

PREMATURE BABY INCUBATOR

A. V. PENDSE

INDUSTRIAL DESIGN CENTRE
INDIAN INSTITUTE OF TECHNOLOGY
BOMBAY
1975

The-DP-50



Design of premature baby

Premature Baby Incubator

Diploma Project

A. V. Pendse

Industrial Design Centre

Diploma Project

*Submitted in partial fulfillment of
the requirements of the programme
Diploma in Industrial Design*

By

A. V. Pendse

I. D. C. Library

10/10/2012

10/10/2012

Industrial Design Centre

Indian Institute of Technology

Mumbai

1975

✓50
Design of Premature Baby Incubator

Diploma Project

Submitted in partial fulfilment of
the requirements of the postgraduate
Diploma in Industrial Design

By

A. V. Pendse

I. D. C. Library
L. I. T. Bombay.

DP/II - 50/1975

Industrial Design Centre
Indian Institute of Technology
Bombay
1975

Approval Sheet

Diploma Project entitled

'Premature Baby Incubator'

by A. V. Pendse is approved for the
Postgraduate Diploma in Industrial
Design.

Guide:

W. S. Thakur

Chairman:

P. M. Chitambar

Examiners:

• R. R. Loday

• W. S. Thakur

Industrial Design Centre
Indian Institute of Technology
Bombay.

Diploma Project Report

Project:

Design of Premature Baby Incubator

A. V. Pendse

Guide:

Shri U. A. Athavankar

Co-guide:

Shri M. Chattopadhyay

My acknowledgments to

Prof. S. Nadkarni

Shri U. A. Athvankar

Shri M. Chattopadhyay

Shri A. G. Rao

Dr. S. N. Deshpande

and other doctors

Technical staff

and my friends.

Contents:

Problem Statement	1
Introduction	2
Information	4
Analysis	18
Hypothesis	35
Synthesis	43
Photographs	48
Bibliography	50

Problem Statement:

To redesign an incubator with a particular emphasis on the following points:

1. Formal Appearance.
2. Ease of operation
3. Economy.

1. Introduction

In fact there are number of Indian and foreign incubators which are now available in India. Still, I feel that there is a need for redesign.

Initially, let us try to understand what is an incubator and why it is used in case of a premature baby. As the name suggests an incubator is essentially a space encloser with a facility of maintaining desired artificial environment inside that encloser.

A premature baby incubator artificially maintains womb temperature and provides a safty from infection to a prematurely born infant.

In the last few years manufacturers in the foreign countries are producing more and more sophesticated and advanced products, but in India first incubator was produced about five years before and all other Indian manufacturers copied the same design. There is no further development that has been done neither a study was done of an incubator to make it most suitable for Indian climate and situation. This incubator at present costs a lot and is beyond the reach of the majority of the hospitals.

Recently, Dr. S.N.Dashpande, a Civil Surgeon from Kolhapur studied this problem and developed an economical incubator

2. Information

The requisit information is collected by conducting a survey of hospitals having premature baby units, by visiting manufacturers, users, and through medical literature. This information is grouped under five sections such as :

1. Premature baby
2. Management and cure in the incubator
3. Present incubators in India
4. Socio-economic problems
5. Indian climate.



2.1.0 Premature baby.

2.1.1. Causes of premature birth (Low birth weight).

There are many factors which are considered to be associated with prematurity but the predisposing causes in India include -

- Socio-economic conditions such as lower class, poor housing mal-nutrition, negligence during pregnancy etc.
- Biological factors such as race small size of mother and birth order etc.

Comparison between Mature and Premature Infants

The following table sets out the chief differences which can be observed on examination:

	Full Term	Premature
Length	20 in. (50 cm.)	Less than 18½ in. (47 cm.).
Weight	7-8 lb. (3,180-3,640 g.)	5½ lb. (2,500 g.) or less.
	(Circumference of head 14 in. (35.5 cm.)	Less than 13 in. (33 cm.)
	Circumference of chest 13 in. (33 cm.)	Less than 11½ in. (29 cm.)
Proportion	Umbilicus midway between symphysis pubis and xiphisternum.	Umbilicus nearer symphysis
	Strong and active	Weak and sluggish
	Wakes for feeds	Drowsy
Vitality	Lusty cry	Weak mewling cry
	Normal temperature	Subnormal temperature
	Suction strong	Suction feeble or absent
Skin	Pink and smooth	Red and wrinkled
	Subcutaneous fat present	Little fat present
	Nipples raised	Nipples flat
	Hard	Soft
Nails	Project beyond finger tips	Just to finger tips or not quite to finger tips.
	Testicles in scrotum	Testicles in abdomen, inguinal canal or scrotum
Genitals	Labia minora covered by labia majora	Labia minora not covered by labia majora

As the majority of the Indian population comes under more or less all the factors mentioned above, rate of premature birth incidence is considerably high as compared to the developed countries.

Still there is a lack of a indigenous medical equipment which is within a reach of majority of hospitals.

