DESIGN OF A SCREEN PRINTING MACHINE

D. I. I. T.

HEMCHANDRA AGASHE

INDUSTRIAL DESIGN CENTRE

INDIAN INSTITUTE OF TECHNOLOGY BOMBAY

1979

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DIPLOMA PROJECT

SUBMITTED IN PARTIAL FULFILMENT OF
THE REQUIREMENT FOR THE POSTGRADUATE
DIPLOMA IN INDUSTRIAL DESIGN

BY HEMCHANDRA AGASHE

INDUSTRIAL DESIGN CENTRE
INDIAN INSTITUTE OF TECHNOLOGY
POWAI BOMBAY 400 076

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APPROVAL SHEET

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GUIDE :

CHAIRMAN :

EXAMINER :

ACKNOWLEDGEMENTS

MY ACKNOWLEDGEMENTS TO MY GUIDE SHRI U.A.ATHAVANKAR FOR THE USEFUL GUIDANCE HE RENDERED THROUGHOUT THIS PROJECT WORK.

I AM ALSO THANKFUL TO ALL THOSE WHO ASSISTED ME IN COMPLETING MY PROJECT.

CONTENTS

1. INTRODUCTION

Silk screen printing process consists of forcing the special paint through the open meshes of the framed screen, part of which is filled up in solid so that paint can pass through those areas of the screen which are left open according to the design to be reproduced.

Unlike most other forms of printing which are mainly confined to paper, this process can be reproduced on practically any surface and is used extensively for the decoration of furniture, textiles, plastics, ceramics, wall paper, glass etc.

Out of these base surfaces, this process is widely used on wall papers when small batch and large size of the material is to be printed. In that case it is impractical and costly to use printing machines. On furniture and ceramics it is very often used mainly because of the depth or richness of the colour. On glass articles like glass tumblers and cold drinks bottles printing is done by screen printing method. But it is not as wide-spread as printing of other surfaces mainly because of the requirement of heavy capital investment in furnaces and non-availability of glass decorating inks in India.

The other earliest use of screen printing was for textiles. In this process textiles are steam heated from below after printing is done. Thus textile screen printing is a different process.

The material which is replacing other materials like glass in daily use is plastics. Most of the plastics are unbreakable, non-toxic, hygenic, light weight, cheap and can be available in various colours so it's use in domestic applications, particularly in packaging, is continuously increasing. The development of blow moulding process has resulted in more and more use of plastic bottles and containers. These articles being used as kitchenwares, there is a need of printing on these articles which can have longer life under service and pleasing appearance.

The methods by which plastic bottles are printed :

1.1 TRANSFER LABELS AND STICKERS

These are first printed by litho, letterpress on screen-printing process. So they can be made in colourful designs. These are pressed on the surface and stuck on the article by adhesive bond.

But PVC stickers are also fused in the article by keeping it in the mould, after electro-charging them, thus becoming a part of the article. But manual location of the sticker in the mould results in reduction of cyclic time compared to screen printing a plastic article after it is moulded. Also these stickers being imported, overall cost goes up.

	Process	Cost/sq.in.
1)	Transfer Labels	2 paisa
2)	Stickers - i) Paper sticker	1.25 to 2 paisa
	ii) PVC sticker	1.75 to 3 paisa (upto 3 colour)

The other drawback of the process using self-adhesive stickers is that, it stays on the surface for very much less time. If a plastic container is used in daily use transfer label on sticker gets peel off.

1.2 SCREEN PRINTING

This process is comparatively cheap. It's cost being - 1.5 paisa/sq.in.

The scratch resistivity of the print results in its use in domestic applications where there is more handling of the container. Also richness of the screen printed ink makes it more appealing as compared to stickers made by usual printing processes.

From the above discussions it is clear that bottles used for domestic applications need a more durable printing. Printing on glass bottles by screen printing method being costly only method preferred is using self-adhesive stickers. But this method is useful only for throwaway bottles. So for repetitive use, drawbacks like, lack of unbreakability, costly and non-durable printing, makes the glass bottles unpopular as compared to plastic bottles.

So bottles of plastics, as a substitute for glass need a relatively permanent, faster and more accurately registered

screen printing.

Thus there is the market for a screen printing machine fulfiling these requirements. So scope of the project is, for screen printing of plastic bottles.

2. DATA COLLECTION

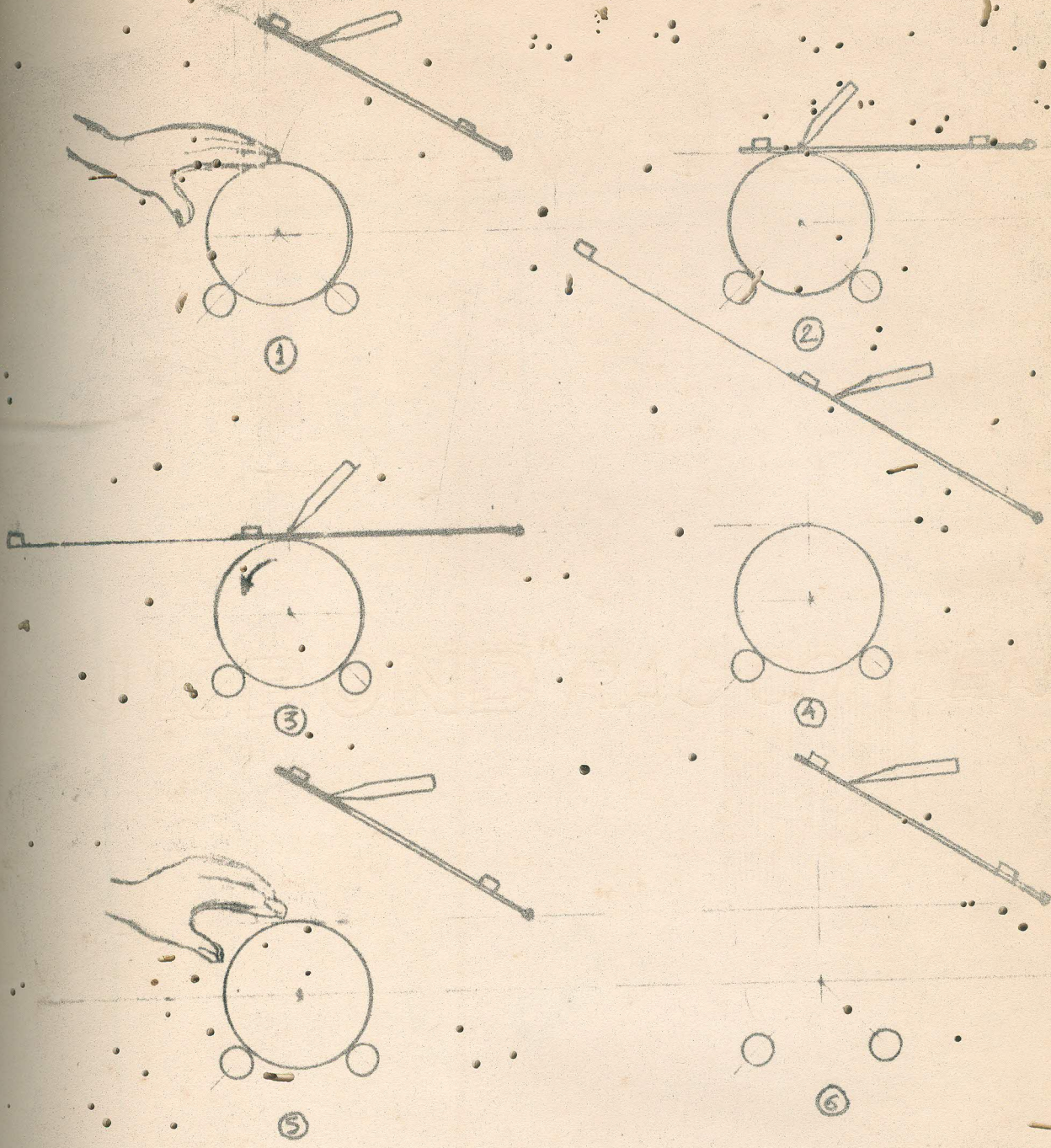
2.1 PRINTING OF PLASTICS

Plastics is a fairly general term and it is not possible to decide on the ink from this description. Commonly used plastics are :

1. P.V.C:
2. Polystyrene
3. Acrylic
4. Polythene - High Density (includes 'Hostalen')
5. Polythene - Low Density
6. Polypropelene

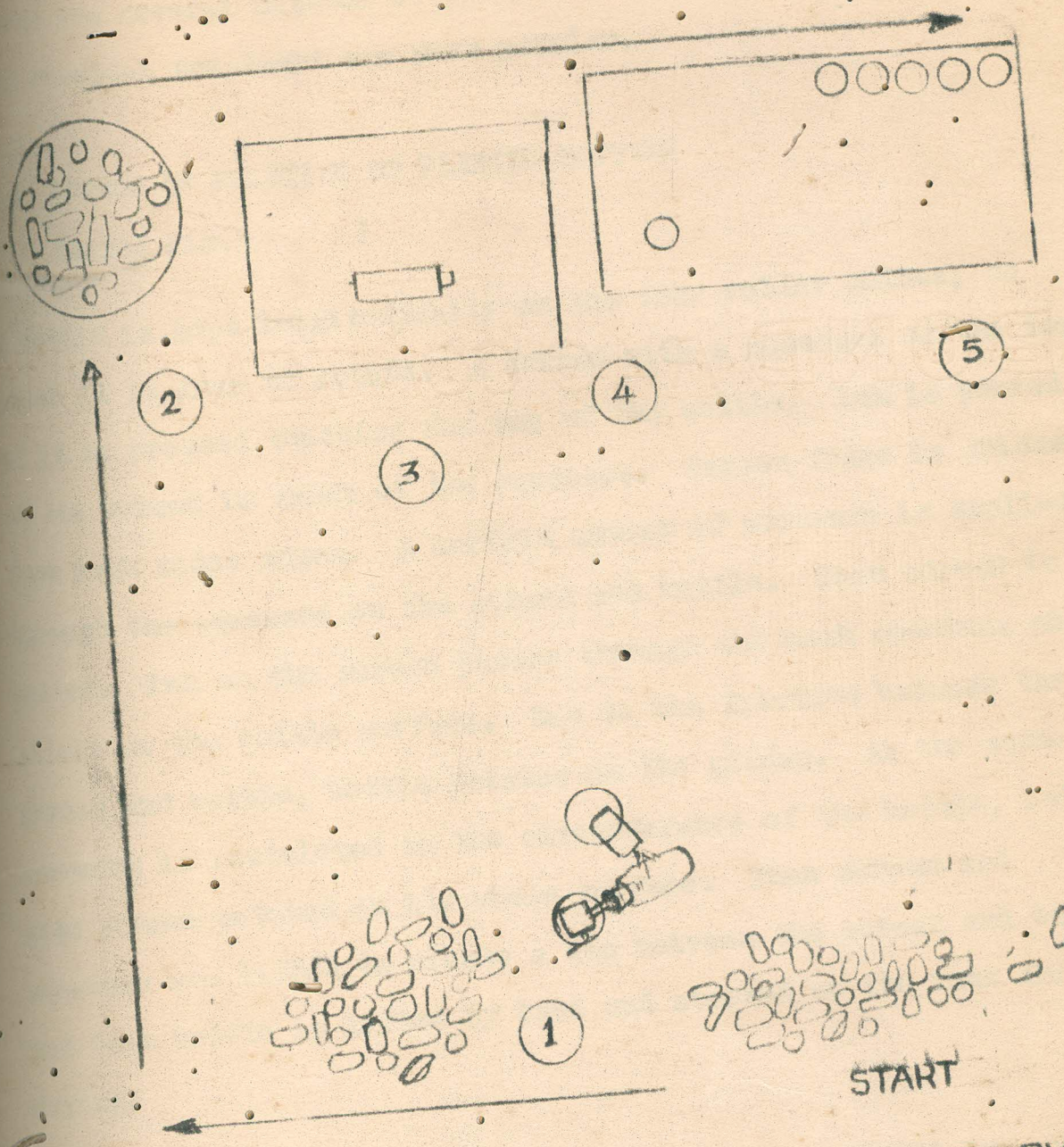
Of these the first three are viz. PVC, Polystyrene and Acrylics are comparatively easy to print on, since they do not require any treatment and can be printed directly with the P.V.C. inks to obtain a permanent printing.

The remaining three surfaces will not receive the printing permanently unless they are pretreated. Two things that should be remembered are i) Printing without treatment is possible but it will not resist scratching although rub resistance can be obtained and ii) Treatment is to be given before printing. Containers which have been warehoused for a longtime should also be pretreated.



CYCLE OF PRINTING

"NUTEX" SCREEN PRINTING MACHINE
FIG.NO.1 NOT TO THE SCALE
H.S.AGASHE • 772705
I.D.C., I.I.T., BOMBAY.



FLOW OF BOTTLES DURING PRINTING CYCLE

'NUTEX' SCREEN PRINTING MACHI
FIG.NO. 2 NOT TO THE SCALE
H.S.AGASHE 772705
I.D.C., I.I.T. BOMBAY.

There are several methods of pretreatment, of which direct flaming and chemical treatment are more popular.

2.2 METHOD OF PRINTING OF PLASTIC BOTTLES

(Refer Fig.1)

A bottle is kept longitudiually on the four roller guides, on which it is free to rotate. A screen with a squeezee on the top of it is pressed touching the top of the bottle. Ink is poured on the screen in front of the squeezee. Screen frame is guided from both sides edges. A certain amount of pressure is applied through the squeezee on the screen and bottle. Then screen is pulled. Ink on the screen passes through the mesh openings and sticks on the bottle surface. Due to the friction between the screen and bottle, bottle rotates on the guides. As the screen movement is restricted to the circumference of the bottle, bottle gets screen printed on its whole surface. Then screen and squeezee are lifted to create a gap between the screen and bottle and then bottle is lifted by hand and stocked on the rack for drying.

