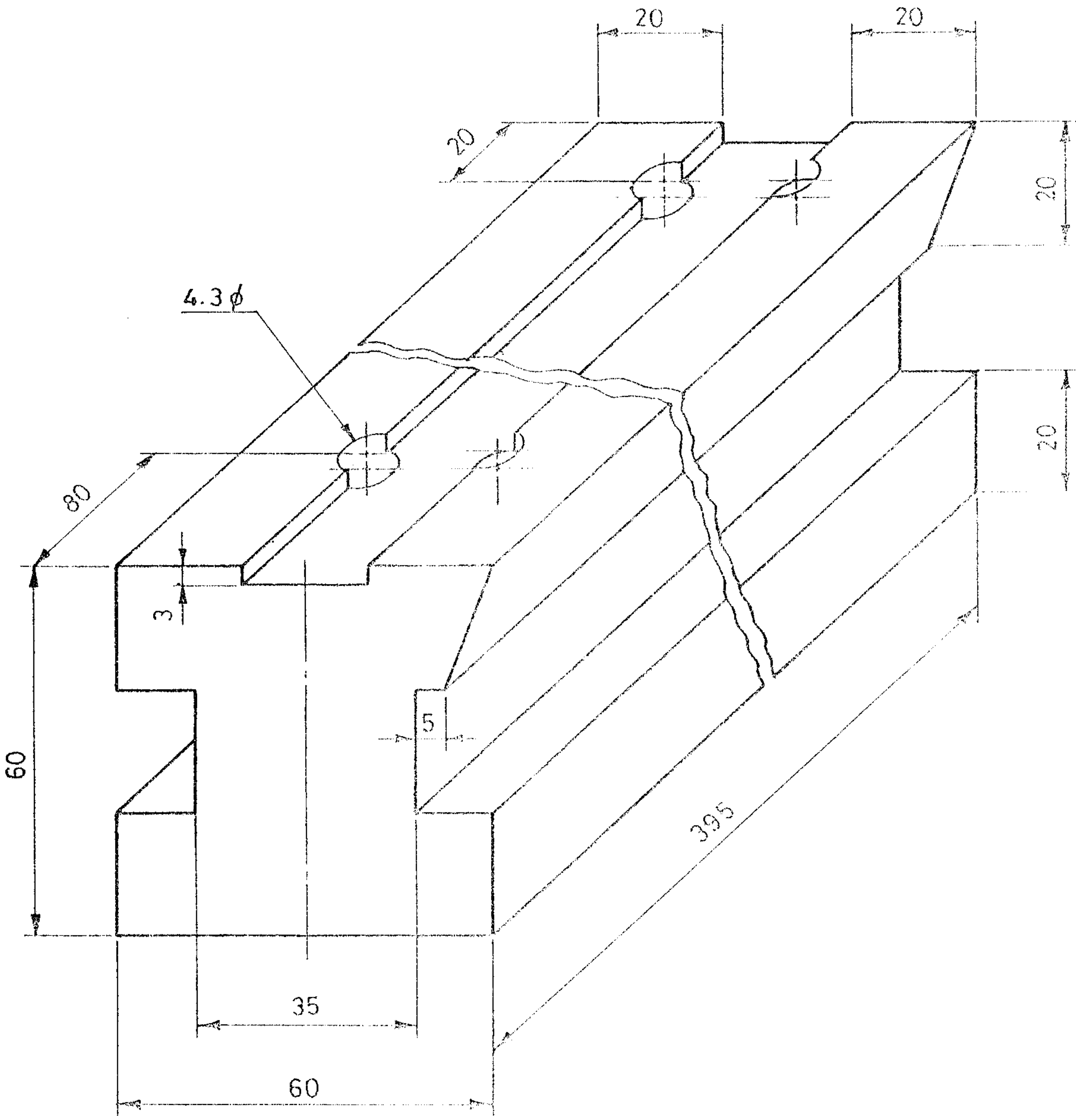
9. BILL OF MATERIALS

S.No.	PARTS NAME	MATERIAL	QUANTITY
01.	Cam shaft	C55 Cr 75	1
02.	Cam	C-55	2
03.	Arm	C.I	2
04.	I.beam	C.I	1
05.	Work holding fixtures	M.S	3
06.	Cylinder	C-55	1
07.	Sprockets	C-30	2
08.	Milling cutter	Plain HSS	1
09.	Bearing housing	M.S	2
10.	Hydraulic copying attachment	--	1
11.	Mechanically operated two way valve	--	1
12.	Allen head screw	H.T.S.	4
13.	Hexagonal head screw	H.T.S.	4
14.	Grub screw	H.T.S.	4

