

Study of Plate Bending Machine and Design and Fabrication of Mechanized Pressure Roller Feeding System

Project Work Submitted By

R. Kamalakannan

R. Ram Narayan

D. Sunny Girish

P-181

Under the Guidance of

Mr. P. Suresh Prabhu, M.E.

In partial fulfilment of the requirements
for the award of degree of
BACHELOR OF ENGINEERING
in **Mechanical Engineering**
of the Bharathiar University, Coimbatore-641 046



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

1991 - 92

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

CERTIFICATE

P-08

This is to Certify that the project entitled
**Study of Plate Bending Machine and Design and
Fabrication of Mechanized Pressure Roller
Feeding System**
has been Submitted by

Mr.

In partial fulfilment of the requirements
for the award of the degree of
BACHELOR OF ENGINEERING
in **Mechanical Engineering**

Branch of the Bharathiar University, Coimbatore-641 046

During the academic year 1991 - '92

.....
Guide

.....
Head of the Dept.

*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



**ASSOCIATED
TYRE MACHINERY
COMPANY LTD.**

Subsidiary of THE ASSOCIATED CEMENT COS. LTD.

Madukkarai Works,
P.O. Madukkarai
Dist. Coimbatore
(Tamilnadu) 641 105.
MADUKKARAI
Phone : Coimbatore 80210 & 80536
Gram : MADUKCEMT,
Telex : 855-410 ACC IN

5th March, 1992

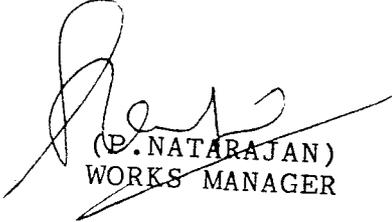
CERTIFICATE

This is to Certify that the following students from Kumaraguru College of Technology, Coimbatore - 641006.

1. Mr. Kamalakannan.R. 88ME17
2. Mr. Ramnarayan.R. 88ME39
3. Mr. Sunny Girish.D. 88ME51

have successfully completed their PROJECT WORK on "The study of Plate Bending Machine and Mechanization of Pressure Roller Feeding on the existing Machine" at ASSOCIATED TYRE MACHINERY CO.LTD., Madukkarai and the machine is also working satisfactorily.




(P. NATARAJAN)
WORKS MANAGER

ACKNOWLEDGEMENT

At the outset we would like to record our deep sense of gratitude to our principal as well as Head of the Department Prof. Major T. S. Ramamoorthy B.E, M.I.S.T.E for providing us the conducive atmosphere in the college for completing our project successfully.

We sincerely express our heart felt thanks to our assistant professor Department of Mechanical Engineering Shri. K. Kandaswamy B.E, M.Sc (Engg.) who by his valuable contact and assistance enabled us to get a sponsored project at Associated Tyre Machinery Co. Ltd, Madukkarai.

We thank profusely our kind and respected guide Shri P. Suresh Prabhu M.E for his assistance and encouragement through out the project without which this project would not have come to the successful stage.

We are also thankful to Mr. P. Natarajan, Works Manager, A.T.M.C, and Mr. Guruswamy, Superintendent Engineer, A.T.M.C giving us the opportunity to do our project at A.T.M.C. Their kind cooperation enabled us to implement the project. We are thankful to the timely advice and criticism of the workers of A.T.M.C.

We faithfully extend our gratitude to Mr. Velrajan, M.E. of Civil Department and Mr. Pugazenthi, M.E of Mechanical Department who helped us in the initial phase of the project.

We faithfully extend our deep gratitude to all those who helped us to complete our project successfully in time.

CONTENTS

S.NO.	TOPIC	PAGE NO.
	SYNOPSIS	1
1.	INTRODUCTION	2
2.	DESCRIPTION OF THE EXISTING MACHINE	4
3.	EXISTING METHOD OF OPERATION	6
4.	THEORY OF PLATE BENDING MACHINE	8
5.	FORCE CALCULATION	
	5.1 SELF WEIGHT OF THE PLATE	9
	5.2 CALCULATIONS OF THE DEFLECTION	11
	5.3 FORCE CALCULATION BY BENDING THEORY	12
	5.4 FORCE SHEETS	16
6.	DETERMINING MACHINE'S CAPACITY	
	6.1 ANALYSIS AT SCREW & NUT	17
	6.2 ANALYSIS AT SUPPORT BRACKET	18
	6.3 ANALYSIS AT VARYING SECTION OF PRESSURE ROLLER	18
7.	CALCULATION OF NUMBER OF FEEDS	20
8.	DESIGN OF MECHANISATION SYSTEM	
	8.1 REQUIREMENTS OF MECHANISATION	21
	8.2 SELECTION OF THE MODE	21
	8.3 POWER CALCULATION	24

9.	DESIGN OF VARIOUS COMPONENTS	
9.1	DESIGN OF SHAFT	27
9.2	CALCULATION OF NO.OF BELTS	35
9.3	DESIGN OF PULLEYS	37
9.4	DESIGN OF SUPPORTS	40
9.5	DESIGN OF FLOOR LEVEL SUPPORTS	41
9.6	SELECTION OF V-BELT	42
9.7	DESIGN OF KEYS	46
9.8	DESIGN OF COUNTER ASSEMBLY	48
9.9	DESIGN OF BELT GUARD	51
10.	INSTALLING THE SYSTEM	52
11.	METHOD OF OPERATION OF NEW SYSTEM	
11.1	INITIAL ADJUSTMENTS	54
11.2	OPERATION	54
11.3	FLOWCHART OF THE NEW SYSTEM	55
12.	OPERATING INSTRUCTIONS	57
13.	MERITS AND DEMERITS OF THE SYSTEM	58
14.	FUTURE DEVELOPMENTS	59
15.	COST ESTIMATION	60
16.	CONCLUSION	61
	BIBLIOGRAPHY	62
	DRAWINGS	63

SYNOPSIS

This project has two parts.

The first one is the study of the Plate Bending Machine. This involves the force calculation for plate bending and the procedure for calculating the accurate number of trials for bending a plate into a shell. The operator's level graphs are drawn in this to find them quickly and easily.

The next part is the design and fabrication of the mechanization system for pressure roller feeding. The mechanization elements are fabricated out of the scrap material available inside the factory. The system is a simple and easy one. No skilled operator is needed for the operations of the machine. The cost of the system comes around Rs. 7000/-.

Introduction

1. INTRODUCTION

The very aim of innovation is the Higher Productivity with improved quality at reduced cost and one of the main ingredients in the innovative technology is reduction of human labour by introducing mechanical means with higher outputs. With this end in view, a survey was conducted to identify potential machines that may need such mechanical device to reduce human labour while enhancing productivity with comparatively advantageous cost-benefit ratio.

One of the machines that was identified was heavy duty plate bending machine of 36 mm bending capacity. Though no original drawings was available, careful study of the machine-working was undertaken with reference to time, human labour, output, cost, etc.. and a special driving device with 3 H.P motor, belt and pulleys was conceived. The arrangement will reduce human labour by 24 man-hours a day in fully operational state and the cost of innovation is absorbed in a month or so.

The entire device is locally fabricated out of scrap material reducing the cost and only motor and belt have to be purchased.

Apart from the higher productivity leading to cost reduction, annual saving of not less than Rs. 45,000 is envisaged in the introduction of this device.

2. DESCRIPTION OF THE MACHINE

Pressure roller : This applies pressure on the plate to be fabricated into shell. It should be heavy, say, 1 ton. It's made out of mild steel. The length of the roller decides the maximum width of the plate that can be processed. It is 300 mm in diameter and 2.5 m long in the existing machine.

Support rollers : These rollers support the plate and the feed is applied at the centre of these two rollers. They are also heavy and of same specifications as that of the pressure roller.

Lead Screw : This is to convert the rotary motion into linear motion, at the end of which the rollers are held. It is of 1/2" pitch, and 3" diameter (12.7 mm pitch and 75 mm diameter).

Nut : This in combination with lead screw and does the conversion from rotary to linear. The nut is held stationary. It is tightly pressed to the worm wheel.

Reduction arrangement : This consists of pinion and gear wheel and a worm and worm wheel set. The purpose of this is to amplify the torque at pinion to a higher value at the lead screw.

Hand Wheel : The pinion is given power through a hand wheel manually in the present system. This is the place where the mechanisation system is interfaced to the machine.

3. EXISTING METHOD OF OPERATION

* Platforms are provided on either sides of the machine below the handwheels, the operator rotates the hand wheel standing on the platform.

* The plate is carried by means of overhead cranes and fed between pressure roller and support rollers.

* The handwheels are rotated till the pressure roller touches the plate.

* The handwheels are rotated simultaneously so as to have uniform feed throughout the span of the plate. The hand wheels are rotated till a particular feed is reached.

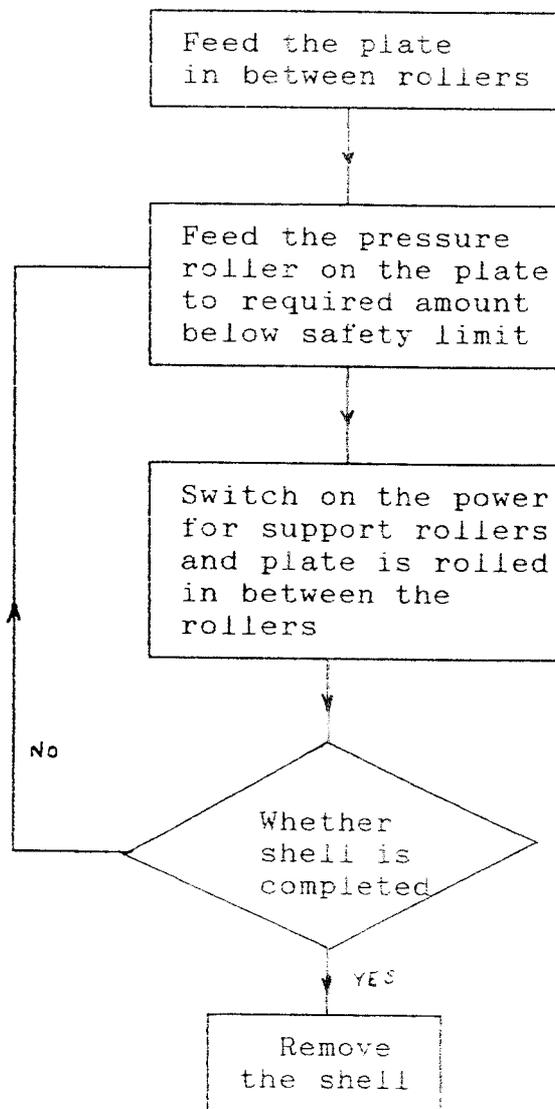
* The support rollers are given power through a heavy motor.

* The plate gets rolled in between the rollers till the other end is reached.

* Again the pressure roller is fed by means of the hand wheel.

* The process is repeated till the complete shell is obtained. The detachable end is removed to release the shell from the machine.

Flow chart of existing method



4.THEORY OF PLATE BENDING MACHINE

When a member supported at its ends, is subjected to a load at its centre the member will have a tendency to deflect symmetrically with respect to its original plane.

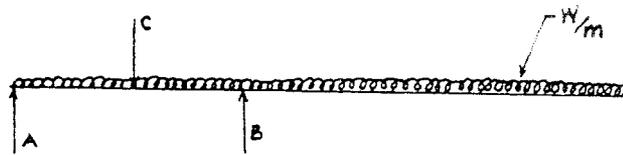
For ductile materials the intensity of deflection is proportional to the load applied. The deflection will be due to the stress caused by the load. If the stress exceeds the yielding limit of that material, the member is permanently distorted and it won't retain its original shape.

The easiest way to arch a plate can be to cause a constant deflection when the plate is under continuous feed between the load and support.

With this idea behind the blue print of plate bending machine was developed and is still continued. Even though the basic idea can't be changed, there is very much a possibility for carrying out modification by fixing some accessories on the existing machine.

5.FORCE CALCULATION

5.1 SELF WEIGHT OF THE PLATE



A and B are the support rollers, C is the pressure roller for applying force on to the plate. Let F be the intensity of the force applied by C. The Uniformly Distributed Load (UDL) intensity w/m is the intensity of self weight of the plate.

The overhang is considered like this because at this condition the maximum force has to be applied for the same deflection.

Self weight of the plate is taken into account because of the reason that the plates processed on the machine are about 3 to 4 M in length (minimum).

We know that the weight of the plate is given by

Weight = volume x density, in kg

Volume = Cross sectional area x length, in cu.m

Cross sectional area = Breadth x thickness, in sq.m

Length = π x diameter of shell + 0.3, in M

0.3 = Prepinching allowance

Let's denote

weight as w , in kg

density as ρ , in kg/cu.m

thickness as d , in m

breadth as b , in m

length as L , in m

diameter of shell as D , in m

So $w = bdL$ kg.

$w/\text{meter} = bdL\rho/L = bd\rho$ kg/m

$w/m = bd\rho$ kg/m

Hence the UDL intensity of the beam is calculated which is the self weight per metre of the plate.

5.2 CALCULATION OF DEFLECTION FOR THE GIVEN DIAMETER

The centre distance cc' is the deflection that has to be got for a given diameter D of the shell. C is the point of contact of the pressure roller and the plate before being bent.

The plane AB is the plane coinciding with the plate before the bending process.

By the triangular properties considering triangle OAC which is right angled at C ,

$$OA^2 = AC^2 + OC^2 \text{ (by Pythagores Theorem)}$$

$$R^2 = AC^2 + OC^2 \text{ (OA = R, the radius D/2)}$$

$$R^2 = (AB/2)^2 + OC^2 \text{ (AC = AB/2 = l/2)}$$

l is the centre distance of support rollers).

$$R^2 = l^2/4 + OC^2$$

$$OC^2 = R^2 - l^2/4$$

$$OC = \sqrt{R^2 - l^2/4}$$

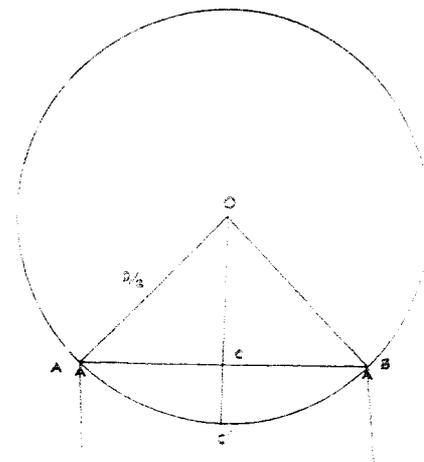
$$OC' = R$$

$$\begin{aligned} CC' &= OC' - OC = R - \sqrt{R^2 - l^2/4} \\ &= D/2 - \sqrt{(D/2)^2 - l^2/4} \\ &= D/2 - \sqrt{(1/4)(D^2 - l^2)} \end{aligned}$$

$$CC' = 1/2 (D - \sqrt{D^2 - l^2})$$

$$CC' = 1/2 (D - \sqrt{(D+l)(D-l)})$$

CC' is the deflection 'y' required at C to get the required curvature.



To simplify the process of calculation a graph is drawn between D and y as l is constant for a machine.

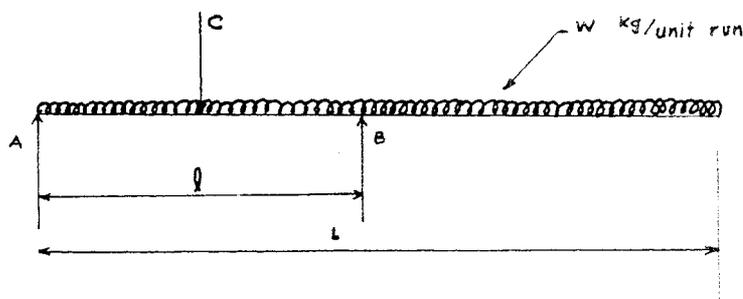
$l = 0.4 \text{ m}$ for our case.

