DESIGN OF PORTABLE NAIL DRIVING MECHINE FOR PACKAGING

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Design of a Portable Nail Driving Machine for Packaging

Diploma Project

Submitted in partial fulfilment of the requirements for the Postgraduate Diploma in Industrial Design

by

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Industrial Design Centre
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Shri A.G. Rao

All Technical staff

All Administrative staff

and

My friends

1. Problem Statement

To design a Nailing Machine
particularly for packaging of wooden cases.

2. Introduction

In every engineering, medical, chemical or textile industry, the goods are packed to transport it from industry to consumer. Packaging of wooden cases involves nailing. In all the industries nailing is done manually by hammer. Generally for the other operations and processes some kind of machines or instruments are used to improve speed and operating convenience. The nailers in the packaging section of industry are nailing constantly for eight hours which causes strain to their hands. So, there is need of making the nailing operation easy by some means. There are some automatic nailing machines, but the rate of making boxes is more, which is not needed. Secondly, its cost is high which an average industry cannot afford just for nailing.

Generally, the nailing is done in the following fields.

1. Box making industries
2. Packaging section of industries
3. Temporary exhibitions, partitions and stages
4. Carpentery works

In some cases (particularly point 3) the nailing is done in very difficult positions like driving the nail horizontally or vertically upward, or hitting the nail by standing on the ladder. It involves nailing in different directions, at different heights and with the different body postures.

3. Information

3.1 Types of industries

3.1.1 Industries producing large number of standard size boxes.

Big industrial areas have hardly two or three such factories which provides standard size boxes for consumer goods like cosmatics, battery cells, clothes, medicines etc.

These industries get wood from outside and they cut it to planks of required size (thickness) which are again cut length wise, then the upper and bottom sides are planed and brought to nailing machine.

Nailing machine has a ram, which is actuated by a flywheel and connecting rod. The flywheel is geared to motor. The ram drives 4 to 8 nails per stroke. Nails are constantly fed by separate mechanism. Necessary accessories are there to keep the finished planks and sides for nailing.

There are two types of nailing machines, one which makes the sides of boxes and other which join the sides to make box.

The machine which makes sides of boxes has a bottom plate which slides to bend the extra length of the nail after completion of the stroke.

The rate of these two machines is 400 boxes per day or 120 nails per minute. Six men are required on these machines. Rough cost of these machines is about Rs.40,000/- to 50,000/- since it is imported.

The machine gives definite pattern of nailing and requires standard size of wood planks and nails.

The wastage of nails in this case is almost nil. The machine requires one mechanic for its maintenance which increases the cost of nailing.

The finished boxes are sent to industries. Transport charges of these boxes are more because of its big volume. In some cases the sides of boxes are carried to the industries and then the boxes are made in the industry.

3.1.2 Small scale box making industry.

These are few industries which produces boxes of variable sizes. Almost all the work is done manually. It is a batch production of variable size boxes by using non-standard material.

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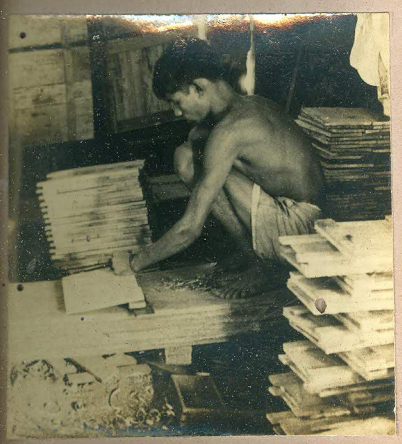
As mentioned above, this involves two types of nailing, one making boxes and other is making sides of boxes.

The industries get standard size wooden planks which are joined to make sides of boxes of required dimensions. In some cases they are making use of used boxes. Most of the cutting and sizing operations are done manually.

Sized planks are arranged on M.S. plate and nail is driven slightly at angle so that after hitting the nail it bends because of M.S. plate.

Finished sides are joined and boxes are made.

The rate of production is 8 to 10 boxes per day per man or about 100 boxes per day by 10 men. These labourers are getting 50 paise to one rupee per box depending upon the size of the box, which comes to hardly Rs.5/- to 6/- per day. The total wastage of nails is 5%.



While making a side of the box the time taken for arranging the planks and keeping the nails on it takes 60 seconds and the total hitting time is about 100 seconds which is about 60% of total nailing time.

3.1.3 Packaging section of industry

The wooden boxes are made in carpentery shop. Carpentery shop gets information from packaging section about the size and number of boxes to be made. Wood is cut to size with power operated machine and nailing is done manually. These boxes with upper cover go to packaging section where the goods are kept inside and cover is nailed. Some times the machine is fitted on base and other sides are joined to it later on. Packing and keeping the goods in boxes itself takes enough time whereas nailing is done within 4-5 minutes only.