2.3 SHOP FLOOR LAYOUT AND THE FLOW OF BOTTLES DURING THE WHOLE PROCESS

A flame treatment unit is kept on the floor. Bottles are spread on the one side of it and after flame-treatment they are kept on the ground on the other side. Then one worker puts all the

bottles in a wooden container and keeps it to the left side of the machine. Worker doing feeding picks up bottles one after the another from it and feeds it. Printing worker stands in front of the machine while other worker removing the bottle stands to the right side. Drying racks ie. Wooden platforms are kept near to him. While fifth worker stands in front of the rack and arranges the bottles in a row.

2.4 TYPE OF SCREEN PRINTING MACHINES FOR PLASTIC BOTTLES

There are two manufacturers in India who manufacture these type of machines :

	cost
1. Semi-automatic machine	Rs.39000/-
Manufacturer:	
Solar Machines Pvt. Ltd.	
2. Hand operated Machine	Rs.1200/-
Manufacturer:	
Nutex India Ltd.	

The difference between these two machines is that, screen movement and lifting of the squeezee is automatic in 'Solar' machine. Also there is a facility of air injection for printing on very thin bottles using a pedal operated switch. But feeding and removing of the bottle is done manually. While in a Nutex machine all the operations are done manually and there is no facility for air-injection.

In 'Solar' machine printing operation being done automatically, a printing worker is not required. So labour cost is reduced.

The hand operated machine is quite compact, its overall dimensions being 1½ ft x 1½ ft x 1 ft as compared to 4 ft x 4 ft x 5 ft of the solar machine.

The rate of production of a 'Solar' machine is 50% more than a 'Nutex' machine. Also it needs one worker less than that of a Nutex machine. Then also initial investment being 25 times more than that of a 'Nutex' machine makes its scope limited only for big industries where large volume of bottles is to be printed.

2.5 WORKING OF A HAND OPERATED MACHINE

It consists of a frame structure and a lifting frame with dead weight. In a frame structure a movable frame is guided on which shafts are mounted. Shafts are provided with four roller guides which can be moved along the shaft and fixed for guiding different lengths of the bottles. Movable frame can be moved upwards or downwards by lifting two knobs on the front and back side of the frame and tightening them. Sliding frame is guided in a lifting frame. On the lifting frame a structure for squeezee fixing is mounted at an angle of 45° to the lifting frame. There are two knobs for vertical lifting of the squeezee and central knob is used for tilting of the squeezee. So by using these knobs squeezee can be brought on the top of the bottle. Dead weight

is used for keeping the lifted frame in a tilted position. Screen frame is gripped using two square bars. For stroke adjustment two slotted plates are mounted on both sides with a wing nut passing through it.

3. ANALYSIS

3.1 After making general observation of the total printing cycle it was found that there are unnecessary movements of the workers. With the possibility of saving idle time of workers during these movements, each activity of the worker is studied through exhaustive activity analysis.

ACTIVITY SAMPLING TECHNIQUE :

In this method an observer records what the worker is doing at certain predetermined time. When the data is completely recorded the investigator can get an estimate of :-

a) The average length of time spent in each activity.

b) The percentage of the worker's total time spent in various activities, of his job

c) The sequence in which the worker performs various activities of his job.

Activities involved in the printing process and the time taken for each activity is as follows :-

i) Initial setting of the machine - 30 to 40 minutes

ii) Flame Treatment - For thin bottles - 2 secs/bottle
For thick bottles- 5 secs/bottle

As flame treated bottles are collected in a container and then fed on the machine for production purpose, their time is catagorised separately.

After bottle is removed, arrangement of the bottles on the drying rack is done, which takes always less than the cycle time of the process. Hence that time is not mentioned below.

Activity	Small Bottles		Big Bottles	
	Without Location	With Location	Without Location	With Location
1. Feeding	1.0	1.5	1.5	2.5
2. Printing	1.0	1.0	1.5	1.5
3. Removing the bottles and keeping in on the racks	1.0	1.0	1.5	1.5

From the above table it is clear that time required to locate the bottle for its flashline is varying from 0.5 to 1.0 secs, while other operations are taking the same time. But in actual practice while a removed bottle is kept on the racks feeding worker starts placing the bottle on the guides, so these two operations are slightly overlapping and hence consuming less time. So, it should be noted that printing operation is taking maximum amount of time.

This overlap being 0.5 secs for small bottles and 0.75 secs for big bottles, total cycle time is as follows :

	Without location	With location
Small Bottles	1 + 1 + 0.5 x 1 = 2.5 sec	3 secs
Big Bottles	3.75 secs	4.75 secs

From the above studies of the activities of the worker it is observed that, unless one activity is completed the next consecutive activity can not be started. For example, unless bottle is fed it cannot be printed and so on. Only exceptional case being overlapping of bottle feeding and keeping the bottle on the rack. So after one activity or operation is done, unless all other activities of the cycle are completed worker can't start with his first operation. Thus he remains idle for that much time.

In an automatic machine, one out of these four operations i.e. Printing has been made automatic and hence fast. This results in very small decrease in the overall cycle time as the operations can be done only in a cyclic order.

Various activities involved in the printing process are analysed on the basis of :

a) Criteriors of design and

b) User's difficulties

3.2 INITIAL SETTING OF THE MACHINE

3.2.1 Cleaning the screen and squeezee

Screen is cleaned with a thinner to clear some blockout meshes of the screen. Cleaning has to be done after completion of the work as there is always a possibility of screen getting clogged due to the fast drying screen printing inks.

3.2.2 Size and Shape of the Roller Guides

Usually roller guides are made according to the shape of the bottles to get perfect guiding of the bottle, which is a recurring cost for the user.

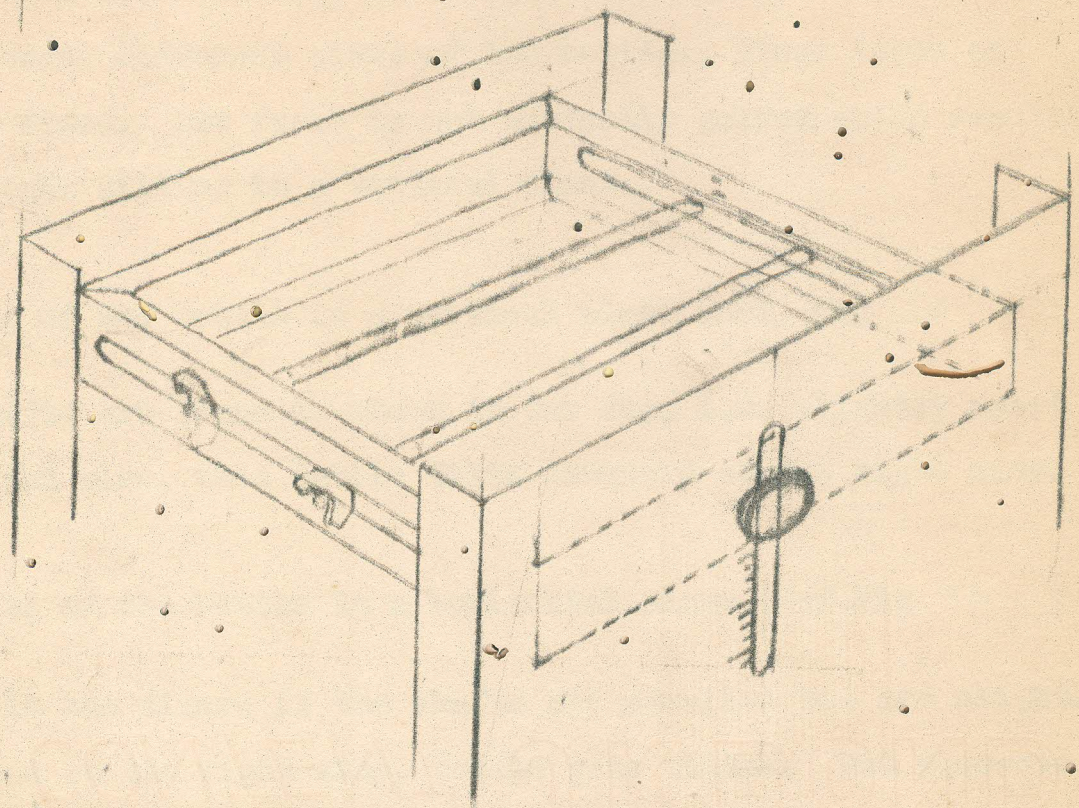
Also blow moulded bottles' size vary, to the maximum extent of 1 mm in length due to the process inaccuracy. This can result in some bottles getting stuck up in between rollers or someone becoming too loose.

In semi-automatic machine roller shape is conical with a collar on one side, (Fig. —) except for some shapes, bottle can remain over the rollers in a tilted position.

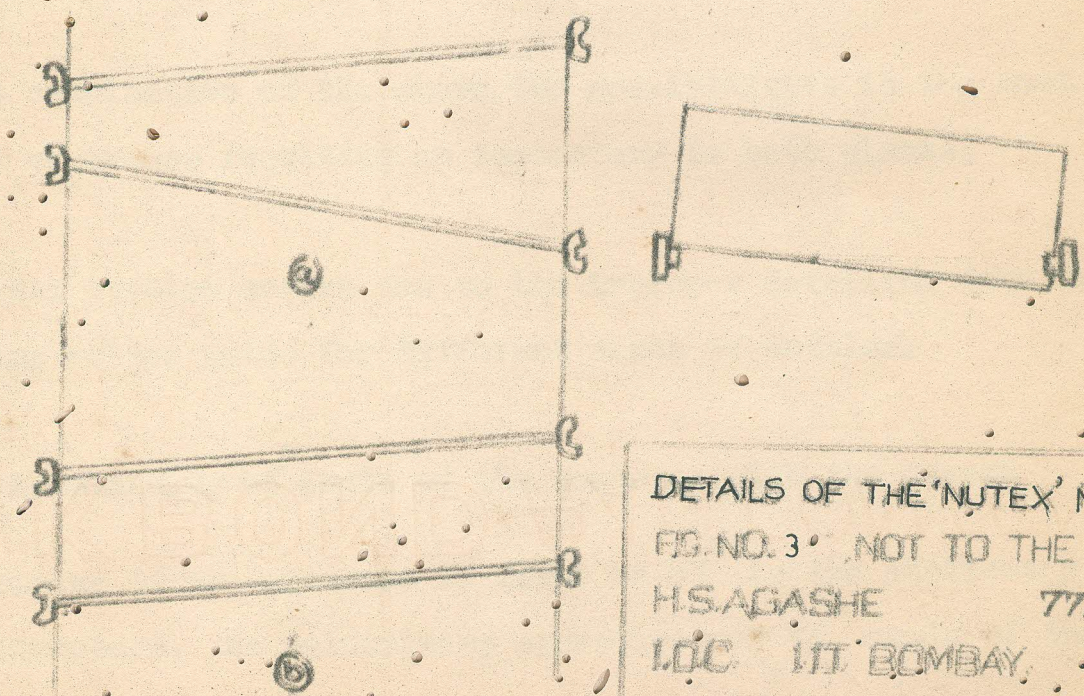
3.2.3 Adjustment of roller guide's distance from the screen for different sizes of the bottles :-

The bottle is guided and rolled on the roller guides; two rollers on each side and other two on another side. The front rollers are mounted on one shaft, while back rollers are mounted on

ADJUSTMENT OF ROLLER GUIDES
FOR THE SIZE OF A BOTTLE



INACCURATE SETTING [EXAGERATED]



DETAILS OF THE 'NUTEX' MACHINE
FIG. NO. 3 NOT TO THE SCALE
H.S.AGASHE 772705
L.D.C. I.I.T. BOMBAY.

other shaft. The two shafts are independently guided on a rectangular frame. The whole frame can be brought up or down and in apposition with the help of a tightening screw. This is done to accommodate different sizes of the bottles, since level of screen is fixed. But frame is not perfectly guided which results in its slight tilting in a vertical plane.

i) Tilting of the bottle in a vertical plane (Ref. Fig 3a)

If the shafts are fixed as shown in the fig. i.e. slightly apart on the right side, then bottle tilts downward on the right side.

ii) Tilting of the bottle in a horizontal plane (Ref.Fig 3b)

As shown in the figure if the shafts are parallel but are slightly moved ahead on the right side, bottle gets tilted. But squeezee being straight results in angular printing.

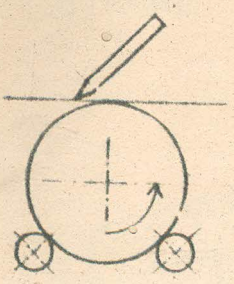
In fact combination of the above two possibilities is the most general occurence resulting an inaccuracy in both planes.

Thus, this problem occurs due to the improper detailing done for adjusting roller guide for different sizes of bottles.

