

DESIGN OF SUGARCANE CRUSHER

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Design of sugarcane crusher. -

Design of Sugarcane Crusher

Diploma project

Submitted in partial fulfillment of the
requirements for the postgraduate diploma in
industrial design

by

Dilip M. Shah

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Industrial Design Centre

Indian Institute of Technology

Bombay

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Approval sheet

Diploma project entitled

Design of Sugarcane Crusher

by Dilip M. Shah is approved for the
postgraduate diploma in industrial design

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Administrative Staff

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Contents

1. Introduction
2. Problem Statement
3. Information
4. Analysis
5. Hypothesis
6. Synthesis
7. Design Development
8. Communication

1.1. Introduction

The sugarcane crusher being considered as it exists today is used for extracting sugarcane juice which is a popular drink both in urban and rural areas. In rural areas bullock driven, engine driven and electric motor driven crushers are used as the scale is much larger.

There it is basically used for manufacture of raw sugar and jaggery. The drink is not the basic aim.

It is tool that provides a very low investment mode of self employment to people and is quite profitable, though it is limited to the uneducated class only.

1.2. Need for Design

The problem of redesigning occurs because it is felt that the present system is chaotically complex. It presents a very complicated and mechanical impression. From the looks of it, it appears unhygienic. No ergonomical factors have been considered in present design. It is also felt necessary to increase the aesthetic value, reduce the cost and to make its operation easier.

2. Problem Statement

Redesign of Sugarcane Crusher for mobile
and stationary shops.

3. Information

Information has been collected from the following categories :

3.1. Manufacturer

3.1.1

The manufacturers are registered under small scale industries. They are equipped with machinery like lathe, drilling machine, shaper, milling machine, welding equipment and hand tools.

3.1.2

Parties undertaking manufacture of sugarcane crusher, run as the batch production as the demand is low. It is never the only product of the organisation.

3.1.3

The monthly production depends upon the number of order received from the customer. The average rate is about 10 to 20 machines for an average manufacturer.

3.1.4

The orders are directly booked by the manufacturer. There is no selling or distributing organisation in between. Delivery is usually within a fortnight.

3.1.5

Different manufacturers have different modifications of the same basic design, offered as attraction. Also, the product has undergone development to a certain extent but the basic principles and functional aspects are unchanged.

3.1.6

The major portions of the cost are due to

(a) Motor, in case of motor driven. The cost is approx. Rs.700.

(b) Rollers, in case stainless steel is used. The cost is approx. Rs.1500.

3.1.7

The need for using other materials like plastics, glass have not been felt by the manufacturers due to apparently satisfactory performance of the present materials.

3.1.8

Most of the parts and fabrications are done by the manufacturer. Only the castings are bought from another party.

3.1.9

As the entire machine is of simple construction and also as it does not involve any complicated mechanism, the complaints regarding the working of the machine are rare. Generally complaints are regarding the motor.

3.1.10

As the basic design has not changed and same manufacturer manufactures all the parts put by him in the machine, availability of spare parts is no problem. They can be had directly from the manufacturer.

3.1.11

Manufacturers give a guarantee of one year against any manufacturing defects.

3.1.12

All repair works are done by the manufacturer and during that period a spare machine is provided at a very nominal rate.

3.1.13

The choice of material depends upon the customer and accordingly price is altered.

3.1.14

The machine delivery is generally on cash payment.

3.1.15

It has been noticed that there are no technical persons to handle the design. People make it just by their past experience.

3.2 User.

3.2.1

Social background of the users:

Generally they are from the villages and have come for earning. Most of them are uneducated and have started this business with their own money or they have taken loan from other sources.

3.2.2

People using hand driven crusher.

- * Average sale per day varies from Rs.30 to Rs. 125. Sale is more during summers and festivals.
- * A bundle of sugarcane cost Rs.7 to Rs.16 from which sugarcane juice worth Rs. 29 to Rs. 35 is extracted.
- * The cost of machine is Rs. 700 with cart and allied decoration the investment goes beyond Rs. 2000.
- * Bank provides the facilities for loan depending upon the requirement and financial condition of the borrower.
- * Owner prefers electric motor operated machine but obtaining electric supply on the road is difficult. Such machine can not be used by mobile shops.



* A license from police and a permission from municipal corporation are must. Defaulters have to pay a fine.

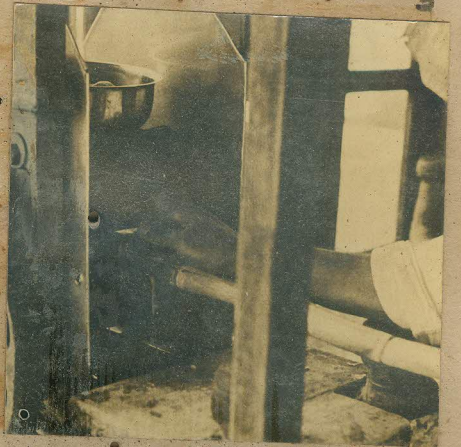
* Maintenance is to lubricate the gears and they have to clean the machine every time when not in use.

* Juice is sold at Rs. 0.50 to Rs. 0.75 per glass.

* For any break down they contact manufacturer.

* One has to exert lot of force to turn the handle when thick sugarcane are to be crushed and sometimes two persons are required to drive the handle.

People using hand driven sugarcane crusher.



3.2.3

People using motor driven crusher.

Most of the informations were same as hand driven crusher.

* The cost of machine is Rs.3000 and in case of stainless steel rollers the cost is Rs.6000.

* The electric consumption is not much.

* In maintenance, lubrication to all moving parts which is simple and does not cost much.

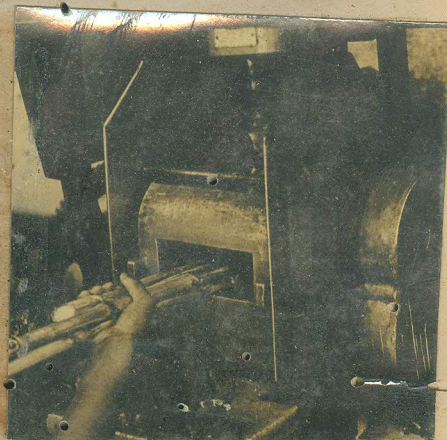
* Hand driven is converted in to motor driven on which they save labour cost.

* Some of them also sell other fruit juices along with sugarcane juice.

* They prefer to have a better looking machine which can match, in appearance with other juice extractor available for different fruits.

* They give juice according to customer's wish, with or without ice.

People using motor driven sugarcane crusher.



3.3 Public.

3.3.1

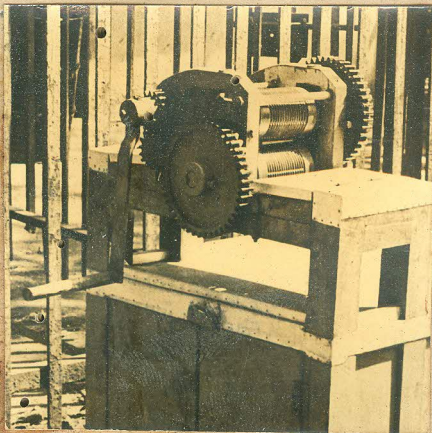
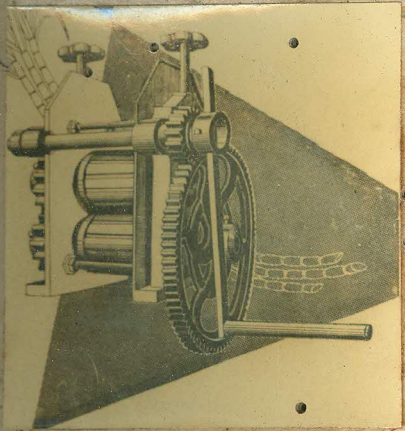
They prefer ice cold juice. They drink for refreshment and for enjoyment. Doctors advice jaundice patients to consume large quantities of sugarcane juice.