2.1.2. Causes of mortality

There are innumerable causes which leads to very high mortality rate, but majority of the incidents occure due to -

Infection

respiratory trouble

heat loss

which can be reduced by keeping an infant in the incubator which provides
protection from infection
help in maintaining respiration
artificial desired temperature.

2.2.0 Management and care

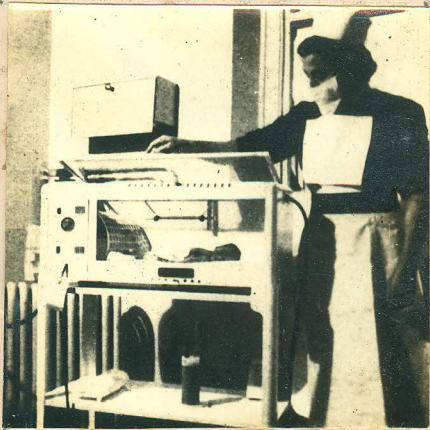
Management and care in the incubator is based on the ordinary management of any new born baby but with certain modifications which are necessary to meet the special needs due to low birth weight.

The most important of these are :

1. Maintenance of body heat
2. Provision of humidity
3. Establishment of respiration and ventilation
4. Protection from infection
5. Careful observation and handling
6. Good management of feeding
7. Medical care.

2.2.1. Maintenance of body heat.

Premature infant has more body surface area as compared to its body weight. Its thermoregulatory centre is also under developed. Such an infant loses body heat or undergoes heat stress. So to avoid this, an artificial environment is created for such an infant in which it is kept at a desired temperature.



But it is more important to obtain stability of the infant temperature than to aim at particular temperature, and experience has shown that there is no need for anxiety unless the rectal temperature falls below 35°C or rises above 37°C . At 32°C the smallest and most weak infant tends to stabilize at $35 - 35^{\circ}\text{C}$.

Attempt to raise the body temperature to the supposedly normal level of 37°C were unnecessary and might even provide detrimental to proper growth, as young premature babies have a thermo regulatory system adjusted to maintain a lower body temperature $35 - 36^{\circ}\text{C}$.

In the light of present knowledge incubator should be kept at a temperature of 32°C until the infants rectal temperature stabilizes about 37°C . Then the temperature of incubator can be reduced.

In few cases the temperature may have to be increased above 35°C but great care must be taken not to overheat the baby.

It is found out that infants loose 30% of body heat by radiation. Therefore heat supply by radiation is ideal.

Some investigators have maintained the skin temperature by infra red radiation but this method is too complicated, expensive and needs a very sophisticated controls.

2.2.2 Provision of humidity.

Doctors have found out that the rate of mortality is reduced by maintaining relatively high humidity inside the incubator. 65 - 70% humidity is considered optimum while higher humidity is maintained for smaller babies during early life as it maintains higher body temperature and have lower mortality rate at (80 - 90%) humidity.

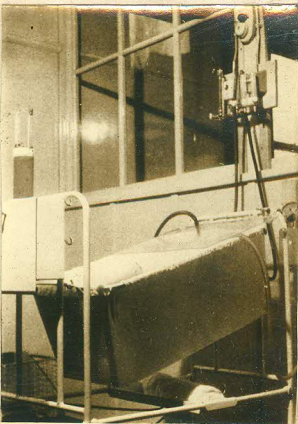
2.2.3 Establishment of respiration and ventilation.

Respiration in smaller infants tends to be irregular in rythm and depth. Cough reflex is also absent making a danger of inhalation of regurgated fluids.

Such a danger can be reduced by keeping that infant in a tilted position.

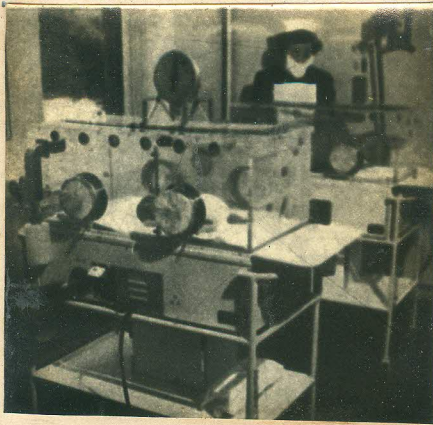
Many times nasal passages are extremely narrow and the mucus membrane extremely weak. In such a case artificial respiration is maintained by an oxygen dome by closing an incubator lid. In such a case nasal route is never employed for administration of oxygen.

In case of a low weight infant without any complications, ventilation is maintained at the rate of 10 to 15 air changes per hour.



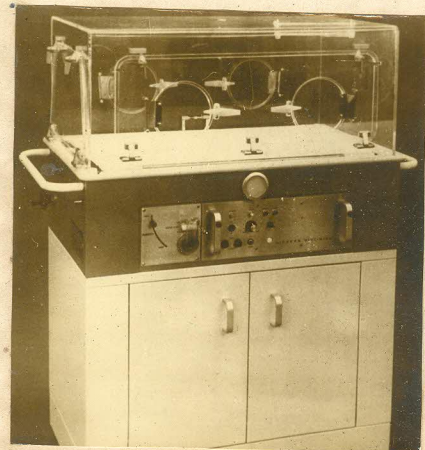
2.2.4 Protection from infection.