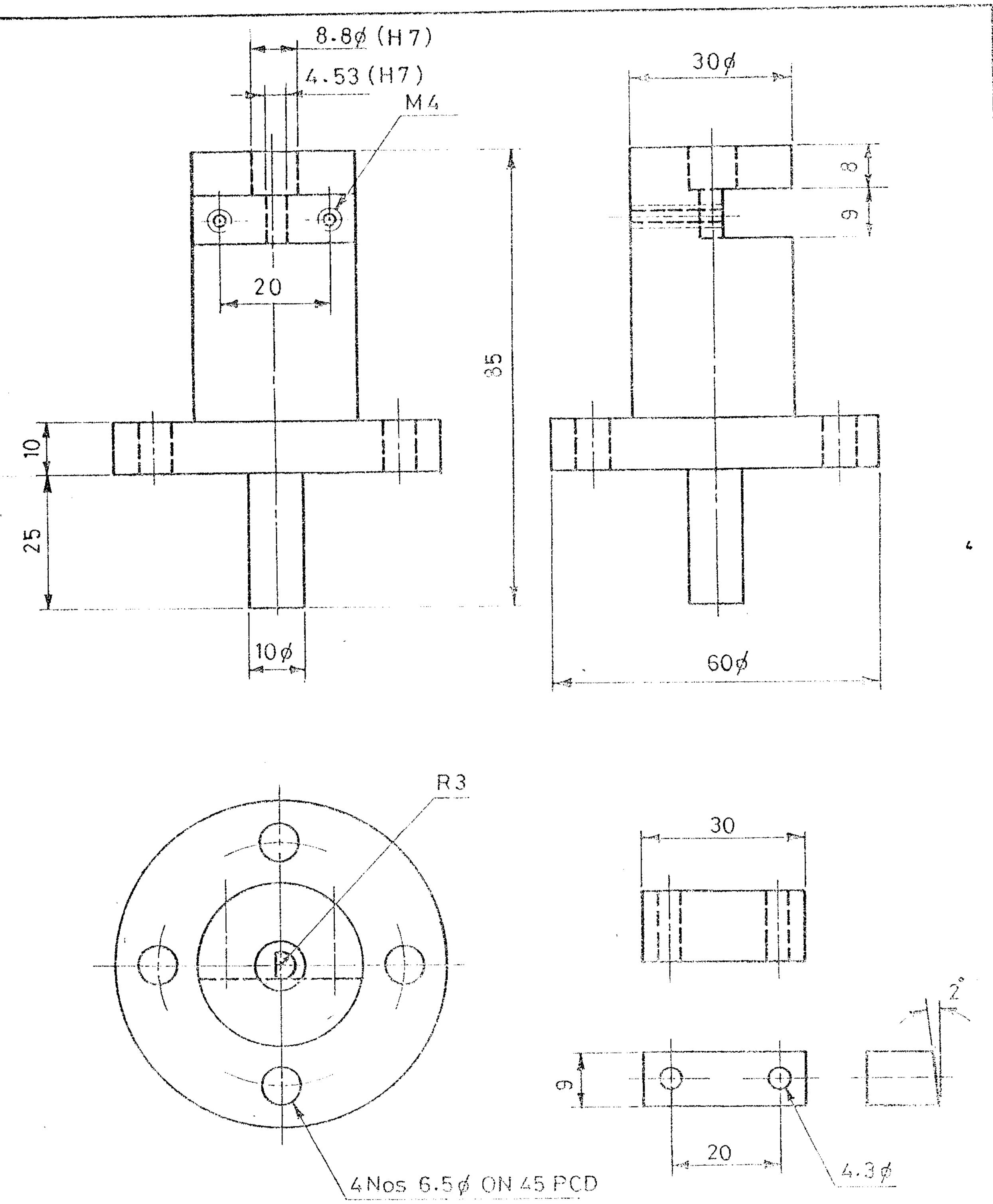
S.No.	PARTS NAME	MATERIAL	QUANTITY
15.	Bolt	H.T.S.	8
16.	Hexagonal nut	H.T.S.	8
17.	Hexagonal nut	H.T.S.	2