3.3.2

Many time they give instructions for keeping the place clean.



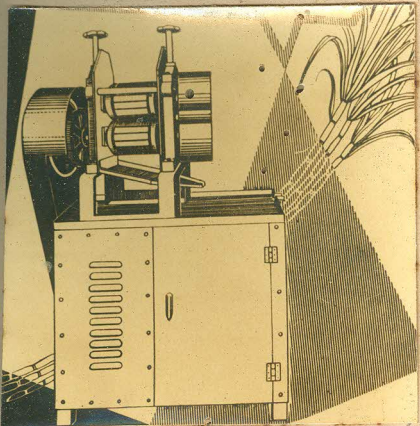
3.4 Existing Sugarcane Crushers



Hand Driven



Hand Driven Converted to Motor Driven

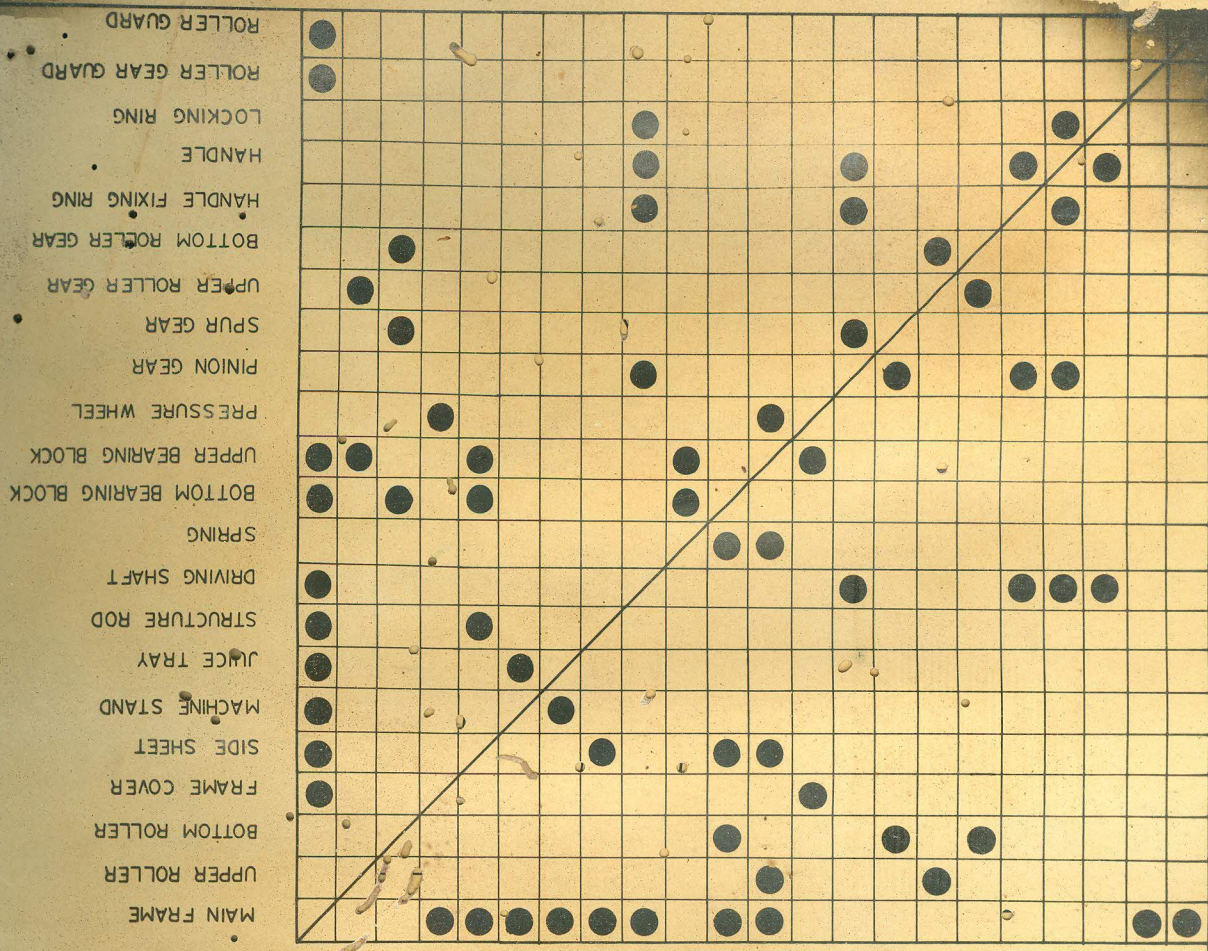


Motor Driven

4. Analysis.

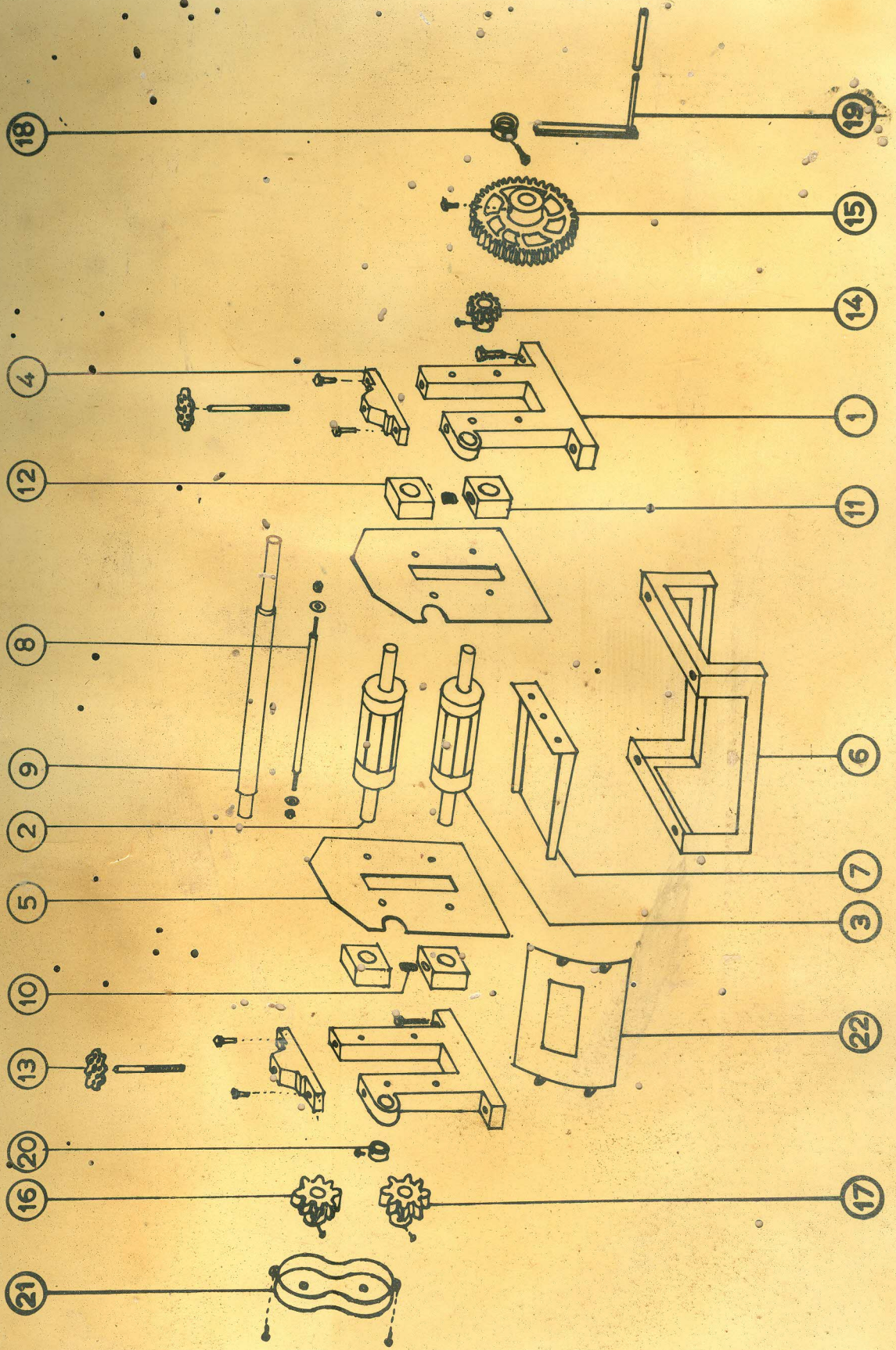
4.1 List of parts

Main Frame	2 off
Roller	2 off
Frame Cover	2 off
Side Sheet	2 off
Machine Stand	1 off
Juice Tray	1 off
Structure Rod	4 off
Driving Shaft	1 off
Spring	2 off
Bearing Block	4 off
Pressure Wheel	2 off
Pinion Gear	1 off
Spur Gear	1 off
Roller Gear	2 off
Handle Fixing Ring	1 off
Handle	1 off
Locking Ring	1 off
Roller Gear Guard	1 off
Roller Guard	1 off



MAIN FRAME
 UPPER ROLLER
 BOTTOM ROLLER
 FRAME COVER
 SIDE SHEET
 MACHINE STAND
 JUICE TRAY
 STRUCTURE ROD
 DRIVING SHAFT
 SPRING
 BOTTOM BEARING BLOCK
 UPPER BEARING BLOCK
 PRESSURE WHEEL
 PINION GEAR
 SPUR GEAR
 UPPER ROLLER GEAR
 BOTTOM ROLLER GEAR
 HANDLE FIXING RING
 HANDLE
 LOCKING RING
 ROLLER GEAR GUARD
 ROLLER GUARD

Roller Relation Chart



4.2 Structural Analysis

4.2.1

Main Frame

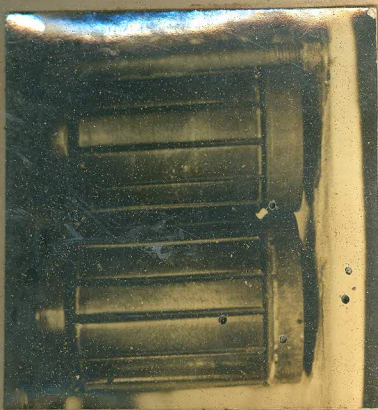
This is made of cast iron, it is sand cast. There is a rectangular opening which provides space for bearing blocks. It has also a hole for providing driving shaft. The machine assembly requires two pieces of this frame.



4.2.2

Rollers

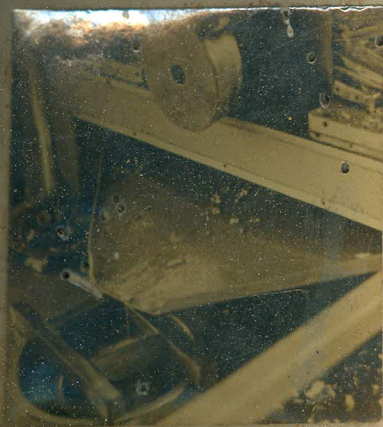