Premature infants are susceptible to infection. So it is isolated from others to all possible extent. Some incubators supply filtered air under slightly higher pressure than atmospheric pressure to prevent anything coming in from outside. For a precaution barrier nursing is strictly adhered. Additionally, premature baby unit is separated from other wards.

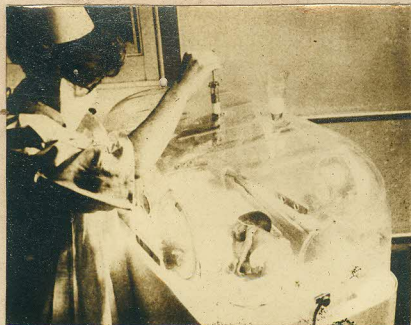


2.2.5. Careful observation and handling.

Incubator provides a clear view of an infant. As in premature infant any change in its body condition can be immediately recognised by observation. This can also help in feeding, changing, examining etc.



Incubator should provide a facility so that an infant can be nursed without taking out of the incubator. These infants being extremely weak should be handled as less as possible.

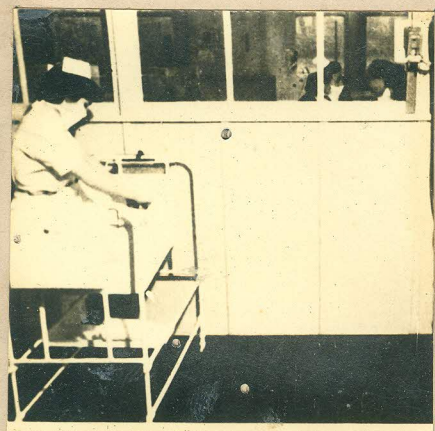


2.2.6. Management of feeding.

Incubator needs a elaborate system of feeding including a facility of tilting . If sucking reflex of such an infant is not developed, nasal feeding is done which requires tilting. Some times throbing is done.

2.2.7. Medical care.

As far as possible all the treatment of an infant should be done in the incubator. It should also provide head up or head down position for infant ($\pm 15^{\circ}$) which is an essential nursing requirement.



2.3.0. Present incubators :

Present incubator is a development of open heated cot and is divided into two types on the basis of various factors such as type of nursery nursing procedure, use etc. Though from the structural and functional point of view the difference is very less.

<u>Open Cot</u>	<u>Open Type</u>	<u>Closed Type</u>
1. Type of nursery: Warm & humid	Hot & not humidified	Warm & not humidified
2. 21°C 60-65% H.	29.5°C	24°C
2. Less is the number of infants better it is.	Less is the number of infants better it is. Maximum number 6 - larger infants	Less is the number of infants better it is. Maximum number 4 - Smaller infants.
3. 4.5 Sq.M/Cot 1.5 M c/c	4.5 Sq.M/Inc. 1.5 M c/c	2.67 Sq. M/inc. 1.5 M c/c
4. OR Partition Screen with .6M clear from all the sides.	10-12 A.C./hour Optimum humidity 65-70%	10-12 A.C./hour Optimum humidity 65-70%
5. Mainly for bigger infants if inc. is not available.	Most useful for larger infants. requiring oxygen but no other complications.	

Open CotOpen TypeClosed Type

6. Advantages :

Cheap

Can be heated easily.

Easy handling of infant

Facility of tilting.

Various makes

Supply correct heat and humidity

Easy O₂ giving.

Easy observation from distance

Freedom of access to the infant

Facility of tilting

Various makes

Supply correct heat and humidity.

Easy observation from distance

Isolates baby from air born infection.

Ventilation with clean air (filtered) under pressure.

Port holes & sleeves for care

Protection well worth extra cost.

7. Disadvantages:

Cannot give correct heat & humidity

O₂ giving is difficult.

Infection.

Expensive

Do not isolate baby from air born infection.

Very expensive.

Port holes and sleeves tend to obscure view.

8. Heating system:

hot bottles or Electric blanket

Heater for heating. Air.

~~Water~~

9. No control

Thermostat or other sophisticated controls with pilot lamp and Alarm.

Thermostat or other sophisticated controls with pilot lamp and Alarm.

2.4.0. Socio-Economic problems.

In India socio-economic problems dominate a product failure if not a design and therefore needs a careful attention for redesigning.

In India very few Government hospitals have premature baby unit. These units do not accept infants below 1500 gms. and such infants are left to God.

The information collected from doctors shows that more premature infants die in unit than outside.

Generally units are always over-loaded and under high pressure of work. So there is always a comparison in offering any facility to infant. Those who have better chances of living are always preferred.

