

DESIGN OF PAPER CUTTING MACHINE

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Design of Paper Cutting Machine

Diploma project

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industrial design

by

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and my friends.

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1. Problem Statement

Design of Paper Cutting Machine

2. Introduction

In the present age paper is used extensively in every sphere of life. Paper is defined as "all kinds of matted or felted sheet of fibre formed on wire screen from water suspension". It includes all types of papers ranging from the thinnest tissue paper to the heaviest board.

The papers and paperboards coming out from the paper mills have to be further cut for everyone's requirements. Much of the further cutting work is done in printing presses. But many times people in design offices, drawing offices, colleges, stationery marts etc. feel the need of a paper cutting machine to meet their individual variant requirements. The guillotine press used in printing presses is too costly, too bulky to be used in design offices. Moreover guillotine machine is a large capacity machine suitable for mass production.

At present ordinary knife, razor blade, stanley knife or kilburn cutter is being used in design offices and paper stationery marts. But these instruments are insufficient to fulfil the purpose.

Hence there is a need of a machine which will meet the needs of design offices, paper marts etc.

3. Information

3.1 Information has been collected from

3.1.1 Printing presses

3.1.2 Architectural designers

3.1.3 Model makers

3.1.4 Graphic designers

3.1.5 Stationery paper marts

3.1.1 Printing presses

They use guillotine press for cutting work.

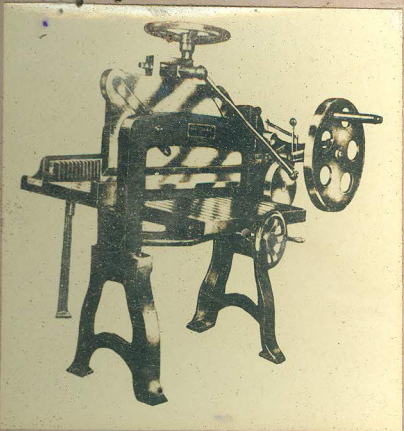
It is used for cutting blank papers, bound books, printed papers, paper boards etc.

Guillotine machine is basically a mass paper cutting machine.

Every small printing press has a guillotine machine. Large printing presses have heavy duty imported guillotine presses. Their cost ranges from Rs.30,000/- to one lakh.

The small capacity machine is manufactured by a company at Amritsar in batch production. It is the side business of the manufacturer. They have sales agents at different places in India.

The machine can be used either as hand operated or as power operated by attaching a motor.



The price and capacity of the machine varies according to the bed width and thickness of pile that it can cut.

Bed width	Thickness of piles	Approx. weight	Drive
18"	4"	120 kg.	Hand
22½"	4"	160 kg.	Hand
26"	4"	200 kg.	Hand
32"	5"	270 kg.	Hand, power
36"	5½"	360 kg.	Hand, power
42"	5½"	450 kg.	Hand, power

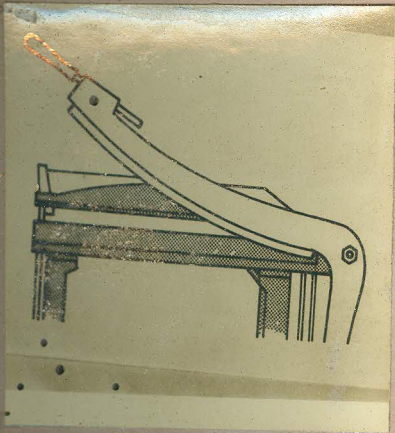
One HP motor is used in case of power operated machine. The price of a 36" hand operated machine is Rs.4,700/- and that of power operated machine is Rs.5,700/-.

The machine is provided with an extra blade which can be used when the working blade is removed for sharpening.

3.1.2 Architectural designers

- They use different types of papers and paper boards for designing and model making. Some design offices make the models in their own office and others give their work to the model makers.
- Many offices use available imperial sizes for their drawing work. Few offices use Din size papers. They get Din size papers cut from the stationery marts.
- Many times they have to cut a certain portion of the standard size for a particular purpose.
- Many times they have to cut a number of sheets at a time.
- Most of the offices use ordinary razor blade or stanley knife along with a steel rule. Cutting with a knife and steel rule is labourious and straining for them. One has to cut very carefully to get a straight long edge.
- Very few offices have Kilburn cutter.
- There is no suitable instrument to cut number of papers at a time. They feel it will be very much useful if such a machine is made available.