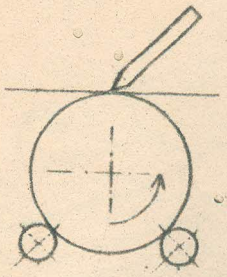
3.2.4 Maintaining 45° angle of the squeezee with the screen

The mounting of the squeezee is fixed at 45° to the stationary frame structure. So maintaining approximately 45° angle of the

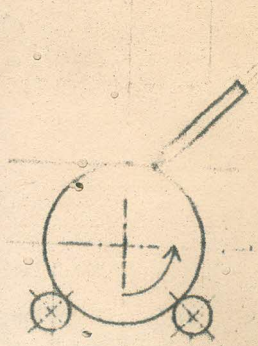
POSITIONING OF THE SQUEEZEE



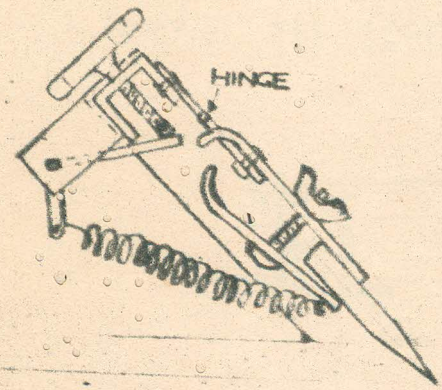
LEADING



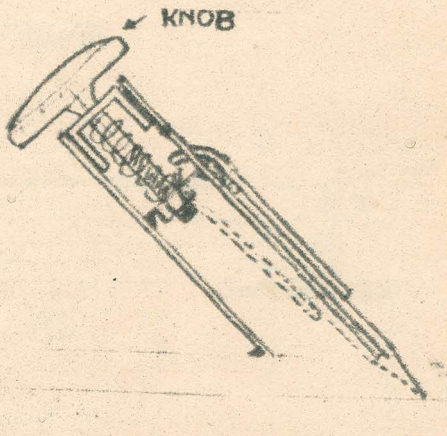
PERFECT



LAGGING



SQUEZEE TILTING



SQUEEZEE LIFTING

DETAILS OF THE 'NUTEX' MACHINE
FIG. NO. 4 NOT TO THE SCALE
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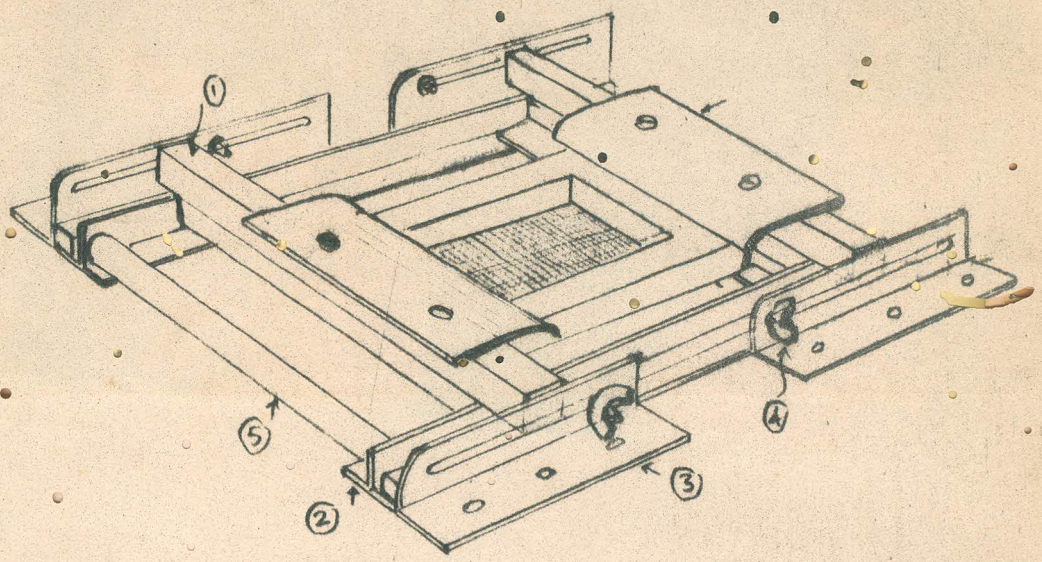
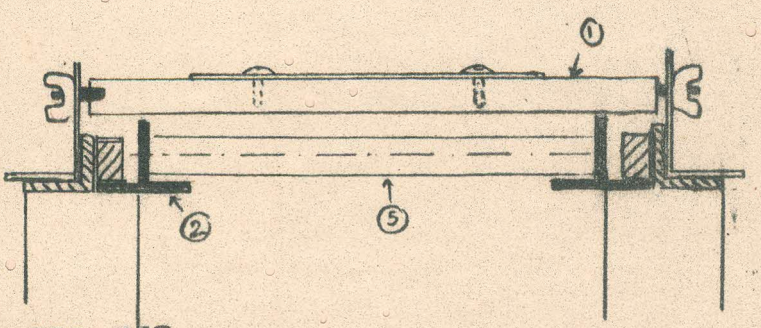
FIXING OF THE SCREEN FRAME

STROKE ADJUSTMENT



GUIDING THE SCREEN FRAME



① SQUARE BAR
② ALUMINIUM T-SECTION
③ SLOTTED ANGLE
④ WING NUT
⑤ HANDLE

DETAILS OF THE 'NUTEX' MACHINE
FIG. NO. 5 NOT TO THE SCALE
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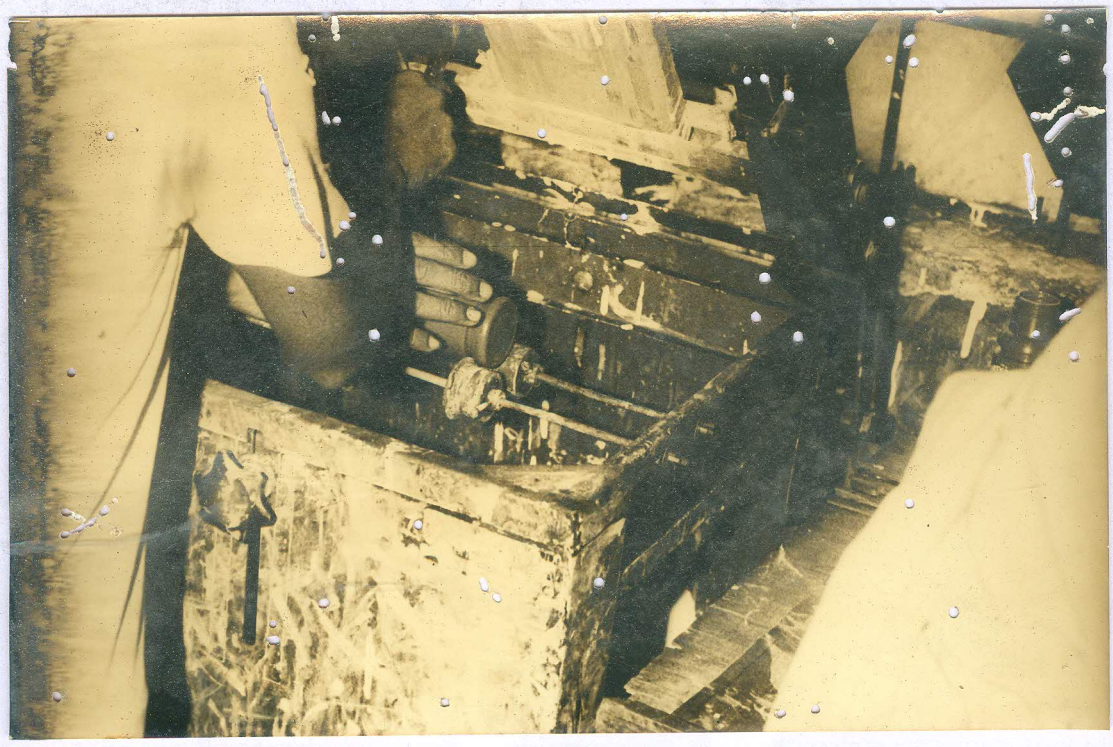


squeezee is a requirement that has to be achieved as printing quality is dependant on that factor. Lesser or more angle results in smudging.

3.2.5 Facility for changing of the squeezee blade for different lengths of the bottles :-

Squeezee blades of different lengths are gripped inbetween two aluminium plates. When screw is tightened squeezee gets pressed inbetween them. But more tightening results in the bending of the plate. (Ref. Fig. 4)

3.2.6 Fixing of the wooden screen frame

Fixing of the frame is done by using two square bars from only two sides. As frame is getting continuous impacts lateral shifting of the frame occurs gradually resulting in misplacement of the printing matter along the length of the bottle. (Refer Photo P1)

3.2.7 Maintaining a squeezee blade's bottom edge exactly on the top of the bottle :-

If blade is kept leading or lagging the bottle it creates smudging problems. So blade's bottom edge must be in on exactly vertical plane of the bottle passing through it's centre along its length.

In the present design since both shafts can be shifted independantly, Rollers and hence the bottle placed on it gets laterally shifted. So achieving the above requirement is difficult and laborious.

3.2.8 Stroke Length Adjustment (Ref. Fig. 5)

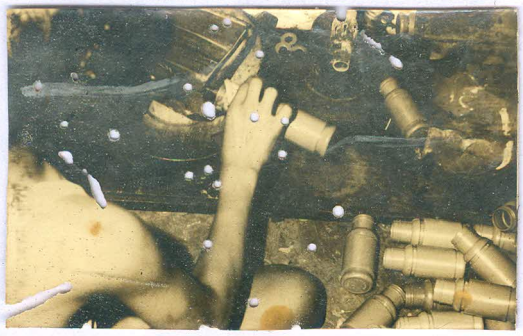
As the diameter of the bottle increases, travel of the screen i.e. stroke also increases. To control this stroke a slotted plate is fixed on the one side of the screen frame. In a slot a wing nut is fixed, which can be moved in that slot. So when moving screen frame touches the wing nut stroke starts, while end of the stroke is judged by the worker.

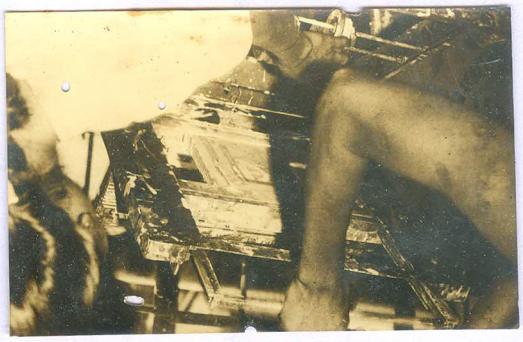
But when printing is to be done on the whole circumference of the bottle (360°) the stroke has to be stopped exactly at certain point, otherwise blank screen will go over the wet printed matter after one revolution is over.

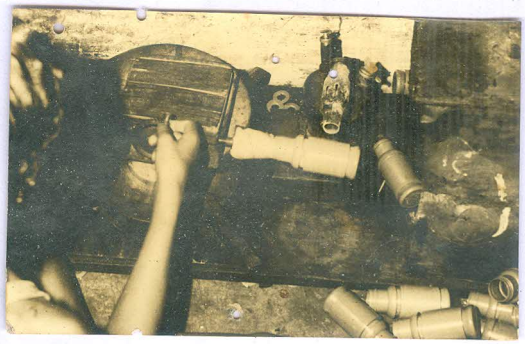
3.3 BOTTLE PRINTING CYCLE

3.3.1 Flame Treatment

The operation of etching the surface by flame treatment is done separately. The total process consists of feeding the bottle on the conical peice, bringing it under a flame, rotating the cone and hence the bottle while it is under the flame and removing the







bottle after moving it away from the flame.

3.3.2 Feeding the bottle on the roller guides

Bottles on which flame treatment is done are collected in a container. That container is kept on one side of the machine. Worker picks up two or three bottles with his left hand and keeps them on the roller guides one at a time with his right hand.

Worker has to feed the below the screen frame by inserting his hand through a triangular gap between sliding frame and frame structure. Thus there is not much access to the worker for feeding the bottle on the roller guides.

3.3.3 Location of the bottle

Blow moulding process creates flash line along the length of the bottle. The customer's requirement is that, since it looks bad and readability of the matter decreases, printing matter should not come on the flash line. So while printing, flashline should be always positioned exactly on the top of the bottle, so that, printing can be started just after it and ended just before it.

To locate the bottle for the flash-line a separate pointer is mounted. The end point of which is used to keep the flash line in line with the pointer.

Locating of the bottle can't be done precisely as bottle is far

oil is used as a lubricant between the guiding surfaces, Aluminium section do get worn out after few months. In which case whole big sized (1" x ¾") T channel has to be replaced which is costly for the user and also cumbersome.

3.3.5.2 Pressure Requirement of the squeezee during the printing Stroke (Ref P2)

About 1 kg to 2 kg of pressure is required to be exerted between the bottle and the squeezee through the screen to get the good printing results. More pressure is required for the thicker and big sized bottles. In the existing machine this pressure is applied by left hand and with the right hand he pulls the sliding frame. For doing next operation of tilting the frame and simultaneously pushing the sliding frame inside, with his right hand, he has to remove his left hand from squeezee and bring it back to it's normal position. Then he keeps the whole frame tilted in his right hand until bottle is removed and a new bottle is fed. After feeding he brings whole sliding frame down and again brings his left hand forward on the squeezee. This way pressure requirement needs unnecessary movements of his left hand.

Also for variation of pressure though there is an arrangement of lowering and tilting of the squeezee using springs, it is not used for applying printing pressure. It is, because that pressure remains during return stroke also. So manual variation of pressure is not advisable, as it harms the quality of printing.

3.3.5.3 Ink collection on one side of the screen frame and squeezee lifting during the return stroke

In the usual process of printing, printing is done only during the forward stroke of the squeezee i.e. while screen frame is pulled towards the worker. When the frame is pushed inside (i.e. during the return stroke) screen is in a tilted position (backwards). So ink remains where stroke has ended i.e. on the other side of the frame. In a semi-automatic 'Solar Screen Printing' machine also, though squeezee is lifted during the return stroke, ink gets collected on the other side of the frame. So the user has to stop the whole process and remove that ink and pour it at the point where stroke starts. Thus overall rate of production is far less than what it should have been.

Squeezee lifting or creating a gap between the squeezee and the screen during the return stroke is very much essential. Otherwise blade takes with it some amount of ink and passes it through the open meshes of the screen when bottle is not in contact with screen. In that case ink does get spread out, deterioting the quality of the printing.

3.6 Removing the bottle and keeping it on the drying racks

After the screen is lifted (tilted) upwards, fourth worker picks up with his left hand by inserting it deep inside, below the screen frame. Then he transfers it to his right hand, as drying

racks are to his right side and then keeps it on the rack by his right hand.

So, firstly there is little access for him to remove the bottle and secondly this travel of the bottle from one hand to another wastes lot of his time.

3.3.7 Arranging the bottles on the drying racks

Bottles are needed to be kept in a row on a drying rack, as bottles can be dried on the drying racks in a compact space. This is done by the fifth worker.

3.4 ERGONOMIC ASPECTS

A flame-treatment operation is done by the first worker by sitting on the ground or on a small (height - 1 ft) stool.

Other workers are doing all the operatios by standing on the ground. Out of these operations only printing operation requires more flexibility of the movement. Other operations can be done in a better way if a stool of proper height is provided for sitting So far printing worker doing work in standing position is justified. as he requires quickness of movement.