These are made of cast iron or stainless steel. They are solid but in some old design, the rollers are made from a hollow cast iron tube and filled with wooden blocks. There are grooves on them for juice to escape.



4.2.3

Side Sheets

They are made from the aluminium or stainless steel or brass sheets. These sheets are attached to main frame with help of structure rods, threaded at both ends and fixed with the nuts.



4.2.4

Juice collecting Tray

It is fabricated from aluminium or stainless steel sheet and fitted to the main frame or to the stand.



4.2.5

Machine Stand

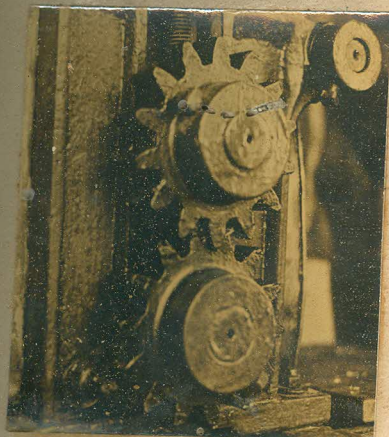
It is a welded M.S. channels or made from wood for supporting the whole machine.



4.2.6

Driving Mechanism

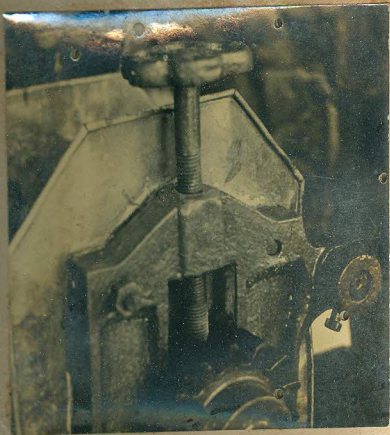
A M.S. driving shaft is fitted to main frame. A M.S. handle is fitted to driving shaft. A pinion gear of cast iron is fitted on the driving shaft. A spur gear of cast iron is fitted to the lower roller and other ends of both the rollers are provided with cast iron gears.



4.2.7

Bearing Blocks

These are sand cast, cast iron blocks. Some of them are provided with brass bushings. Bearing blocks are machine finished.



4.2.8

Pressure Wheels

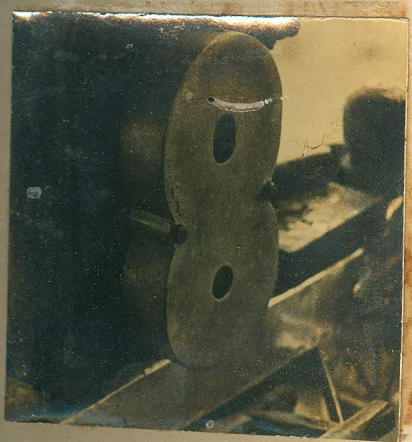
The wheels are of cast iron fitted on M.S. rods which are half the length threaded.



4.2.9

Roller Guard

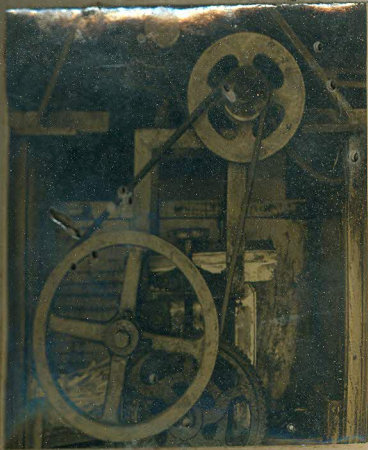
This is made of aluminium and it is sand cast. It is fitted to the main frame.



4.2.10

Roller Gear Guard

This is fabricated from aluminium sheet and it is fitted to main frame.