3.1.3 Model makers

They usually use paper boards for making architectural and product models. They use stanley knife, razor blade and scissors to cut paper boards. Some people use millboard cutter which can cut 30" board of 1/8" thickness.

3.1.4 Graphic designers

- They use many types of papers.
- They use ordinary razor blade or stanley knife or a pair of scissors.
- The size of the papers varies according to the work. Hence they have to cut the available paper into smaller parts.
- Some times they need to cut a number of papers at a time. But no suitable instrument is available. Hence they have to cut sheet by sheet.

3.1.5 Stationery paper marts

- They sell different types of papers and paper boards.
- Many times customers ask for half imperial size papers or paper boards. In such conditions they fold two or three sheets and cut with ordinary knife. Some merchants use razor blade and scale.
- They find difficulty in cutting number of papers and cardboards.



3.2 Paper

Paper is used for writing, typing, printing, design and drawing work, decoration work, packaging etc. Also there are pressure sensitive coated papers like photographic papers, blue print papers and ammonia papers.

Paper is described by the weight in grammes per square meter (gsm) sheet of paper. Paper is sold in reams (500 sheets).

3.2.1 Tear resistance of paper

It serves to indicate the energy required to tear or shear the paper. It is broadly classified into two viz. internal tear resistance and external tear resistance.

While the former represents the energy required to propagate a precut tear, the latter is the energy required to start and continue a tear. The internal tear resistance is most common.

Internal tear strength is defined as "force needed to tear a single sheet when a cut is made in the sample before hand". Some values are given below.

Type of paper	Thickness	Internal tear strength
Kraft paper	250 microns	0.4 kgf.
Rag paper	250 "	0.7 kgf.

3.2.2 Types of papers and paper boards

Type of paper	Weight of thickness	Use
Writing paper	70-80 gsm	Writing, typing
Std. newsprint	60-75	Printing newspaper
Cartridge paper	80-100	Printing books
Drawing paper (rough)	100-110	Rough drawing and sketching
Scholar drawing paper	120-130	Fair drawing work
T.K. Japan	140	Presentation work
Tracing paper (rough)	60-70	Rough design and sketching
Gateway tracing paper	70-75	Final drawing work
Pastel paper (black)	160-170	Display of photographs, base paper, title sheet
Marble paper	70-80	Decoration, presentation
Kraft paper	70-100	Wrapping
Paper boards:		
Grey board	Thickness less than 0.5 mm	Model making, backing paper for books
Mill board	Greater than 1 mm	Model making, book binding
Straw board	Available in diff. thicknesses	Book binding

3.2.3 Sizes of paper

Traditional sizes

Imperial	22" x 30"
Fool seap	27" x 17"
Crown	15" x 20"
Demy	17½" x 22½"
Royal	22" x 25"
Medium	18" x 23"

Roll sizes

17½" width x 15' length

40" width x 40' length

Din sizes

In Din size the sides of the paper are in the ratio of 1:1:√4.

Din	Size mm
A0	840 x 1188
A1	594 x 840
A2	297 x 420
A3	210 x 297
A4	148 x 210



3.3 Types of cutters

3.3.1 Kilburn paper cutter

- This cutter is used to cut papers upto 0.15 mm thickness.
- It is basically a single paper cutter.
- A circular wheel shears the paper along a straight edge. The wheel rolls while moving along the straight edge.
- It is 117 cm long and has a 30 cm wide wooden base.
- The paper has to be first measured with the scale and marked to the required length before cutting, since there is no scale on the machine.
- Getting the exact right angle cut is difficult since there is no guide for the paper. The cut part of the paper falls down.
- It costs about Rs.400/-. This seems very high as compared to its material and manufacturing cost.



3.3.2 Paper trimmer

It is used to cut writing papers, trim photographs. It has two blades, one fixed to the base and the other one moving about a hinge. The moving blade shears the paper along the fixed edge. The moving blade is made to slide exactly against the edge of the fixed blade with the help of a leaf spring at the hinge. There is a scale in cms. along the edge at right angles to the cutting edge. The paper is also guided along this scaled edge. The paper or photograph has to be held firmly with left hand while cutting and this causes fatigue. It costs about Rs.100/-.