From the graph the value of y for a given D can be determined, quickly.

5.3 FORCE CALCULATION BY BENDING THEORY

For any plate bending machine the centre distance of support rollers is a constant and the value of constant will be decided depending upon the capacity of the machine, the diameter of shell and the minimum thickness of plate it can process. We know the deflection "y" in terms diameter D.

The free Body diagram of the working case is shown below



The central deflection can be derived as follows.

for equilibrium, the net moment about A is zero (i.e. $M_A = 0$)

Let R_A and R_B be the reactions at A and B.

Taking moment about A;

$$R_B \times l - F \times l/2 - WL / 2 = 0$$

$$R_B = (F/2 + WL/2l)$$

and for equilibrium, total upward force = total downward force, (i.e) $V = 0$

$$R_A + R_B = F + Wl$$

$$R_A = F + WL = R_B$$

$$R_A = F + WL - F/2 - WL^2/2l = -(F/2 + WL^2/2) + WL$$

$$R_A = F/2 + (WL/2l)(2l-L)$$

By deflection equation,

Using Macaulay's method of sections

$$EI \frac{d^2y}{dx^2} = R_A x - \frac{wx^2}{2} - F(x-l/2) \dots\dots (i)$$

$$EI \frac{dy}{dx} = R_A \frac{x^2}{2} - \frac{wx^3}{6} + c_1 - \frac{F(x-l/2)^2}{2} \dots\dots (ii)$$

$$EI \cdot y = R_A \frac{x^3}{6} - \frac{wx^4}{24} + c_1 x + c_2 - \frac{F(x-l/2)^3}{6} \dots\dots (iii)$$

at $x = 0$; $y=0$ and at $x = l$; $y = 0$.

Substituting these values in (iii)

Condition I,

$0 = 0 + C_2$ (the term $(F(x-l/2)^3)/6$ is not considered as it is not lying in $x = 0$).

Condition 2,

$$0 = R_A \frac{l^3}{6} - \frac{wl^4}{24} + c_1 l - \frac{Fl^3}{48}$$

$$c_1 = \left(\frac{wl^4}{24} + \frac{Fl^3}{48} - \frac{RAl^3}{6} \right) \times \frac{1}{l}$$

Substituting back the value of constants in (iii) we get

$$EIY = \frac{R_A x^3}{6} - \frac{wx^4}{24} + \left[\frac{F l^3}{48} + \frac{w l^4}{24} - \frac{R_A l^3}{6} \right] \frac{x}{l}$$

Our requirement is the deflection at the mid span i.e. at $x = l/2$

$$EIY = \frac{R_A l^3}{48} - \frac{w l^4}{384} + \left[\frac{F l^3}{48} + \frac{w l^4}{24} - \frac{R_A l^3}{6} \right] \frac{l}{2}$$

$$= \frac{R_A l^3}{48} - \frac{w l^4}{384} + \left[\frac{F l^3}{48} + \frac{w l^4}{24} - \frac{R_A l^3}{6} \right] \frac{l}{2}$$

substituting for $R_A = (F/2 + wL(2l-L))$

$$EIY = \left[\frac{F}{2} + \frac{wL}{2l}(2l-L) \right] \frac{l^3}{48} - \frac{w l^4}{384} + \frac{F l^3}{96}$$

$$+ \frac{w l^4}{48} - \left[\frac{F}{2} + \frac{wL}{2l}(2l-L) \right] \frac{l^3}{12}$$

$$EIY = \frac{7}{384} w l^4 + \frac{F l^3}{96} - \left[\frac{F}{2} + \frac{wL}{2l}(2l-L) \right] \frac{l^3}{16}$$

$$= \frac{w l^2}{384} [7l^2 - 12L(2l-L)] - \frac{F l^3}{48}$$

$$\frac{F l^3}{48} = \frac{w l^2}{384} [7l^2 - 24.Ll + 12L^2] - EIY$$

$$F = \frac{w}{81} [7l^2 - 24.Ll + 12L^2] - \frac{EIY.48}{l^3}$$

$$= \frac{w}{81} [7l^2 - 75.4 lD + 118.4 D^2] - \frac{EIY.48}{l^3}$$

$$F = \frac{bd}{81} [71^2 - 75.4 lD + 118.4 D^2] - \frac{EIV.48}{l^3}$$

y is downward deflection so it will come in negative sense

$$F = \frac{bd}{81} [71^2 - 75.4 lD + 118.4 D^2] - \frac{E bd^3 Y.48}{12 l^3}$$

$$= bd \left[\frac{1}{81} (71^2 - 75.4 lD + 118.4 D^2) + \frac{4Ed^2 y}{l^3} \right]$$

$$\frac{F}{b} = d \left[\frac{1}{81} (71^2 - 75.4 lD + 118.4 D^2) + \frac{4Ed^2}{2l^3} (D - \sqrt{D^2 - l^2}) \right]$$

For the given machine

$$l = 400 \text{ mm} = 0.4 \text{ m}$$

and from the Company's data the material of the plate worked often is mild steel whose density = 7833 kg/cu.m

and the young's modulus $E = 2 \times 10^{10}$ kg/sq.m

So taking the material worked to be mild steel the formula for force calculation is modified by substituting these values as $F/b = d \{ (7833/0.32) \times (1.12 - 30.16 D + 118.4 D^2) + (4 \times 10^{10} d^2/0.064) \times (D - \sqrt{D^2 - 0.16}) \}$

F -> Force to be applied, kgf

b -> breadth of the plate, in m

d -> thickness of the plate, in m

D -> Diameter of the shell to be made in m

5.4 FORCE SHEETS

Let's have F/b as the force factor F' . A graph FORCESHEET I is drawn between D and F' for constant values of d .

The second graph FORCE SHEET II is drawn between F' and F for constant values of b .

Hence by knowing the values of d and b of the plate, D of the shell the force necessary for that is calculated.

Depending upon the material and centre distance of support rollers the formula can be varied and different sets of graphs are drawn for different materials and centre distance of support rollers.

Our graph is for mild steel plate and for 0.4 m centre distance of support rollers

6. DETERMINATION OF MACHINE'S CAPACITY

Determining capacity means analysing the chances of failure at critical points on the machine.

By design methods the 3 critical areas are

- (i) The screw and nut bearing area,
- (ii) the support bracket of pressure roller and
- (iii) the step on the pressure roller.

6.1 ANALYSIS AT SCREW AND NUT

Here there are two chances of failure that is the bearing failure and the shearing failure.

Data : Length of the nut = 1'2" = 356 mm

Major diameter = 76.2 mm

Minor diameter = 12.7 mm

Bearing area is so high than the shearing area. So analysing the shearing failure,

No. of threads in contact with nut = 27

Area of shear in nut = $27 \times \pi(76.2 - 2 \times 6.5 \times 3.5)$

Area = 34200 sq.mm

Shear stress of gun metal = 20 kgf/sq.mm

taking factor of safety as 2

$\sigma_s = 10 \text{ kgf/sq.mm}$

Force withstood by the screw and nut = $\sigma_s \times A$

$$= 34200 \times 10 = 342000 \text{ kgf.}$$

$$= 342 \text{ tonnes.}$$

Let this be denoted as $F_1 = 342 \text{ tonnes}$

6.2 ANALYSING THE SUPPORTING BRACKET

The bracket may fail due to crushing load of the roller.

Data : diameter of supported roller = 203.2 mm

length of bracket = 203.2 mm

Bearing area = $203.2 \times 203.2 = 41209 \text{ sq.mm}$

Crushing stress of bracket material (M.S) = 15 kgf/sq.mm

Force withstood by the bracket = $15 \times 41209 = 618135 \text{ kgf}$

$$= 619 \text{ tonnes.}$$

Let this be denoted as $F_2 = 619 \text{ tonnes.}$

6.3 ANALYSING THE VARYING SECTION ON THE ROLLER

The section will fail due to the bending load. So the moment taken by the section at the reduced diameter should be found using moment equation.

Data : Bending stress of (M.S.) $\sigma_b = 13 \text{ kgf/sq.mm}$

Diameter at the reduced section = 203.2 mm

Moment equation,

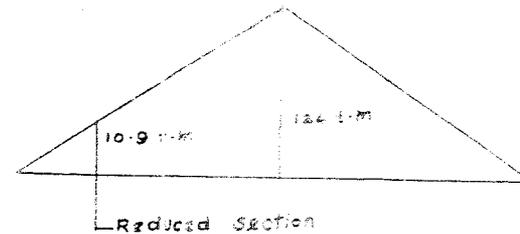
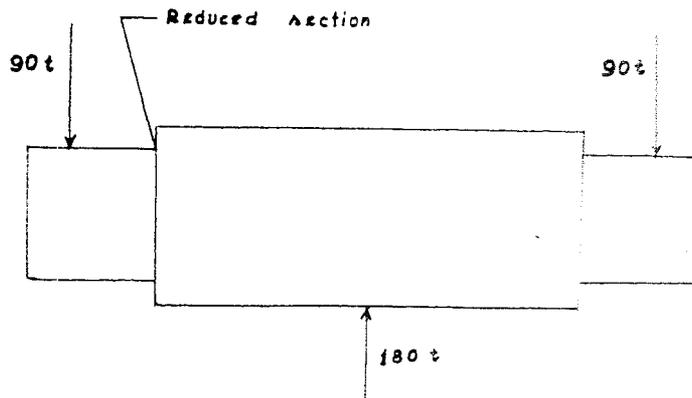
$$M/I = \sigma_b/y$$

$$\Rightarrow M/(\pi \times (203.2)^4/64) = 13/(203.2/2)$$

$$M = 10872889 \text{ kgf-mm} = 10.9 \text{ tonne - m}$$

PRESSURE ROLLER LOAD REPRESENTATION

BENDING MOMENT DIAGRAM



The reduced section will take a moment of 10.9 tonne-m. By triangular properties the moment at the middle will be 124 tonnes - m. For this the support reactions will be 106 tonnes. So the value of W can be 212 tonnes.

This means the machine can withstand upto a force of 212 tonnes on the pressure roller, upto which the screw and nut, the bracket and the varying section are able to take up the load safely.

To be on the safer side, let's have the withstanding capacity to be 180 tonnes, at this load the supports have to offer a reaction of 90 tonnes which is well below the F_1 and F_2 .

Hence the capacity of the machine is 180 tonnes.

7. CALCULATION OF NUMBER OF FEEDS OF PRESSURE ROLLER

- * Find the force required F using force sheets I and II and the deflection y for given diameter of shell D using D vs y graph, provided with this.

- * Force has to be divided by the capacity of the machine and the value has to be rounded to a whole number which gives the number of trials 'N' that has to be carried out.

- * Divide y by N which gives the amount of feed in mm

- * The feed in mm when divided by the fraction 0.127 will give the number of revolutions that the machine pulley has to rotate per feed.

8. DESIGN OF THE MECHANISATION SYSTEM

8.1 REQUIREMENTS OF THE MECHANISATION

(i) The system should not disturb the plate being processed

(ii) The system should be flexible so that the detachable end of the machine can be easily detached whenever required.

(iii) The system should be in such a way that the feeding is uniform at either ends of the pressure roller.

(iv) There should not be any difficulty in assembling or dismantling the system.

(v) The operation should be easier for the operator.

(vi) The cost of the system should be as low as possible to satisfy the sole aim of the project.

8.2 SELECTION OF THE MODE OF MECHANISATION

The mechanisation can be carried by using any of the following modes

(i) Electric motor

(ii) Hydraulic

(iii) Pneumatic

(iv) Servo mechanism

The hydraulic and pneumatic system cannot be implemented as they need the alteration of existing system and secondly the cost factor.

Servo mechanism is also costlier .

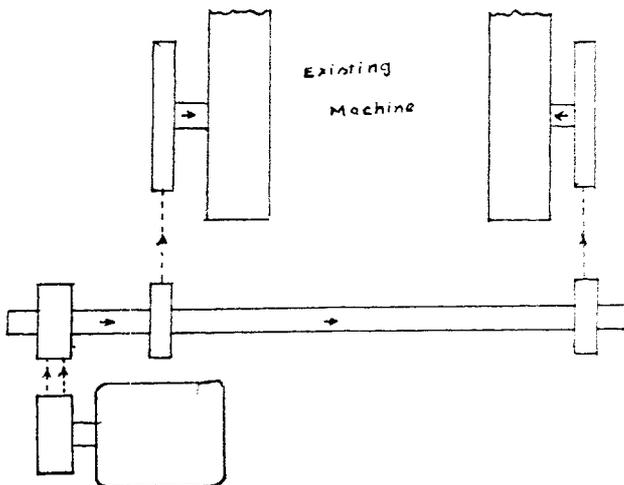
So we are left with the only alternative viz. the electric motor. Here, two individual motors are to be used on either sides. But synchronization is not possible.

To satisfy the synchronization requirement there should be common shaft running between the two pinions.

If the shaft is introduced between the two pinions, it is an obstruction during the process.

Thus only possibility is to mount the shaft at the floor level and to transmit the power through belts running on pulleys.

The design should be such that the drive motor is within the machine boundaries. The shaft is given power again through belt from the motor situated parallel to the shaft. The system is shown below in simple manner



This system does not disturb the plates in process. The detachable end can be easily released by removing the belt. The operation is smooth and noiseless. Perfect synchronization is obtained ignoring the negligible slip.

Hence, this is the perfect mechanisation attachment for the existing machines.

Advantages :

- (i) The system cost is cheaper
- (ii) Easy in operation
- (iii) No skilled persons required for operation
- (iv) High response

Disadvantages :

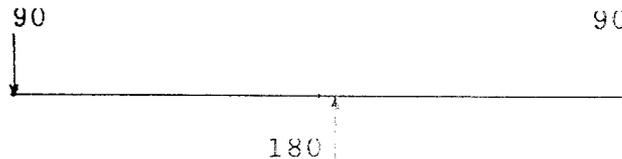
The unavoidable meagre slip causes a micron difference between the levels of pressure roller ends as the advance of pressure roller is 0.12 mm per revolution of pinion shaft.

Components of the system :

- 1. Motor
- 2. Pulleys
- 3. Shaft
- 4. Supports
- 5. Belts

8.3 POWER CALCULATION

As we know that the capacity of the machine is 180 tonnes, each screw has to apply a force of 90 tonnes.



90 tonnes is applied by the screw which in turn is from a nut, integrated with the worm wheel. By simple screw jack rule the torque required at the radius of the worm wheel can be found using the formula

$$T = \mu_e W r_c + \mu W r_m \frac{(P + \mu \pi d_m)}{(\pi d_m - \mu P)}$$

(Theory of machines by Balaney)

μ_c -> collar friction = (.125)

W -> load on screw = 90 tonnes

r_c -> effective collar radius = $\frac{2 \times (r_1^3 - r_2^3)}{3 \times (r_1^2 - r_2^2)}$

r_1 -> outer radius of collar (= 88 mm)

r_2 -> inner radius of collar (= 32 mm)

r_m -> mean radius of screw = $d_m/2$

d_m -> mean diameter of screw = $(D_o + D_i)/2$

D_o -> major diameter of screw = 76.2 mm

D_i -> root diameter of screw = 53.2 mm

P -> pitch of the screw = 13 mm

μ -> screw and nut friction = 0.1

Substituting all these values in the formula

we get $T = 1234$ Tonne - mm

Which implies Torque = 1234 kgf.- m

This is the torque that is to be applied at the worm wheel end, which receives the torque from a worm shaft.