Negligence takes place due to high pressure of work and therefore barrier nursing is not followed very strictly.

Big city hospitals face peculiar

problems of the staff. These hospitals do not get adequate number of nurses. Whichever nurse they train for premature unit, rushes up for foreign country. While untrained nurse is incapable of handling a sophisticated incubator.

In the present Government hospital set up, doctors rarely have a chance for qualitative selection for equipment. So they tend to select lesser of the evil. Therefore, infants in the present incubator are likely to be burnt alive or cooled to death.

Present incubators are costly and functionally inadequate and being a copy of foreign incubator, does not make use of favourable Indian climate. So nursing in this incubator also becomes costly.

Naturally within last five years of use of such an incubator, Indian doctors have developed an adverse opinion about it.

2.5.0.

Indian Climate

Climatic condition of various places in India throughout the year was studied from a critical angle and it is ascertained that Indian climate is favourable for nursing and this fact can be utilised in designing an incubator.

Statistical information gives the following result :

% Area under different zone at different period.

Condition	Tempe.	Humidity	JAN	MAY	AUG	NOV	AVA TOTAL
1. Cold & dry	15°C	25-50%	2%	1%			
Cold & humid		50-75%	12%	0.5%		5%	7%
Cold & very humid		75-100%	4%	0.5%	1%	4%	
2. Cool & dry	15-20°C	25-50%	13%	2%		5%	
Cool & humid		50-75%	23%	2%	2%	8%	16%
Cool & very humid		75-100%	2%	1%	4%	3%	
3. Temperate & dry	20-30°C	25-50%	17%	4%		19%	
Temperate & humid		50-75%	23%	15%	28%	45%	60%
Temperate & very humid		75-100%	4%	10%	60%	12%	
4. Hot & very dry	30-35°C	25-50%		8%			
Hot & dry		50-75%		35%			17%
Hot & humid		75-100%		19%	5%		
Hot & very humid				1%			
5. Very hot & dry				1%			

This shows that 76% places in India have temperature between 15-30°C while more than 80% places have humidity in between 50-75%.

3 Analysis.

3.1.0. Structural analysis.

Being a hospital equipment, it was not possible to study imported incubators from the analytical point of view. So analysis mainly deals with Indian incubators. Though wherever possible, foreign incubators are also referred.

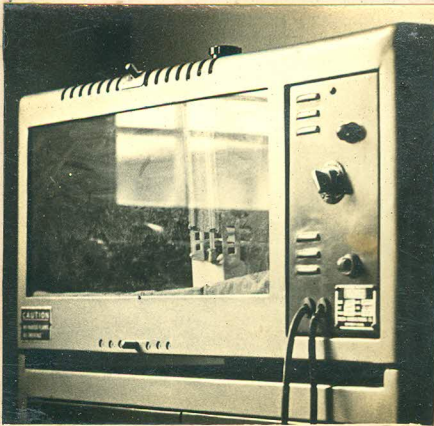
Assembly.

An incubator is made up of two principal units, the infant chamber and heating chamber which are created by putting a mesh partition in between.

The total assembly comprises of M.S. angles fitted with glass panels with a hinge operated lid at the top. It is finished with M.S. sheet.

'L' shape M.S. angles which are real structural members seems to be bigger and stronger than the necessity. 6 mm thick plain or toughened glass satisfy the structural requirement.

M.S. angles and sheet (18 or 20 gauge) is welded together which makes the total



assembly strong. In the open type, top lid serves as an access, while in the closed type, port holes and sleeves is an additional access.

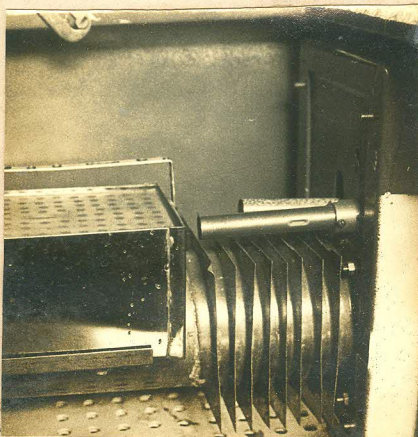
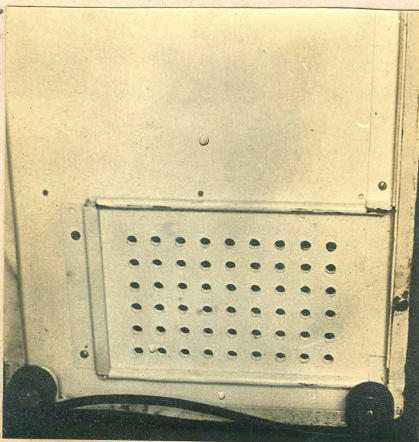
The incubator is mounted on a steel cupboard with a stacking facility which also offers tilting facility. The incubator takes support of cupboard for tilting. The cupboard is fitted with rubber castors for mobility additionally. Incubator also has handles for carrying it in hands which looks delicate as compared to the size and weight of the incubator.