3.3.3 Photographic paper cutter

It is used to cut photographic paper to the required size before printing. There are two blades making an angle with each other in the vertical plane, the lower blade being fixed. The upper blade is attached to an inclined plate hinged on one side and the plate is held in the upper position by spring at the bottom. The paper is inserted between the blades and the upper blade is pressed with the hands. The paper is guided along one edge on which there are graduations in inches. It is difficult to get right angle and straight edge.



3.3.4 Stanley cutter



It is commonly used in design offices and by model makers. One of the sides of the blade is sharpened along its length. While cutting the paper a steel rule is used as a guide and is held firmly on the paper with the left hand. The cutter cuts the paper along the edge of the scale. The left hand has to be moved as the blade moves along the scale, so as to have maximum pressure on the scale at the point of cutting. This is very difficult and strenuous. The blade is marked with grooves parallel to the cutting side. Depending upon the frequency of use the edge becomes blunt after some days and a new sharpened edge is obtained by cutting the blade along the nearest groove on it. The cutter can cut 0.4 mm thickness of paper.

3.3.5 Razor blade

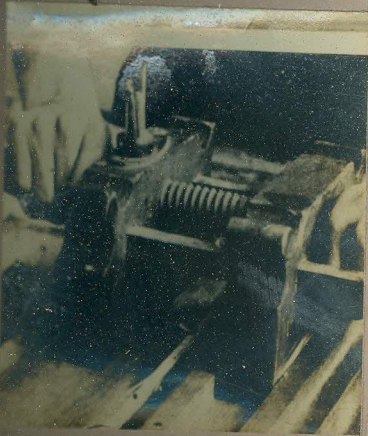
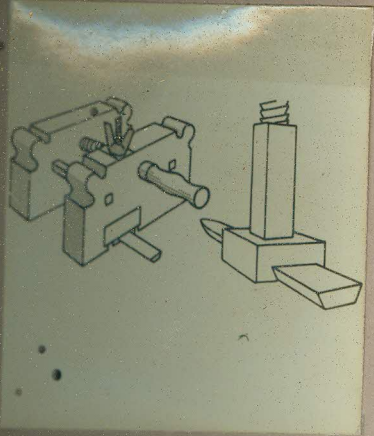
Some people prefer to use the razor blade to the stanley knife since it is cheaper. It can cut only single paper. It is difficult to hold it while cutting. Cutting with razor blade is tiresome and fatiguing.

3.3.6 The plough

This is a tool for cutting the edges of books and boards. It was largely replaced by the guillotine in the mid 19th century.

The book is held between two cheeks. A screw with a dovetail groove in one end holds the blade against two metal plates.

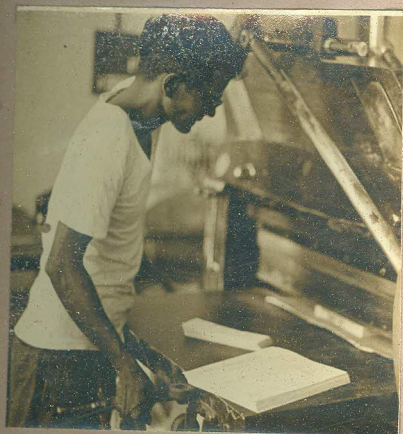
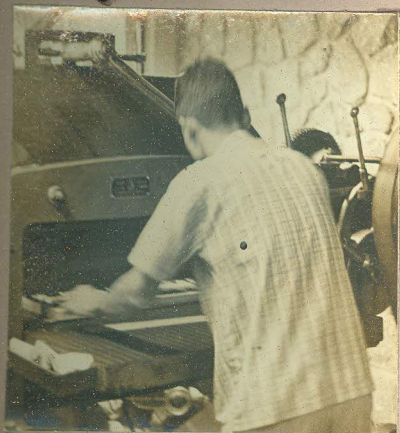
The plough held by the screw and handle and guided by the runners on the press, is moved backwards and forwards. A slight turn of the screw at each movement brings the knife forward.