This machine being a table unit, height of the handle and overall working height of the machine varies from one user to other, resulting in a discomfort for the workers. So height of the table on which it is to be kept should be specified or a stand of proper height should be provided.

4. HYPOTHESIS

4.1 The idle time of a worker while printing cycle is getting completed should be reduced.

4.2 Each operation should be done in a better and faster way, either by reducing the unnecessary hand movements or by some other means.

4.3 Workers should have a better access for the bottle when placing it on rollers and withdrawing it.

4.4 During return stroke there should be a gap between screen and a squeezee.

4.5 The ink should not get collected at the end of the printing stroke.

4.6 The required amount of printing pressure that is to be applied on the squeezee only during the printing stroke, should be variable.

4.7 The mostly used bottles are cylindrical and conical. Their diameter varies from 4 cm to 10 cm with a maximum length of 30 cm. So bottles of this size should be printed.

5. SYNTHESIS

5.1 BASICS OF THE DESIGN SOLUTION

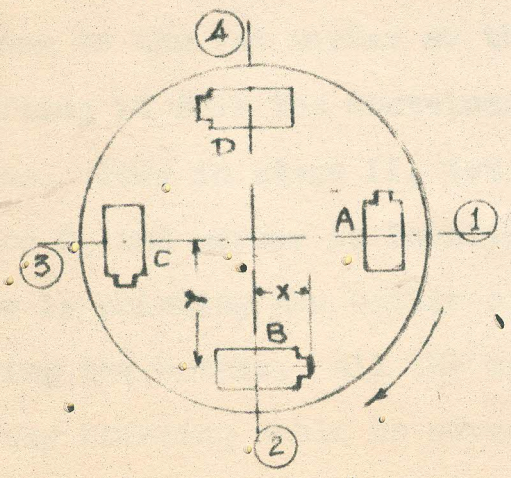
(Refer Fig. 6)

By giving clear access to the bottles - the idle time of the workers can be minimised while feeding and removing. Operations like feeding, locating and bottle removing should be done separately at different stations and away from the printing unit, instead of doing them below the screen frame. Also the proposed design allows simultaneous operations, instead of consecutive operations. Hence time is reduced due to overlaps.

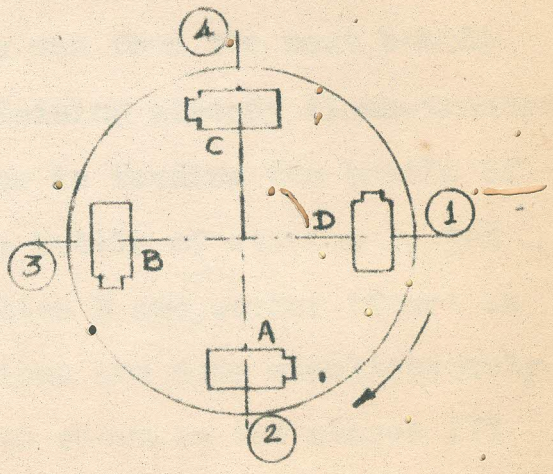
The adjoining figure explains the principle of printing cycle. A, B, C and D are the four stations and 1,2,3,4 are the four workers doing four operations. These four stations are part of a rotating table on which four bottles are mounted and guided. Each bottle being guided on four roller guides of each station. Station three, which is one quadrant of the turn table only, has a stationary printing unit, fixed separately above it.

1st worker feeds the bottle on the station A and rotates the table by hand, through approximately 90°. Exact rotation and stopping of the table by 90° is done by using a ball clutch fixed on the frame structure of the printing unit. Thus, after Stage I as shown in the Stage II, fed bottle comes to the 2nd worker for location purpose. Already located bottle of station B comes

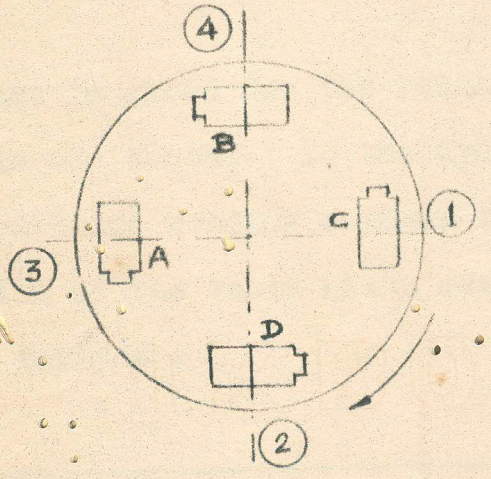
PROPOSED PRINTING CYCLE



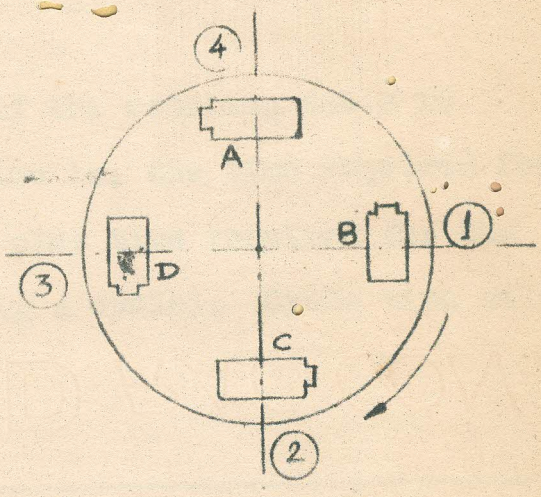
STAGE I



STAGE II
AFTER 90° ROTATION



STAGE III
AFTER 180° ROTATION



STAGE IV
AFTER 270° ROTATION

OPERATIONS OF THE WORKERS

(1) FEEDING AND TURN TABLE ROTATION

(2) BOTTLE LOCATING

(3) BOTTLE PRINTING

(4) BOTTLE REMOVING

A PROPOSED SCREEN PRINTING MACHINE FOR PLASTIC BOTTLES
FIG NO. 6 , NOT TO THE SCALE
H.S.AGASHE , 772705
I.D.C., I.I.T. BOMBAY.

under the printing unit, to the 3rd worker. Bottle printed on station C (see stage I) goes to the 4th worker for removing the bottle and keeping it on the drying rack, While station D advances to the 1st worker so that he can feed the next bottle by lifting it from the container containing already flame-treated bottles. Thus in stage II, 1st worker is feeding the bottle of station D, 2nd worker is locating the bottle of station A, 3rd worker is printing the bottle of station B and 4th worker 'four' is removing the bottle. All the operations are done simultaneously. This way rotating table is advanced as shown in the stages III and IV and during one complete rotation of the table four bottles are printed.

The time required for the rotation of the rotating table is maximum one second. So the cycle time is, the time required for the operation needing maximum time; plus time required for the rotation of the table (i.e. advancing a cycle). Cycle time will be as follows :

	Operational Time in secs	Turn table rotation time in secs	Total cycle time in secs.
Small bottles	1.0	1.0	2.0
Big bottles	1.5	1.0	2.5

So decrease in the cycle time being 1 sec. for small bottles

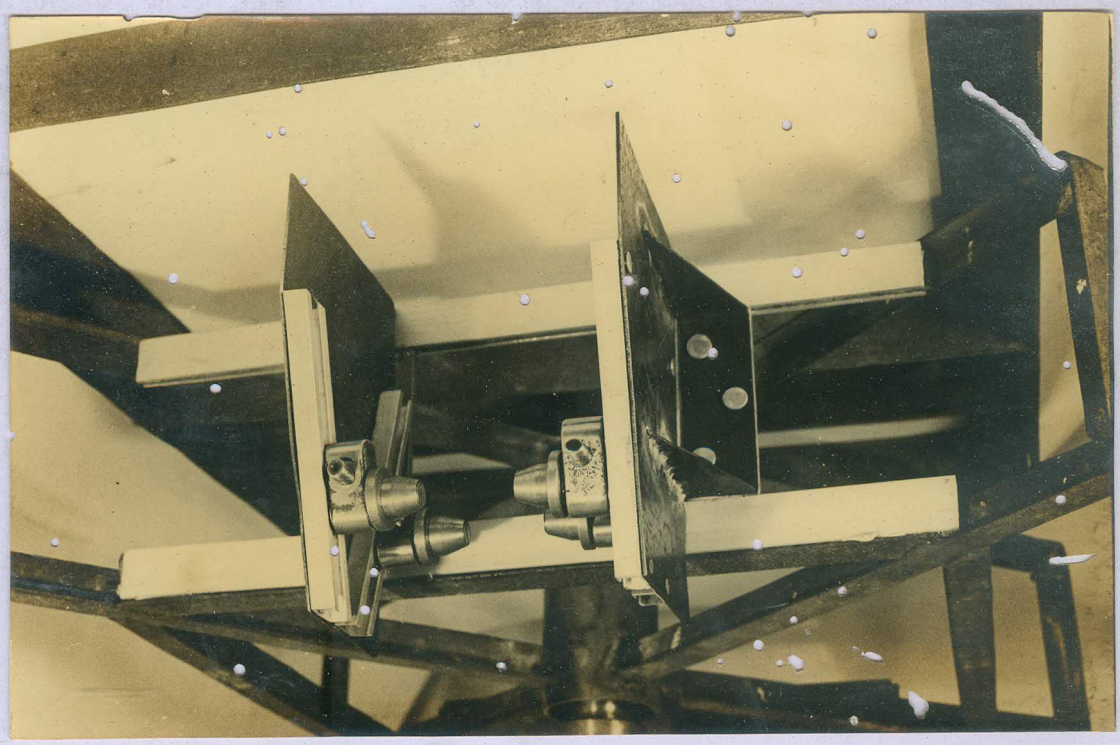
and 2.25 secs for big bottles, as compared to a 'Nutex Machine'. Thus, increase in the rate of production for this machine is 50% to 90%.

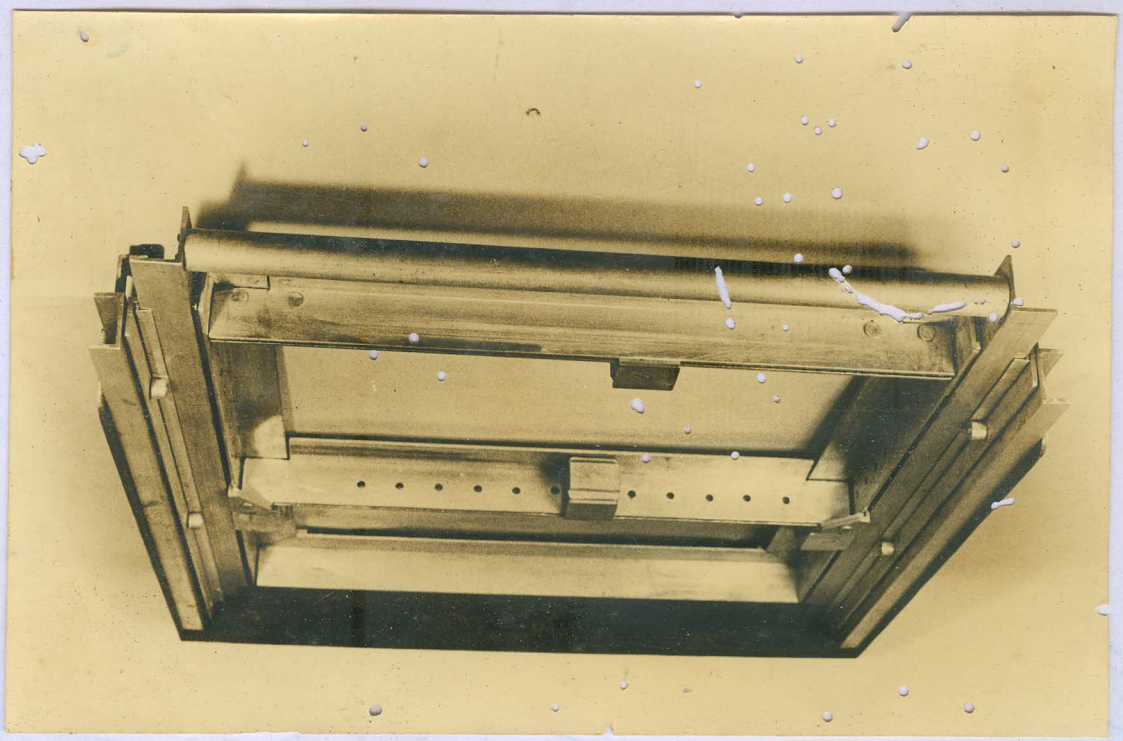
In the 'Nutex Machine' worker used to take time of 0.5 secs. for the location of the bottle, along it's flash-line. But in this principle, he gets 1.0 to 1.5 secs. for doing the same job. So he is expected to do it in a better or efficient way. The three stations, namely feeding, locating, bottle removing, where workers have to put their hands, for the bottles, are accessible to them, as there is no obstruction on the top of the bottles. So workers can do their hand movements, during the operation, in a better and faster way, thus increasing the operational efficiency.