By power equation,

$$\frac{T_1}{t_1} = 0.75 \frac{T_2}{t_2} \quad \dots \text{transmission efficiency of worm and worm wheel} = 0.75$$

T_1 and T_2 are torque on worm wheel and worm shaft respectively

t_1 is the no. of teeth on worm wheel = 24

t_2 is the no. of starts on worm shaft = 1

$$T_2 = 69 \text{ kgf.m}$$

T_2 is the torque applied by worm shaft. The worm shaft is driven by a gear wheel. So the gear wheel is also needed to transmit the same torque T_2 . The gear wheel in turn is driven by a pinion.

The torque applied by pinion is calculated by the equation

$$\frac{T_2}{t_2} = 0.9 \frac{T_3}{t_3} \quad \dots \text{gear efficiency} = 0.9$$

T_2 = torque on gear wheel = 69 kgf.m

T_3 = torque on pinion

t_2 = number of teeth on gear wheel = 112

t_3 = number of teeth on pinion = 19

T_3 = 13 kgf.m

This pinion is the last stage of reduction and a torque of 13 kgf.m on it can apply a torque of 1234 kgf.m on the screw rod.

Allowing a speed of 60 rpm to the pinion the power required for rotating the pinion is

$$P = 2\pi NT_{\max} / 4500 \text{ H.P.}$$

N -> speed 60 rpm

T -> torque 13 kgf.m

T_{\max} -> $1.5T = 19.5 \text{ kgf.m}$

$$P = 0.92 \text{ H.P} = 1 \text{ H.P}$$

This 1 H.P is the power for one screw, so totally we need 2 H.P for both ends, giving a factor of safety 1.5

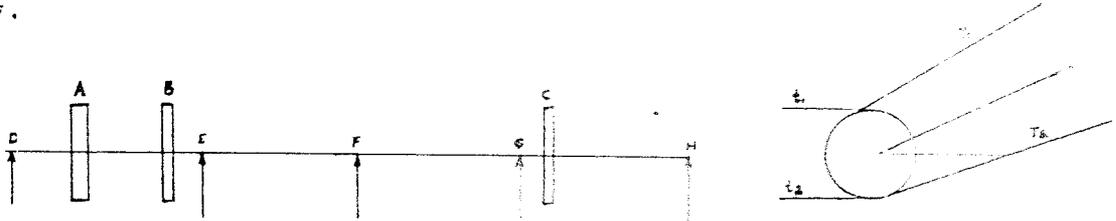
The power of the motor is 3 H.P

The conventional motor will have a speed as high as 1500 rpm. This has to be reduced to 60 rpm. This will introduce complexity in the system. To avoid this we can use geared motor. Allowing a net reduction ratio of 2 we can select the motor speed to be 120 rpm. From standard WITCO geared motor manual the availability is 3 H.P 120 rpm. Refer to Drawing No.1.

9. DESIGN OF VARIOUS COMPONENTS

9.1 DESIGN OF SHAFT

The free body diagram of the drive shaft is shown below.



Calculation of belt tensions :

We know the equation

$$(t_1 / t_2) = e^{\mu \theta \operatorname{cosec} \alpha} \quad \dots 1$$

t_1 and t_2 → tight and slack side tensions

μ → coefficient of friction between belt and pulley material

θ → half of the v groove angle

and also

$$(t_1 - t_2) \times v / 75 = P \quad \dots 2$$

v → velocity of the belt in m/s

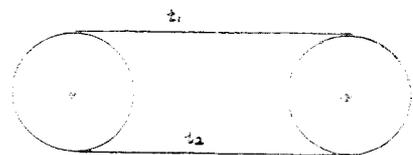
P → power transmitted in H.P

t_1 and t_2 : Belt tension for motor and shaft

$$\mu = 0.15 \quad \theta = \pi \text{ rad} \quad \alpha = 19^\circ$$

$$\begin{aligned} t_1/t_2 &= e^{0.15 \times \pi \times \operatorname{cosec} 19^\circ} \\ &= 2.14 \end{aligned}$$

$$v = \pi \times 0.25 \times 40/60 = 0.52 \text{ m/s}$$



$$P = 3 \text{ H.P}$$

$$(t_1 - t_2) = 143 \text{ kgf}$$

$$t_1 = 268 \text{ kgf}$$

$$t_2 = 125 \text{ kgf}$$

T_1 and T_2 : Belt tension for shaft and machine

$$\mu = 0.15 \quad \alpha = 19^\circ \quad \theta = 180 - 60 \times (D-d)/C = 175^\circ$$

$$= 3.06 \text{ rad.}$$

$$T_1/T_2 = e^{0.15 \times 3.06 \times \operatorname{cosec} 19^\circ}$$

$$= 2.03$$

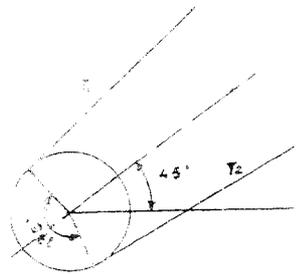
$$v = \pi \times 0.25 \times 40/60 = 0.52 \text{ m/s} \quad P = 1 \text{ H.P}$$

$$(T_1 - T_2) \times 0.52/75 = 1$$

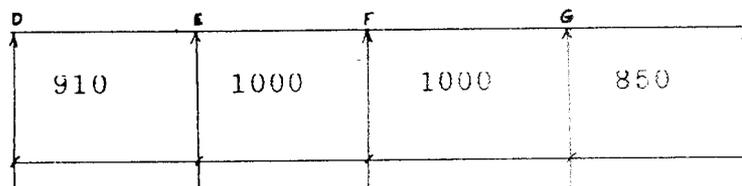
$$(T_1 - T_2) = 48$$

$$T_1 = 94 \text{ kgf}$$

$$T_2 = 46 \text{ kgf}$$



For the shaft we'll have 5 supports as shown below

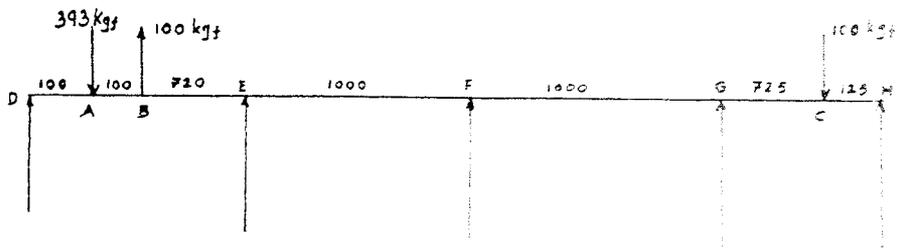


Since the power transmission belt from shaft to machine is inclined we'll have horizontal and vertical resolutions of load.

I case : Horizontal load analysis

$$\text{Load at A} = t_1 + t_2 = 393 \text{ kgf}$$

$$\text{Load at B and C} = (T_1 + T_2) \cos 45 = 100 \text{ kgf}$$



$\Sigma H = 0$ (total upward load = downward load.)

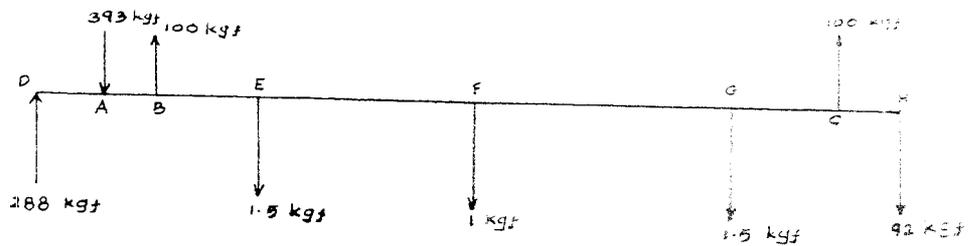
$\Sigma M = 0$ (moment about any point on left side = moment about that point on the other side)

Hence

$$H_D = 288 \text{ kgf} \quad H_E = -1.5 \text{ kgf} \quad H_F = -1 \text{ kgf} \quad H_G = -1.5 \text{ kgf}$$

$$H_H = -92 \text{ kgf}$$

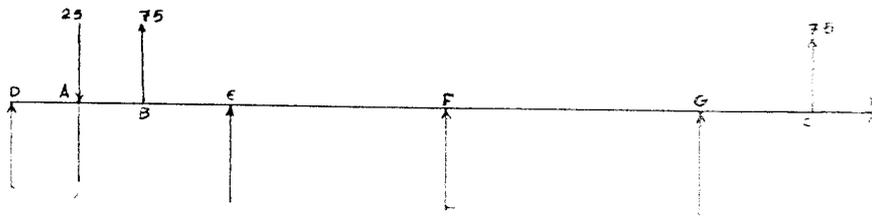
Modified load diagram



II case : Vertical load analysis

Load at A = self weight of pulley = 25 kgs

Load at C and B = $(T_1 + T_2) \sin 45$ - self weight of pulley = 75 kgs



$$\Sigma V = 0$$

$$\Sigma M = 0$$

Hence

$$V_D = -76.33 \text{ kgf}$$

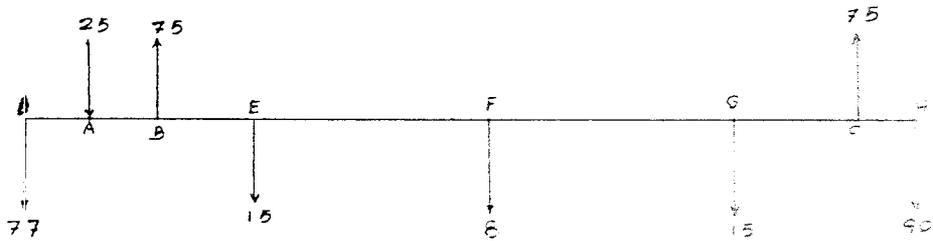
$$V_E = -15 \text{ kgf}$$

$$V_F = -8 \text{ kgf}$$

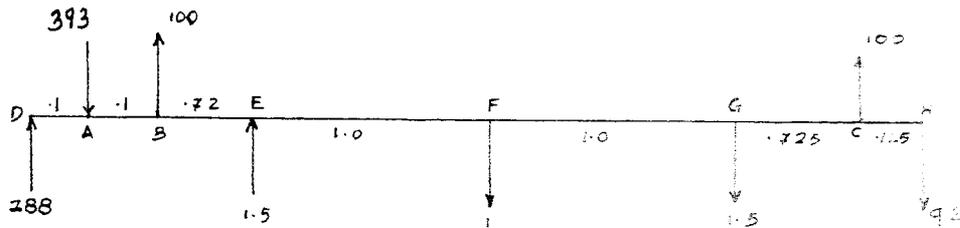
$$V_G = -15 \text{ kgf}$$

$$V_H = -90 \text{ kgf}$$

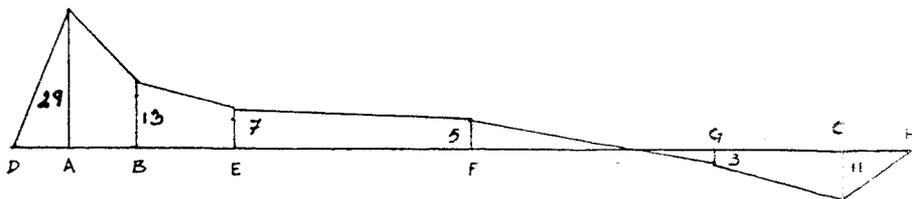
Modified load diagram



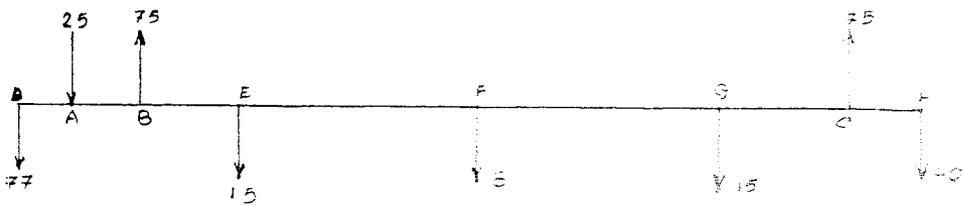
HORIZONTAL LOAD DIAGRAM:



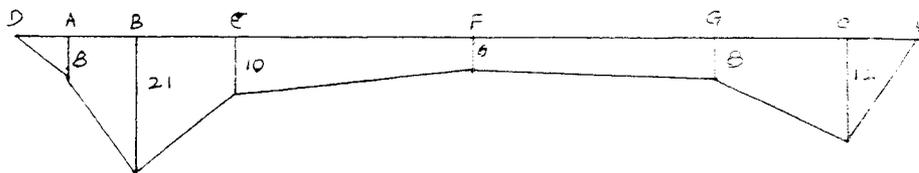
HORIZONTAL B.M. DIAGRAM:



VERTICAL LOAD DIAGRAM:



VERTICAL B.M. DIAGRAM:



$$\text{Equivalent moment} = \sqrt{(\text{vertical moment})^2 + (\text{horizontal moment})^2}$$

$$\text{E.M at A} = 29.8 \text{ kgf.m}$$

$$\text{E.M at B} = 24.8 \text{ kgf.m}$$

$$\text{E.M at C} = 16.0 \text{ kgf.m}$$

$$\text{E.M at E} = 12.0 \text{ kgf.m}$$

$$\text{E.M at F} = 8.0 \text{ kgf.m}$$

$$\text{E.M at G} = 9.0 \text{ kgf.m}$$

The maximum bending moment occurs at A and the value is 30 kgf.m

$$\text{Torque transmitted by the shaft} = 18 \text{ kgf.m}$$

$$\begin{aligned} \text{Equivalent B.M} &= 1/2 [M + \sqrt{(M^2 + T^2)}] & M &= 30 \text{ kgf.m} \\ & & T &= 18 \text{ kgf.m} \\ &= 33 \text{ kgf.m} \end{aligned}$$

$$\begin{aligned} \text{Equivalent torque} &= 1/2 \sqrt{(M^2 + T^2)} \\ &= 35 \text{ kgf.m} \end{aligned}$$

The torque and moment on the shaft are on the heavy duty side. So the material should be selected carefully.

Mild Steel cannot be selected as it has got a low strength compared to our application. The next choice is obviously EN8D steel, as it is the widely used shaft material.

Its tensile strength is 65 kgf/sq.mm

Its shear stress is 30 kgf/sq.mm

Its bending stress is 40 kgf/sq.mm

Calculation of diameter of shaft

We know the bending equation

$$M/I = f_b/y$$

$$M = 33 \text{ kgf.m} = 33000 \text{ kgf.mm}$$

$$I = \pi d^4/64 \text{ (Section inertia)}$$

$$f_b = 40/3 \text{ kgf/sq.mm (Factor of safety = 3)}$$

$$y = d/2 \text{ (radius)}$$

$$\dots \frac{33000}{(\pi d^4/64)} = \frac{40/3}{d/2}$$

$$d = 45 \text{ mm}$$

We know the torque equation,

$$\frac{T}{J} = \frac{f_s}{R}$$

$$T = 35 \text{ kgf.m}$$

$$J = \pi d^4 / 32 \text{ (Section modulus)}$$

$$f_s = 30/3 \text{ kgf/sq.mm (F.S = 3)}$$

$$R = d/2$$

$$\frac{35}{\pi d^4/32} = \frac{30/3}{d/2}$$

$$d = 42 \text{ mm}$$

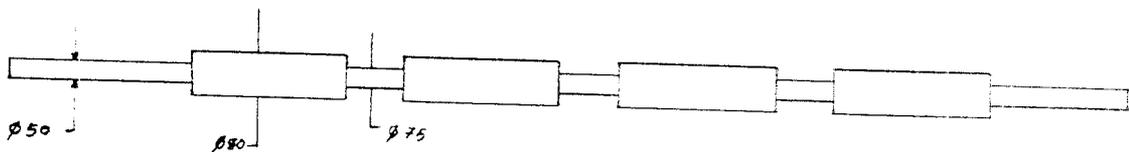
Taking the biggest value of d to be the diameter the value of d = 45 mm

From R₂₀ preferred series

$$d = 50 \text{ mm}$$

But the material available in the stores was 4m long and 80 mm in diameter. Just to reduce the machining cost the shaft is turned to 50 mm at the ends upto the length required (i.e) 310 mm in the left and 250 mm in the right and it is turned to 75 mm diameter for 120 mm length at the places where the shaft rests in plummer blocks.