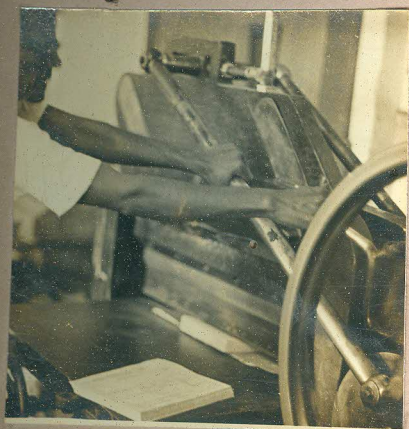


4. Analysis

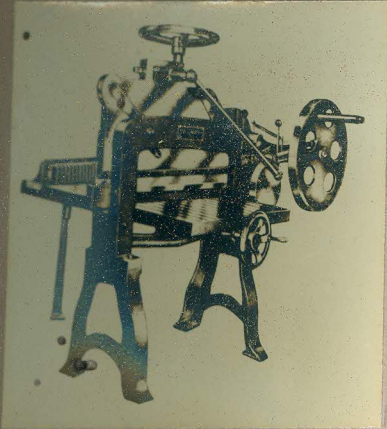
4.1 Operation of guillotine press

The pile of papers to be cut is stacked properly by lifting the papers vertically and releasing on to the table. The perfectly stacked edge is inserted into the machine and this edge is made to match against the guide at the back. The guide is operated by a hand wheel at the front of the table. The guide moves towards or away from the cutting edge. The length of the paper to be cut is adjusted by moving the guide. The movement of the guide is measured by a scale at the side. The papers are held firmly on the table by pressing with a pressure plate which is operated by a hand wheel at the top.





The machine is started by starting the motor in case of power operated machine or by turning the flywheel in case of hand operated machine. After 3-4 revolutions of the flywheel the clutch is operated so that the cutting blade is engaged with the wheel. The blade moves down diagonally with its cutting edge remaining horizontal throughout and after completion of the cutting stroke it moves up and then it is automatically disengaged.



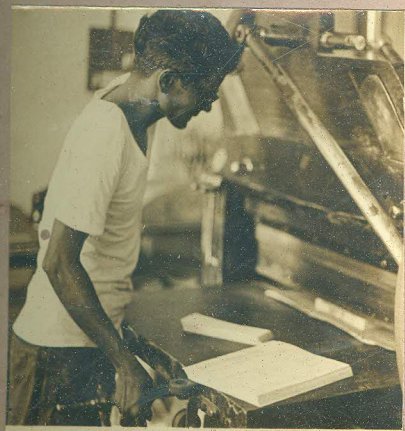
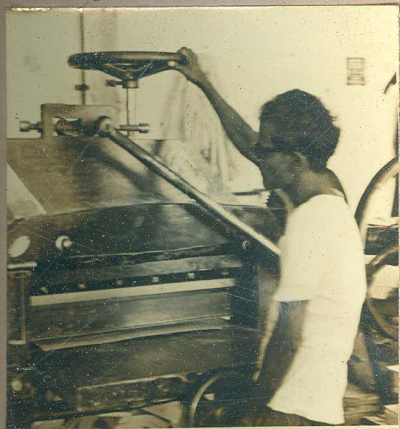
4.2 Structural analysis

- The main body which comprises the housing for the blade, is made up of cast iron. It is made in two 'U' shaped pieces and bolted together.
- The main body is bolted to the C.I. stands on both sides. The two stands support the whole assembly.
- There is a C.I. truss in between the two stands.
- The C.I. horizontal table rests on the truss. The table is marked with inch scale lines at right angle to the cutting edge.
- There is a C.I. support for the table at the back.
- The cutting blade is made up of high carbon-high chromium steel.
- The blade is bolted to a C.I. plate which has two inclined parallel grooves. The plate is guided along the grooves by two rectangular M.S. guide blocks fitted to the main body.
- There is a C.I. pressure block at the back of the main body which can move vertically upwards and downwards. The movement of the pressure block is obtained by a screw and nut mechanism. The nut is in the main body and the screw is turned by a handwheel at the top.

- . The driving mechanism of the machine consists of a C.I. flywheel attached to the main body. The flywheel is coupled with the crank and connecting rod mechanism through reduction gears. The crank consists of two circular discs on either side of the blade.
- . The connecting rod consists of two hardened steel rods on either sides.
- . There is a paper guiding block at the back of the table. It can be moved towards or away from the blade and its movement is controlled by a handwheel in front of the table, through a screw and nut mechanism.
- . A block with many slots is fitted to the guide block. It is useful for cutting narrow strips of paper. It can be removed whenever not required.