Gratings are used for packing big control panels and cupboards etc. Gratings are nailed in industry. The sides of boxes, however, are some times got readymade from box making industry and are joined in packaging section of industry.

The net requirements of such industries, as far as nailing is concerned, are very less in comparison with the output of automatic nailing machine.

3.1.4 Temporary exhibitions, stages and partitions.

Temporary erection of structure is generally done by nailing. Here the nature of nailing

is different. The ease of operation and convenience with regard to position and direction is very important. The speed or rate of nailing is a secondary criteria.

3.2 Material data and cost.

Rough estimate of material cost and labour may be summed as below.

Wood cost	80% of the cost of box
Nail cost	10%
Labour	10%

Transport cost is an independent criteria and depends mainly upon the distance.

3.2.1 Nails

- Cost of nail - Rs.150/- per 50 kg.
- Wt. of 6 cm nail - 4 gms.
- Sizes of nail
  - Sunk diameter - 1.5 to 2.5 mm
  - Length of the nail - 3 cm to 7 cm
- Nail head diameter variation - 6%
- Sunk diameter - 12%

3.2.2 Labour

Efficiency: 8 to 10 boxes of average size

Wages for labour: Rs.5/- to 8/- per day
i.e. Re.0.50 to Re.1/- per box.

3.3 Time study of hand nailing.

Total time to make one side of box - 3 min.

Total time to make one box - 30 min.

Nailing rate - 8 to 10 nails per minute.

Sixty per cent of the total time of nailing is required for hammering the nail.

3.4 Portable nailing machines

3.4.1 One stroke pneumatic nailer

This consists of an impact cylinder and a piston operated by two-way valve and actuated by compressed air.

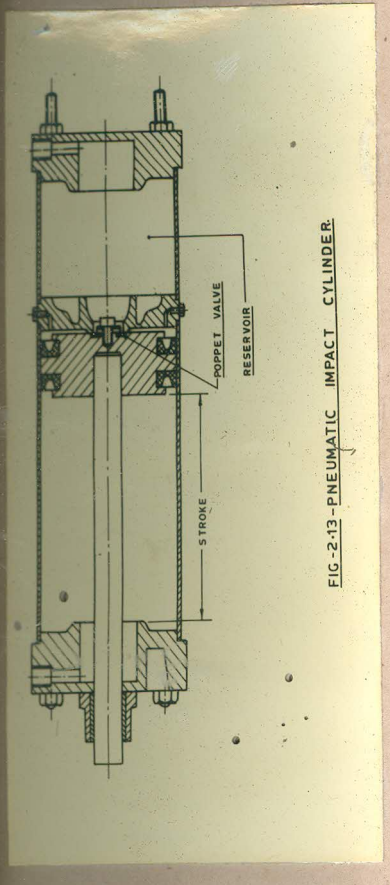


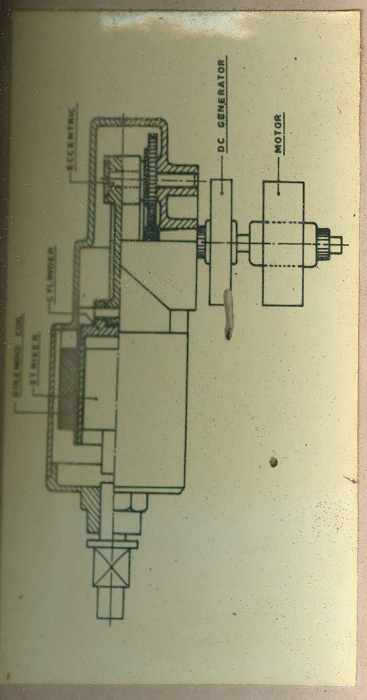
FIG-2.13-PNEUMATIC IMPACT CYLINDER.

On pressing the trigger the air from compressor rushes inside the cylinder and the piston is accelerated with high speed. Then the striker connected to the piston hits the nail which is guided properly in small cylinder. Spring loaded nail magazine feeds the nail continuously. The speed of nailing is about 25 nails per minute and the weight of the machine is 3 to 4 kg. At present this machine is not used in India.

3.4.2 Hammer type nailers

3.4.2.1 Pneumo-Electric multiblow hammer.

This tool consists of a D.C. generator driven by electric motor. A cylinder guided in a field of solenoid reciprocates in vertical direction, by means of eccentric mounted on



the motor. There is one piston inside the cylinder, which gives impact on the striker.

When the cylinder moves downward, air trapped get compressed and piston is accelerated thereby giving impact on the striker. The solenoid field helps in accelerating the piston. When cylinder moves backwards, vacuum is created and piston is pulled back. Power to weight ratio is more. This tool requires maintenance.