Hence the rough look of the drive shaft is as shown below



Tolerance on machining portion

In the $\phi 50$ mm portion the fit is going to be assembly fit between pulley and shaft. Referring to PSG DDB page 3.5 the tolerance for that fit is $H_7 h_7$.

The shaft is to be given allowance to h_8 . The allowance limits are

$$\begin{array}{r} -0.000 \\ 50 \quad \text{mm} \\ -0.030 \end{array}$$

In the $\phi 75$ mm portion the fit is a sliding fit between shaft and plummer block bush. The preferred allowance is $H_8 d_9$

∴ The allowance limit on shaft is

$$\begin{array}{r} -0.120 \\ 50 \quad \text{mm} \\ -0.174 \end{array}$$

Key Way:

Referring to PSG DDB Page 5.21 for diameter 50 mm the standard key way details for taper keys are

key way depth = 6 mm (+0.1)

key way width = 16 mm

Since two pulleys are there on left side the length of key way on left side is selected as 170 mm and on the right side as 110 mm, as it holds a single pulley.

Refer to DRG No. 2

9.2 CALCULATION OF NUMBER OF BELTS

MOTOR TO SHAFT

For 3 h.p power transmission C section belts are preferable.

Kilowatt rating equation from PSG DDB Page No. 7.62 for C-Section belts.

$$KW = (1.475^{-0.09} - 142.7/d_e - 2.34 \times 10^{-4} S^2)S$$

where

KW = maximum power in KW at 180 arc of contact for a belt of average length.

S = belt speed m/sec

d_e = equivalent pitch diameter = $d_p \times F_b$

d_p = pitch diameter of the smaller pulley
(assumed 250 mm)

F_b = the small diameter factor to account for variation of arc contact.

$S = \pi d_p N / 60$ m/sec

$$d_p = 250 \text{ mm} = 0.25 \text{ m}$$

$$N = 120 \text{ rpm}$$

$$\therefore S = 1.5707 \text{ m/Sec}$$

$$d_e = d_p \times F_b$$

$$F_b = 1$$

$$\therefore d_e = 250 \text{ mm}$$

By substituting these values

$$KW = 1.31942 \text{ KW}$$

Hence the number of belts = Power $\times F_a$ / (KW $\times F_c \times F_d$)

$$F_a = \text{service factor} = 1.1$$

$$F_c = \text{length factor} = 0.9$$

$$F_d = \text{arc of contact factor} = 1$$

$$\therefore \text{number of belts} = 1.673 \text{ or } 2$$

SHAFT TO MACHINE

For 1 h.p power transmission B Section belts are preferable

Kilowatt rating equation from PSG DDB Page No. 7.62

$$KW = (0.79 S^{-0.09} - 50.8/d_e - 1.32 \times 10^{-4} S^2) S$$

$$S = \pi d_p N / 60 \text{ m/sec}$$

$$d_p = 250 \text{ mm}$$

$$N = 120 \text{ rpm}$$

$$\therefore S = 1.5707 \text{ m/sec.}$$

$$d_e = d_p \times F_b$$

$$\therefore F_b = 1$$

$$\therefore d_e = 250 \text{ mm}$$

$$\text{Hence } KW = 0.87169 \text{ KW}$$

$$\text{No. of belts} = \text{Power} \times F_a / (\text{KW} \times F_c \times F_d)$$

$$F_a = 1.1 \quad F_c = 1.19 \quad F_d = 0.99$$

$$\text{No. of belts} = 0.8443 \text{ or } 1$$

9.3 PULLEY DESIGN

MOTOR TO SHAFT

This pulley is named as MOTOR PULLEY.

From the calculation it is known that there are two belts required for power transmission of C section. So pulley is to be double grooved.

From the scrap availability the PCD of pulley is selected as 250 mm

From PSG DDB Page 7.70

the groove details of C section pulleys are

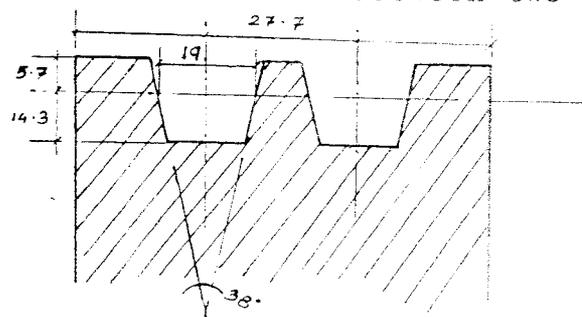
Groove angle = 38°

Pitch width = 19 mm

Minimum distance down to pitch line = 5.7 mm

Minimum depth below pitch line = 14.3 mm

Centre to centre distance between two grooves = 27.7 mm



The width of the pulley = 57 mm as per the scrap available.

The height of the rim = 50 mm (= width)

The web thickness = $1/3 \times$ width

= 19 mm

diameter of shaft hole = 50 mm (H7)

diameter of hub = $2 \times$ diameter of shaft hole = 100 mm

key way details : As per PSG DDB for 50 mm hole

width of key way = 16 mm

depth of key way = 3.4 mm

Since no reduction is required two pulleys of same specification can be used on both motor and shaft.

Refer to DRG. No.3

PULLEYS FOR SHAFT TO MACHINE

PULLEY ON SHAFT

This pulley is named as DRIVE PULLEY

For this pulley also the PCD may be selected 250 mm as per the scrap availability, and is preferred as this and the previous pulley are on the same shaft, in the floor level.

The number of belts is one for this case as per B - Section.

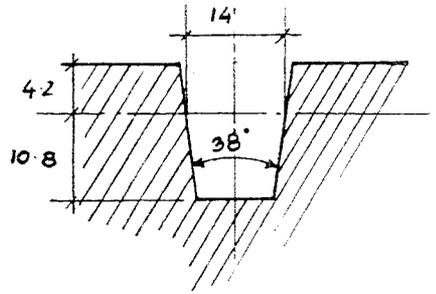
The groove details of B - Section is selected from PSG DDB.

Angle of groove = 38°

Pitch width = 14 mm

Minimum distance down to pitch line = 4.2 mm

depth below pitch line = 10.8 mm



Rim width is selected as 40 mm

The depth of rim = width of rim = 40 mm

Thickness of web = $1/3 \times \text{width} = 16 \text{ mm}$

diameter of shaft hole = 50 mm (H7)

diameter of hub = 100 mm

key way details ; As per PSG DDB for 50 mm hole

width of key way = 16 mm

depth of keyway = 3.4 mm

Refer to DRG. No. 4

PULLEY ON MACHINE

This pulley is named as MACHINE PULLEY.

Groove details are same as above

The rim width = 56 mm as per scrap thickness

The depth of rim = 50 mm

The web thickness = $1/3 \times \text{width} = 20 \text{ mm}$

diameter of shaft hole = 50 mm (H7)

diameter of hub = 110 mm

Key way details as per PSC DDB

keyway width = 16 mm

keyway depth = 3.4 mm

The PCD of this pulley as per the design is 500 mm. But as scrap availability it is selected as 400 mm.

Refer to DRG NO. 5

Hence one pulley set of 250 PCD each is required for motor to shaft and is double grooved, C Section.

Two pulley sets of 250 PCD and 400 PCD is required for shaft to machine on either sides.

9.4 DESIGN OF SUPPORTS

The support should be flexible for easy maintainance. Ball bearings cannot be used as the support surfaces on the shaft are under cut.

So plummer blocks with split bushes can be the right choice.

The plummer blocks are readily available in the market for the sizes 50 mm and 75 mm. They are of replacable bush type. Hence the centre height of the bush from the plummer block base is maintained in both cases.

Dimensions of 50 mm plummer block

Inner diameter of bush = 50 mm

Centre height of bush = 100 mm

Centre distance between base holes = 195 mm

Refer to DRG No. 6.

Dimensions of 75 mm plummer block

Inner diameter of bush = 75 mm

Centre height of bush = 100 mm

Centre distance between base holes = 195 mm

Refer to DRG No. 7

9.5 DESIGN OF BOTTOM SUPPORTS

The plummer blocks are to be held on the floor. If they are held on floor we won't get the uniformity and also we need some space below the pulleys. So the centre of shaft should be raised to 250 mm at least.

Already plummer block gives a rise of 100 mm. The remaining 150 mm rise can be had through keeping a C channel below the plummer block

The Channel ISJC 150 is selected for this. And according to the centre distance of plummer base and the centre to centre distance between plummer blocks the bolt holes and stud holes are drilled in the channel. The stud hole is to hold the channel on the floor. The bolt hole is to hold the plummer block on the channel.

To economise the channel length and for the rigidity of the support two channels of length, about 2200 mm is required for middle 36 locks.

Refer to DRG No. 8.

And 4 channels of 250 mm length are required for 2 plummer blocks at the ends and 2 for seating the motor. Refer to DRG. NO.9.

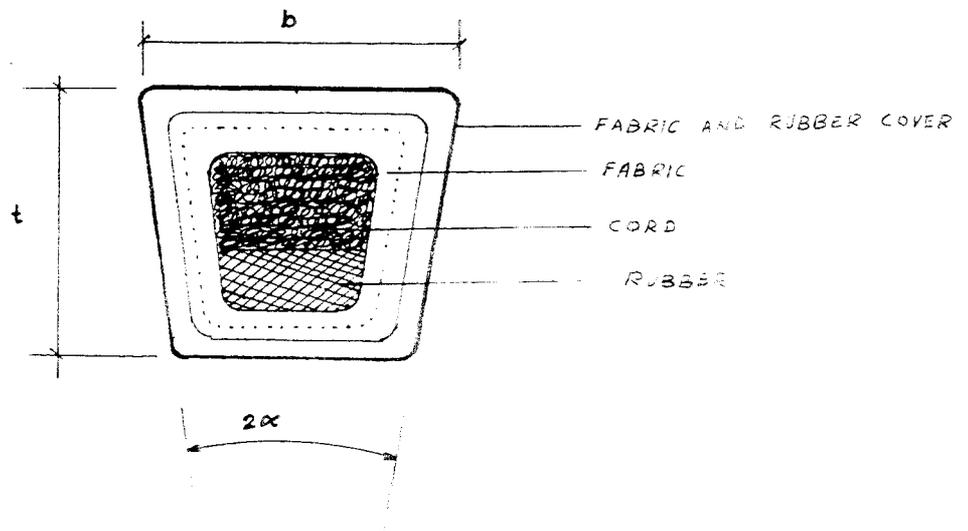
Holes are drilled in the channels by looking through centre distance of plummer holes, plummer block centres and also the holes provided in the motor base.

The diameter of holes is 17 mm each to enable m16 studs to get into.

9.6 SELECTION OF V-BELT

V-BELT DRIVE

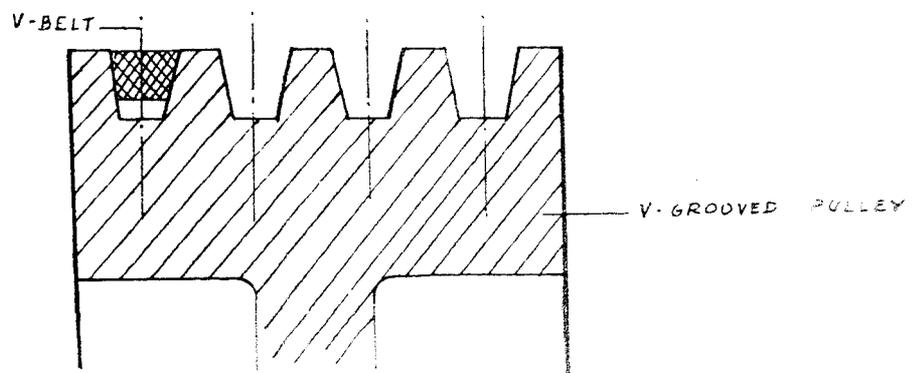
The V-belts are made of fabric and moulded in rubber and covered with fabric and rubber as shown in fig(i).



These are particularly suitable for short drives i.e. when the shafts are at a short distance apart. The included angle

for the V-belt is axially from 30-40°. In case of flat belt drive the belt runs over the pulleys where as in case of V-belt drive the rim of the pulley is grooved in which the V-belt drives. The effect of the groove is to increase the frictional grip of the V-belt on the pulley and thus to reduce the tendency of slipping. In order to have a good grip on the pulley, the V-belt is in contact with the side faces of the groove and not at the bottom. The power is transmitted by the wedging action between the belt and the V-groove in the pulley.

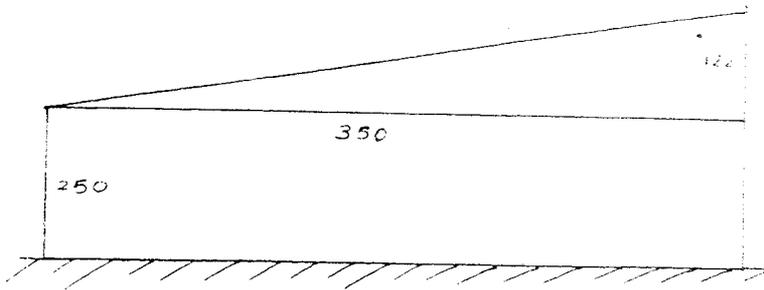
A clearance must be provided at the bottom of the groove as shown in the fig.(ii) in order to prevent touching of the bottom as it becomes narrower from wear.



The V-belt drive may be inclined at any angle with tight side either at top or bottom. In order to increase the power output several V-belts may be operated side by side. It may be noted that in multiple V-belt drive, all the belts should stretch at the same rate so that the load is equally divided between them. When one of the set of

belts break, the entire set should be replaced at the same time. If only one belt is replaced the new unworn and unstretched belt will be more tightly stretched and will move the different velocity.

FOR MOTOR TO SHAFT



Allowing a distance of 350 mm to the floor level between two pulleys, the centre distance between them will be

$$\sqrt{(350^2 + 122^2)} = 371 \text{ mm}$$

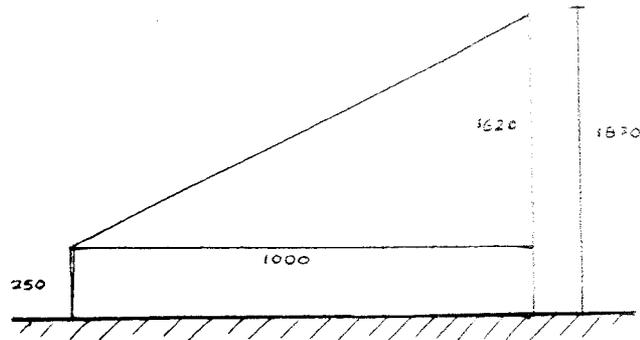
As these pulleys are of same size 250 PCD the belt pitch length comes to be

$$L = 2e + \frac{\pi}{2}(D+D) = 1526.7 \text{ mm}$$

But referring to std. fenner V-belt manual the std. pitch length available is 1530 mm.

The centre distance for this length is 372 mm which will result in 352 mm parallel to the floor level between their centres. The specification of this belt is C58.