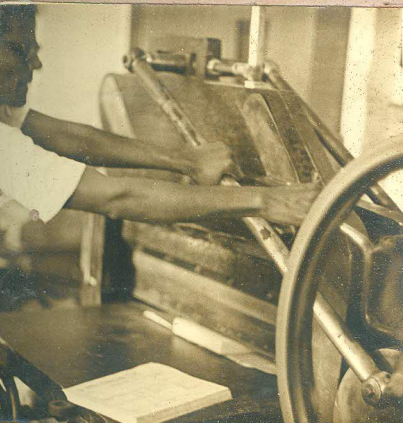
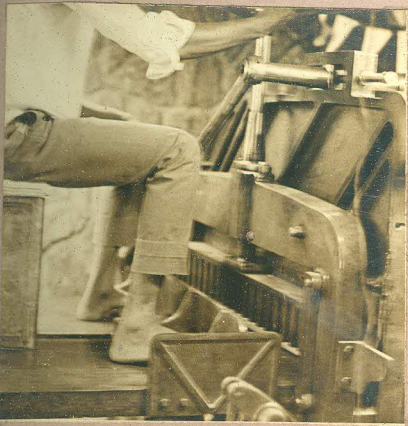
4.3 . Functional analysis

- The angle of the cutting edge is $30-35^{\circ}$ with the vertical. When the machine is started the blade moves diagonally with the edge remaining perfectly horizontal. The cutting takes place because of combined compressive and shear forces.
- The paper inserted in the machine is held firmly by the pressure block. The pressure block can be moved up or down by turning the handwheel at the top.
- The guide block at the back can be moved towards or away from the blade by turning the handwheel at the front of the table. Thus the stack of paper is guided.
- The machine is started by turning the flywheel either by hand or by means of induction motor. The flywheel moves freely for first 3-4 revolutions. During this time the flywheel stores energy.
- The flywheel is engaged with the gears by operating the clutch. The motion of the gears is transmitted to the blade through crank and connecting rod.



4.4 Formal analysis

- The overall look of the machine is very poor.
- The stands having curved 'U' shape look odd with the other structure of the machine.
- The single support at the back looks awkward.
- The driving mechanism is kept open and it creates very poor appearance.
- The blade plate has a odd shape which is solely guided by function.



4.5 Ergonomical analysis

- The position of the handwheel to operate the pressure block is high. It is much above the shoulder level of an average man. Some times a second person sits at the back of the table to operate the handwheel.
- The clutch operating handle is very near to the rotating flywheel, hence chances of accident.
- The blade is not guarded.
- The flywheel, the motor and the gears are kept open.

4.6 Socio-economic analysis

Even though the flywheel, motor and belt are provided with guard, people remove the guard leaving the moving parts open. The guard for gears is also some times removed. This shows the indifference of the people towards safety rules.

5. Hypothesis

5.1 Structural

- . The structure should be strong enough to take up a total load of 30 kgs.
- . The machine parts should be strong enough to take a slight overload at certain times.
- . Standard size material should be used.
- . The parts should be made up of non-corrodable materials like cast iron, chromium steel, plastics or painted metals.
- . The method of joining two parts should be simple so that it can be done in a small scale industry.
- . The process of making individual parts should be simple and be within the reach of a small scale industry.
- . The variety of materials to be used should be minimum to reduce the storage and also unnecessary investment.
- . The material and process cost should be minimum from the manufacturer's point of view.

5.2 Functional

- It should be able to cut all types of papers and paper boards with all available sizes.
- The machine should be able to cut maximum of 1 cm thickness of paper, i.e. about 100 writing papers, 30-40 drawing sheets and 10-15 paper boards.
- A surface to guide the paper along an edge is essential.
- The paper cut in the machine should give right angle edges.
- The quality of cut should be good.
- A scale should be provided on the machine which can measure the length of the paper.
- An arrangement, to hold the paper firmly on the table, should be provided.

5.3 Formal

- The paper cutting machine should be attractive in design, appearance and workmanship.
- Sharp edges and corners should be avoided.
- Colour should be pleasing and should go with the environment.
- Parts like screws and nuts should not protrude outside.
- The machine should be compact.

5.4 Ergonomical

- The machine should be easy and convenient to operate.
- All operating parts should be within the easy reach of the operating person.
- The force required to operate the machine should be within the capacity of an average man.
- The scale provided for measuring the length of the paper should be clear and easily readable from the distance at which the operating person is standing.
- Moving parts like gears, belts etc. should be completely enclosed.
- The cutting blade should be guarded.