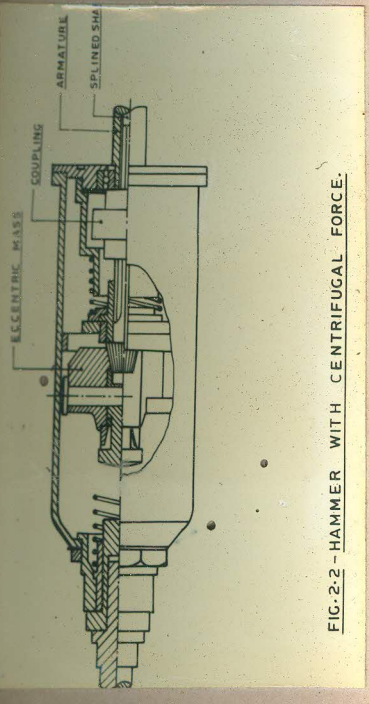


FIG-2-2-HAMMER WITH CENTRIFUGAL FORCE.

3.4.2.2 Hammer with centrifugal force.
Here the unbalanced force of rotating masses is used for giving impact on striker. Power of motor is transmitted to rotary masses by bevel gears. Wheels turn in opposite direction so that unbalanced force is along armeture axis which gives impact on striker.

It is economical considering the initial cost, operating cost and maintenance. Power to weight ratio is also more.

3.4.2.3 Cam controlled hammer.
Working of this machine is same as pneumo-electric type hammer. The piston while moving forward slips over the spring loaded plate and gives impact on a striker. While coming back the spring is compressed and energy is.

stored for the next stroke.

Initial cost is less, but the maintenance cost is more.

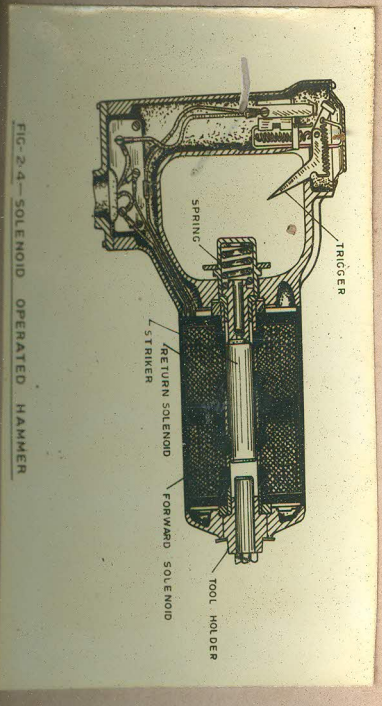


FIG-2.4—SOLENOID OPERATED HAMMER

3.4.2.4 Solenoid operated hammer.
In this tool the striker itself acts as a coil which moves in electromagnetic field. On operating the trigger coil gets magnetised and the striker is pulled back against spring force and energy is stored in it. But at the end of stroke the connections are reversed and the other coil pulls the striker resulting in impact on the tool.

It gives 3000 blows per minute. Simple in construction, but has low cost and power to weight ratio is less.

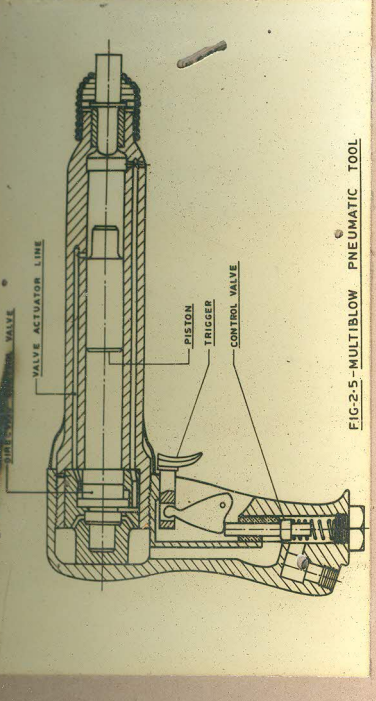


FIG-2.5-MULTIBLOW PNEUMATIC TOOL

3.4.2.5 Multiblow pneumatic hammer.
A piston moves due to compressed air. There is direction control valve, which is actuated by position of piston itself. The direction control valve pressurises backside of the piston, resulting high acceleration gives impact on striker. But now the direction valve is operated and piston starts moving upwards.

The energy available during the return of the piston is not used for having impact on the striker. It is air lubricated. Power to weight ratio is favourable. It gives vibrations on hand.

3.4.2.6 Explosion type of nailing machine. High pressure obtained by the explosion is used for impact on the striker. Explosion results in the heating of the tool.

4. Analysis

4.1 Functional analysis of hand nailing.

There are two steps in making a box by hand nailing.

4.1.1 Making sides of box

Following are the salient points.