4.2.11

A Set of Pulleys

These are provided in case of motor driven machine. These are of cast iron and have 'V' grooves on the rim to accommodate the belt.

4.2.12

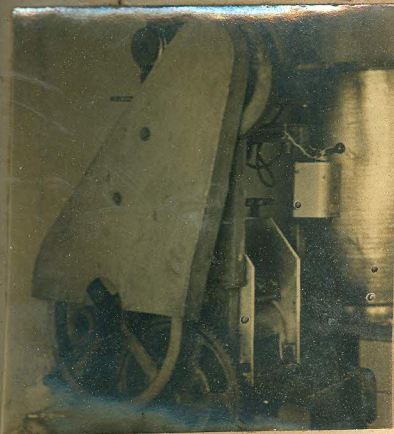
Motor

It has cast iron body and a base plate with four holes. A pulley is mounted on the shaft of the motor. Motor is of 1.5 H.P.

4.2.13

Driving Mechanism Safe Guard

It is fabricated from M.S. sheets and fitted to the structure.



4.3 Functional Analysis

4.3.1

Main Frames

These support the rotating parts like rollers, in bearing blocks, driving shaft. The side sheets, roller guard and gear guard are fitted on these. There is provision for fixing the pressure wheels.

4.3.2

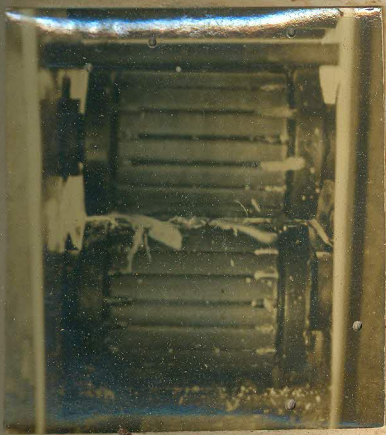
Rollers

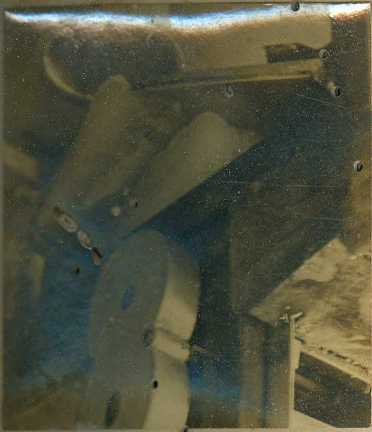
The function of the rollers is to crush the sugarcane and grooves on them provide the escape for juice. Since the juice is sticky the bagasse fill the grooves and this has to be scraped with knife or with a sharp tool. The other reason of filling the grooves is the horizontal grooves.

4.3.3

Side Sheets

They prevent the juice from coming in contact with lubricant and also protect the gears and bearings from juice and water but as it exists the function is not efficiently carried out.





4.3.4

Juice Collecting Tray

This takes the falling juice to the container and it is also used for keeping the ice.

4.3.5

Driving Mechanism

A pinion fitted on the handle shaft moves as the handle is turned, pinion is meshed with a spur gear which is fitted to the bottom roller. The bottom roller moves the upper one since they are engaged by means of gears at other end. When a thicker sugarcane is pushed in between the rollers the upper roller lifts up a little. It is necessary to drive both the rollers since the skin of the sugarcane is very smooth.

4.3.6

Pressure Wheels

These prevent the upper roller from lifting up and it is also provided for adjusting the gap between the rollers. This arrangement is rarely used because the normal gap between the rollers is sufficient to push the sugarcane through.

4.3.7

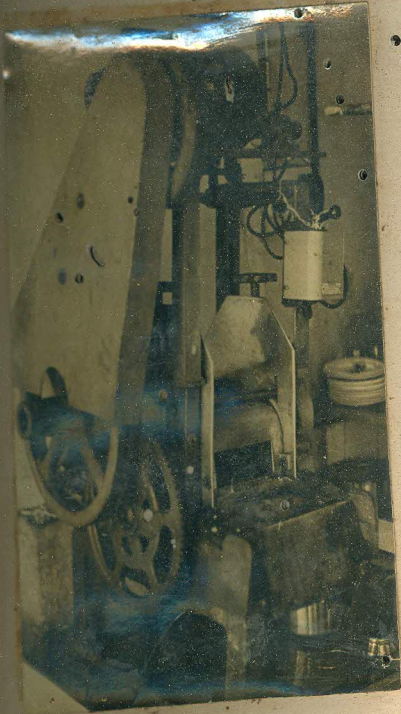
A Set of Pulleys

These are used for reduction between the motor
r.p.m. 1440 to rollers r.p.m. 30.

4.3.8

Filtering of Juice

This is to be done separately as there is no
such attachment. This is time consuming
especially at peak hours and can not be avoided
since along with juice some bagasse
portion also goes.



4.4 Formal Analysis

4.4.1

The general appearance is very crude, clumsy and mechanical. Many a times it raises doubts about hygienical cleanliness of juice.

4.4.2

All moving parts are visible and bear no formal relation to each other.

4.4.3

Though the formal changes are made, they are not aesthetic. The quality of finish is extremely poor.

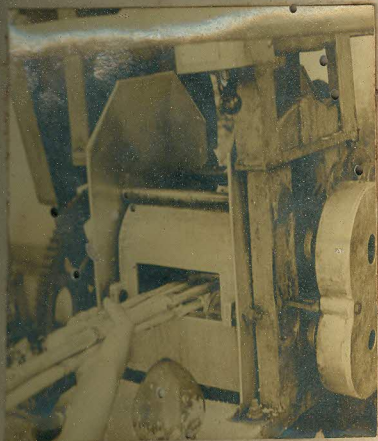
4.4.4

The machine is built up from a number of parts and bolted together at number of places which spoils the overall appearance of the product.

4.5 Ergonomical Analysis

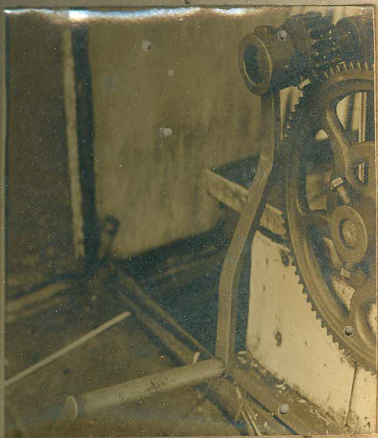
4.5.1

The sharp corners are bound to trouble the user.



4.5.2

The handle is made from a bar and on which a tube of M.S. is inserted which does not provide any grip while turning the handle.



4.5.3

In case of motor drive the position of switch is not considered and it is difficult to see the 'on-off' positions.



4.5.4

All the moving parts are not provided with guards and where provided are sometimes removed due to user's inconvenience in cleaning.

4.5.5

The accidents are very rare and generally they are of trapping of fingers in between rollers as in many cases the guard is removed or not provided.

4.6 Socio-Economical Analysis

4.6.1

No attention is given in designing the machine due to lack of technological knowledge of people manufacturing it.

4.6.2

Sugarcane crusher provides easy employment for two to three people at very small cost. They are made self earning and independent hence can play a significant role in society.

4.6.3

Cleanliness around sugarcane juice shop raises doubts sometimes because of improper maintenance since the people are uneducated.

5. Hypothesis

5.1 Structural

5.1.1

Structure should be extremely sturdy, stable and ensure reliability over a long period.

Structure should be rigid enough to hold the rollers.

5.1.2

The design should be done for batch production and the material should be exploited in an economical way.