5.5 Economical

- The machine should be hand operated since the maximum cutting load is restricted to 1 cm thickness.
- The cost of the machine should not exceed Rs.500/-.
- The machine should not occupy much space.

6. Synthesis

- The maximum capacity of the machine has been decided to 1 cm thickness of paper, which comes to about 100 writing papers and 30-40 drawing sheets.
- The maximum size of the paper that the machine should cut is the imperial size (22" x 30") since this is the usual size available in the market.
- The main body for the machine will be of cast iron since it is a cheap material, it allows different shape possibilities.
- The blade will be fitted to a cast iron plate. This plate will have two guides which will move in the corresponding grooves in the main body.
- The blade will get its motion through crank and connecting rod mechanism. The crank is geared to a hand wheel which is rotated manually.
- The blade moves diagonally with its edge remaining perfectly horizontal throughout the motion.
- The machine will be covered with sheet metal.
- The whole structure of the machine will be fitted to a C.I. plate at the bottom.

- A wooden table will be provided on the C.I. plate. The table will be made up of teak wood finished with either lacquer or covered with veneer or sunmica on the top.
- A mechanism will be provided for gripping the paper firmly on the table.
- A guide will be provided at right angle to the edge of the blade.
- A scale will be provided to measure the length of the paper to be cut.
- A paper storing unit will be provided under the machine.
- The machine will be supported on a mild steel structure.
- The height of the table will be 3 ft. from ground level. This height is convenient for working in standing posture.
- The force needed at the hand wheel to cut the maximum number of sheets will be within the capacity of an average man.
- The colour combination will be pleasant and go with the official environment.

7. Design development

- The machine is a hand operated unit suitable for any design office, paper stationery marts and colleges.
- The main body of the machine consists of two vertical C.I. structures between which the blade will be sliding. Only those surfaces of the structures will be machined which come in contact with the sliding blade. Each of the structure has two inclined grooves, in which the guides of the blade plate will be sliding.
- The cutting blade is made up of high carbon-chromium steel. The percentage of carbon is 0.9 to 1 and that of chromium is 0.75 to 1.25.
- The blade is fitted to the C.I. plate with countersunk screws. The plate has corresponding threads.
- The guide plate has two rectangular mild steel guides fitted to it with screws.
- The connecting rod has an I section and is connected to the blade plate at one end and to the reduction gear at the other end. This gear acts as the crank.

- . The reduction gear meshes with the pinion.
- . A hand wheel having 220 mm diameter is fitted on the shaft of the pinion. An average person can exert a force of 12 kgf. at the periphery of this hand wheel. This force is magnified through reduction gear.
- . The ratio of the diameters of reduction gear to pinion is 2:1.
- . The blade moves down and cuts the paper during the first revolution of the hand wheel and moves up during the second revolution. Thus two revolutions of the hand wheel are needed for cutting.
- . The machine is covered with mild steel sheet metal from safety and appearance point of view. All the parts except the hand wheel are covered. The cover consists of two parts, each part fitted on either side of the structure. Screw fittings are not seen from outside.
- . The machine structure is fitted to a C.I. base plate at the bottom, with bolts and nuts.
- . Two wooden planks which form the table, are fitted to the base plate on either sides of the machine. The planks are made up of seasoned teak wood. The table may be either lacquer finished which gives the natural

grains of the wood or covered with veneer or with sunmica sheet.

- Only 1 ft. width of the table is provided on each side of the machine, which economises space.
- There is a mechanism which applies pressure on the paper. It is fitted to the table near the edge of the blade. The mechanism consists of a cam operated pressure plate. The pressure plate is kept always in contact with the cam by means of springs . The cam is operated with a knob. The mechanism is covered with sheet metal.
- There are two guide plates each on either sides of the machine, at right angle to the blade. These guide plates guide the paper perfectly at right angle to the cutting edge and thus the papers cut in this machine will have right angle edges.
- There are also scales in centimeters on the guides. Each scale starts with zero from the cutting edge. Thus the length of the paper on either side of the cutting edge can be measured.
- The extra length of the paper beyond the width of the table can be measured with a scale sliding behind the front scale. This sliding scale can be pulled out whenever

necessary. The sliding scale avoids the need of extra width of the table.