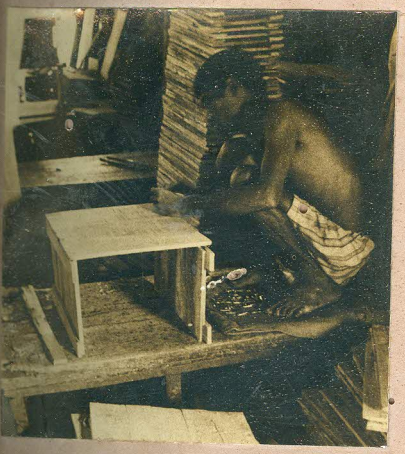
- Planks are arranged, butting against each other on a mild steel plate.
- At the edges two planks are kept perpendicular to the above planks.
- Three to four nails are picked up from the storage.
- The nail is positioned first, slightly inclined and holding it firmly in left hand, one hammer stroke is given by right hand. Thereafter, left hand is removed then three or four strokes are given to drive it inside.
- Last stroke is given to ensure full sinking of the nail, i.e. head of the nail is touching to the surface of wood.

- During this time the nail goes across the grains of both the pieces.
- Completion of one side takes 3 minutes.
- Hammering of nails takes about 60% of of total time.
- After completion of the stroke in wood the nail gets bent at lower tip which in

turn again pierses in the lower plank adding to rigidity.

4.1.2 Making the boxes.

- One side of box which is already prepared is kept vertical and is hold tightly.
- Second side is supported on a finished box, to be square with the first one.
- That side is matched exactly with the vertical side.
- Nails at the corners are driven first and then the remaining ones.
- Each of the joints requires about 8 to 10 nails.
- Total time for nailing the joints of one box is about 12 to 15 minutes.
- The nail goes straight along the grains of plank in the vertical side and across the grain in upper side.



4.2 The phenomenon of the nailing.

Nailing requires substantial impact rather than static force. This impact is in turn dependent upon mass and square of the velocity of the hammer. Though with the mass the impact may be increased, increasing the hammer weight is offset by other considerations like lifting problem etc.

Now velocity can be increased by increasing the length of arm of the hammer. But this poses aiming problem i.e. it becomes difficult to hit exactly on the nail head.

The adjustment of the hammer blow also needs consideration, if ever hammer blow is delivered inclined on the nail, there are wide possibilities of nail getting bent. Due to angular motion given by hand, only if exactly adjusted the blow is delivered square on the head.

4.3 Socio-economic analysis

At present a portable nailing machine costs about Rs.800/- in addition to the cost of power unit like compressor. Totally the cost of 2 or 3 machines and a compressor unit comes about Rs.4,000/- which a small industry cannot afford to spend. Only big firms and big box making industries can afford to spend such lump sum amount.

Though the nailing rate of automatic machine is high, extraordinary cost prohibits its use in small scale industries. More over, the demand for the nailing rate is also low. In case of automatic nailing machine the material handling is high. Two or three persons are continuously engaged for that purpose.

In India, automation is not the only purpose because we can cheaply utilise labour resources available in plenty and needing employment.

In designing such a machine, ease of operation coupled with operating convenience is the main purpose rather than going to automation.

4.4 Safety

In case of hand nailing, if the nail is long, it flyes off and miss the subsequent stroke, at that time hammer may hit the hand. At times, incorrect holding of the nail may also lead to hand coming in between the blow and injuring the same. Secondly, it may also bend the nail particularly if its length is more.

4.5 Accuracy and efficiency

Many times, positioning and alignment leads to the nail coming out of he plank. It may develop crack in wood, thereby lessening its strength, the nail in that case is mere wastage. The reasons for that may be summed up as below.

. Wrong positioning of the nail
. Bending of nail

Five to ten per cent nails are wastage.

5. Hypothesis

5.1 Functional aspects

Tool should be portable so that it can be carried to work place very easily. More over it should be light also.

Degree of automisation should be less so that it should utilise manpower. CONSIDERABLE

It should have temporary storage of nails and the feeding of them should be automatic so that sufficient speed can be achieved along with easier operation.

Nail should be guided properly so that

a) it won't bedd or fly while hammering

b) powerful impact can be applied on it easily.

The hitting area of the striker should be more enough so that slightly out of plumb hammer stroke will not alter the direction of nail driving and it will go straight and vertical.

The nail should be positioned accurately at the middle of the thickness of the plank while making a box, so that nailing will be accurate and wastage of nails will be reduced.

The nail should be driven in a single stroke only with larger impact for driving it efficiently.

The upper plank should be gripped properly while nailing the joint of the box.

5.2 Socio-economical aspects

Nailing machine should utilise manpower, but giving comfort to operator at the same time. The cost should be about Rs.100/- so that small industries can also afford to make use of it.

5.3 Ergonomical aspects

The grip and the trigger should have the holding and operating comforts.

The nail when positioned should be visible so that one will be sure of accurate positioning.

The operator should have an idea regarding number of stored nails at any time during operation.

It should take care of all heights of operation and at all angles.

The feeding of nails in the temporary storage should be easy.

5.4 Structural aspects

Total tool should be sturdy enough to withstand hammer strokes.