FOR SHAFT TO MACHINE



The centre distance is calculated by allowing a base distance of 1000 mm between pulley centre and shaft centre which is equal to

$$\sqrt{(1000^2 + 1620^2)} = 1904 \text{ mm}$$

For this centre distance and pulleys 250 PCD & 400 PCD the length of the belt is calculated using the formula

$$L = 2e + \frac{\pi}{2}(D+d) + \frac{(D-d)^2}{4e}$$

$$= 4832 \text{ mm}$$

But standard availability from fenner manual is 4870 mm.

For this length the centre distance comes to be 1925.09 mm.

For this centre distance the floor level distance between shaft centre and m/c pulley centre comes to 1040 mm. Since the m/c boundary is at 440 mm from the m/c pulley centre, the shaft has to be placed 600 mm away from the m/c boundary.

The specification of this belt is B 190.

**MAXIMUM RECOMMENDED
RETAIL PRICES**

**FENNER PRECISION BUILT / P/B
PREMIUM QUALITY V-BELTS
STANDARD SIZES**

**EFFECTIVE DATE
19th August 1991**

A SECTION 13 X 8 mm

Symbol No.	Pitch length (in mm)	Price Each (Rs. P)	Symbol No.	Pitch length (in mm)	Price Each (Rs. P)	Symbol No.	Pitch length (in mm)	Price Each (Rs. P)	Symbol No.	Pitch length (in mm)	Price Each (Rs. P)
A19	(520)	40.20	A45	(1180)	59.00	A72	(1860)	77.60	A100	(2450)	114.10
A20	(540)	40.40	A46	(1200)	59.70	A73	(1890)	78.90	A105	(2550)	117.80
A21	(570)	40.60	A47	(1230)	60.30	A74	(1920)	79.60	A107	(2600)	121.00
A22	(590)	40.80	A48	(1250)	62.20	A75	(1940)	80.20	A108	(2650)	123.10
A23	(620)	40.90	A49	(1280)	62.90	A76	(1960)	81.50	A110	(2700)	125.90
A24	(640)	41.10	A50	(1300)	63.30	A77	(1990)	82.70	A112	(2800)	130.20
A25	(670)	41.60	A51	(1330)	63.50	A78	(2020)	83.40	A115	(2900)	135.00
A26	(700)	41.80	A52	(1360)	64.80	A79	(2050)	84.70	A116	(2950)	136.30
A27	(720)	42.60	A53	(1380)	65.00	A80	(2070)	85.40	A118	(3000)	138.80
A28	(740)	43.90	A54	(1410)	65.50	A81	(2090)	86.70	A120	(3050)	137.30
A29	(770)	44.60	A55	(1430)	65.70	A82	(2120)	86.90	A124	(3150)	141.80
A30	(790)	44.70	A56	(1460)	66.10	A83	(2140)	87.20	A125	(3200)	144.80
A31	(820)	45.50	A57	(1480)	66.80	A84	(2170)	87.70	A128	(3300)	153.00
A32	(850)	46.20	A58	(1510)	67.20	A85	(2200)	88.60	A130	(3350)	154.10
A33	(870)	47.70	A59	(1530)	68.00	A86	(2220)	97.50	A134	(3450)	158.80
A34	(890)	48.10	A60	(1550)	71.30	A87	(2240)	98.80	A136	(3500)	162.30
A35	(920)	50.70	A61	(1580)	71.60	A88	(2270)	100.10	A140	(3600)	167.80
A36	(950)	51.90	A62	(1610)	71.80	A89	(2300)	101.30	A144	(3700)	174.30
A37	(970)	53.10	A63	(1640)	72.20	A90	(2320)	102.60	A158	(4070)	176.80
A38	(990)	53.40	A64	(1660)	72.50	A91	(2350)	103.70	A160	(4100)	177.90
A39	(1020)	53.60	A65	(1690)	73.20	A92	(2370)	105.10	A162	(4150)	179.30
A40	(1050)	54.30	A66	(1710)	73.40	A93	(2400)	106.40	A168	(4300)	182.10
A41	(1070)	55.70	A67	(1740)	73.80	A94	(2420)	107.70	A173	(4400)	188.40
A42	(1100)	56.30	A68	(1760)	74.50	A95	(2450)	108.20	A174	(4450)	191.20
A43	(1130)	57.50	A69	(1790)	75.70	A96	(2480)	109.60	A180	(4600)	192.40
A44	(1150)	58.20	A70	(1810)	76.30	A97.5	(2500)	110.90			
A44.5	(1160)	58.50	A71	(1840)	77.00	A98	(2520)	112.20			

B SECTION 17 X 11 mm

20	(550)	50.20	B49	(1290)	77.60	B79	(2050)	109.70	B120	(3300)	187.50
21	(580)	50.70	B50	(1310)	78.70	B80	(2070)	111.50	B122	(3400)	190.80
22	(600)	51.50	B51	(1340)	78.90	B81	(2100)	112.90	B124	(3500)	195.10
23	(630)	51.90	B52	(1370)	79.60	B82	(2130)	115.50	B128	(3600)	199.40
24	(650)	52.50	B53	(1390)	80.20	B83	(2150)	116.20	B130	(3700)	204.70
25	(680)	53.20	B54	(1410)	82.70	B84	(2180)	116.40	B132	(3800)	204.40
26	(700)	55.10	B55	(1440)	85.40	B85	(2200)	116.70	B134	(3900)	206.80
27	(730)	55.80	B56	(1460)	85.90	B86	(2230)	133.40	B136	(3950)	208.10
28	(750)	56.40	B57	(1490)	86.60	B87	(2250)	135.90	B140	(4050)	217.30
29	(780)	57.10	B58	(1510)	87.20	B88	(2280)	137.90	B142	(4100)	221.00
29.5	(790)	59.70	B59	(1540)	88.90	B89	(2300)	139.20	B144	(4200)	223.60
30	(800)	60.30	B60	(1560)	89.50	B90	(2330)	140.50	B146	(4300)	235.30
31	(830)	61.40	B61	(1590)	90.60	B91	(2350)	143.70	B148	(4350)	236.60
32	(860)	61.50	B62	(1620)	91.70	B92	(2380)	145.00	B150	(4400)	237.90
33	(880)	61.60	B63	(1640)	93.00	B93	(2400)	145.60	B152	(4500)	241.10
34	(910)	61.80	B64	(1670)	94.30	B94	(2430)	147.60	B156	(4600)	244.30
35	(930)	61.90	B65	(1690)	95.60	B95	(2450)	147.80	B158	(4700)	246.80
36	(960)	62.70	B66	(1720)	95.80	B96	(2480)	148.30	B162	(4800)	252.00
37	(980)	63.90	B66.5	(1730)	96.30	B97	(2500)	148.60	B168	(4900)	259.80
38	(1000)	64.80	B67	(1750)	96.50	B98	(2530)	148.80	B169	(5000)	261.40
39	(1030)	65.80	B68	(1760)	96.70	B100	(2580)	152.80	B173	(5100)	262.30
40	(1060)	67.10	B69	(1800)	98.10	B102	(2630)	153.30	B180	(5300)	267.40
41	(1080)	68.30	B70	(1820)	98.50	B104	(2680)	160.50	B190	(5400)	291.30
42	(1100)	69.00	B71	(1850)	99.40	B105	(2700)	161.70	B195	(5500)	295.20
43	(1130)	70.20	B72	(1870)	100.80	B108	(2790)	168.20	B210	(5700)	311.30
44	(1160)	71.20	B73	(1900)	103.80	B110	(2840)	171.40	B238	(6000)	322.40
45	(1180)	73.20	B74	(1920)	104.00	B112	(2890)	175.90	B275	(6300)	334.10
46	(1210)	73.90	B75	(1950)	104.50	B115	(2960)	183.00	B275.5	(6400)	335.00
47	(1240)	75.70	B76	(1970)	105.30	B116	(2990)	184.30	B275.6	(6500)	338.20
48	(1260)	76.30	B77	(2000)	107.10	B117	(3020)	185.60			
48.5	(1280)	77.00	B78	(2020)	109.10	B118	(3040)	186.20			

C SECTION 22 X 14 mm

C36	(980)	101.40	C57	(1510)	129.50	C78	(2040)	162.70	C144	(2710)	333.40
C37	(1000)	101.50	C58	(1530)	130.20	C79	(2070)	165.20	C150	(2870)	336.40
C38	(1030)	101.60	C59	(1560)	130.40	C80	(2090)	167.90	C152	(2920)	336.60
C39	(1050)	101.90	C60	(1580)	130.80	C81	(2110)	168.30	C158	(3050)	337.60
C40	(1070)	102.00	C61	(1610)	132.80	C85	(2200)	171.10	C162	(3170)	340.90
C41	(1100)	102.20	C62	(1630)	134.00	C90	(2340)	193.30	C173	(3450)	353.90
C42	(1120)	102.40	C63	(1650)	135.30	C93	(2420)	205.50	C180	(3530)	360.90
C43	(1150)	102.70	C64	(1680)	137.80	C96	(2490)	215.30	C185	(3760)	387.30
C44	(1170)	104.10	C65	(1700)	139.90	C100	(2600)	226.30	C190	(3890)	399.60
C45	(1200)	106.40	C66	(1740)	141.80	C105	(2720)	241.00	C195	(4010)	408.70
C46	(1230)	114.10	C67	(1760)	142.90	C108	(2800)	250.10	C204	(4240)	414.40
C47	(1260)	114.30	C68	(1780)	144.20	C112	(2900)	262.60	C210	(4350)	425.90
C48	(1280)	114.60	C69	(1810)	145.60	C116	(3000)	265.20	C225	(4770)	464.00
C49	(1300)	114.80	C70	(1840)	147.10	C118	(3050)	269.80	C238	(4900)	486.60
C50	(1330)	115.20	C71	(1860)	148.00	C120	(3100)	273.00	C268	(4950)	551.00
C51	(1350)	115.50	C72	(1890)	149.70	C124	(3210)	277.80	C298	(4960)	614.10
C52	(1380)	116.10	C73	(1910)	151.60	C126	(3260)	281.70	C318	(4990)	679.90
C53	(1400)	117.90	C74	(1940)	152.90	C128	(3310)	284.20	C358	(5170)	763.70
C54	(1430)	118.40	C75	(1950)	154.20	C130	(3360)	313.20	C418	(10570)	1020.80
C55	(1450)	119.20	C76	(1990)	157.40	C136	(3520)	317.10			
C56	(1480)	124.40	C77	(2010)	158.70	C140	(3610)	319.00			

D SECTION 32 X 19 mm

D75	(1990)	373.20	D144	(3730)	556.60	D210	(5400)	809.70	D350	(9990)	1813.60
D88	(2320)	414.40	D158	(4080)	608.50	D238	(6120)	929.80	D418	(10700)	1938.20
D90	(2370)	414.70	D162	(4190)	620.50	D268	(6890)	1057.70	D450	(11510)	2088.70
D90.5	(2380)	415.00	D173	(4470)	659.80	D298	(7650)	1186.70	D478	(12200)	2211.60
D95	(2500)	415.10	D180	(4650)	680.70	D314	(8060)	1255.00	D538	(13700)	2484.90
D120	(3130)	447.20	D195	(5030)	743.90	D328	(8410)	1315.70	D558	(15200)	2761.00
D128	(3330)	484.60	D204	(5260)	783.80	D358	(9070)	1443.50			

E SECTION 38 X 23 mm

E180	(4660)	1302.10	E268	(6850)	1923.70	E394	(10100)	2981.30	E598	(15280)	4144.50
E195	(5040)	1408.00	E298	(7650)	2134.20	E418	(10710)	3101.90			
E210	(5420)	1514.50	E328	(8430)	2346.00	E478	(12230)	3404.40			
E238	(6100)	1710.60	E358	(9150)	2558.40	E538	(13750)	3827.60			

BB SECTION

BB75	141.10	BB83	173.30	BB90	232.70	BB115	305.90
BB80	149.70	BB85	219.00	BB96	247.50	BB120	315.60
						BB136	344.10

- NOTE :**
1. At Present sizes upto 150 of A,B & C sections are precision built belts and can be identified with **PIB** marking on the belts
 2. In between sizes not listed above can also be supplied on request, provided minimum quantity prescribed by the company is ordered for.
 3. All prices are subject to alteration without notice. Local taxes and duties extra. Wholesaler/export orders are free to sell at lower prices.

BRANCH/AREA OFFICES :

AHMEDABAD BANGALORE BOMBAY
 CALCUTTA CUTTACK DELHI
 INDORE JAIPUR KANPUR LUDHIANA
 MADRAS MADURAI SECUNDERABAD.

CENTRAL MARKETING OFFICE :

9-1-87, SAROJINI DEVI ROAD,
 SECUNDERABAD - 500 003
 TEL. 822299, 825727
 TELEX. 0425 - 6875 FENR IN.
 GRAM : FENNERIND

REGD. OFFICE :

3, MADURAI - MELAKKAL ROAD, MADURAI - 625 016.

9.7 DESIGN OF KEYS

(1) For motor pulley: For this 50 mm hole the std availability from PSG DDB is 10 x 16 cross section. The length may be taken considerably the rim width. (ie) the length = 70 mm.

Checking for shear failure

Torque transmitted = 18 Kgf.m

$$\begin{aligned}\text{Shear stress} &= \frac{T}{b \times l \times d/2} \\ &= \frac{18 \times 10^3}{70 \times 16 \times 50/2} = .645 \text{ Kgf/mm}^2\end{aligned}$$

This .645 is well below the value 10 Kgf/mm² that is the shear stress for the key material ms.

Crushing failure

$$\begin{aligned}\text{Crushing stress} &= \frac{T}{l \times (d/2) \times (d/2)} \\ &= \frac{18 \times 10^3}{70 \times 5 \times 25} = 2.05 \text{ Kgf/mm}^2\end{aligned}$$

This is well below the value 15 Kgf/mm² which is the crushing stress for the key material ms. Hence the key dimension are safe.

(2) For drive pulley on shaft

Here the key length reduces to 45 mm as the rim width reduces to 40 mm. And the cross section remains same as the diameter remains 50 mm.

Checking shear failure

$$f_s = \frac{T}{b \times l \times d/2}$$

$T = 18 \text{ Kgf-m}$
 $b = 16$
 $l = 40$
 $d = 50$

$$f_s = 1.125 \text{ Kgf/mm}^2$$

This is well less than the f_s value of mild steel.

Checking crushing failure

$$f_c = \frac{T}{l \times t/2 \times d/2} = 3.2 \text{ Kgf/mm}^2$$

This is very well less than the f_c value of mild steel and hence this key is safe in its dimensions.

(3) For m/c pulley

As per preferred dimensions from PSG DDB here also the selection is 16x10x70 for the 50 mm shaft.

Checking shear failure

$$f_s = \frac{T}{l \times b \times d/2} = .96 \text{ Kgf/mm}^2$$

$$T = 27 \text{ Kgf-m}$$

$$l = 70 \text{ mm}$$

$$b = 16 \text{ mm}$$

$$d = 50 \text{ mm}$$

The f_s value is safely below the f_s value of m_s and hence the key is safe in design.

Checking crushing failure

$$f_c = \frac{T}{l_x t / 2 \times f / 2} = 3.1 \text{ Kgf/mm}^2$$

This value is well below the f_e value of m_s and hence the design is safe.

9.8 DESIGN OF COUNTER ASSEMBLY

This is to count the number of revolutions of machine pulley.

This constituted 2 parts namely the transducer and the counter cum display set.

Transducer Set

The transducer set, is for the generation of clock pulse corresponding to the revolutions of the machine pulley. The transducer set constituted a metal obstacle and proximity switch.

Proximity switch : This is a magnetically operated pulse generator. The principle of which is that when the obstacle crosses the face of the proximity switch a magnetic

switch which is very sensible inside the proximity switch gets closed thereby giving out a clock pulse.