The system discussed above comprises the whole machine. The customer can purchase this unit and use it by keeping it on a table available in the office.

The other solution suggested is with the stand structure to which the machine unit can be fitted.

- . The stand consists of square section mild steel pipes welded at the junctions.
- . There is a paper storing unit fitted with the stand, which is made up of teak wood. It has three drawers in which imperial size papers can be stored.
- . The sheet metal covers provided for the machine and the pressure plate are first pretreated and then spray painted by air drying paint.
- . The machine covers an approx. area of 3'x2'.

7.1 Operation of the machine

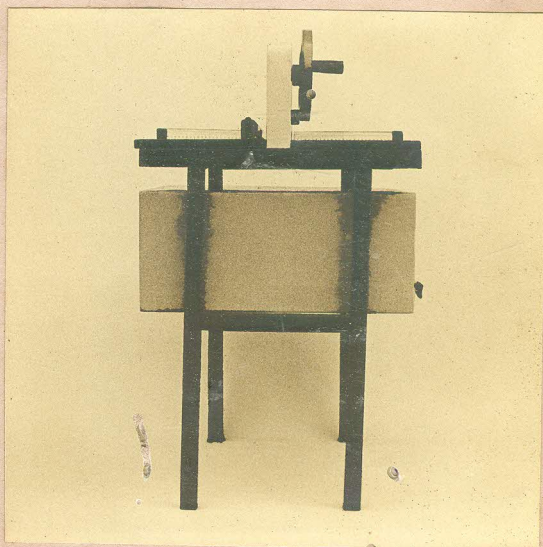
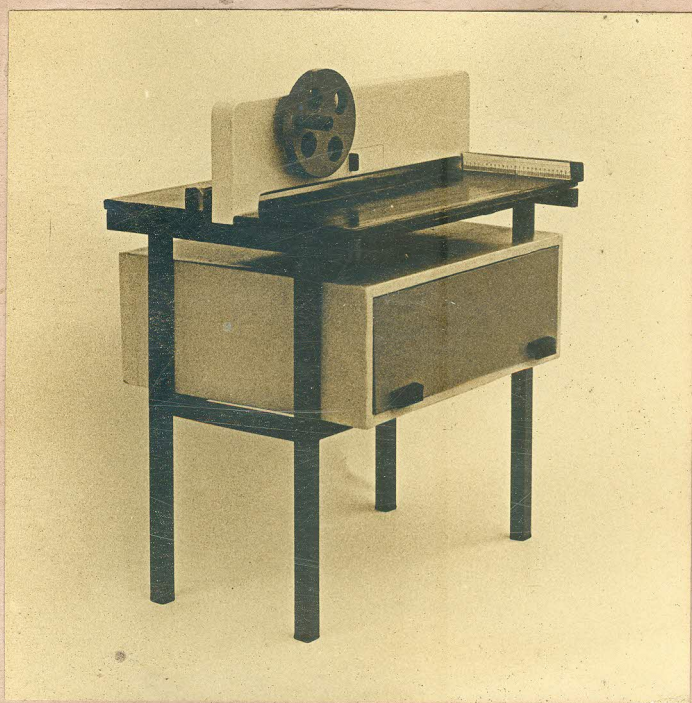
- The operator has to stand in line with the machine in between the two sides of the table.
- Firstly the pressure plate will be in its upper position.
- The paper is inserted into the machine and at the same time it is guided along the guide plate.
- The length of the paper is adjusted by measuring along the scale.
- Then the pressure is applied on the paper by turning the knob of the pressure plate.
- The hand wheel is rotated twice in clockwise direction and the paper is cut.