ALL DIMENSIONS ARE IN mm		PROJECT WORK
SCALE NTS	QTY 2	TITLE
MATL CI		ARM
DRG No 1		
PROJECTION		KUMARAGURU COLLEGE OF TECHNOLOGY COIMBATORE



ALL DIMENSIONS ARE IN mm		PROJECT WORK
SCALE 1:1	QTY 1	TITLE I BEAM
MATL CI		
DRG No 2		
PROJECTION		KUMARAGURU COLLEGE OF TECHNOLOGY COIMBATORE



ALL DIMENSIONS ARE IN mm | PROJECT WORK

SCALE 1 1 | QTY 1 | TITLE WORK HOLDING FIXTURE (For Component I)

MATL MS

DRG No 3

PROJECTION

KUMARAGURU COLLEGE OF TECHNOLOGY

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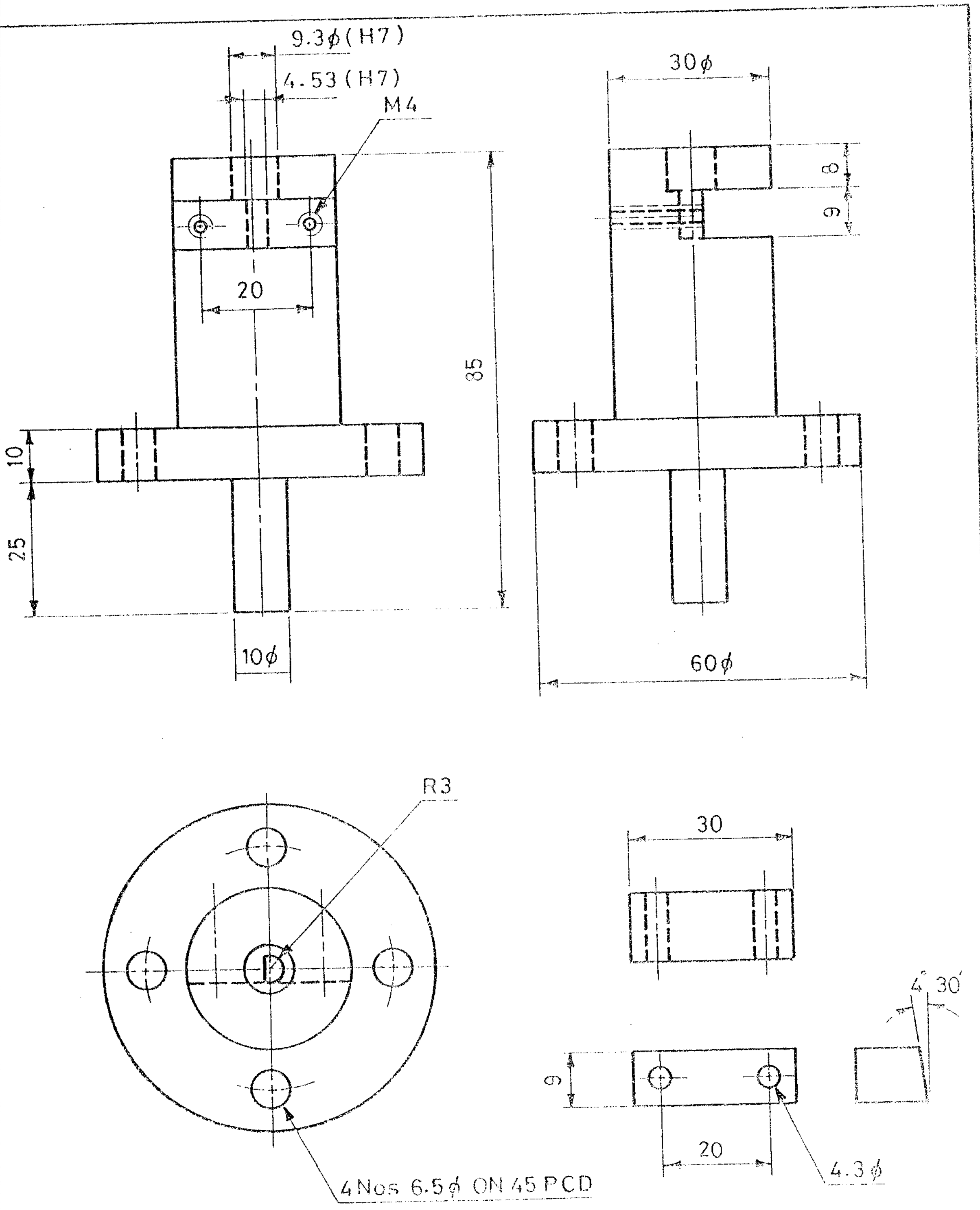
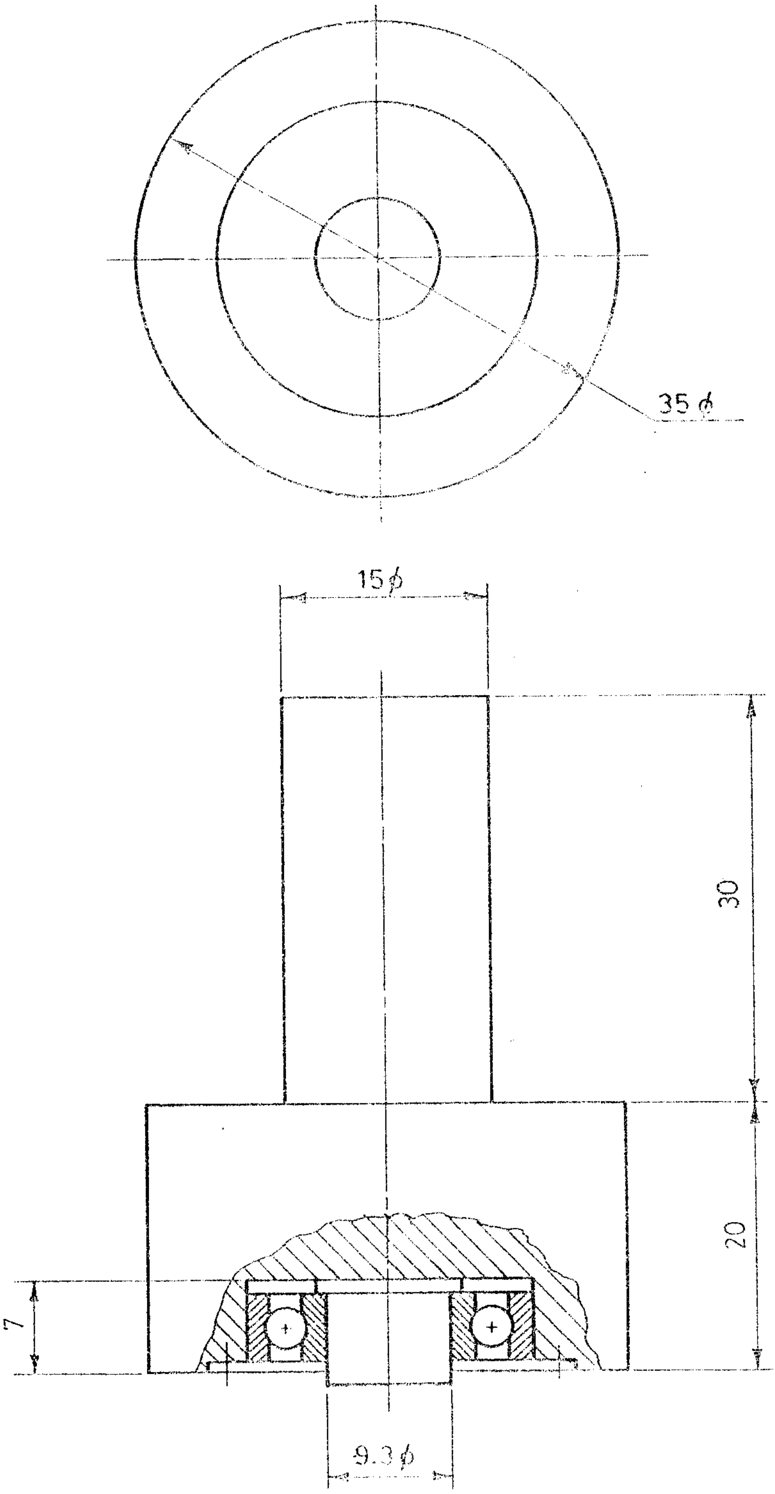
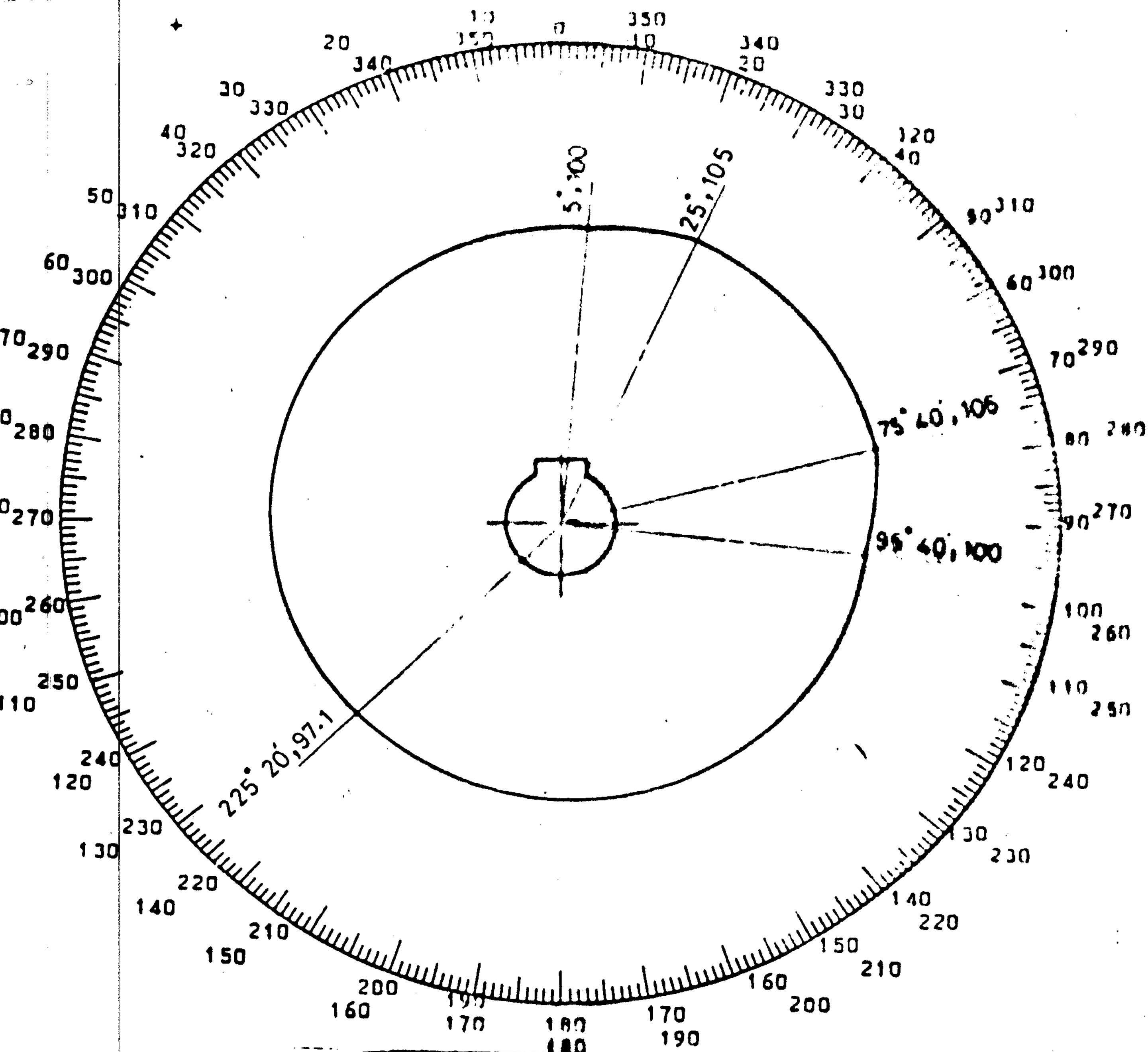


ALL DIMENSIONS ARE IN mm			PROJECT WORK
SCALE 1:1	QTY 1	TITLE WORK HOLDING FIXTURE (For Component II)	
MATL MS			
DRG No 4			
PROJECTION		KUMARAGURU COLLEGE OF TECHNOLOGE COIMBATORE	



ALL DIMENSIONS ARE IN mm		PROJECT WORK
SCALE 2:1	QTY 1	TITLE WORK HOLDING FIXTURE
MATL MS		
DRG No 6		
PROJECTION		KUMAGURU COLLEGE OF TECHNOLOGY COIMBATORE



ALL DIMENSIONS ARE IN mm		PROJECT WORK
SCALE NTS	QTY 1	TITLE CAM
MATL C55		
DRG No 8		
PROJECTION		KUMARAGURU COLLEGE OF TECHNOLOGY COIMBATORE

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