The obstacle is kept at about 500 mm away from the face of the switch. The obstacle is rigidly welded to the m/c pulley so that when the pulley rotates a clock pulse is generated for each revolution of the m/c pulley. The clock pulse is given at the clock input of the counter circuit which is explained next.

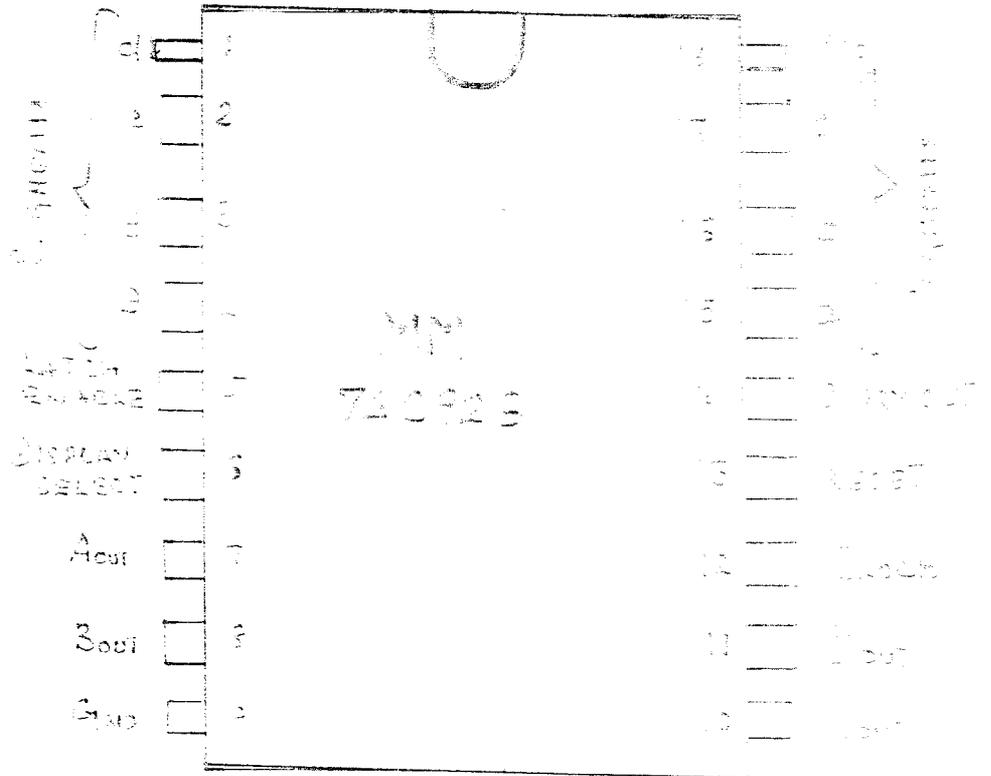
Counter cum Display set

A simpler counter display circuit can be constructed using IC 74C926.

74C926 is an advanced technology which comprises a 4-digit counter, an internal output latch and npn sourcing driver for 7-segment display. It has an internal multiplexing circuitry with four multiplexed outputs. The multiplexing circuit has its own free running oscillator and requires no external clock.

The CMOS integrated circuit is an 18-pin, dual-in-line package. It has four decade counters, latch and reset inputs. A CARRY OUT pin is available for cascading counters. This pin is essential for increasing a number of digits from four to eight or more.

PIN CONFIGURATION OF 74C923



PIN CONFIGURATION OF
IS 74C923

The counters advance on negative edge of the clock. A high signal on the reset input resets the counter to zero. A low signal on LATCH ENABLE input latches the count at the output. A high signal on DISPLAY SELELCT input selects the number in the counter to be displayed. A low signal selects the number in the output latch to be displayed.

The IC has input protection circuitry consisting of a series resistor and a diode connected to ground. The input should not be allowed to exceed 15V. The display used for this chip is 7-segment common cathode type.

The functional description of pins is given here.

RESET : Asynchronous, active high.

DISPLAY SELECT : Active high displays out of counter.

Active low displays out of latch.

LATCH ENABLE : Active low latches the condition

Active high flows through condition.

IC 74C926 features a wide range of supply from 3V to 6V, guaranteed noise margin of IV, high noise immunity and high sourcing current for segments.

The chip is manufactured by National Semiconductor, USA, and is easily available in India for around Rs.100. It replaces conventional counter decoder and latch ICs, thereby minimising the circuit configuration and cost.

Parts list for the Counter circuit

Semiconductors

ICI - 74C926 4-digit counter
T1-T4 - SL100 npn drive transistor
DLS1-DLS4 - FND500 common cathode, 7 segment display

Resistors (1/4 watt \pm 5% carbon)

R1-R4 - 1 Kilo ohm
R5-R11 - 56 Ohm
R12 - R13 - 100 Kilo ohm

Miscellaneous

S1 - Push-to-on switch
- PCB, IC, sockets, hardware etc.

9.9 DESIGN OF BELT GUARD

A belt guard is locally fabricated for our requirement and is attached to the machine by hinges to ease its maintainance.

10. INSTALLING THE SYSTEM

1) First, the floor work is carried out as per the DRG.No.10. At the holes shown in the diagram M16 studs are concreted in the floor.

2) The channel-I is mounted over Bed I & II. 2 Nos. of channel I are mounted at Bed II & III. The other 2 nos. of channel-II are inverted and placed on bed IV & V.

3) The centre plummer blocks are placed over the channels and bolted.

4) The shaft is mounted on the plummer blocks and the plummer blocks are aligned such that the shaft seats perfectly on the bushes.

5) The cap of the plummer blocks are replaced and bolted.

6) The pulleys are mounted on the shaft & keyed.

7) The motor is placed on the bed IV & V and bolted.

8) The motor pulley is mounted on the motor shaft and keyed.

9) The alignment of which are mounted on the shaft and the m/c pulleys is done. They are keyed to the shaft tightly.

10) The belts are assembled over the pulleys.

11) The end plummer blocks are then mounted to shaft & bolted.

12) The proximity switch is fixed to the m/c at a suitable place where the obstacle namely the metal strip welded on to the m/c pulley crosses through the switch face.

13) Finally the wiring is done to the motor and the switch. Switch is fixed to the control panel.

14) Power connections are given between the counter assembly and the transducer.

11. METHOD OF OPERATION OF THE NEW SYSTEM

11.1 INITIAL ADJUSTMENTS

Detachable end belt is removed. By switching on the other machine pulley, the pressure roller is set parallel to the machine surface. This is done by checking with spirit level. The detachable end belt is mounted over the machine pulley.

11.2 OPERATION

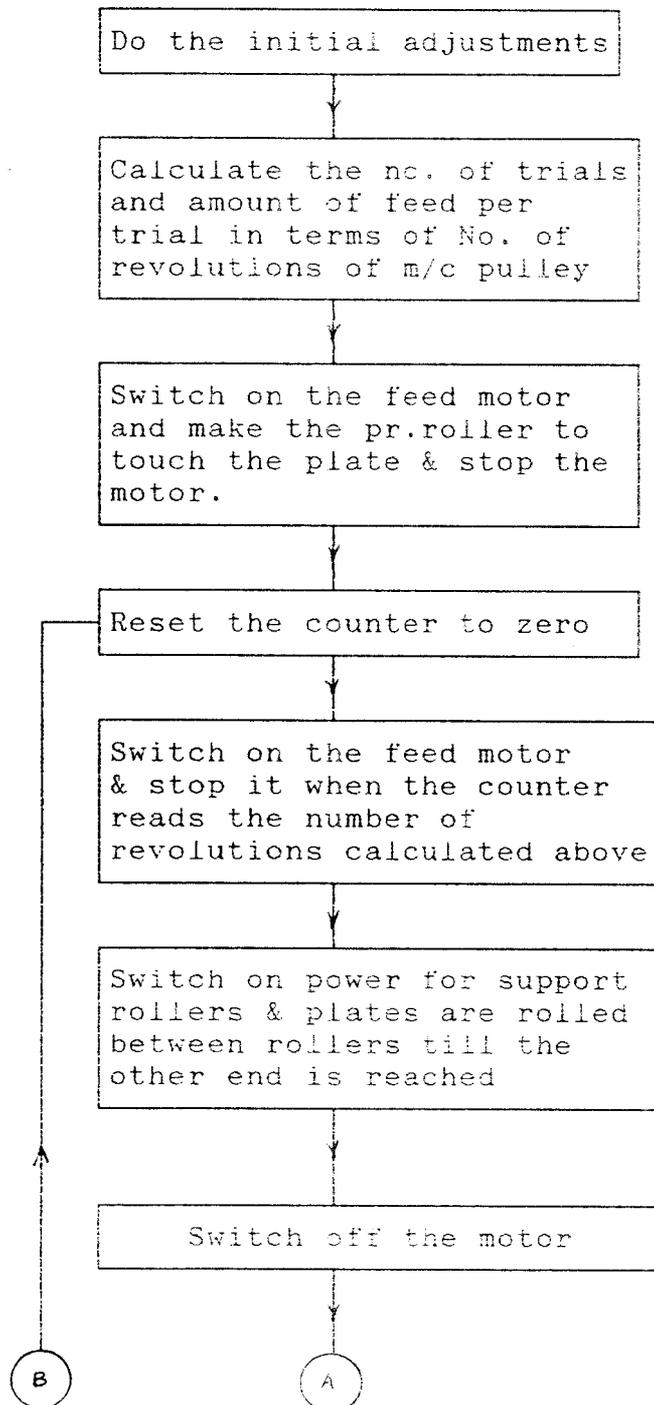
The plate which is to be processed is fed in between the rollers by means of over head crane. The feed motor is switched on. It is switched off when the pressure roller touches the plate. The counter is reset. Using the formula given in the earlier pages the amount of feed, in terms of number of revolution of machine pulley, per attempt or trial is calculated.

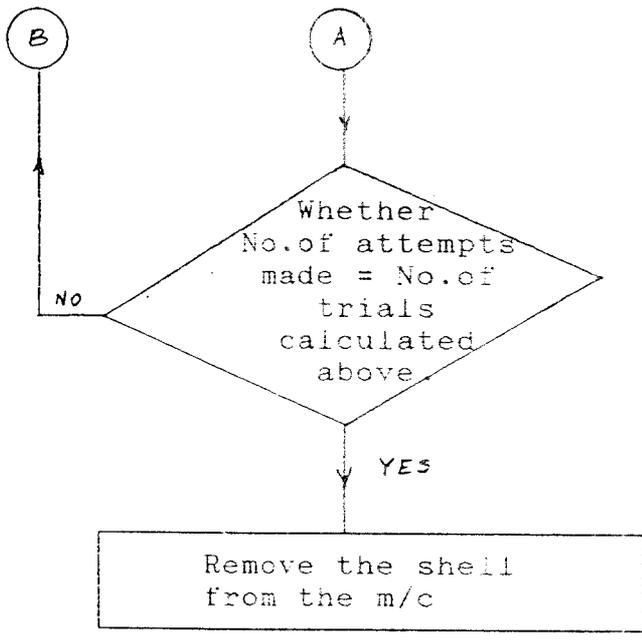
Now the feed motor is again switched on and is stopped when the counter reaches required no. of revolutions. Now, the feed rollers are run by power and the plate gets rolled between rollers. The process is stopped when the other end of the plate is reached.

Again, the feed motor is switched and the above process is carried out for the number of attempts already calculated by using the early formulae. Thus, shell is fabricated from the plate by trials.

The belt and the detachable ends are removed and the shell is removed from m/c.

11.3 FLOW CHART OF NEW METHOD OF OPERATION





12. OPERATING INSTRUCTIONS

- * The pressure roller should be exactly set parallel to the m/c surface before operation.

- * The counter should be reset to zero before every feed of pressure roller.

- * Close the belt guard when the m/c is under operation

- * Both motors should not be operated at the same time.

13. MERITS AND DEMERITS OF THE SYSTEM

MERITS

1. Comparatively faster and reliable in operation.
2. Movement of the feed roller is controlled
3. The labour cost is reduced.
4. From the various experimental trials it was found that the bending was accurate than the earlier operation.
5. Adaptability to various thickness.
6. Maintenance cost is low.
7. Smooth operation with respect to various parts.
8. Low cost the parts like pulley, shaft of the machine are made out of the scrap materials available in the industry campus.

DEMERITS

1. To take out the shell every time after the operation, the belt is to be slipped off.
2. There occurs a negligible unavoidable slip between belt and pulley.

14. FUTURE DEVELOPMENTS

To achieve precised synchronization of 2 pulleys, stepper or servo mechanism aided by a microprocessor can be used by having individual motors at either ends.

A CNC control can be introduced on the above system, which will take care of the number of trials, rate of feed automatic switching of the two motors. The operator's work is only to feed the values of plate dimensions and diameter of shell to be made.

15. COST ESTIMATION

Machined Components

S.No	Name of the components	Qty	Machining Cost per hour Rs	Machining Per hour	Net Cost Rs.
1.	Machine pulley	2	40	5	400.00
2.	Drive pulley	2	40	5	400.00
3.	Motor pulley	2	40	7	500.00
4.	Drive shaft	1	100	15	1500.00
5.	Channel-I	2	20	1	40.00
6.	Channel-II	4	20	0.5	40.00
					----- 2880.00

Purchased Items

Sno.	Name of the Items	Qty	Cost per Item	Net Cost Rs
1.	50 mm Plummer Block	2	300	600.00
2.	75 mm Plummer Block	3	400	1200.00
3.	Fenner V-Belt B-190	2	291.30	582.60
4.	Fenner V-Belt C-58	2	130.20	260.40
5.	M-160 Stud nut set	14	10.00	140.00
6.	M-16 Bolt nut set	14	18.00	252.00
				----- 2895.00
Installing cost				500.00
Miscellaneous				605.00
Total Cost				5000.00

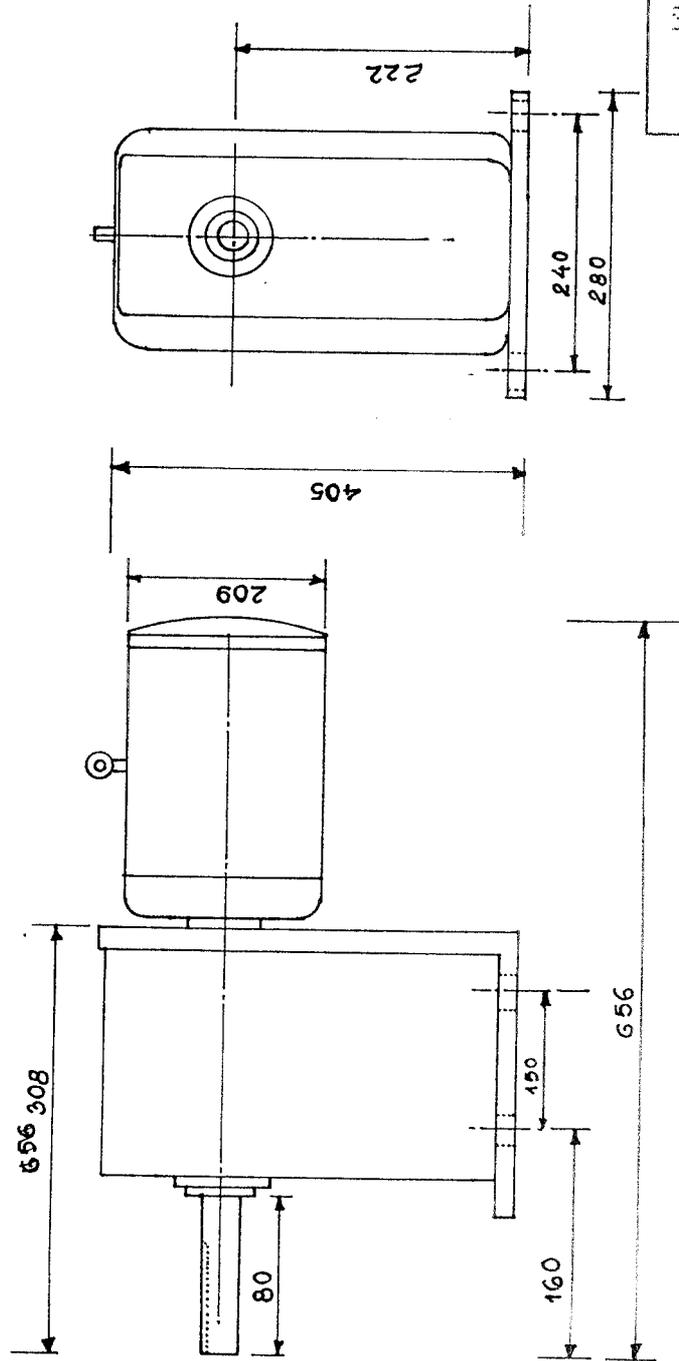
16. CONCLUSION

By introduction of this special innovative driving system adequate benefits will surely be derived by the industrial unit.