Systems.

Incubator has air inlet at the bottom and air outlet at the top both operatable from the front. Both are structurally very simple to manufacture and to operate.

Heating mechanism comprises of a heater along with a radiating fins. This system demands a substantial space.

A stainless steel water trough is mounted on the heater along with a water



filling funnel and draining out cock fitted from outside. Though structurally sound, the system is too complicated to assemble as it is liable to leak.

Control Panel :

Control panel is made out of M.S. sheet also acts as a support and access to heating element. It is well marked to indicate knob position.

Additionally a hygrometer is maintained inside the incubator which gives temperature and humidity inside.

Safety device :

Heater is associated with thermostats or other control devices, which are mostly imported, along with Alarm and pilot lamp system which is situated in a heating chamber or can be connected to the incubator.

It seems that the present incubator design is dominated by the production method. There are number of manufacturers but none of them produces more than

100 pieces per year. So all the details
are suitable for fabrication and assembly
rather than a mass production.

3.2.0 Functional analysis

The basic function of an incubator is to maintain a prematurely born infant in it at a temperature within a range of 30° to 37° C, relative humidity of 60 to 90%, ventilation at the rate of 10 to 15 Airchanges per hour and give a protection to the infant from infection. Present incubators have various systems to serve these needs.

3.2.1. Heating - Old system :

- a) Use of hot water bottles along the infant - Though this system is the cheapest, this does not maintain a constant temperature. A constant supervision and frequent hot water replacement is needed. Leakage is an additional nuisance.
- b) In this system, air is passed around hot water drum, but this makes a system structurally complicated and the total incubator large in size.

Present system :

- a) Use of heater - Use of heater made incubator extremely suitable for maintenance. It also reduced its unnecessary bulk.

Now a days heater is used with the following accessories for control.

Heater + thermostat - made crude and sturdy but no precision.

Heater + thermocouple - precise but very delicate.

Heater + timer - precise but costly

Heater + thermister - precise but very costly.

but such costly devices made incubator beyond the reach of majority of the hospitals. Where after-sale care of equipment is not envisaged, this proved to be a failure.

Heater of such a high capacity is used to reduce time of heating but in the Indian climate, where ambient temperature and required temperature is not much, it is unnecessary.

Incubators do heating in two ways.

a) In some incubators heating chamber is located by the side of infant chamber. In this case, body portion nearer the heater gets more heat and heating becomes uneven.

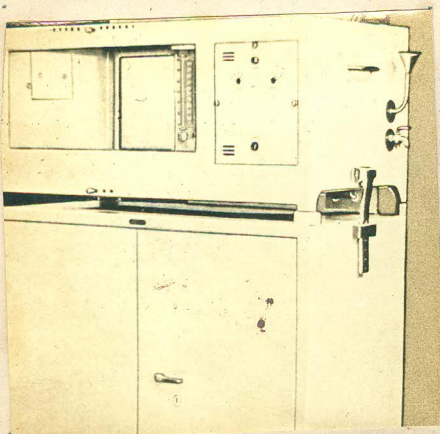
b) In this system, heater is located below the bed and heating is also even but there is an increased danger of an accident as heater is just below the infant.

Some manufacturers go for infra red light heating by radiation but this system is extremely complicated and therefore not welcomed by the hospitals.

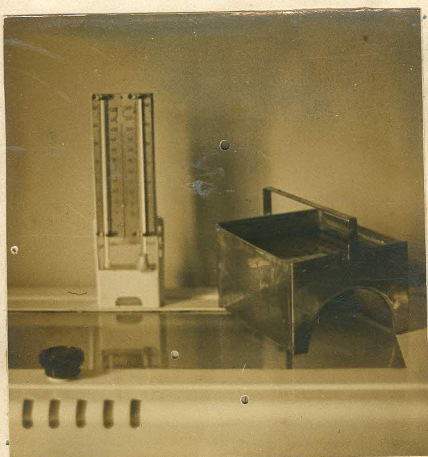
All the present incubators have oblong shape. Therefore surface area of the incubator is more as compared to the volume of air in it. This increased heat loss by the air additionally air remains stagnant in the corner and cool down which results in uneven heating. This proves that the present incubators shape is not functional in retaining heat.

3.2.2. Humidity :

High humidity is maintained in a simple way by keeping a water trough inside the infant chamber but this method can not give required (between 60 to 90%) percentage.



In some incubators, water trough is kept above heater. Many times this creates excess vapour pressure. The required precise percentage is achieved by increasing or reducing effective contact of water surface with air but this system is too complicated and is unnecessary in Indian conditions. Water pouring and draining system is not very hygienic but reduces the work of nurse. Water trough is not seen from outside.