5.1.3

The joining of parts should be simple and processes of making individual parts should be within the capacity of a small scale industry.

5.1.4

All the moving parts should be provided with proper bearings.

5.2 Functional

5.2.1

As the juice is sticky, it fills up the grooves with bagasse thereby causing cleaning problems which should be simplified.

5.2.2

The gap between the rollers should be adjusted without any extra mechanism at the same time it should not affect the power transmission through the gears.

5.2.3

There should be provision for filtering the juice built in the machine.

5.2.4

Cleaning should be easy and there should be a provision for drainage of cleaning water.

5.2.5.

Lubricating oil should not come in contact with the juice.

5.3 Formal

5.3.1

Machine should have a clean and simple outward appearance.

5.3.2

Formal changes should be coherent and smooth.

5.3.3

Sharp edges and corners should be avoided as far as possible.

5.3.4

Colour scheme should emphasize the simplicity and cleanliness of the machine and also it should not be harsh.

5.3.5

Screws, nuts, bolts and other fastenings should be so placed that they do not spoil the outward appearance.

5.3.6

Quality of finish should be improved.

5.4 Ergonomical.

5.4.1

For a hand driven machine the handle should be designed in such a way that it provides sufficient grip and fits well in the contour of the folded palms.

5.4.2

All moving parts like belts, pulleys, rollers etc. should be provided with proper guards.

5.4.3

For motor driven machines the wiring should not be kept open whereby protecting it against wearing and fraying.

5.4.4

The switch for 'on-off' function should be clearly visible and within easy reach of the operator from his working position. As the operators are likely to be uneducated, the switch should have clear and easily understandable graphic markings to indicate its working positions for forward and reverse directions of the rollers.

5.4.5

The materials of construction, keeping in mind the fact that they come in contact with juice, should be non-toxic and non-reactive; e.g. Stainless steel, Cast Iron, Glass etc..

5.5 Socio-Economical

5.5.1

Since there exists demands for both modes of drives, manual and motored, it is necessary that the machine possess a built in adaptability to either type of drive.

5.5.2

The prices of the manual and motor driven units should be competitive with the prevailing market prices for such units available in the market.

5.5.3

The juice should be extracted in hygienic way so that it is acceptable to the public.

6. Synthesis

6.1

The crushing rollers will be of cast iron or stainless steel and there will be grooves on the circumference for juice to escape.

6.2

The springs will be provided on top of the bearing blocks. The blocks will be movable in vertical direction. The gap between the rollers will be controlled by the spring load and the upper roller weight.

6.3

A bottle will be fitted to the juice tray for collecting juice. This bottle will be easily removable. The bottle will be of glass.

6.4.

The collected juice will be seen in the bottle. This will avoid any kind of adulteration.

6.5

The rollers will be covered on all the sides and there will be proper inlet and outlet for sugarcane. The covers will protect the rollers from dust and flies.

6.6

The covers will open on either side of the rollers for easy cleaning.

6.7

The driving mechanism will be enclosed in the main body and hence will not be seen from out side.

6.8

Since the driving mechanism will be enclosed and it is on one side only, the juice will be safe from mixing with lubricating oils.

6.9

A hand wheel^{will} be provided for easy operation and the handle of it will be removable for converting in motor drive. There will be 'V' groove on the rim for belt.

6.10

The motor drive will need a motor and a set of pulleys. These will be accommodated in a cabinet.

6.11

All the moving parts will be provided with proper brass bushings at bearing surfaces.

6.12

The colour scheme will be pleasant and will go with the environment.

6.13

The form of the total machine will be rectangular with smooth transition.

7. Design Development

The hand driven unit is designed such that it can be easily converted to motor driven.

- * The rollers have grooves on the circumference for escaping of the juice and also help in crushing and splitting the sugarcane fibers. A very slight taper is given on both the rollers which gives facility for initial crushing of sugarcane without much difficulty. The rollers are of cast iron or stainless steel. The choice is of the purchaser.
- * The distance between the rollers is adjusted automatically by the pressure load of springs, weight of the upper roller and the pushing force of the sugarcane.
- * The driving mechanism consists of a hand wheel fitted to the driving shaft. When the hand wheel is turned, the shaft moves and a pinion fitted on the shaft moves which drives the spur gear, engaged to it. The spur gear is fitted to the bottom roller. As the bottom roller moves the upper roller moves as both the rollers are engaged with the roller gears.
- * The driving mechanism is fitted inside the main body casting which is of cast iron. The main body carries the bearing block for upper roller and the bottom roller is direct-

-ly fitted to it with brass bushing. The other ends of both the rollers are fitted to supporting cover which is of cast iron. The driving shaft passes through the supporting cover, main body and gear box cover. All the outer surfaces are finished with the painting.

* A hand wheel of cast iron is fitted to driving shaft. The handle of it can be removed which is of M.S.. There is a 'V' groove on the rim for belt to convert the machine into motor driven.

* A juice tray of aluminium casting is fitted to the main body and supporting cover by means of two studs and other two studs are fitted to top portion of supporting cover and main body. The studs take the cantilever load of the hanging portion. The tray has provision for fixing glass bottle and a under cut for strainer. The strainer can be removed while cleaning.

* A glass bottle has capacity of 6 to 8 glass of 200 ml. each. The bottle is fitted to tray by means of a quarter turn threading.

* A front cover of aluminium casting has three flaps which open inside and sugarcane or sugarcanes can be pushed through these flaps in between the rollers. The cover can be opened for cleaning. Flaps close under their own weight.

- * A back cover has a flap for disposal of the bagasse. The flap opens on the outside and closes under its own weight. The cover can be open for cleaning. The cover is of aluminium casting.
- * A top cover is provided with perforated aluminium sheet for circulation of air and it holds both front and back covers. The cover is of aluminium casting.
- * The suggested height for mounting of the machine for both hand and motor driven is 67.5cms. and 8 cms. from front edge of the work surface.
- * The cabinet for motor drive is made from the M.S. sheet and M.S. channels welded together. A sheet metal cover is provided on the side for easy fixing of the motor and a set of pulleys inside the cabinet as shown in drawing. Cabinet is divided in to two compartments, one for motor and pulleys and other for keeping miscellaneous. The top is of wood and it is covered with aluminium sheet. A sink is provided with drain pipe for draining cleaning water. The pipe is of rubber or P.V.C. which takes the water to proper place.
- * A switch is provided with proper graphical indication at proper height for easy identification and operation.

For mobil and stationary shop using hand operated unit, similar arrangement is suggested for relative position of sink and machine.

Salient Features of Design.

- * Since the juice never gets exposed to open air right from extraction to collection in an enclosed bottle, these provides hygienic way of extracting the juice.
- * Since the collecting vessel is transparent glass bottle no adulteration is possible and glass bottle is easy to clean. A spare bottle can be had at very nominal rate.
- * The rollers are enclosed with covers and hence any contact of dust or flies with rollers is effectively prevented.
- * The cover opening arrangement facilitate the roller's accessibility for cleaning.
- * The peripheral grooves facilitate easy cleaning.
- * Since the driving mechanism is totally compartmentalized, seepage of lubricants into the juice extracting and collecting sectors is prevented.
- * This machine has a very good convertibility for manual to motorized drive.
- * Since the handle design is from ergonomical view points, it provides a better grip and also the handle shaft carries a uniform mass distribution which aids in avoiding jerky transmission.
- * The total cost of the machine is competitive with the currently available machines.