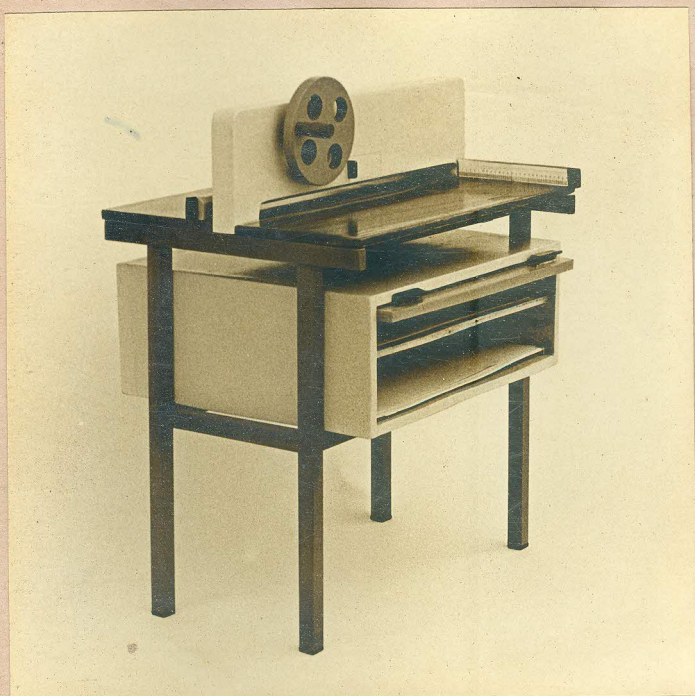
8. Communication

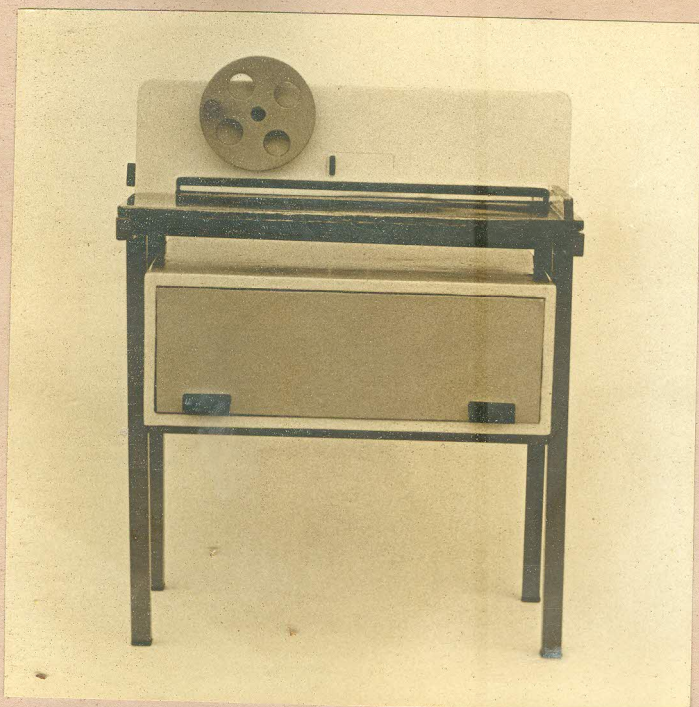
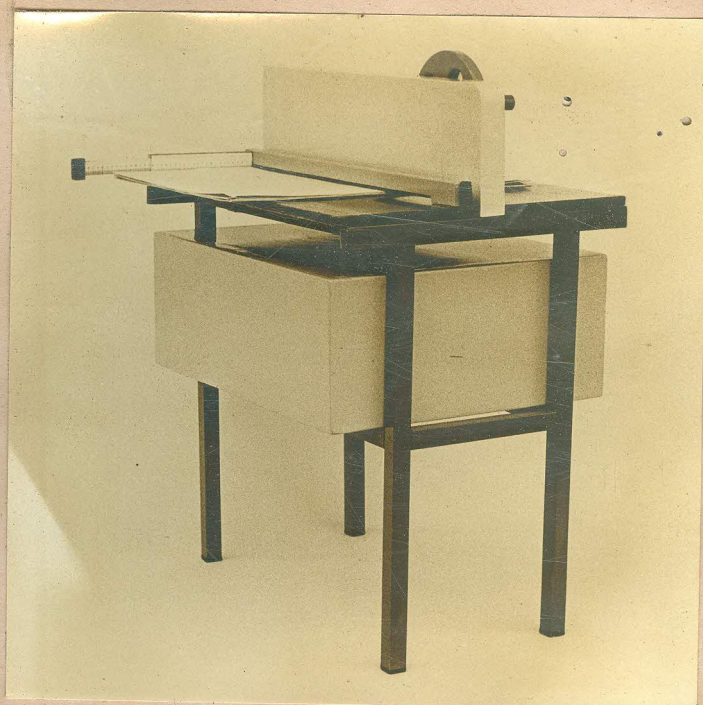
8.1 Photographs

8.2 Technical drawings

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DIPLOMA PROJECT PAPER CUTTING MACHINE

ASSEMBLY IN SECTION

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