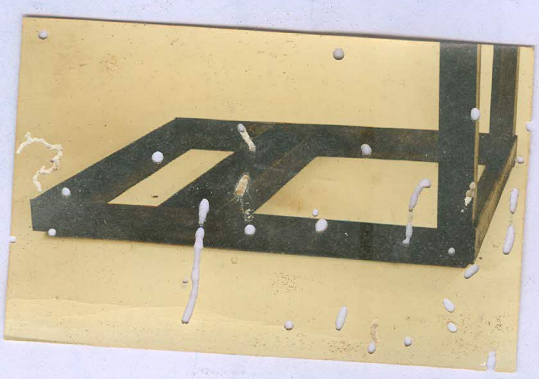
5.2 WORKING OF THE PROPOSED MACHINE

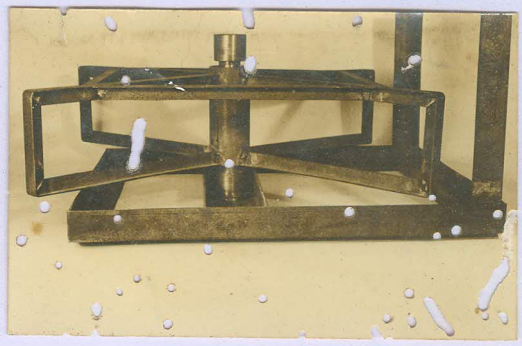
(Refer Fig. , P 3)

Rotating table consists of a structure made up of Mild steel T sections which are welded to the central mild steel pipe. A Mild steel shaft passes through the centre of the pipe, which is kept stationary. A thrust bearing at the bottom and ball bearing at the top are force fitted inbetween the shaft and the pipe. Rotating table structure is covered with a thin mild steel sheet. Central shaft is fixed to the base structure which is made up of mild steel L sections. Structure of the turn-table forms four stations on which four bottles are to be supported. Each station consists of two I sections of aluminium fixed on









the upper and lower sides of the station. Through the upper and lower C - guide channels, two aluminium rectangular plates are guided to which bottle supporting units are fixed. These units consist of a M.S. sheet on which two closed C - channels of aluminium are fixed at an angle of 40^{o} with each other. Along these channels, two roller guides are guided, so that they can be simultaneously made closer and lifted upwards. This arrangement accommodates different sizes of bottles. A similar unit facing this unit is also having two roller guides. On these four roller guides, a bottle is supported horizontally. A unit of the right side is guided for minor adjustments, while unit on the left side is shifted on either side for supporting different lengths of the bottles. As shown in the diagram, there will be two units on each station, mounted in such a way that adjacent bottles would be perpendicular to each other. Also distance of Y units of the topmost edge of the longitudinal vertical plane passing through the bottle axis and a distance of X units would remain same for the other bottles, supported on remaining three stations.

Screen frame together with the sliding frame and a frame structure are kept tilting downward towards the front so that, ink collected on the back side of the screen at the end of a printing stroke flows down towards it's front from both sides of the screen.

Two cams, one on either side, are used for creating a gap between screen frame and the squeezee; screen frame and the bottle. After the printing stroke, when cam is rotated by a handle, it first

lifts the squeezee to create a gap between screen and squeezee; then during the remaining rotation of the cam, total frame is lifted, to create a gap between screen and a bottle; so that a wet ink of the printed matter does not get wiped off, when bottle moves ahead and simultaneously the next bottle can come into it's position below the screen frame. Due to this mechanism, during the return stroke, squeezee does not touch the screen.

Majority of the plastic bottles' size lies between 4 cm and 10 cm, hence scope of the project is limited for printing these sized bottles.

Stroke adjustment is done using a rack.

The biggest size of screen frame that can be gripped in a sliding frame, from all four sides, is corresponding to a stroke of 30 cm.

DESIGN SOLUTION

5.3 INITIAL SETTING OF THE MACHINE

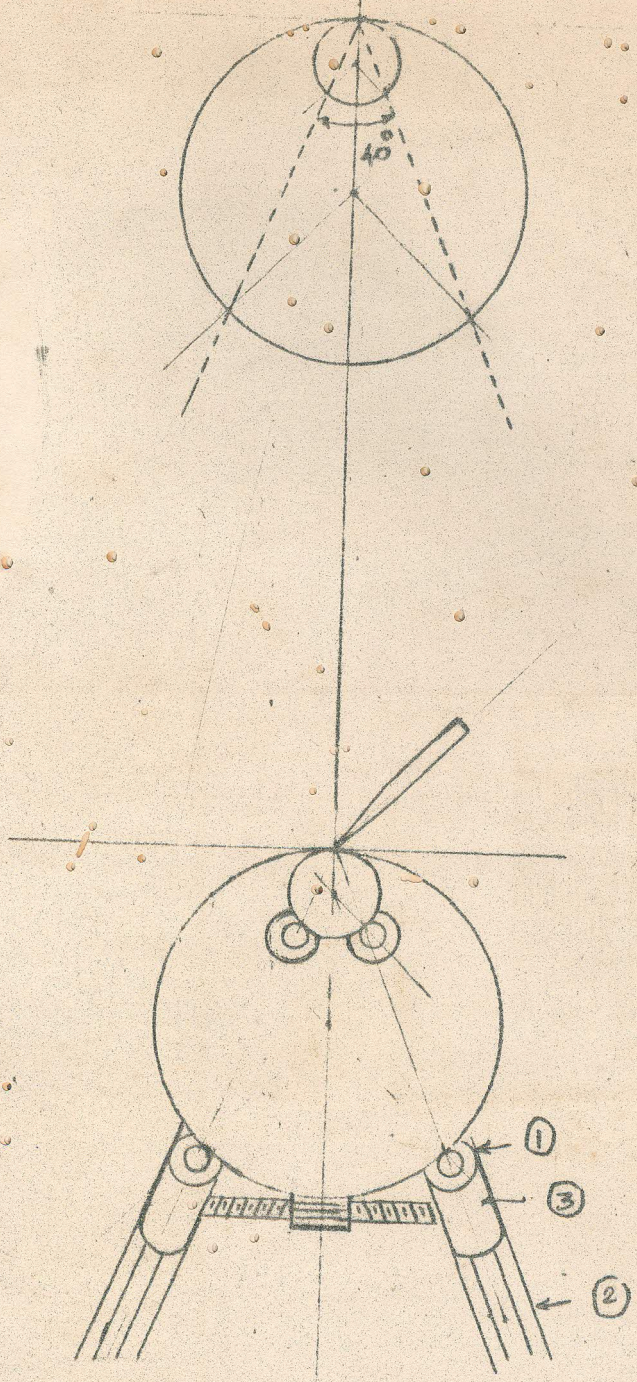
5.3.1 Setting of roller guides for different sizes of the bottles (Ref. F7 P4)

A screen level and squeezee position being fixed, the roller guides has to be shifted upwards and made closer to each other when size of the bottle to be supported reduces. So, roller guides centre traverses along a triangular path (as shown in the diagram), the triangle having an apex angle of 40^{o}.

A closed C section of aluminium is fixed along this path. The central shaft of the rollers is fixed in a rectangular block. On this shaft to the bottom side two rollers are mounted. Rollers are free to rotate on the shafts fixed to the block. These rollers can be rolled along a closed C section. Same type of unit is fixed at an angle of 40^{o} on a sheet metal piece. Rectangular blocks are having a hole at an angle of 70^{o} with the respective channels. One block is having a left handed threading while other is having a right handed threading. Then a screw knob with a left handed and right handed threadings on each side is passed through the blocks. When knob is rotated respective blocks and rollers guides either move upward and come closer or move downwards and go apart, deperding upon the direction of rotation.

Similar unit is used to support the other end of the bottle. A

SETTING OF ROLLER GUIDES FOR DIFFERENT DIAMETERS OF BOTTLES



(1) ROLLER GUIDES

(2) CLOSED C-CHANNEL

(3) RECTANGULAR BLOCK

A PROPOSED SCREEN PRINTING MACHINE FOR PLASTIC BOTTLES
FIG NO. 7 ; NOT TO THE SCALE
H.S.AGASHE, 772305
I.D.C., I.I.T. BOMBAY.

vertical longitudinal plane passing through the axis of the bottle is kept at a same distance from the centre of the rotating table, for all four stations.

With this arrangement it is also possible to print on conical bottles by lifting roller guides at one side at a higher level.

5.3.2 Size and shape of the roller guides

Shape of the roller guides is as shown in the (Fig. — .) straight face is used to support the bottle from below, while vertical face (i.e. collar) restricts it's movement in a longitudinal direction. Thus any shape of the bottle can be perfectly guided on this shape of rollers. It's size is decided as small as possible, after considering the strength requirements of the roller and guide shaft.

5.3.3 Maintaining about 45° angle of the squeezee (Ref. Fig. 8)

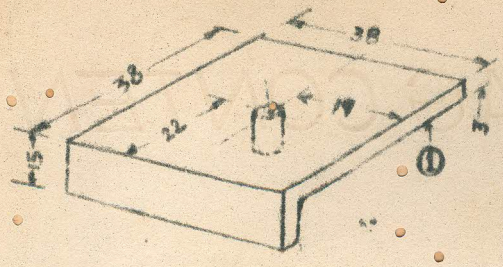
A squeezee should be maintained at an angle of about 45° to the screen, to get good printing results. But about 5° variation on either side is desirable.

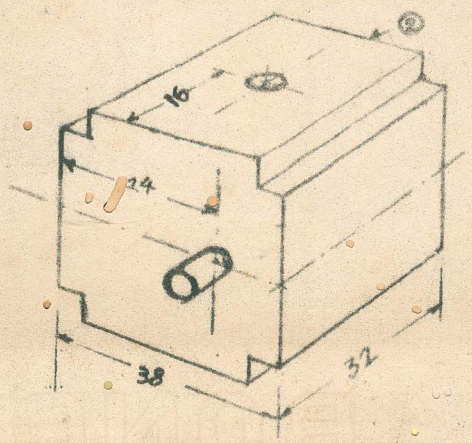
A window shutter stay is used for adjusting the angle of the

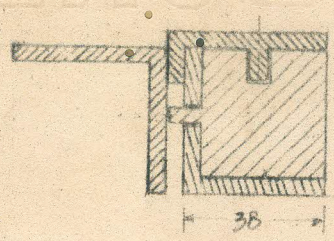
squeezee blade and a wing nut to fix it. So by adjusting the angle as required between 40 to 50° and simultaneously lowering the squeezee, bottom edge of the squeezee blade can be maintained on the topmost edge of the longitudinal vertical plane passing through the centre of the bottle. This is necessary to avoid smudging of ink while printing.

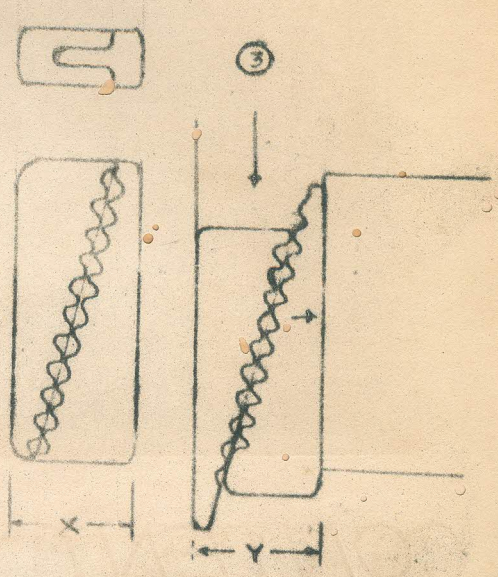
5.3.4 Facility for changing of the squeezee blade for different lengths of the bottles and maintaining squeezee on the topmost line of the bottle (Refer Fig. 8, P5)

An aluminium section as shown in the figure is used for fixing rubber or polyurethane squeezee blade. Back supporting section is hinged to the aluminium angle. To the front side (inner side) of the section, three flat springs are fixed. A squeezee is temporarily inserted between the springs and the back supporting section. Depending upon the length, squeezee is fixed in the first spring or in the first two springs (from right edge) or in all the three springs. Then by changing the angle of the back-support section with the horizontal and simultaneously moving the squeezee upward or downward, squeezee's bottom edge can be brought exactly on the top of the centre of the bottle and make it touch with equal pressure. It should be noted that relative levels of squeezee and bottle top are kept in such a way that, dead weight acts on the bottle through squeezee, before two side channels in which dead weights are fixed rest over the M.S. frame structure.

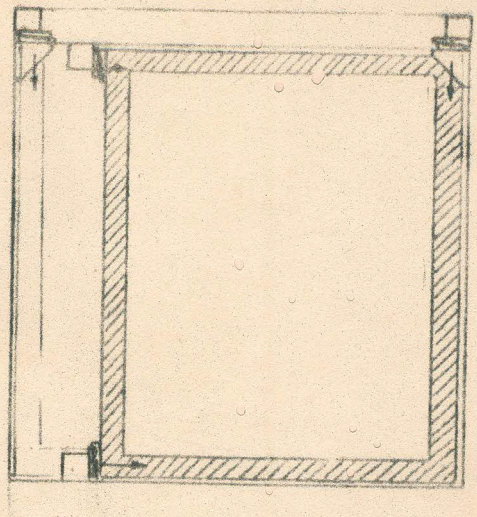


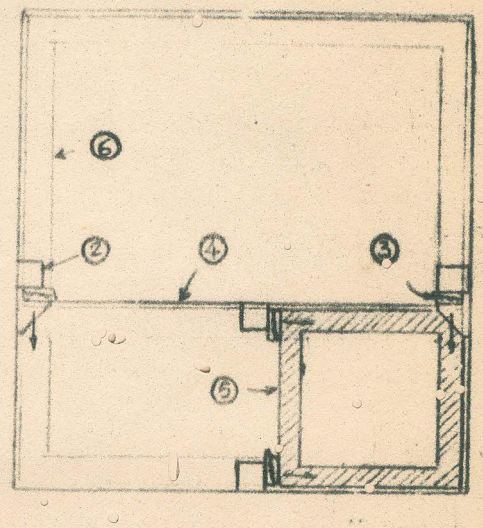






1. CLIP
2. HOLDING BLOCK
3. TAPERING WEDGES
4. SLIDING MEMBER
5. SCREEN FRAME
6. SLIDING FRAME





A PROPOSED SCREEN PRINTING MACHINE FOR PLASTIC BOTTLES
FIG NO. 9 ; NOT TO THE SCALE
H.S.AGASHE, 772705
I.D.C., I.I.T. BOMBAY.

After blade is positioned loose top channel is kept on the blade. Two screws with knobs at either ends are provided on the top cover. These screws are threaded to the nut fixed on the bottom channel. So when screws are tightened squeezee blade is gripped finally between the two channels. So this system has the following advantages :

i) Ease with which initial adjustment of the positioning of the squeezee is done.

ii) Bending of the top channel due to heavy tightening of the blade gripping screw is avoided.

iii) Head of the squeezee gripping screw gets worn out due to the frequency of the operation. Since in this detail it is provided with a knob this problem is avoided and also this operation can be done quickly.