It is obvious that the other units will also adopt this technique wherever such machines carry out normal operation.

BIBLIOGRAPHY

1. Theory of plates and shell
- Timo Shinko
McGraw Hill International Edition
2. Strength of Materials
- Ramamrutham
3. Strength of Materials
- R.S.Kurmi
4. Theory of Machines
- Balleny
5. Theory of Machines
- R.S.Kurmi
7. PSG Design Data Book
8. Production Technology
- R.K.Jain
9. Industrial Product Finder
- Edition 1988-89
1989-90
1991-92
10. Fenner V-Belt Manual
11. WITCO Industrial Motor Manual
12. SKF Standard Plummer Block Manual
13. ISI Standard Hand Book
14. Electronics for you
- January 1988 Edition



KUMHARAGURU COLLEGE OF
TECHNOLOGY

MATERIAL: DRIVE MOTOR
3 HP/120 R.P.M.

ALL DIMNS.
IN MM.

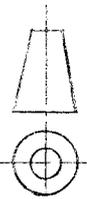
QTY.: 1

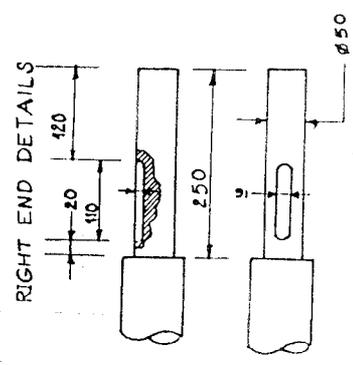
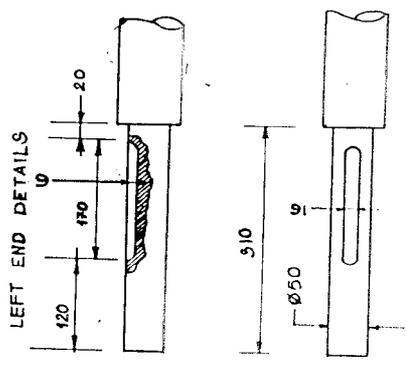
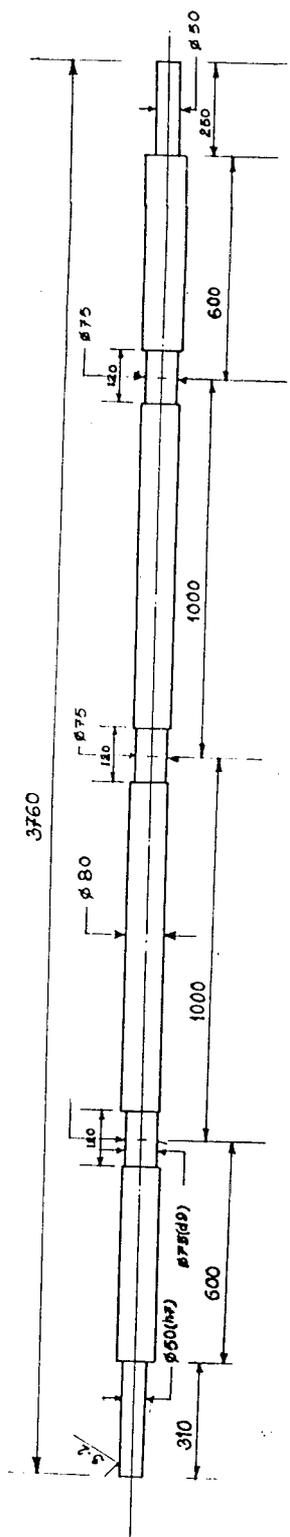
B.E.

PROJECT WORK

DRG. NO:
1

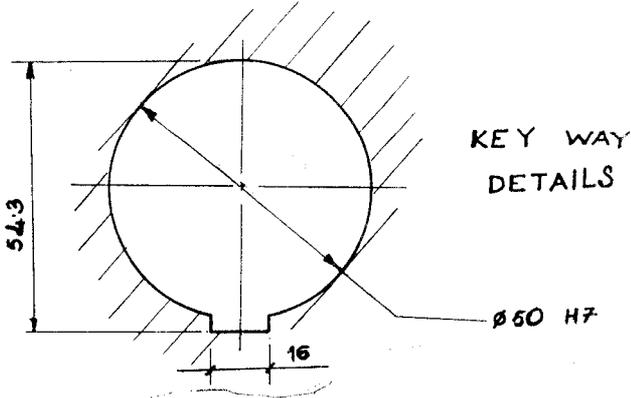
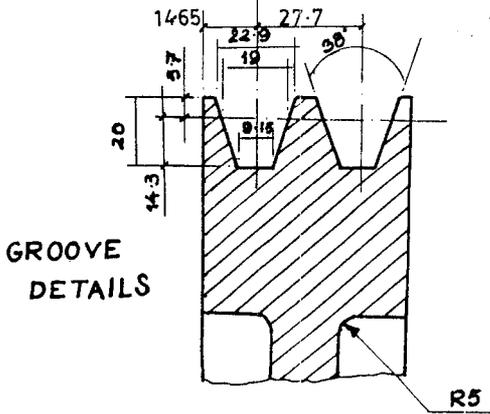
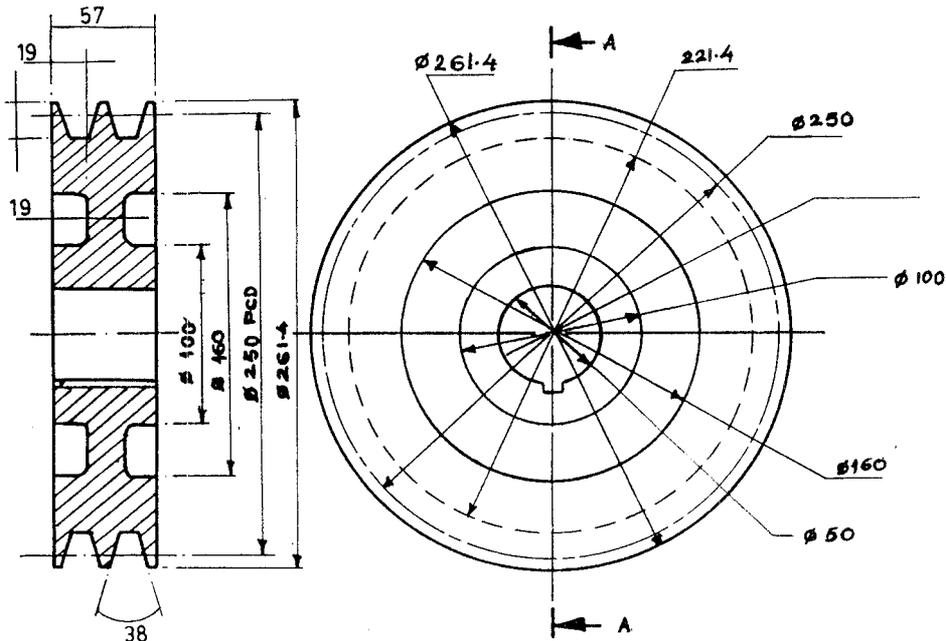
1991-92





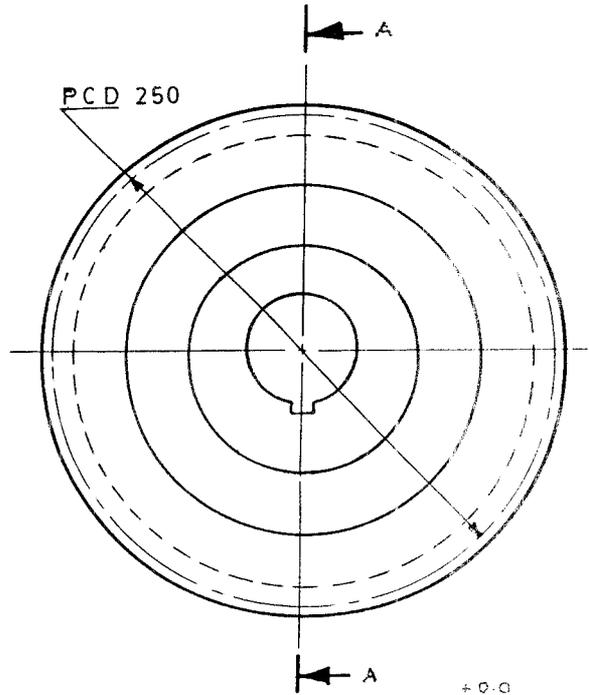
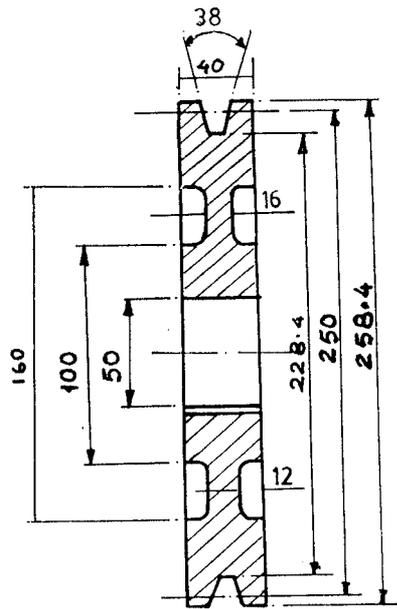
KUMHARIGURU COLLEGE OF TECHNOLOGY		DRIVE SHAFT	ALL DIMS. IN MM.
MATERIAL: EN8D	QTY.: 1	B.E.	PROJECT WORK
		1991-92	

SEC. "A-A"

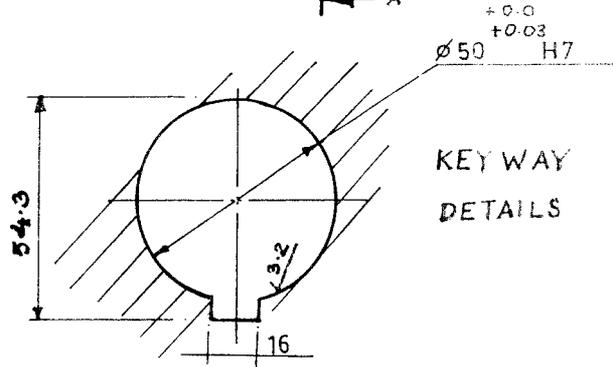
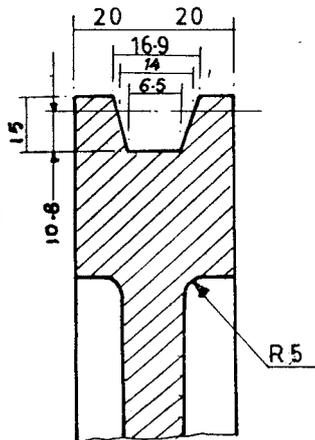


KUMARAGURU COLLEGE OF TECHNOLOGY		
MATERIAL: MS.	MOTOR PULLEY	ALL DIMNS. IN MM.
QTY. = 2	B. E.	
DRG. NO: 3	PROJECT WORK 1991-92	

SEC - A - A

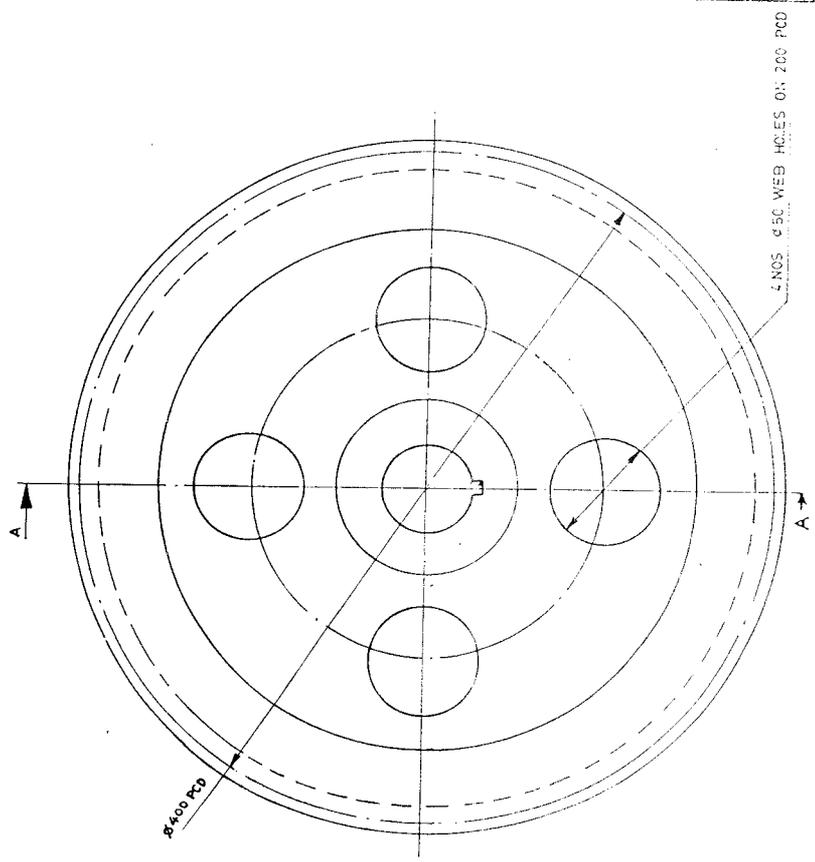
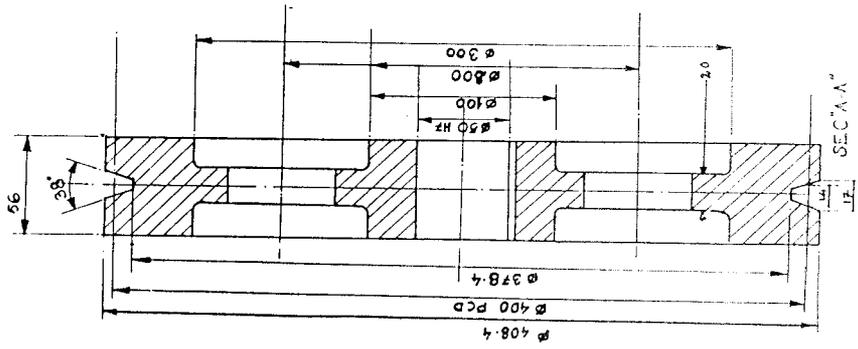