The nail guide should be free from impact. The impact should be directed only on the nail head.

Vibration and jerks should be minimised.

5.5 Functional aspects

It should take nails varying in the range.

2 mm to 2.5 mm sunk diameter

5 cm to 6.5 cm length

6. Synthesis and Design development.

The tool is made portable and light in weight so that handling of the tool to work site is easy.

One can give sufficient impact so that the nail can be sunk very easily in one stroke.

The automisation is reduced and manpower is utilised considering sufficient comfort of the operator, still one important feature being the rate of about 25 nails per minute, which is almost same as that of power nailer.

The cost is reduced to about Rs.100/- which any small scale industry can afford.

A steel plunger of diameter equal to that of nail head (8 mm) guided in a steel sleeve, is used to transmit the impact vertically on the nail head.

The plunger is loaded with light spring, which takes it back above the nail after each stroke.

The cylindrical guide (sleeve) is fitted in two aluminium die casted pieces.

A nail magzine support along with handle which is die casted in aluminium contains about 100 nails arranged in two rows. The nails are spring loaded, the magzine is separate unit in itself, made up of extruded transparent polysterene, so the nails are visible from top.

The handle has a trigger, on pressing of which a mechanism comes into action and the nail is fed in the guide as well as plank is gripped. This aids in positioning of the nail and at the same time driving it without any change in the position thereafter.

The trigger is so positioned that while handle is gripped, trigger is pressed automatically because it is a part of the handle. This being the case no other operation is involved separately either for gripping or for feeding

of the nails.

Depending upon the purpose and the site of the nail to be driven, the sleeve is changed for particular time period. There are two types of sleeves 8 mm and 6 mm inner diameter.

The feeding of the nails can be done by hand or by typical slotted tray, which is made to oscilate by a mechanism. Hand feeding rate is about 50 nails per minute, so after every 5 minutes the magzine is either fed by hand or by typical slotted tray.

The handle is kept inclined so that sufficient pressure can be applied for holding it rigidly on the planks.

Because of light weight and larger hitting area, it can be used for nailing in horizontal, vertical or any other direction.

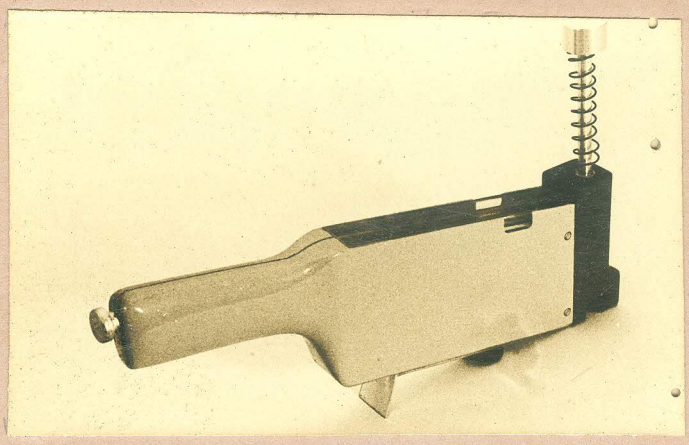
The length of the tool itself is such that one can increase the length of the hammer arm to give sufficient impact.

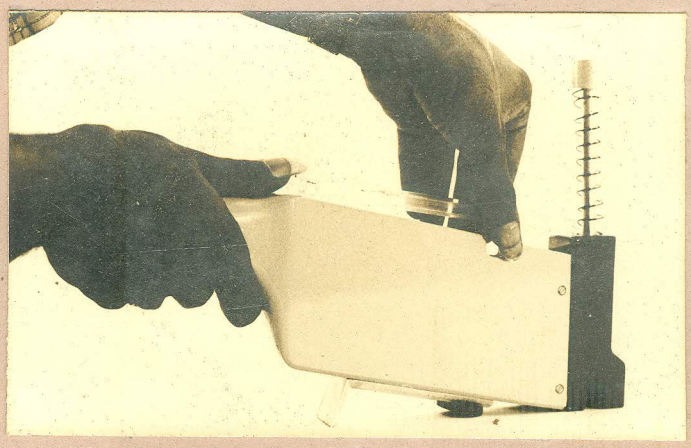
The colour is such that it gives a feeling of being heavy and strengthy at the front side and of lightness at back side.