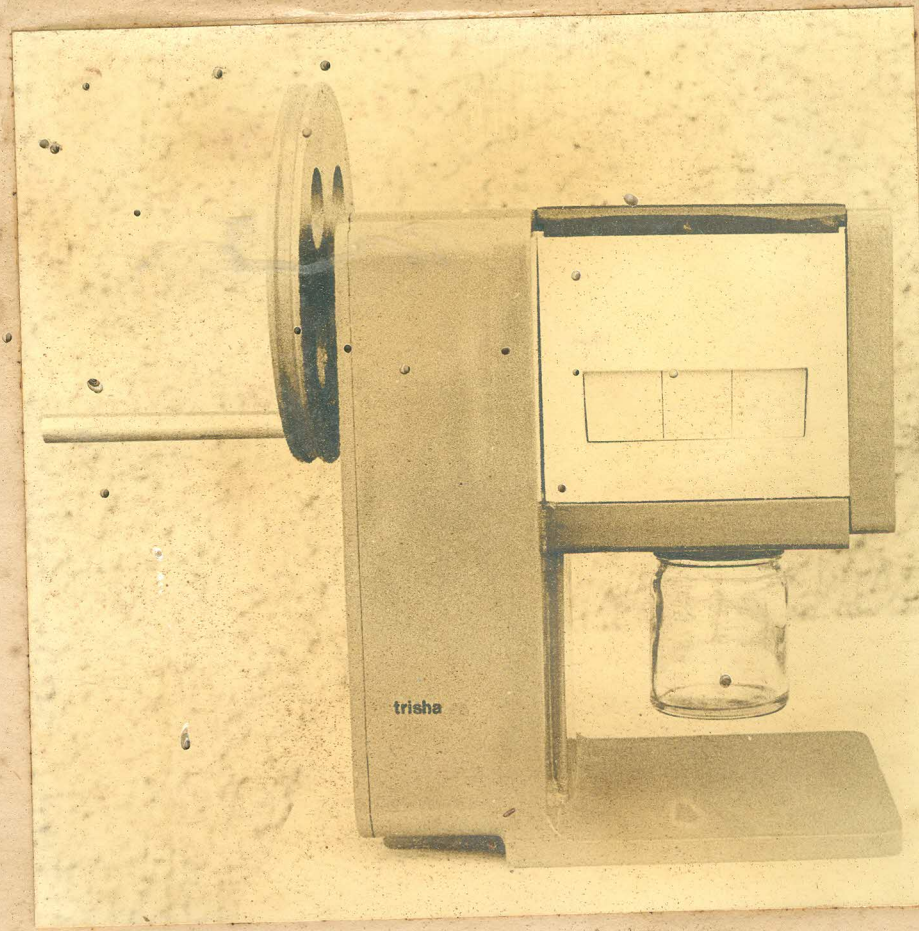
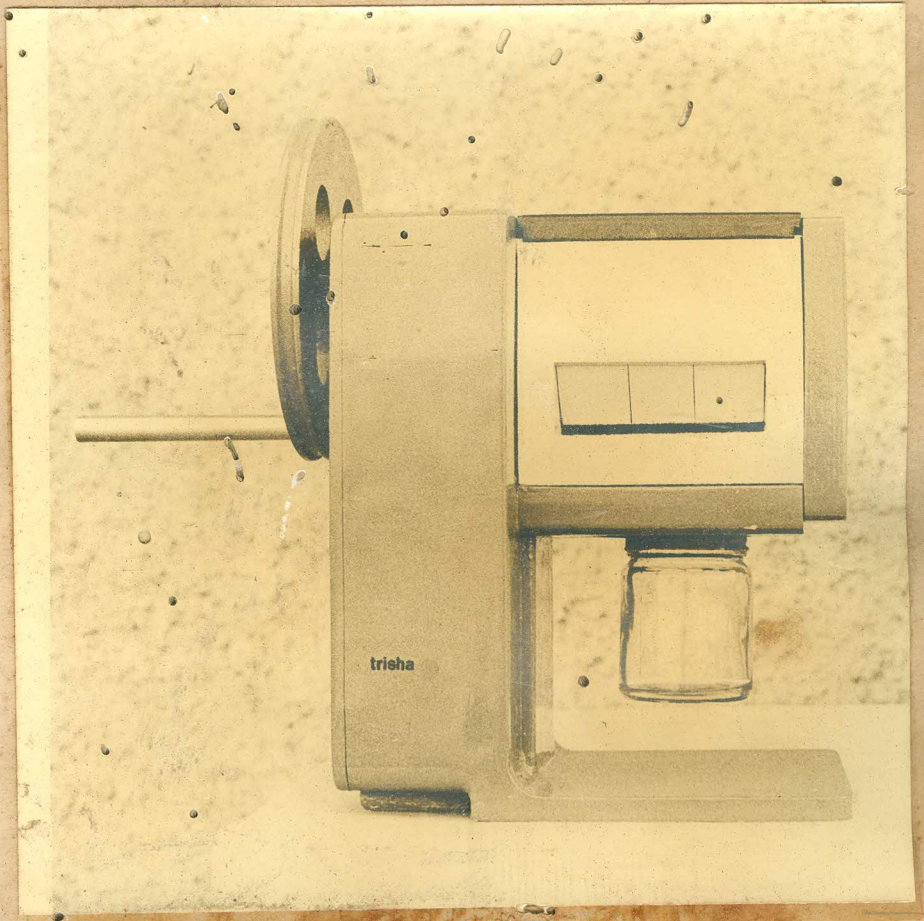
* The colour scheme is in harmony with the environment because it is pleasing and gives a hygienic look to machine.