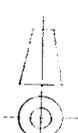
GROOVE DETAILS

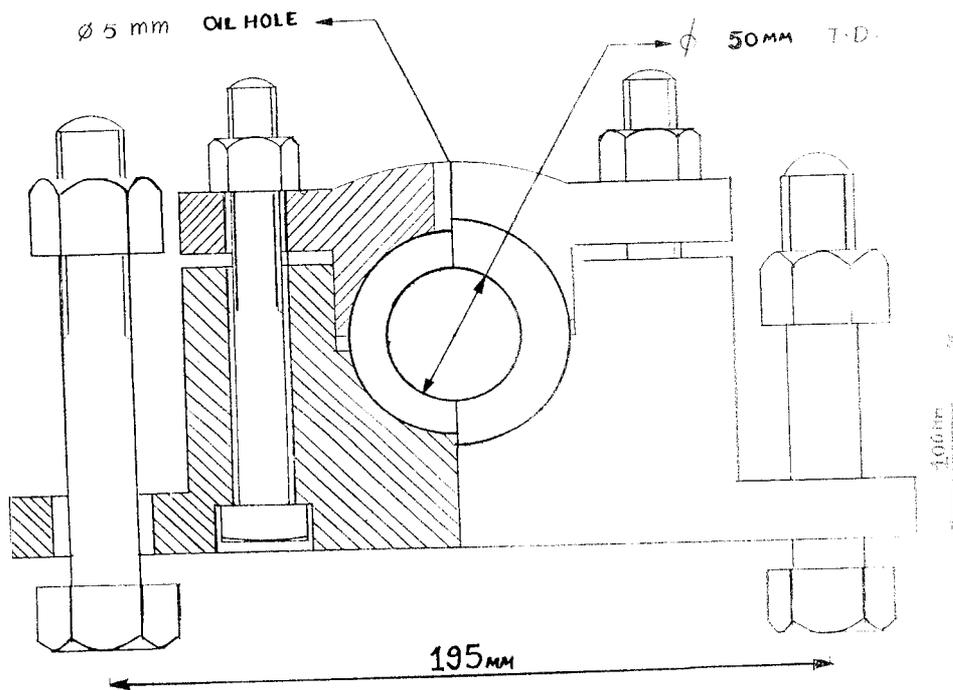


KEY WAY
DETAILS

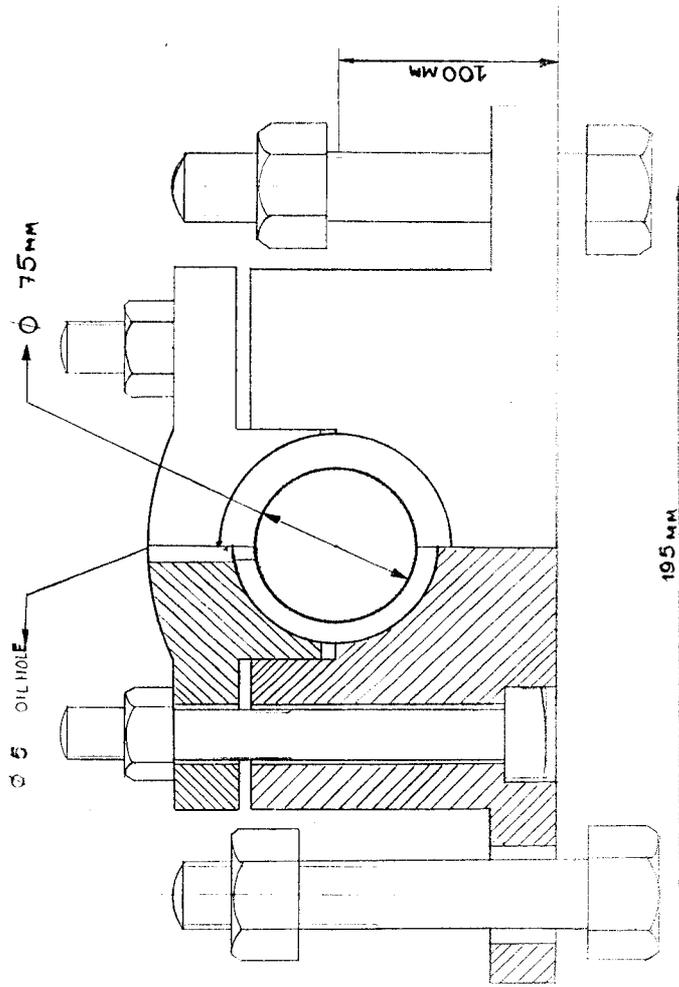
KUMARAGURU COLLEGE OF TECHNOLOGY		
MATERIAL: MS.	DRIVE PULLEY	ALL DIMNS. IN MM.
QTY.: 2	B.E.	
DRG. NO: 4	PROJECT WORK 1991 - 92	



KUMARIGURU COLLEGE OF TECHNOLOGY		
MATERIAL: MACHINE MS		
PROJECT: MACHINE PULLEY IN MS		E.E. PROJECT WORK 1991-92
QTY.: 2	DRG. NO: 5	



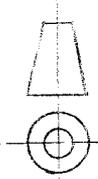
KUMARAGURU COLLEGE OF TECHNOLOGY		
MATERIAL: C.I	$\phi 50 \text{ mm}$ PLUMMER BLOCK	ALL DIMS. IN MM.
QTY.: 2	B.E.	
DRG. NO: 6	PROJECT WORK, 1991-92	



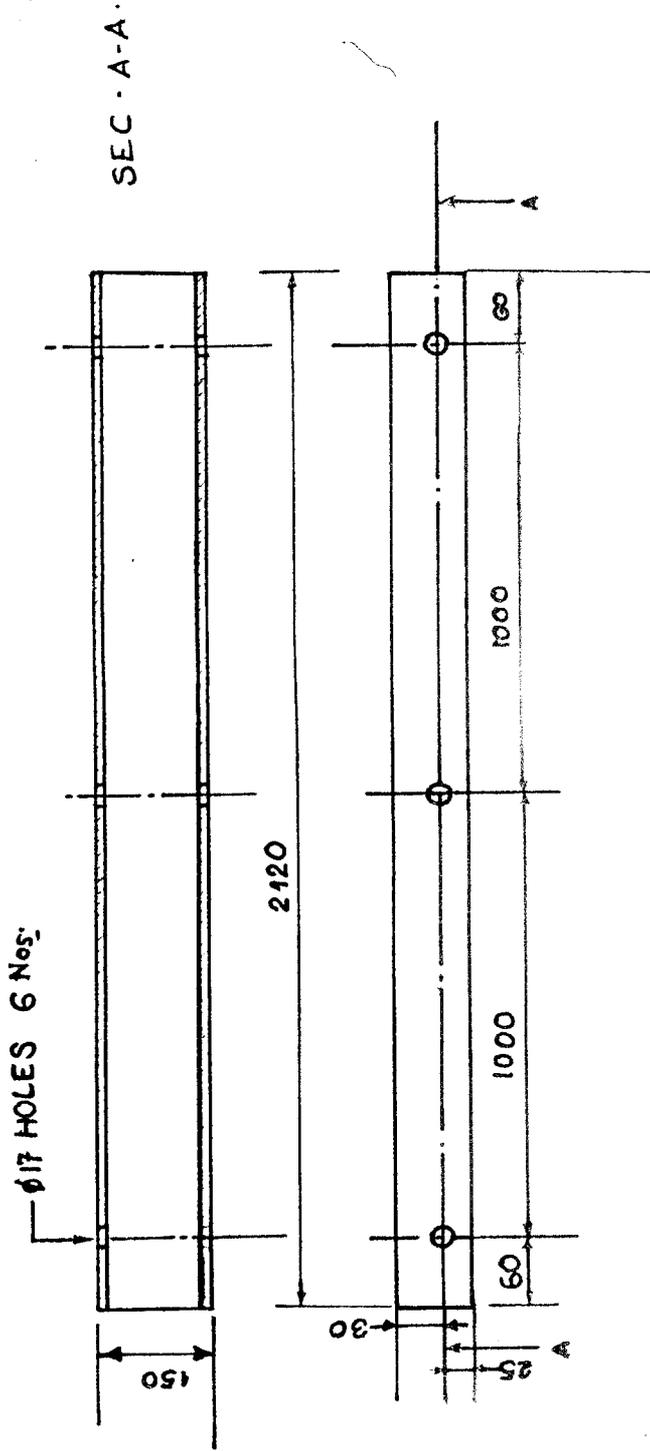
KUMARAGURU COLLEGE OF
TECHNOLOGY

MATERIAL: $\phi 75$ mm
C.I. PLUMMER BLOCK
IN MFL

QTY.: 3



DRG. NO: 7
B.E. PROJECT WORK,
1991-92.



KUNARAGURU COLLEGE OF
TECHNOLOGY

MATERIAL: CHANNEL - II
ROLLED STEEL

ALL DIMNS.
IN MM.

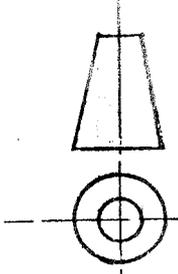
QTY.: 4

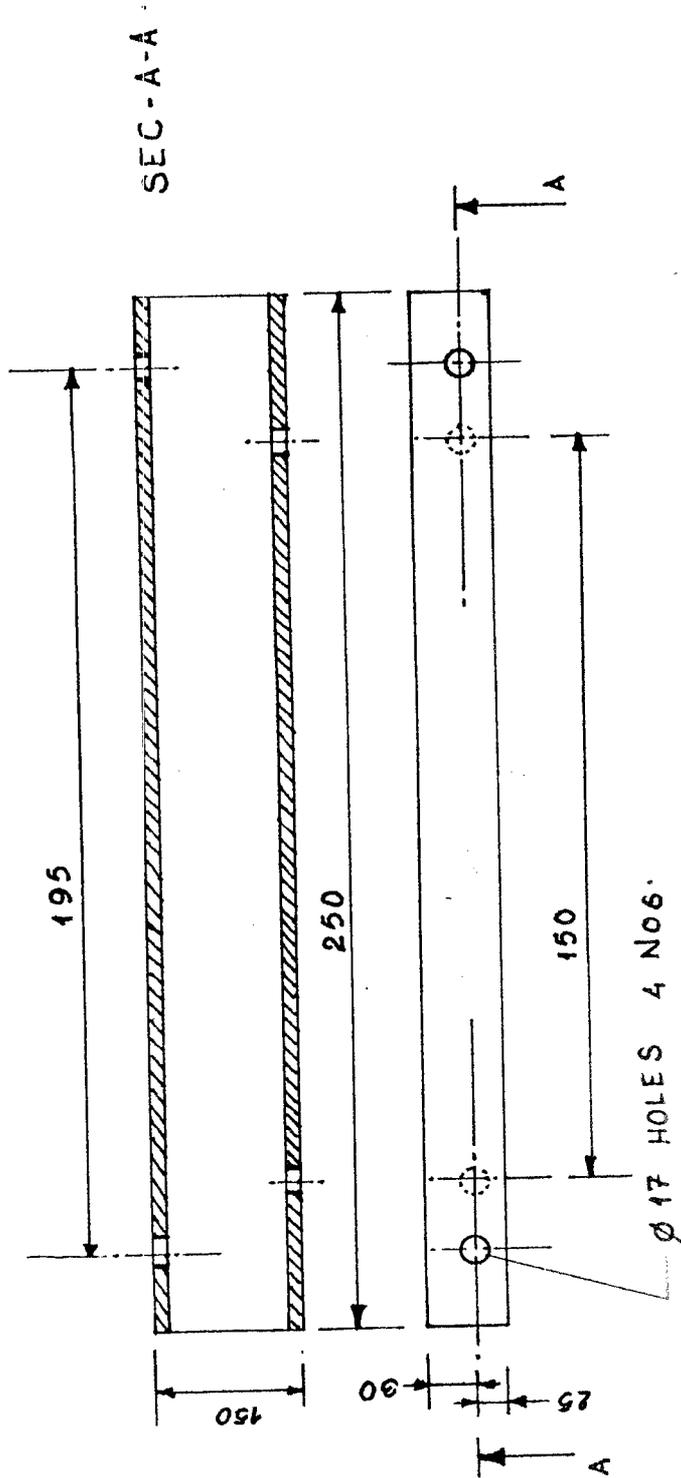
B.E.

DRG. NO:

PROJECT WORK

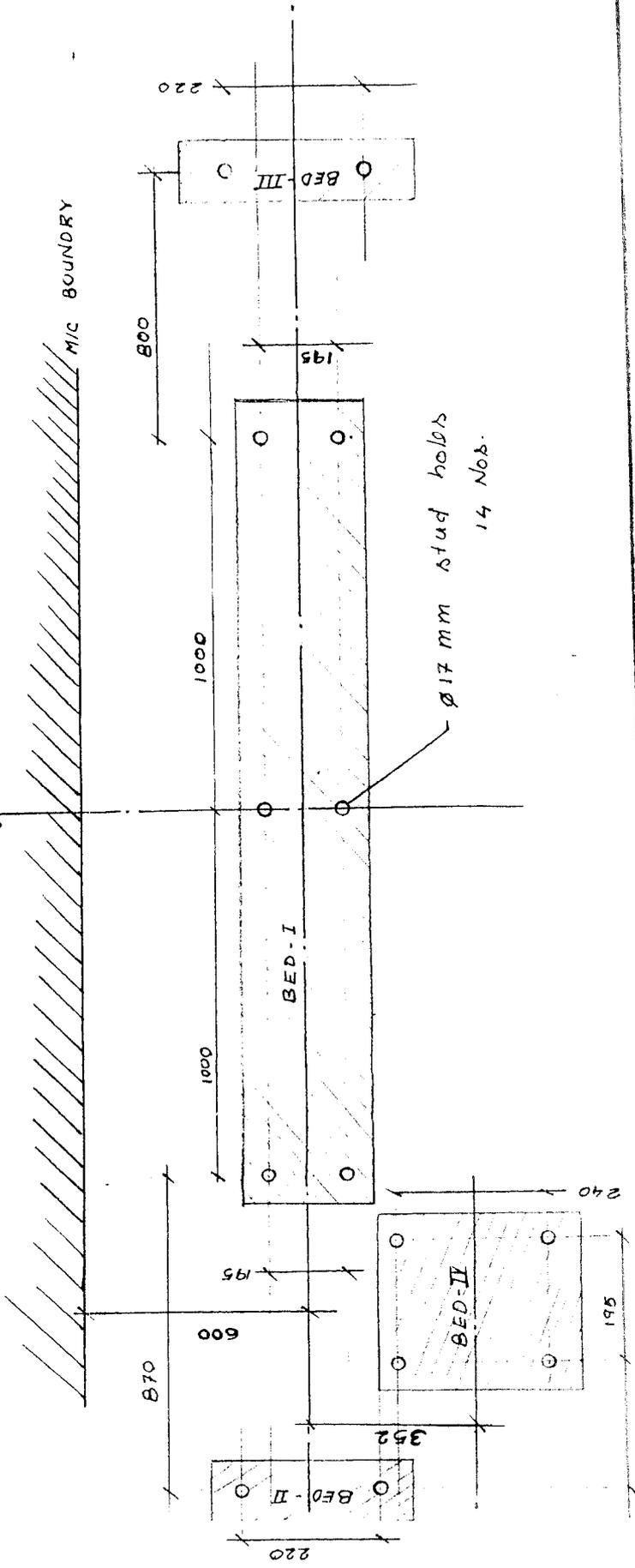
1991 - 92





KUMHARIGURU COLLEGE OF TECHNOLOGY		CHANNEL - I	ALL DIMNS. IN MM.	
MATERIAL: ROLLED STEEL	E. E.		PROJECT WORK	
QTY.: 2	1991 - 92			
DRG. NO: 9				

CENTRE OF T1
M/C.



KUMARAGURU COLLEGE OF
TECHNOLOGY

MATERIAL: PLAN OF FLOOR
WORK:

ALL DIMS.
IN MM.

CITY: -
ORG. NO:
11

B.E.
PROJECT WORK
1991-92