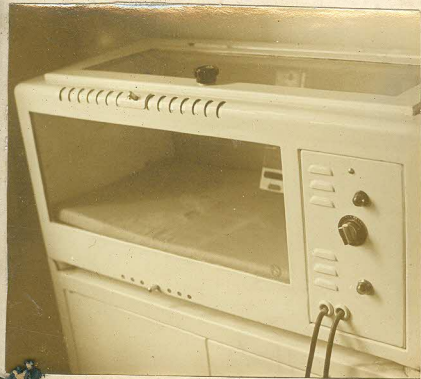


3.2.3 Ventilation :

Depending on the type of incubator, mainly two systems are followed :

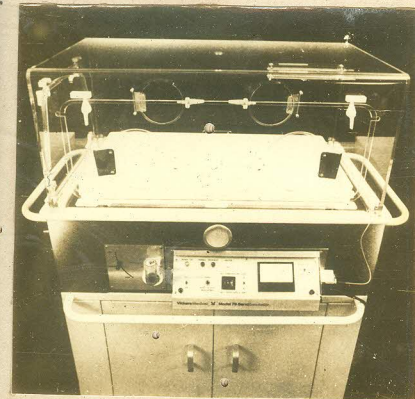
Natural Flow System -

In this system, inlet is at the lowest level and outlet at the top. Air is passed on the heating element first and then on the infant. This system does not isolate infant in a strict sense and therefore degree of protection from infection is less.



Forced ventilation -

In this system, filtered air is passed on a water surface and heating element under pressure which is slightly more than atmospheric pressure. This reduces chances of infection from the inlet as well as out let as inside air prevents outside air entering from the out let.



Whenever oxygen is given, inlet is closed and oxygen is given through oxygen inlet (Oxygen 1 : 3 Air)

3.2.4. Infant care.

Incubator provides the facility of observing infant from out side through the glass without opening it, but this do not offer a complete view. It also provides protection to the infant from any object falling on it. For this reason incubator should not be opened from the top.

Incubator bed provides a comfortable soft surface which can be tilted to $\pm 15^\circ$ to maintain easy respiration or circulation.

In the open type incubator, infant is taken out of the incubator for nursing. Though, this saves lot of nursing time, is bad for infant health. Incubator design does not facilitate nursing inside incubator.

Closed type incubators have facility of nursing within incubator. Such incubators require more space for infant chamber. Time required for nursing is also considerably more but it provides the best possible treatment to the infant.



3.2.5. Storage.

Though an essentiality as far as possible this facility is rejected. As present incubator cupboard is heavy and very big and has substantial height. This is under utilised and reduces mobility of the incubator cup-board, also facilitates tilting.

3.2.6. Control.

Present incubators have on-off switch and two control knobs with a pilot lamp but to explain a selection and knob position, there is a complicated explanation sheet. This makes a simple control difficult to operate.

3.2.7. Maintenance.

Present incubator design is most utilitarian and has bear minimum parts. This is easy to clean and maintain, but if the heating system fails, this incubator can not be repaired without the help of a skilled agency.

3.3.0. Formal analysis is restricted to only Indian incubator.

All the present incubators have the same form which differ only in detailing of transition from one plain to another.

The visual proportions a total unit is odd. It is very high and has less width.

All incubators avoid sharp corner but they can not hide deformation at the joint of three plains.

Angles supporting glass panel gives a very rigid and harsh shape to glass panel.

Opaque frame work stands in contrast to transparent glass panel and is responsible for giving it a sturdy appearance.

Four verticle angles acting as legs do not have good proportions. They are more wide and short.

Bottom and rear side is true to its

structure without any surplus finishing.

Sides of the incubator are plain with number of parts stuck on it.

Oxygen inlet on one side is hardly recognisable.

Funnel for pouring water and water draining cock have totally different character. The point is strictly utilitarian sides are enamel finished while tap and funnel are out of stainless steel.

Stainless steel strips for tilting adjustment look as if unnecessary extension stuck on the side. It has a functional form.

Standard handles on both sides and on the top lid do not go with the total assembly. They look extremely delicate.

Control panel on the front is not well differentiated. It is in the same plain and of the same colour.

Knobs and pilot lamps are so much away from each other that they loose their identity as one unit of controls.

Knobs are small as compared to the front panel and black colour on grey or white back ground gives a still smaller impression.

Graphics is well marked.

Incubator is finished with grey or white enamel and has a smooth finish, which gives a total unit polished and sophisticated appearance.

3.4.0. Ergonomical analysis.

3.4.1. Infant space.

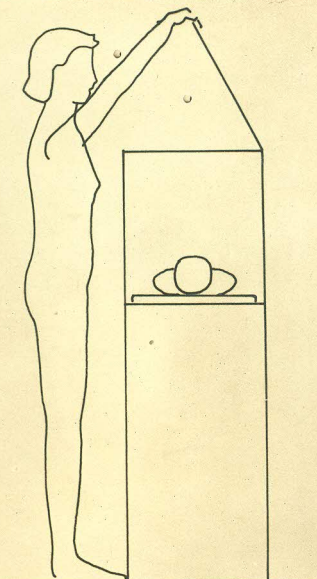
All the present incubators have oblong shape and infant chamber is around 24" x 18" x 18" (height). Considering infant's body measurements at birth and at the time of discharge, this chamber does not allow rolling or fully stretched body positions.