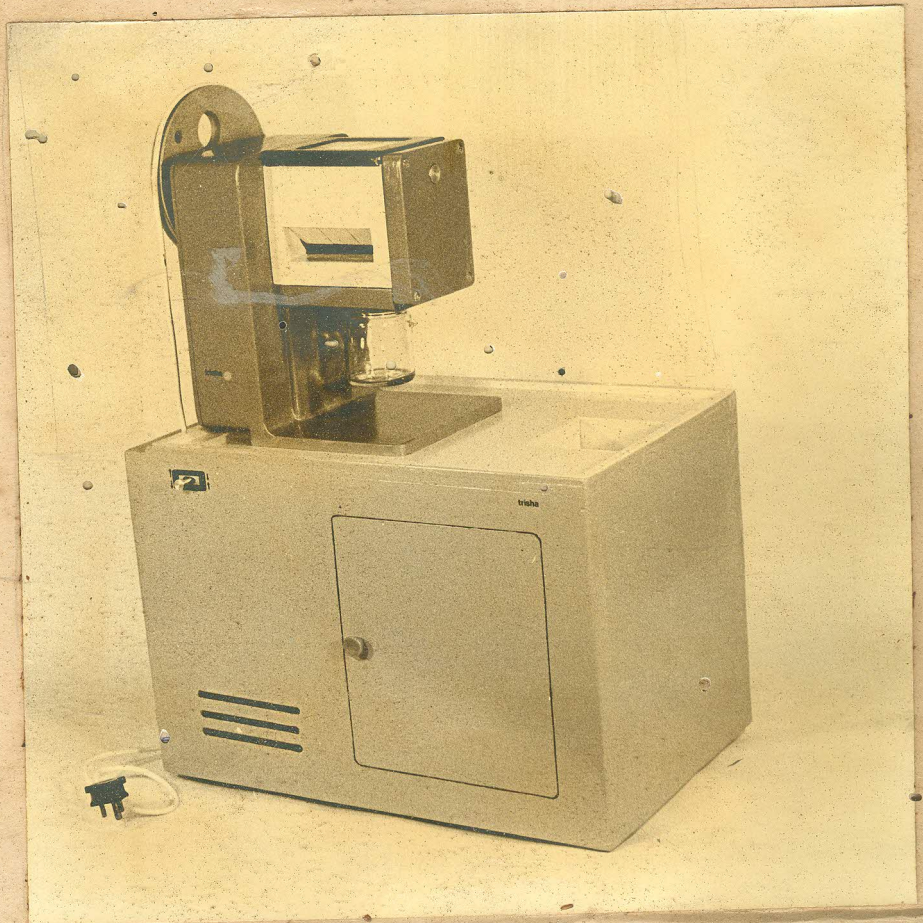
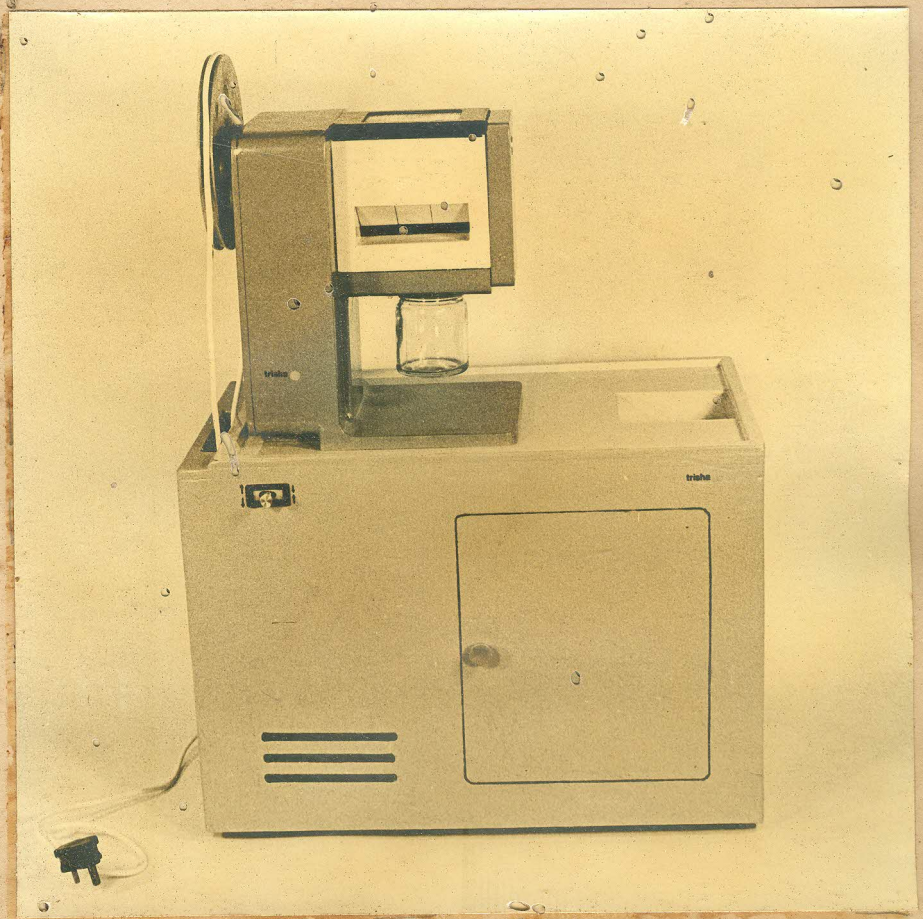
* Since the product is made by small scale industry and also it is in the batch production, all the parts are either cast or fabricated, which does not involve any specialized machinery.

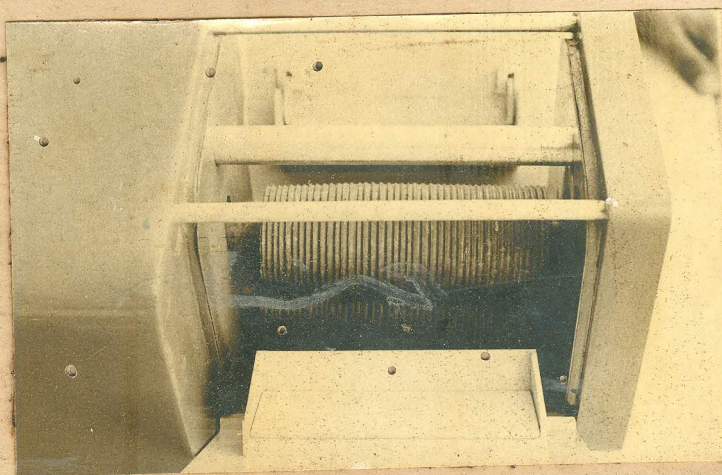
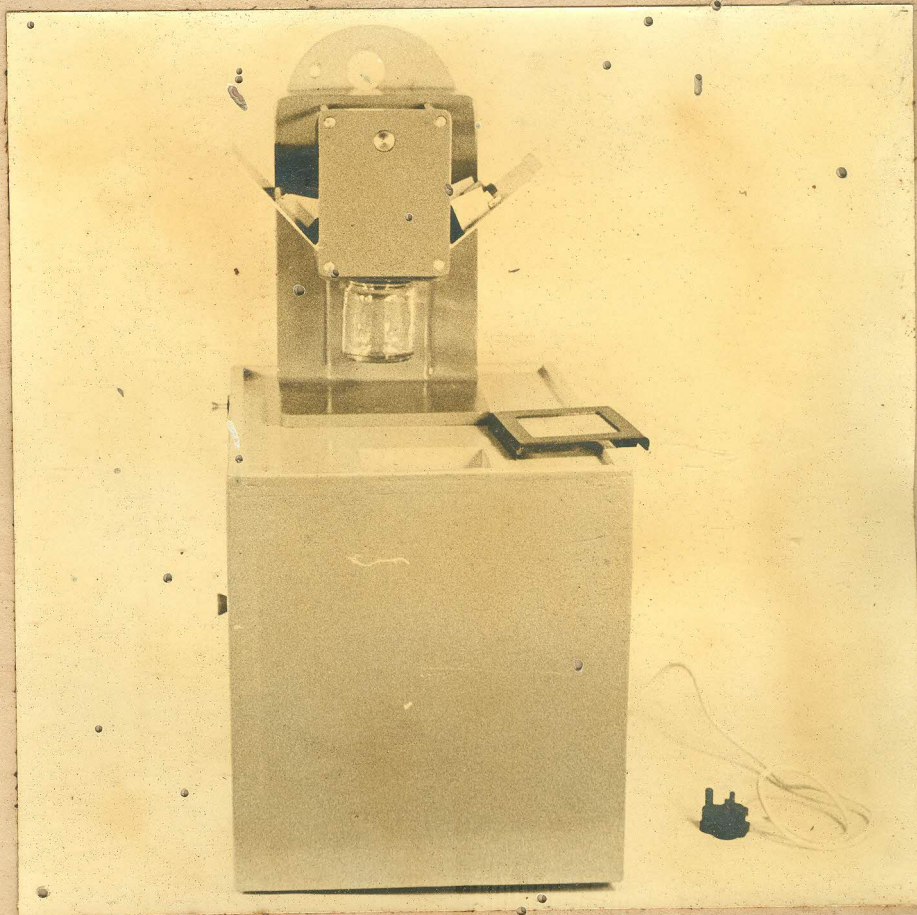
8. Communication