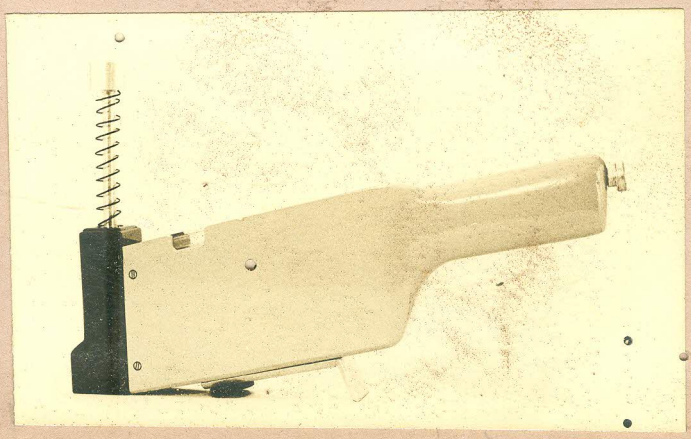
7. Communication

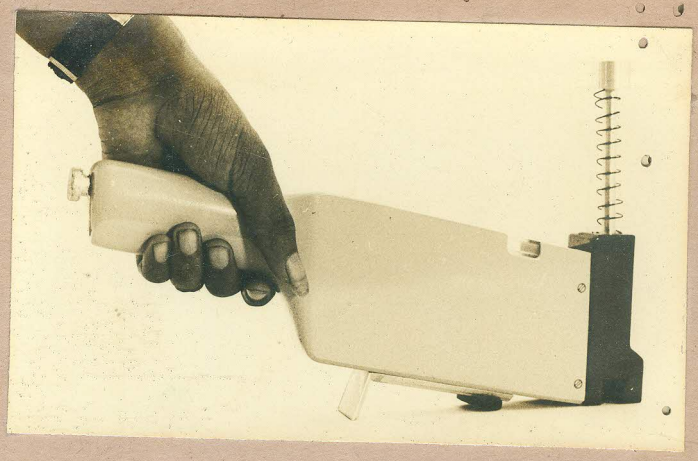
7.1 Photographs

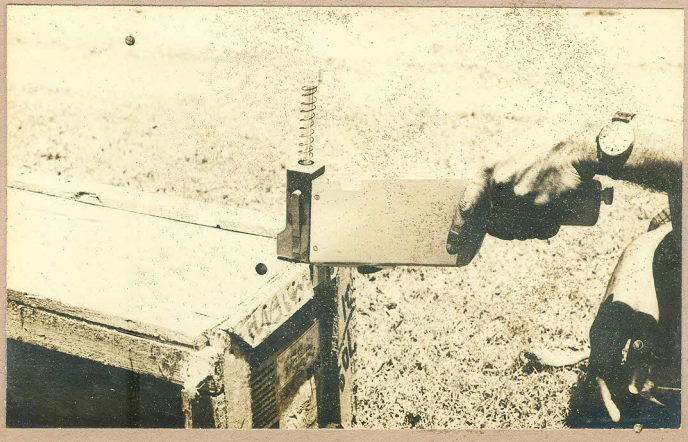
7.2 Drawings

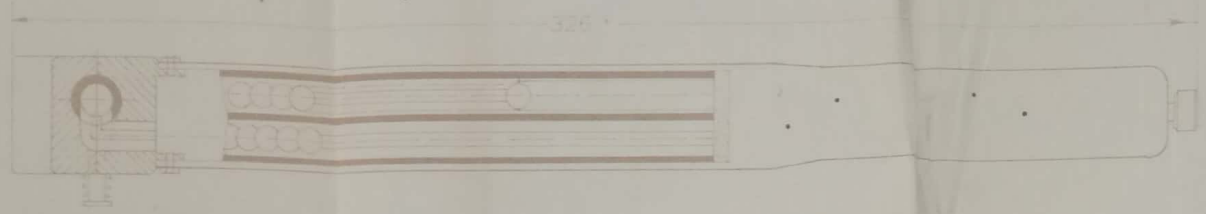


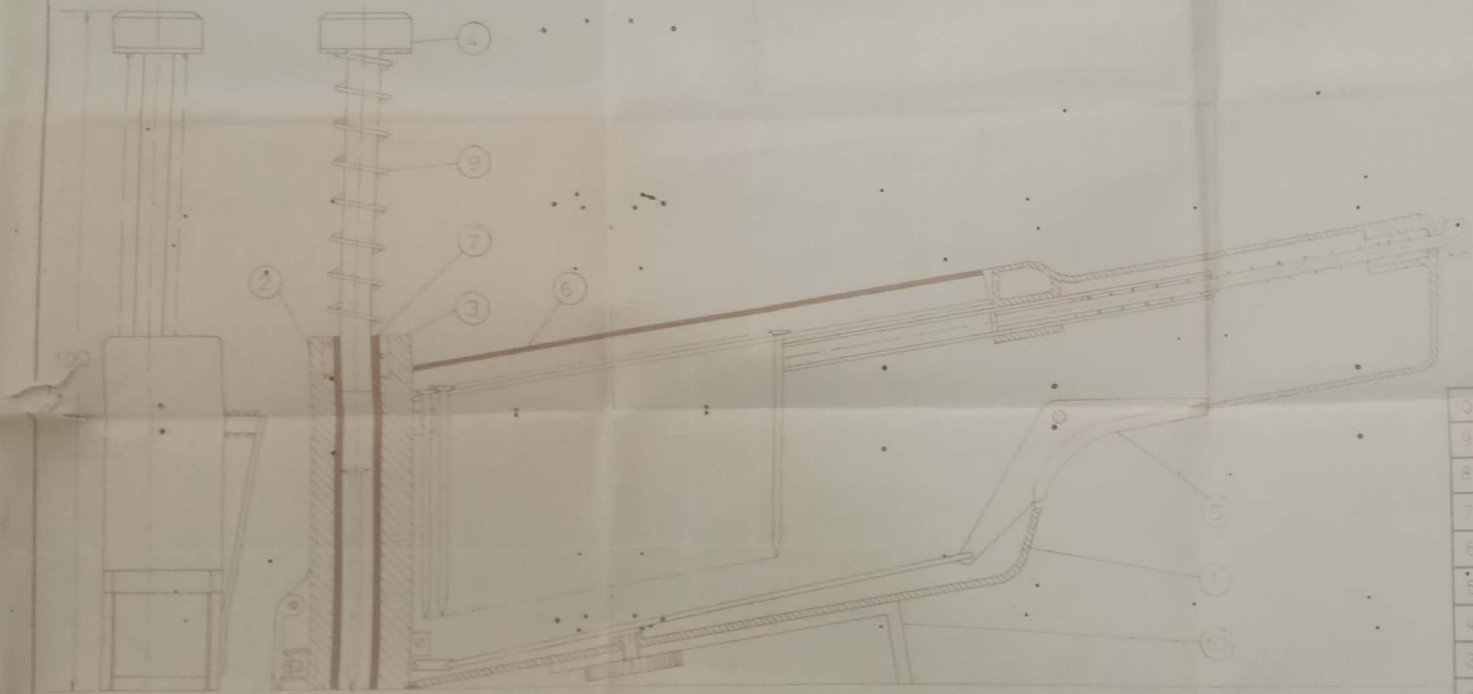












NO	DISCRIPTION	MATERIAL	NO	FINISH
9	SUPPORT	M. STEEL	1	
9	SPRING		1	
8	JAW	STEEL	1	MACHINE
7	SLEEVE	C. STEEL	1	MACHINE
6	NAIL MAGZINE	POLISTYRENE	1	
5	TRIGGER	M. STEEL	1	PAINTING
4	PLUNGER	C. STEEL	1	MACHINE
3	GUIDE BACK HALF	DIE CAST AL	1	PAINTING
2	GUIDE FRONT HALF	DIE CAST AL	1	PAINTING
1	MAIN BODY	DIE CAST AL	1	PAINTING