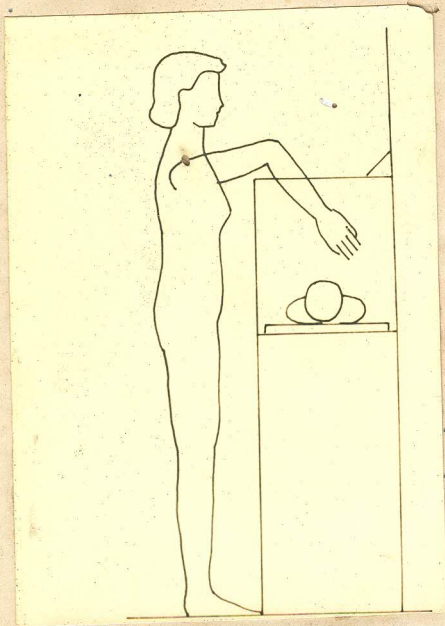
Cotton mattress used in the Indian incubator is warm and comfortable. In some foreign hospitals water beds are used but they are extremely cool. Thermocole ball mattress is soft, comfortable, quick drying, easy to clean and it allows air circulation within the mattress.

Present incubator beds can be tilted through $\pm 15^\circ$ which fully satisfy all needs for nursing.

3.4.2. Nursing problems.

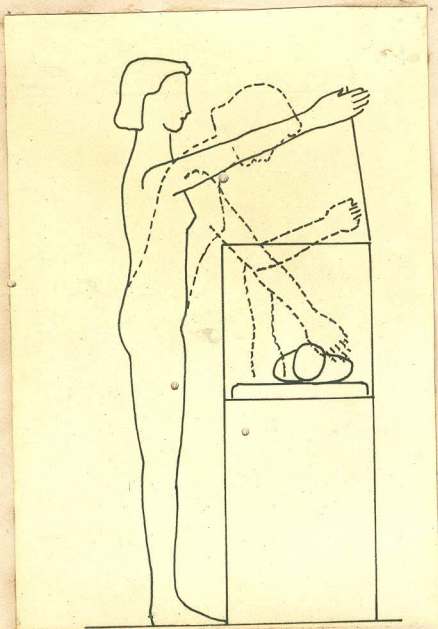
Present incubator being a copy of foreign design, does not take care of physical limitations due to body measurement of Indian nurses.





This incubator if accepted along with the trolley, its bed height and incubator top from the floor is at a higher level than what a nurse would like to have. Therefore, 'taking out' and keeping in the infant becomes difficult. The opening is also inadequate.

This incubator takes support of the trolley for tilting and the whole unit is tilted. This is tiresome and nurse tends to add support under the bed rather than tilting it.



In case of a present incubator, for any operation bending is essential.

The length of an incubator is such that one man can not lift it easily. It has only one handle on each side so in transport it may swing towards right or left.

4.0.0. Hypothesis.

4.1.0. Structural hypothesis.

4.1.1. Incubator should be developed with an idea of fabrication and assembly by manual work. Production process should avoid methods of mass production.

4.1.2. Incubator should be light in weight, strong against any shock. It should have simple joining details which makes the unit air tight.

4.1.3. It should protect that infant from any object falling on it.

4.1.4. It should provide a comfortable bed and an easy tilting arrangement ($\pm 15^\circ$).

4.1.5. Incubator should be structurally simple to assemble and disassemble. It should be easy to clean. In case of a system failure, its parts must be easily replaceable without the help of any skilled agency.

4.1.6. Incubator should have water pouring facility, very simple and water level

should be seen from outside.

4.1.7. Structurally incubator should provide facilities such that the incubator can be utilised both ways, either as open type or as a closed type.

4.1.8. Incubator should be made up of two principal units. The infant chamber and heating chamber. Heating chamber should be located below the infant chamber.

4.1.9. Assembly should avoid 'skin and bone' construction. It should reduce number of parts to the minimum possible extent.

4.1.10. Heating element should avoid over heating and should be economical and easily replaceable.

4.1.11 Electrical risk should be avoided. Infant chamber should be well guarded against any power leakage and fire hazard.

4.2.0. Functional hypothesis.

- 4.2.1. The shape of the incubator should be such that it should hold maximum air volume in the minimum surface area.
- 4.2.2. Incubator should provide complete and clear view of the infant.
- 4.2.3. Incubator should avoid sharp corners. Infant chamber should provide heat by radiation to the maximum possible extent. It should also reduce heat loss by convection or conduction.
- 4.2.4. Heating element should be capable of providing any temperature within a range of 30 to 37° C with an accuracy of $\pm .5^{\circ}$ C. Heating element should reach the required temperature within 15 minutes.
- 4.2.5. Heating must be even throughout the chamber.
- 4.2.6. Incubator should maintain a water trough in such a way that it maintains a relative humidity of 60 to 90 %.