5.3.5 Fixing the wooden Screen Frame
(Refer Fig. 9, P 6)

Gripping any size of the screen frame is required because of the following reasons :

a) As the bottle size is varying from 4 cm to 10 cm in dia. and 4 cm to 30 cm in length, size of the screen frame varies

b) As screen and frame sizes are not standardised, there is a need of gripping any size of the screen frame.

A rectangular sliding frame is fabricated using aluminium

L-angles. Screen frame is placed at the nearest right side corner. From third side it is pressed by the sliding member. This member can be slid backward or forward so that it can support different lengths of the screen frames. It is slid from it's both sides along a slot type gap provided inbetween two L-angles on each side. So this member is positioned to support the 3rd edge of the screen frame.

Two holding blocks A and B are placed as near as possible to the sliding member. On the 4th side C block is placed on the bottom face of the sliding member and D block is placed on the bottom face of sliding frame. Holding blocks are having an eccentric pin, with an eccentricity of 10 mm. There are series of holes on the vertical faces of the sliding frame and sliding member, with a pitch of 30 mm. So the gap between screen frame and holding block can be varies by 10 mm, with the position of the pin remaining same corresponding to the nearest hole. Afterwards clips are inserted from the top in the block, so block is held in it's position.

Final tightening is done by using pairs of tapered wedges, sliding against each other. These pairs of tapered wedges are inserted in gap between holding block and screen frame. Suppose (as shown in the Fig.9) gap between holding block and screen frame is Y units and tapered wedges are having a width of X units in the normal position. When they are slided against each other to make their width slightly more than Y units, due to

wedge action tightening force is applied on the screen frame. On the A and B holding blocks side, this force is applied through a sliding member and on C and D blocks side it is applied directly on the screen frame.

This newly designed system, has the following advantages, over the previous one :

i) Since screen frame is gripped from all the four sides, it's movement or loosening does not occur.

ii) Placement of the screen frame is always on the nearest right corner of the frame. Hence time does not get wasted in seeing it's relative position with the bottle.

iii) A screen frame for a maximum of 10 cm bottle can be fixed in it

5.3.6 Stroke Length Adjustment

(Refer Fig 8, P 7)

A stroke is required to be adjusted according to the variation in the diameter of the bottles. Also some times bottles are needed to be printed partially. So travel of the screen and hence sliding frame has to be adjusted precisely, otherwise blank screen, going over the wet ink of the just printed matter can wipe it off.

A rack is fixed along a length of a sliding frame on the outside vertical face of a Z formed due to two angles. Another aluminium

angle in which it is guided is a fixed member. At it's front end, which is angularly cut is fixed. L-section

A stroke adjustment piece is having mild steel guiding plate, angularly cut piece of rack and a tightening knob. Guiding plate is passed through a gap formed between two angles. A piece of rack is inserted from the bottom side on the rack and knob is tightened. Hence when frame is pulled this rack-piece comes upto the stationary piece and stops. This way by shifting the rack piece along the length of the rack, travel of the sliding frame; and hence, stroke, is adjusted. Minor adjustments equal to the pitch of the rack are made by shifting the piece downwards and then tightening it.

This system has the following advantages :

i) In the previous design sliding frame used striker on the wing nut used for stroke adjustment. Since it can move along a slotted plate this frictional lock can't take continuous impacts and wing nut can move along it. But in this system a positive lock is used which avoids this problem.

5.4 BOTTLE PRINTING CYCLE

5.4.1 Flame Treatment

Process of flame-treatment is kept same. Only two containers are provided one for feeding and other for collecting the bottles.

A stool has been provided to the worker for sitting and flame-treatment unit is kept at a seat height of the worker.

5.4.2 Feeding

Bottles are collected in a container kept on the right side of the 1st worker. He picks up the bottle with his right hand and keeps it on the roller guides.

In this method since there is unhindered access, the same operation can be done by him, in a better and faster way. Since this operation takes less time, he is also available to rotate the table. The table gets positioned at an exactly 90° by a latch.

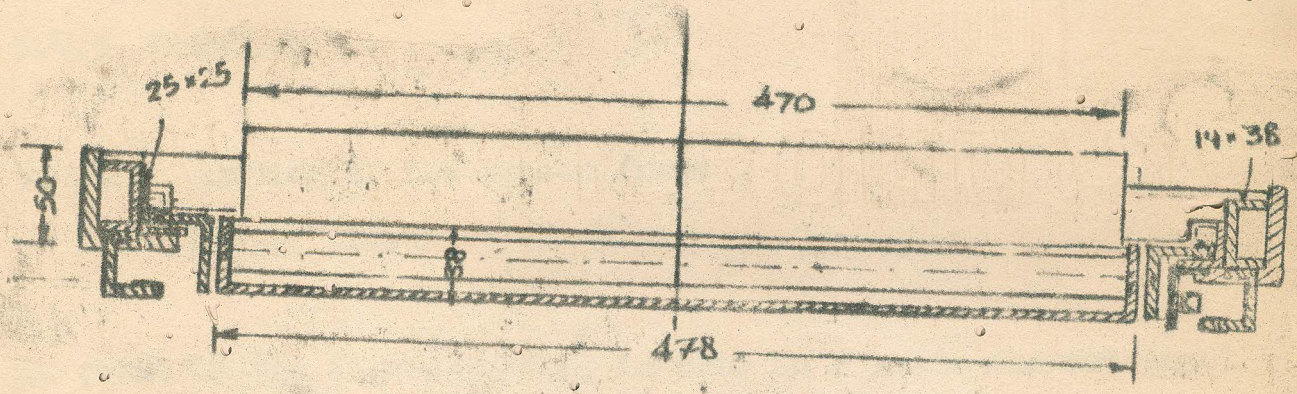
Since this machine is a table unit, rotation is done by hand. It can be done by a pedals in a better way, but it is not advisable to incur more cost in it.

5.4.3 Location of the bottle along it's flash-line

Since location of the bottle is done separately on station by 'second' worker, he can do it accurately, as more time has been given to him to do the same work.

For this operation a pointer is fixed on the sheet metal part on which roller guides are mounted. It is fixed vertically in a plane passing through the centre of the bottle.

SLIDING FRAME



A PROPOSED SCREEN PRINTING MACHINE FOR PLASTIC BOTTLES
FIG NO. 10 , NOT TO THE SCALE
H.S.AGASHE , 772705
I.D.C., I.I.T. BOMBAY.

5.4.4 Air Injection

From the users survey it was found that only less than 10% of the bottles need air injection. This needs a air compressor and some other accessories, due to which total cost goes up. So by seeing a market, it is not advisable to go in for providing this facility only when very small percentage of very thin bottles are manufactured which needs screen printing.

So scope of the machine is limited for bottles not needing air-injection.

5.4.5 Printing

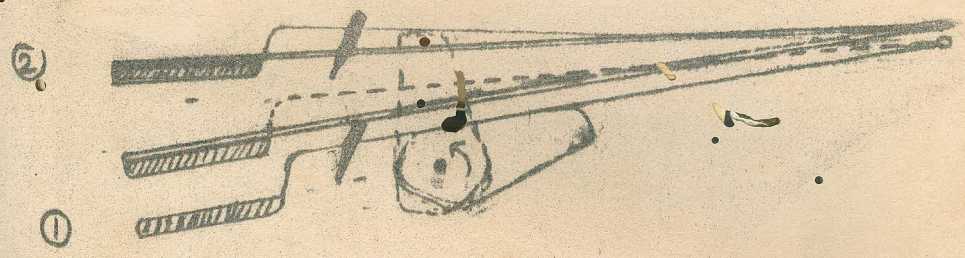
5.4.5.1 Guiding of the screen frame

(Refer Fig.10)

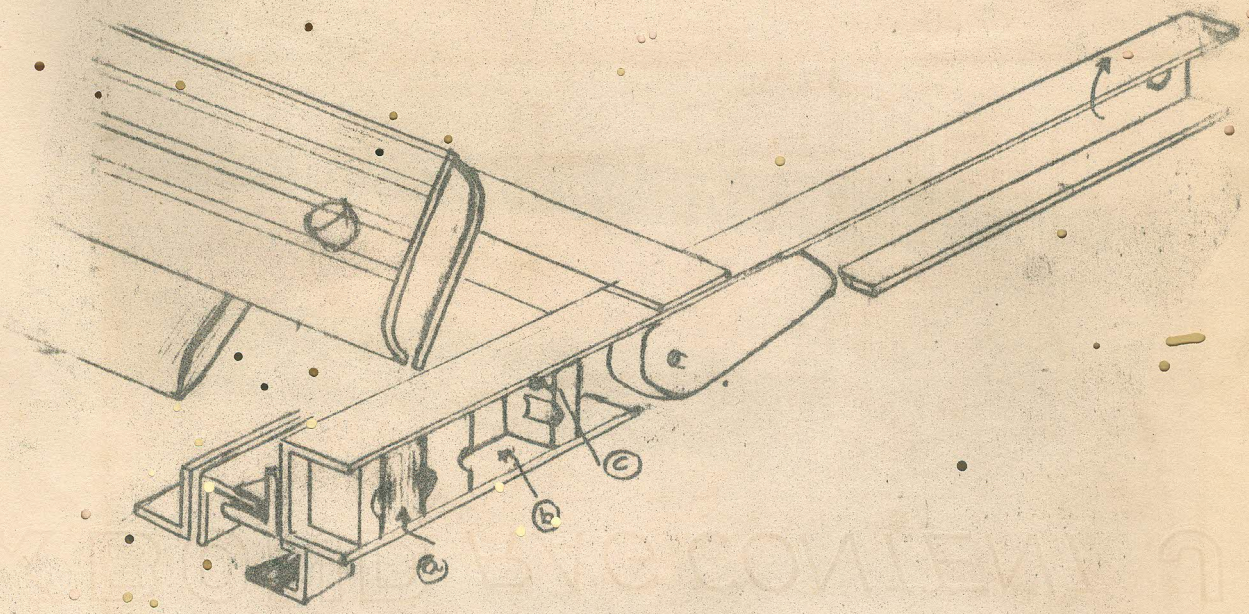
As shown in the figure, guiding is done in a guide channel which is fixed at it's far end by screws on an aluminium angle. While two rollers are fixed on the top of it, along it's length, to constrain movement of the channel upwards.

This system has the advantages that even if small aluminium guide channel gets worn out, it can be replaced. It's size being very small, recurring cost in the maintenance of the machine is less.