8.1 Photographs

8.2 Technical Drawings

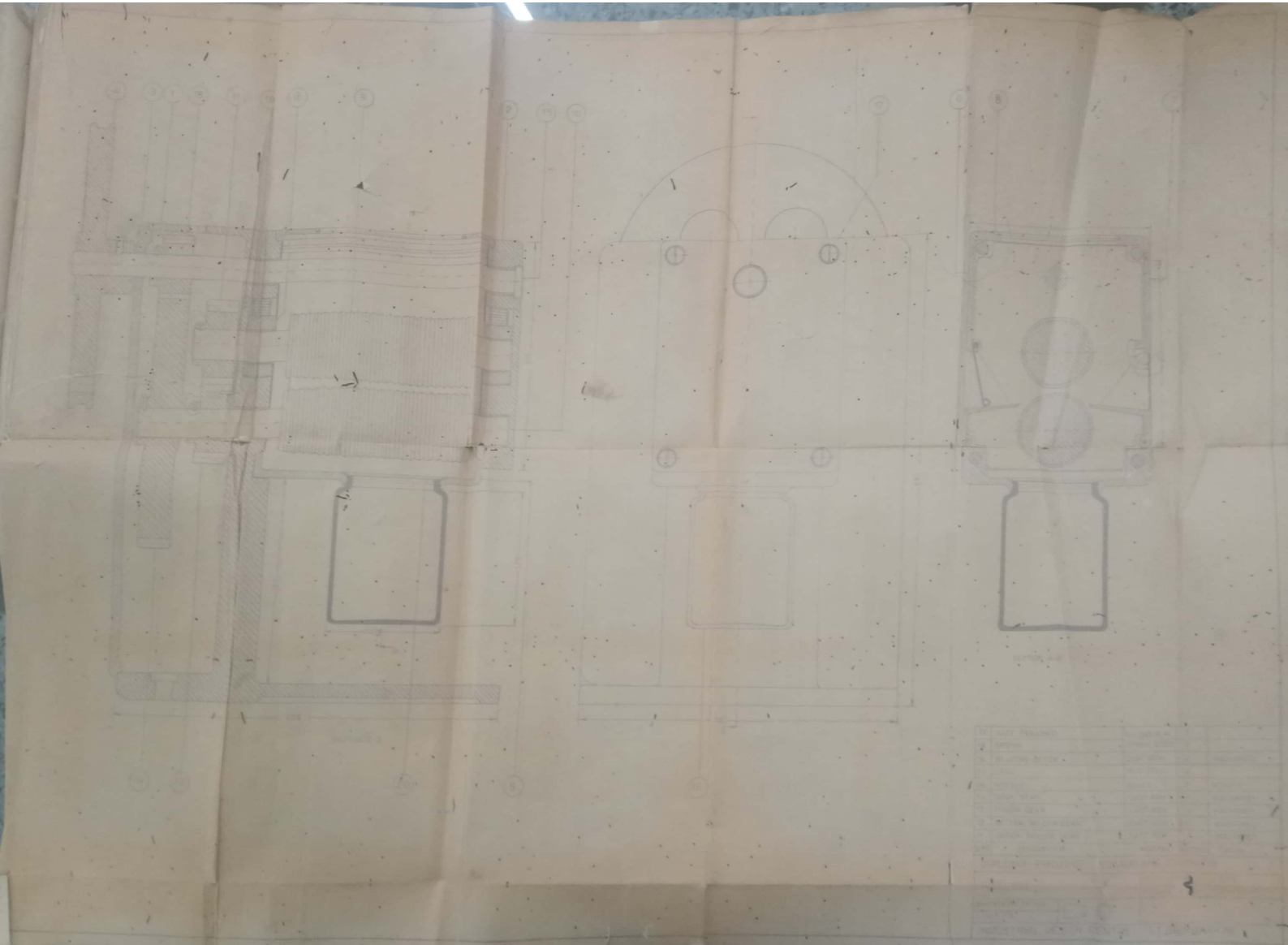


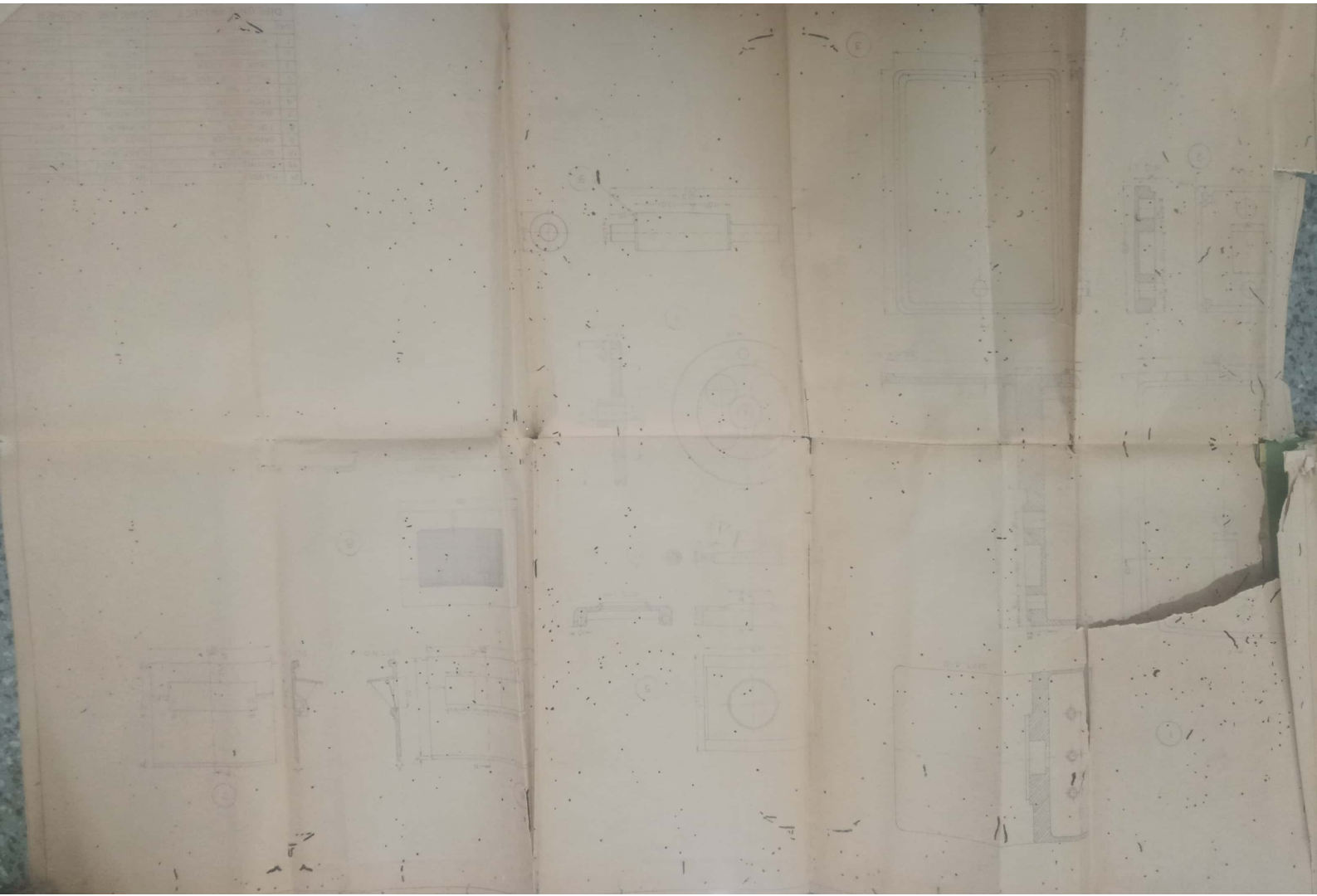




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