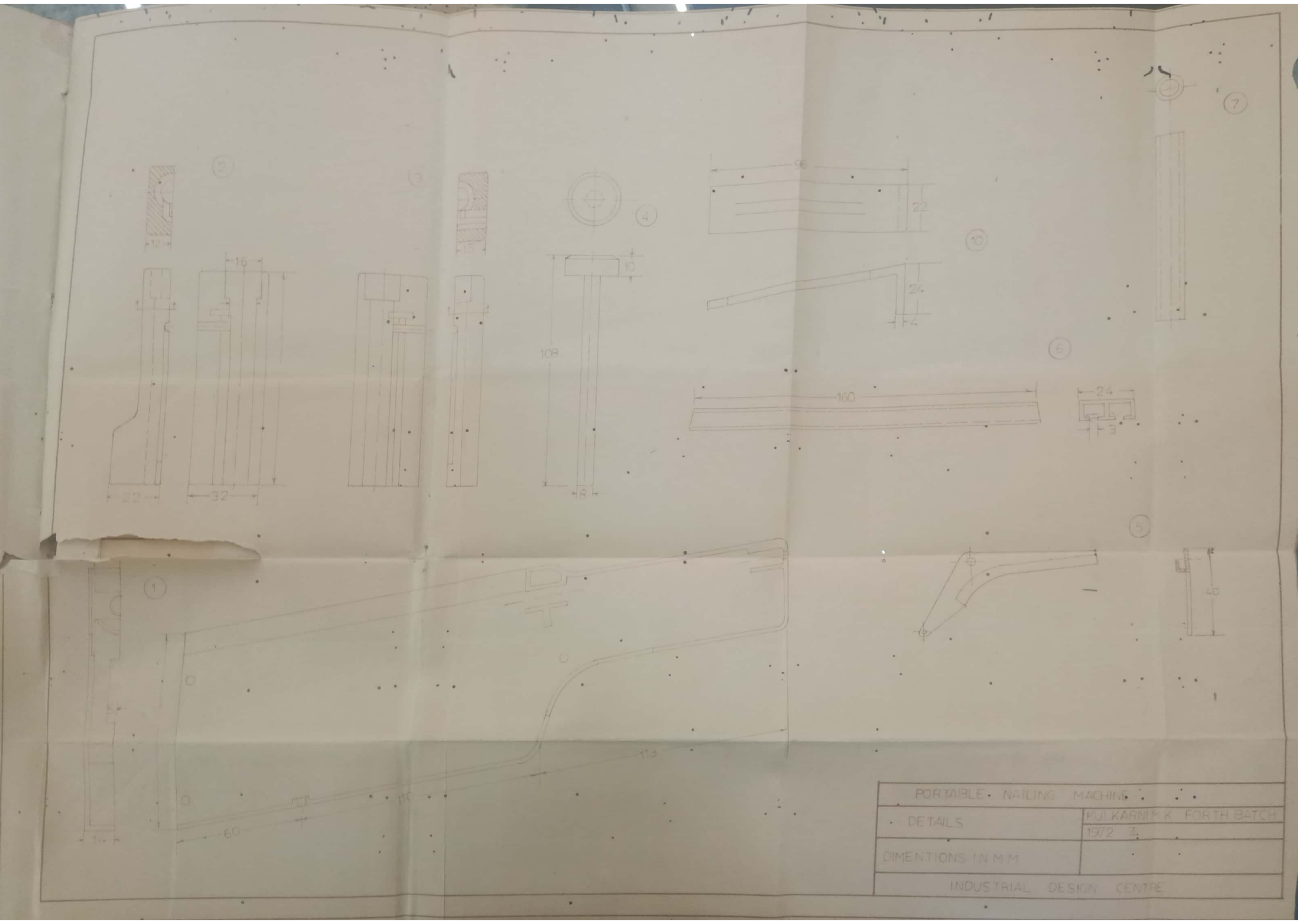
PORTABLE NAILING MACHINE

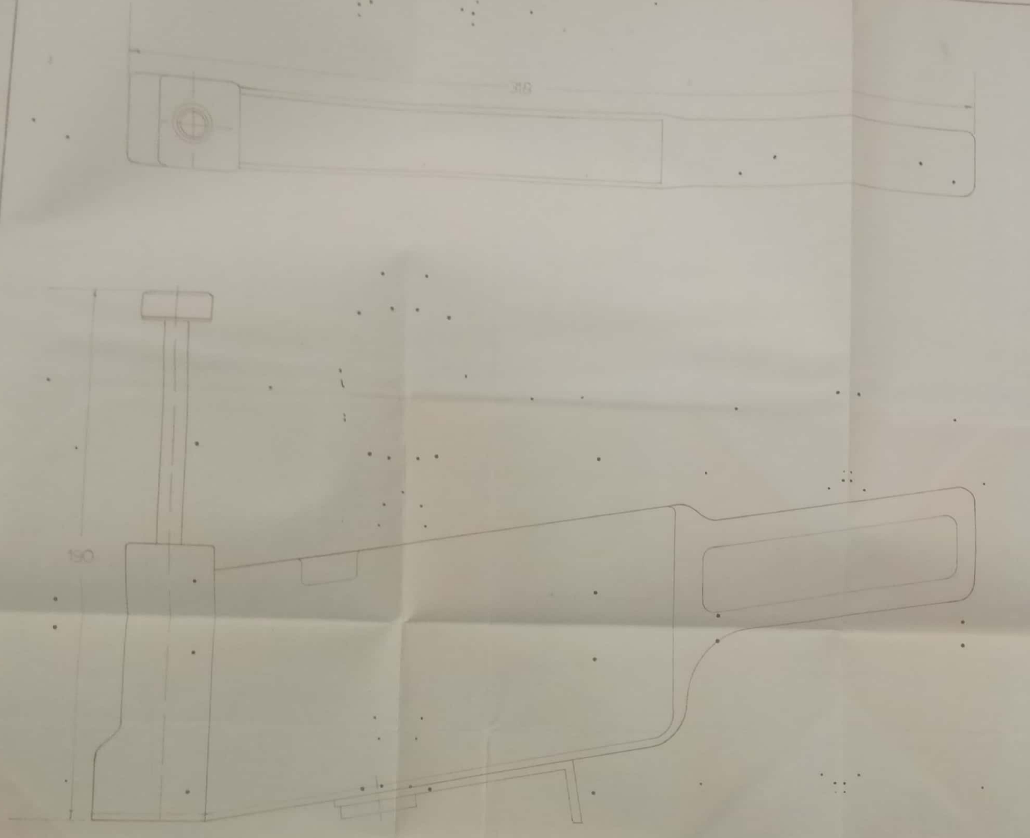
ASSEMBLY

KULKARNI M.K. FOURTH BATCH
1973-74

FULL SCALE
DIMENTIONS IN MM

INDUSTRIAL DESIGN CENTRE





PORTABLE NIAILING MACHINE		
ASSEMBLY		M.KKULKARNI FOURTH BATCH 1972 74
FULL SCALE		
INDUSTRIAL DESIGN CENTRE		