PRINCIPAL OF SQUEEZEE LIFTING



VARIATION OF SQUEEZEE PRESSURE
GUIDING OF THE SLIDING FRAME



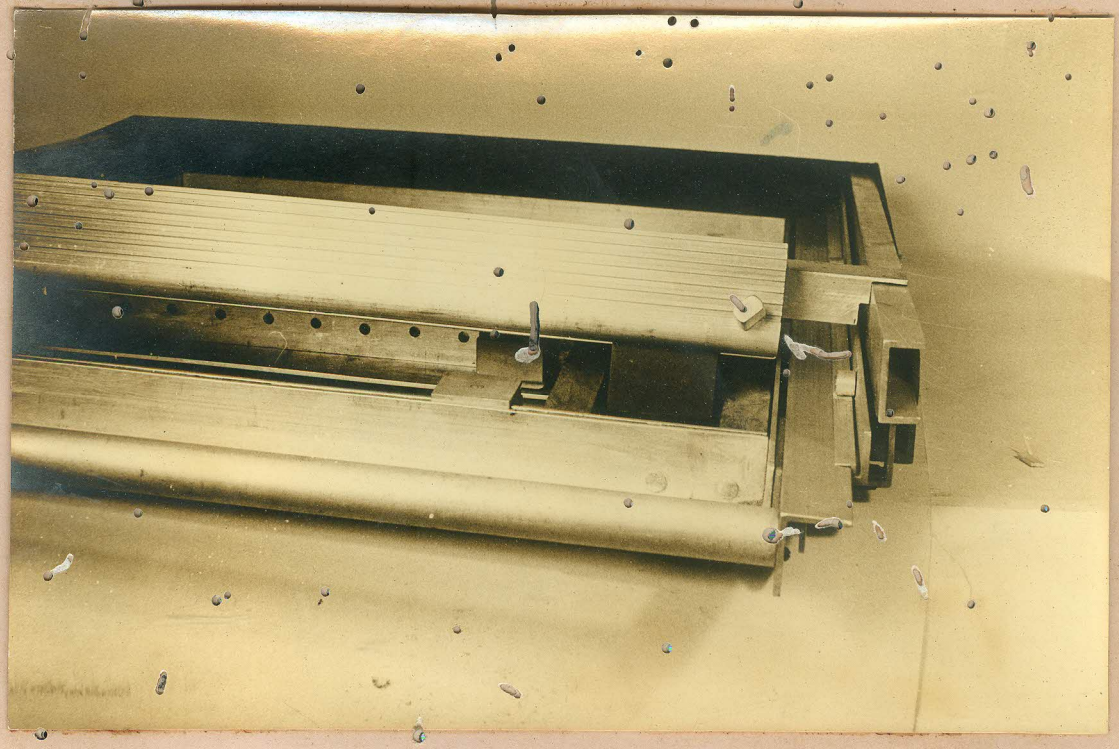
ⓐ DEAD WEIGHT BLOCK

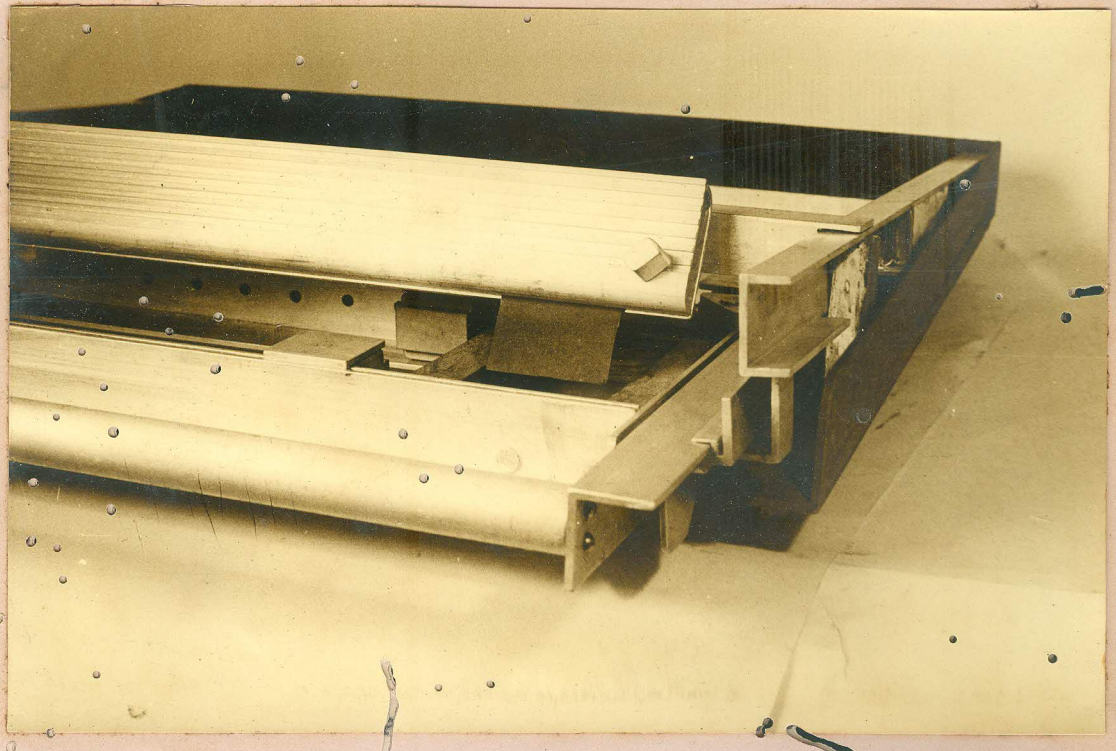
ⓑ COMPORTMENT FOR TWO DEAD WEIGHTS

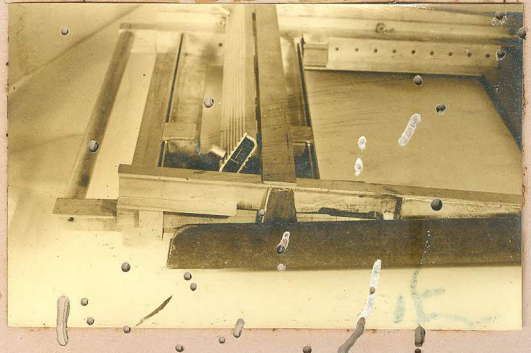
ⓒ BALL CLUTCH

A PROPOSED SCREEN PRINTING MACHINE FOR PLASTIC BOTTLES
FIG NO. 11 , NOT TO THE SCALE
H.S.AGASHE, 772705
I.D.C., I.I.T. BOMBAY.

P 8







5.4.5.2 Requirement of the variation in Squeezee pressure.
(Refer Fig.11, P 9)

To get good printing results a pressure has to be applied on the squeezee during printing more pressure is required for printing on thicker and bigger bottles.

In this method pressure of the squeezee blade is applied by the dead weight fixed on the two side C channels. These two C channels are connected to each other by an aluminium L angle. On this angle is fixed a squeezee tilting mechanism.

For dead weights, heavy metal (lead) is used. Fixed dead weight is about 1.5 kg, half being used on either side. For varying the dead weight, casted lead blocks are used. One, two or three blocks (each of 150 gm) can be fitted on the front side of the channel to increase the dead weight.

5.4.5.3 Squeezee lifting and slide frame lifting
(Refer fig.11, P 9)

A gap between a squeezee and screen is necessary during the return stroke, so that ink does not pass through the meshes of the screen frame. While a gap between sliding frame (and hence screen frame) and a bottle is necessary to be created so that printed bottle goes ahead and already located bottle comes below the screen frame, without touching it. So it is not needed to wipe of the

screen from below to avoid smudging.

As cam is rotated, first C channel and hence squeezee fixed on it gets lifted. A cam shape has been designed in such a way that further rotation of the cam is not possible unless large amount of force is applied. Also in a vertical position of the cam, it remains stable and sliding frame can be rested on the top flat head of the cam. This way a gap is created between squeezee and the screen. During a further rotation of the cam C channel lifts sliding frame with it and both together go up to create a gap between screen and the bottle.

5.5 BOTTLE REMOVING

After printing table is rotated by 90°, printed bottle comes at the fourth station. Operator lifts the bottle with his right hand and keeps it on the rack. Since operatour does not have to insert his hand, right below the frame, he gets a undistructed access to the bottle.

Secondly he does not have to pick up the bottle with his left hand and then shift it to the right hand for keeping it on the drying rack.

5.6 ARRANGING THE BOTTLES ON A DRYING RACK

Drying rack is recommended to be kept to the right side of the

worker doing removing operation. After bottle is kept on the rack, a fifth worker arranges them in a row so that they can be dried in a compact space (as 7 to 8 hours drying is necessary).

6. ANNEXURE

6.1 SCREEN PRINTING

In this method unlike any other method of printing, the ink is transferred to the receiving surface directly through the screen and not picked up on the surface and transferred to another like a rubber stamp. This is the reason why so many objects which can be printed with this unique system can not be printed with any other method.

This method of printing has specific advantages over the other processes :

a) No other method can give the depth or richness of colour which can compare with it.
b) It can be used for printing on any surface
c) It is a cheap method for a small batch of articles. Cost of each elements is as follows :

Screen making	-	80 paisa/sq.in
Negative	-	50 paisa/sq.in
Ink	-	60 Rs/Kg (for ordinary)
		90 Rs/Kg (for special)

So as the number of articles to be printed increases, cost goes up due to the recurring cost in the printing ink.

Total cost of screen printing on plastic surfaces is 1 to 2.

paisa/sq.in. So as compared to the processes like, Hot Embossing on plastic surface, which costs 2 to 3 paisa/sq.in., this process is cheap.

d) Large sizes of articles in small batches can be printed on which it is impractical to print by other processes.

The screen printing process has the above mentioned advantages as compared to other processess, Though it is having few limitations :

i) While using this process one should not insist on printing half-tones, absolutely fine line designs or fine scrif letters, fine lines or tiny dots. Such jobs which can be faithfully and accurately reproduced by the letter press or litho process may not be feasible with screen printing owing to various factors such as the mesh material, the relatively thick consistency of the ink and the purely manual operations.

ii) The second limitation is quantity, when thousands of copies are to be printed off, you should not, as far as possible resort to screen printing. The reasons for this are :

a) The printing process being largely manual and involving deposition of the ink on the surface by pressing it through the mesh, the consumption of ink is more; since the ink consumption increases with the number of copies to be printed, it follows that printing a thousand copies by screen printing process would work out much costlier than by any other process - in terms of the cost of the inks alone.

b) Portions of the mesh may get clogged with ink-calling for elaborate, time consuming cleaning.

c) In between the printing of two or more colours, the paper (having absorbed one impression) contracts ever so slightly, resulting in improper registration while printing the next colour.

d) Longer drying time : Screen process inks take a longer time to dry and therefore the printed stock can not be stacked one over the other - each piece has to be kept separately for a few hours to dry completely before printing the next colour.

Obviously, such large, quick jobs are more economical and suited for letterpress or litho process.

The other processess and medias are Transfer Labels and Stickers.

6.2 TRANSFERS

Transfers are designs printed on a sheet of paper which has been treated with some kind of adhesive solution. The paper on which, the printing is done is special, known as Simplex Transfer Paper, it was imported all these years. Now Indian Simplex paper is available from "Ravel". Transfers are printed by letterpress as well as by the screen printing process using what are known as flexible transfer inks.

All you have to do is to cut the paper in proper size, print the background shape through a screen made from coarse (No.14 or 16)

cloth on the gummed surface so as to obtain a thicker ink layer. When the background is dry, print the second colour on it and so on using finer cloth.

For transfering the label, soak the label in water for about 45 seconds or so. At the end of this time the printed image should easily slide over the paper with slight push. If it does not, soak for a little longer. When the image slides easily, position the paper on article to be labelled. Hold the image with thumb and pull the paper out from under the image. Position the image correctly and allow to dry. When thoroughly dry, the label will have a fairly high resistance to rubbing.

The manufacturers finds a good and inexpensive medium in transfers as they can be produced in various colourful designs, can be applied easily on any surface, and stay there for a long time. Transfers are used for placing trade names or symbols, 'product selling' pictures on glass panels, in cars and buses on shop windows or on any decorative or industrial article.

6.3 STICKERS

Stickers are self-adhesive (or pressure sensitive) labels coated with a special type of adhesive on backside which remains tacky. To use the label, its backing is just peeled off and label pressed down on surface with a light finger pressure.

Stickers have now occupied a very prominent place as an advertising medium and also as a labelling technique.

6.4 SCREEN PRINTING OF PLASTICS

Plastics have to be pretreated to get a good adhesion between ink and the surface and a scratch resistivity (not only rub resistivity). This is necessary, not only for plastic bottles but also for some other uses like display signs.

There are two methods of pretreatment which are discussed below in detail :

6.4.1 Flame Treatment

This is the simplest and economical method of pretreatment for plastic bottles.

In this, article is rotated in contact with the tip of a blue flame (oxygen rich flame) obtained from kerosene gas burner or domestic gas and compressed air for a few revolutions. The flame oxidises the surface.

Care should be taken to see that the flame should not deposit soot on printing surface. It should be noted that it is the flame that treats the surface and not the heat as such no purpose will be served by mere heating of the articles. For thin polythene

bottles, care should be taken to avoid over-flaming as it can melt the polythene.

For very low melting point articles like polythene bags and sheets, an electrostatic treatment is given.

Testing : It is done by dipping polythene container in water aftertreatment. A uniform film of water indicates proper treatment. Droplets and puddles mean that container has not been treated properly.

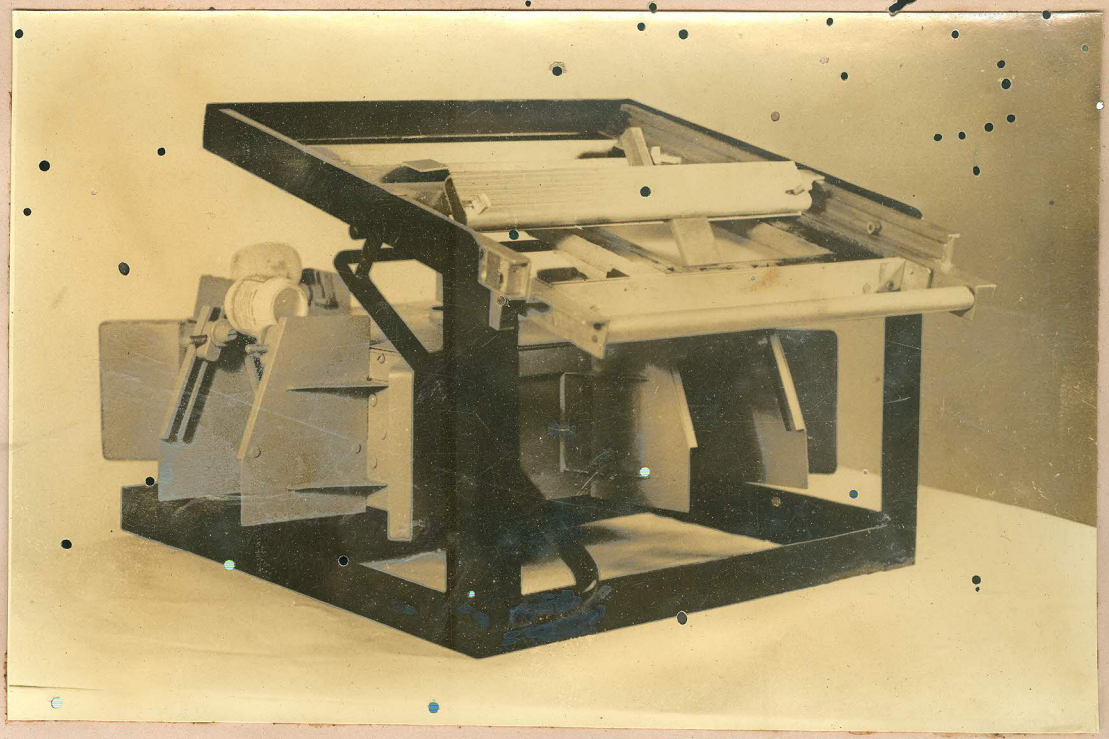
6.4.2 Chemical Treatment

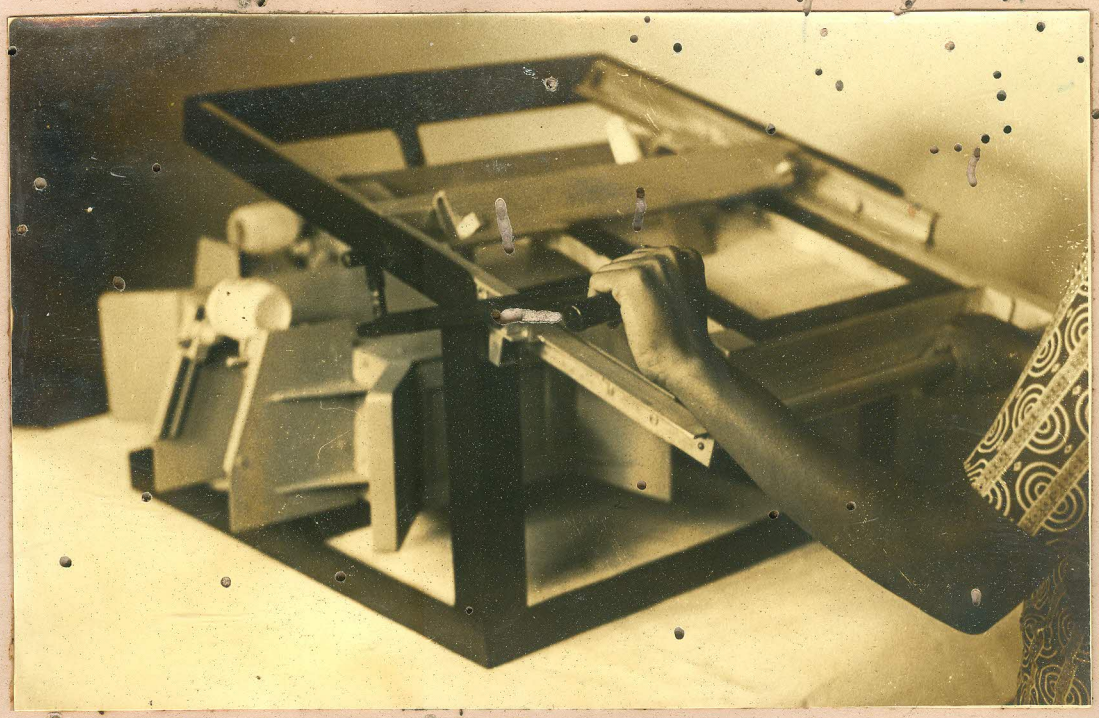
The solution is made up of :

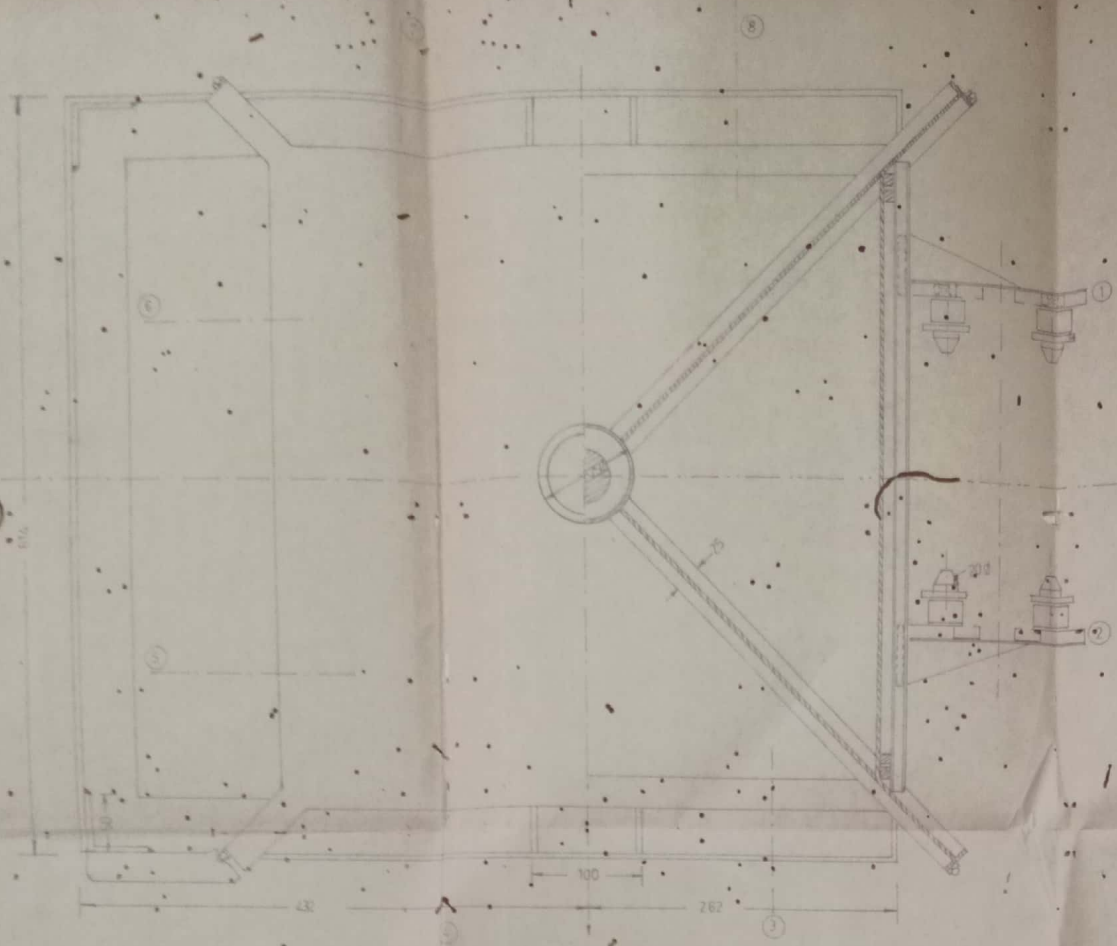
Conc. Sulphuric Acid	-	150 parts by weight
Potassium Bichromate	-	7.5 " " "
Distilled Water	-	12 " " "

The article to be treated is immersed in this solution for about 5 minutes at room temperature and then thoroughly washed under running water. The treatment of surface, obviously will be very uniform over contoured surfaces also.

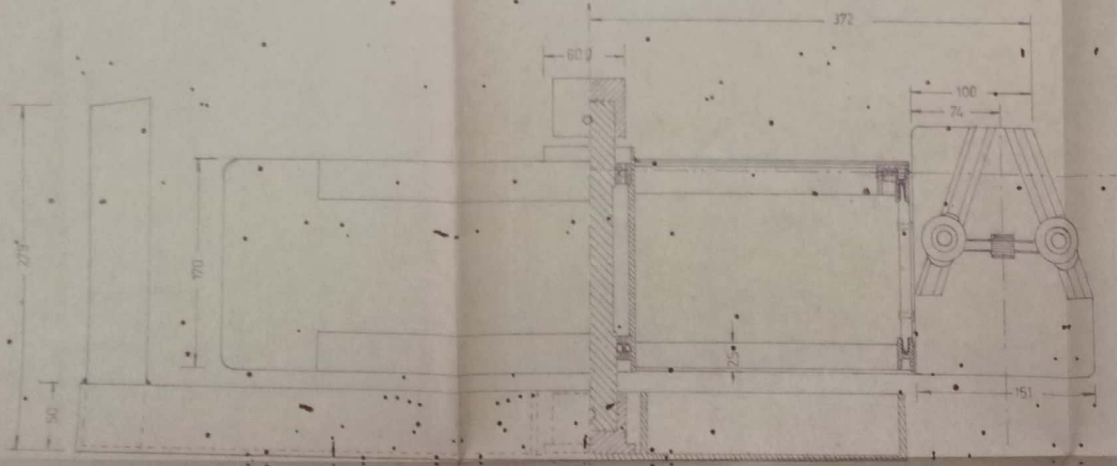
Printing should preferably be done within a couple of hours. But you can always be certain of perfect adhesion if printing is done immediately, after flame treatment. Also, after the treatment, the articles should be protected from grease and dust etc.







① TO ⑧ BOTTLE SUPPORTING UNITS



DESIGN OF SCREEN PRINTING MACHINE

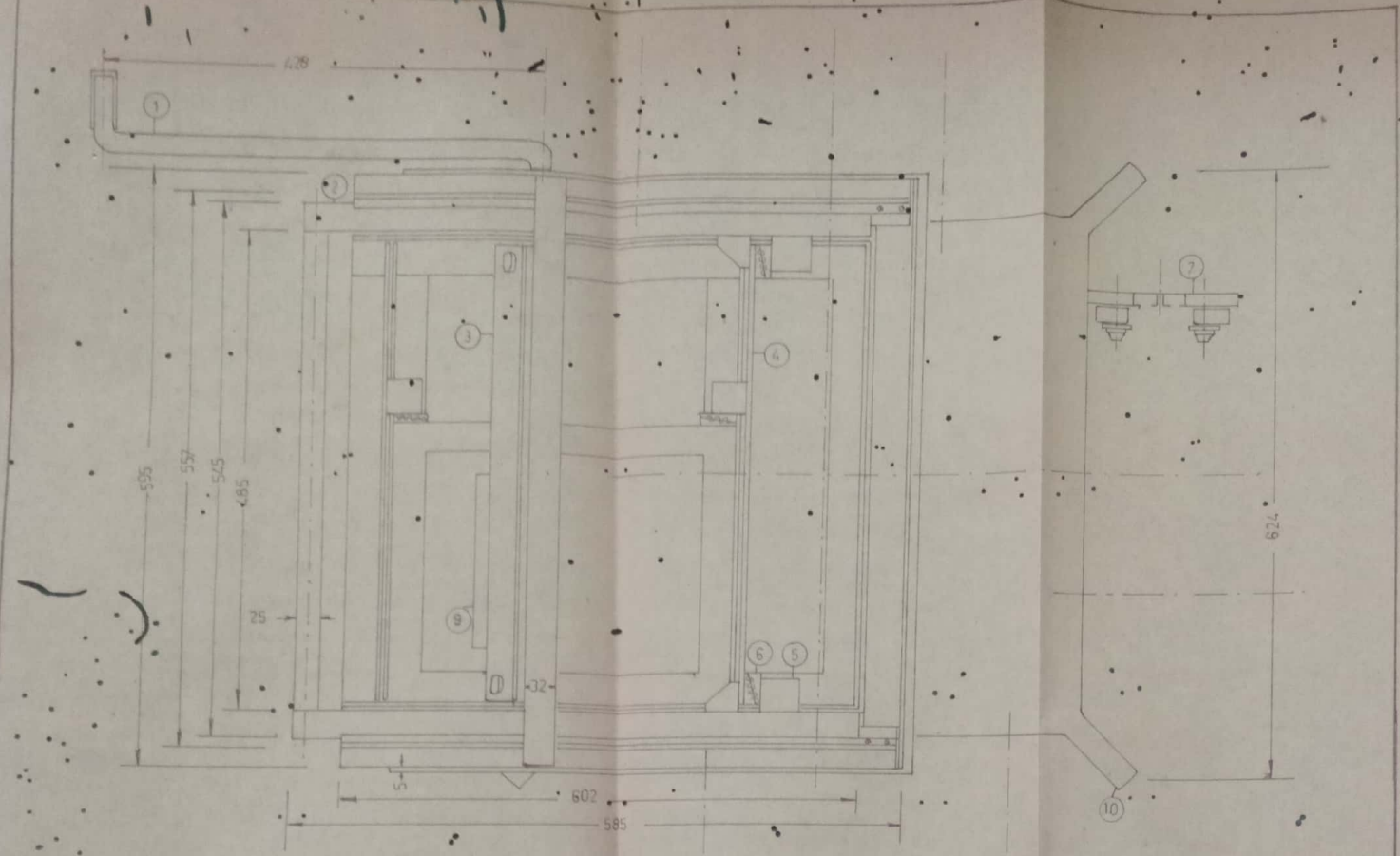
ROTATING TABLE

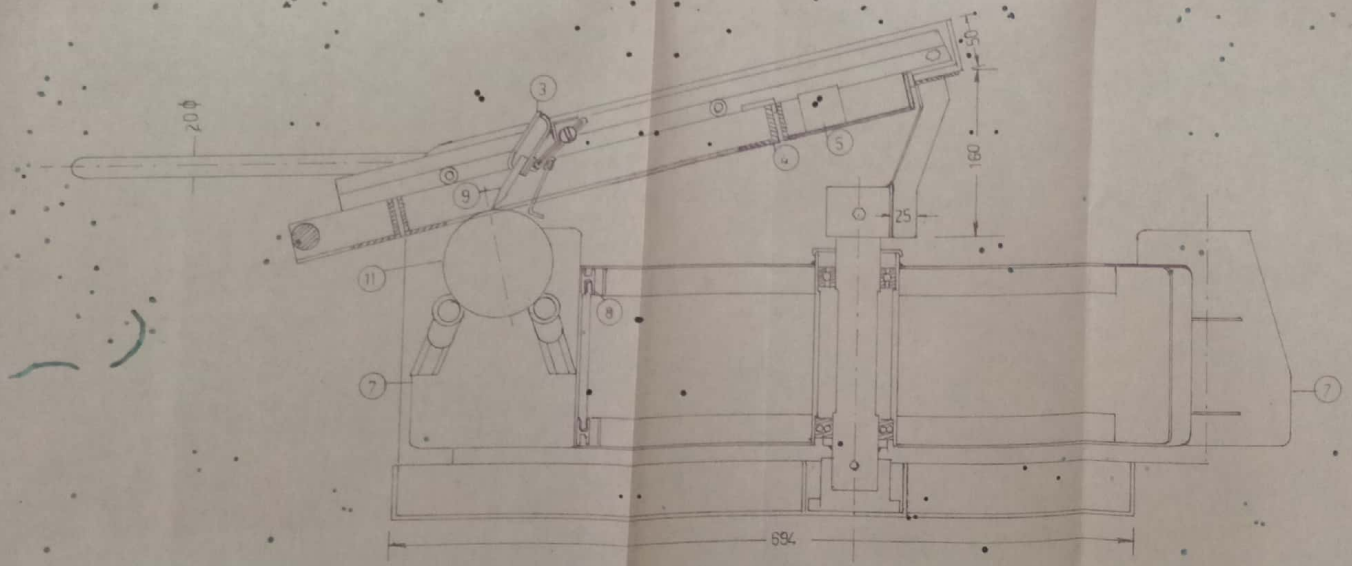
H.S. AGASHE 77205
1978-79 XIII TH BATCH

ALL DIMENSIONS IN MM
SCALE 1:1

DRAWING NO. 1

INDUSTRIAL DESIGN CENTRE I.I.T. BOMBAY





NO	DESCRIPTION	MATERIAL	NO OFF
11	BOTTLE	PLASTICS	4
10	TURN TABLE	M.S.	1
9	SQUEEZEE	POLYURETHANE	1
8	SLIDING I-SECTION	AL.	8
7	BOTTLE SUPPORTING UNIT	M.S.	8
6	TAPERED WEDGES	C.I.	4
5	HOLDING BLOCK	AL	4
4	SLIDING MEMBER	AL.	1
3	SQUEEZEE FIXING CHANNELS	AL	1
2	SLIDING FRAME	AL	1
1	CAM ROTATING HANDLE	M.S.	1

DESIGN OF SCREEN PRINTING MACHINE

ASSEMBLY

H.S. AGASHE • 772705
1978-79 VIII TH BATCH

ALL DIMENSIONS IN M.M.
SCALE 1:4

DRAWING NO. 2

INDUSTRIAL DESIGN CENTRE I.I.T. BOMBAY