- 4.2.7. It should maintain a ventilation of 10 to 15 air changes per hour, but it should not allow any air leakage i.e. air entering inside from out excepting the inlet for the air.
- 4.2.8. Incubator should isolate infant from other environment to all possible extent. It should offer an infant protection from the infection.
- 4.2.9. Incubator should provide a facility of nursing within the incubator.
- 4.2.10. Incubator bed should be soft and warm and of quick drying material. It should not offer strain to body muscles. The bed should have a facility of tilting it through $\pm 15^{\circ}$.
- 4.2.11. Incubator control should be easy to operate and free from any reference or calculations.
- 4.2.12. Incubator should be easy to clean, maintain and to repair.

4.5.0. Formal hypothesis.

- 4.3.1. Incubator should have a very simple and attractive form. The visual proportions of the total unit should be pleasant. The form should be truly functional.
- 4.3.2. It should be free from any deformation at the joint. It should avoid sharp corners or edges.
- 4.3.3. Transperent panel should have an attractive shape which is functional and goes with the total unit.
- 4.3.4. The unit should have a smooth surface finished with opaque white or ivory colour from inside and white or grey or any colour from outside which gives it a dignity.
- 4.3.5. Any element or fixture on the outer skin of the incubator should have a convincing form with respect to its function and should be well merged with the total assembly.

4.3.6. If necessary, colour coding or other symbols should be used to indicate a certain function, priority or emergency.

4.3.7. Control panel should be in proportion to the incubator. It should be well differentiated and well marked on the front face. It should have very simple form finished with an attractive and inviting colour. It should be well marked or embossed with a graphics etc. It should be well organised.

4.4.0. Ergonomical hypothesis.

4.4.1. Infant space in the incubator should be adequate. It should allow rolling or free body movements within the chamber.

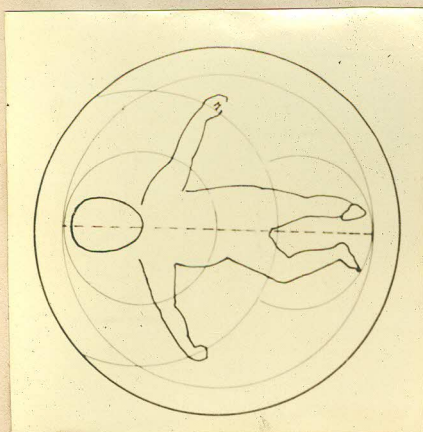
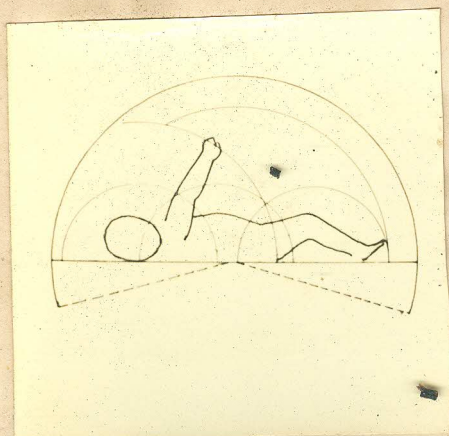
4.4.2. Infant chamber should also facilitate free movement of the hand (and fore arm) and easy reach for all the nursing requirements.

4.4.3. It should use a mattress which is comfortable, easy to maintain, easy to clean and quick drying. It should remain warm and should allow air circulation within the mattress.

4.4.4. Incubator bed should have a facility of tilting it through $\pm 15^\circ$.

4.4.5. Incubator design should take care of physical limitations due to body measurements of Indian nurses being an operator of the equipment.

4.4.6. Incubator should be supported on a stand in such a way that incubator top is easily operatable.



- 4.4.7. Incubator bed level and opening should be such that the infant can be easily 'kept in' and 'taken out' of it without lifting it.
- 4.4.8. Incubator should be such that nursing can be done without leaning forward unnecessarily.
- 4.4.9. Incubator should be easy to lift or to transport by one person.
- 4.4.10. Control should be designed to give accuracy in manual adjustment. Knobs should be designed to have a firm grip and easy adjustment.
- 4.4.11 Graphics, colour code, letters (type) etc. should be carefully selected taking into consideration time required for setting and limitations of human eye and human action.

5.

Synthesis.

A survey of the existing incubators and the needs of the hospitals who use them showed that there is a need of an economical incubator to serve, mainly hospitals in the small town where skilled but untrained (for premature unit) nurses are available.

As incubators are manufactured on ordered by the process of fabrication and assembly, this leads to a design of details suitable for such industry only.

The main design constraints were complete view of the infant, maintenance of heat, ventilation, humidity and protection from infection which leads to an air-tight and rigid construction which is easy to manufacture, maintain and to repair.

A number of shapes were sketched and studied in terms of their suitability. They were also visualized with different kinds of systems (alternatives).

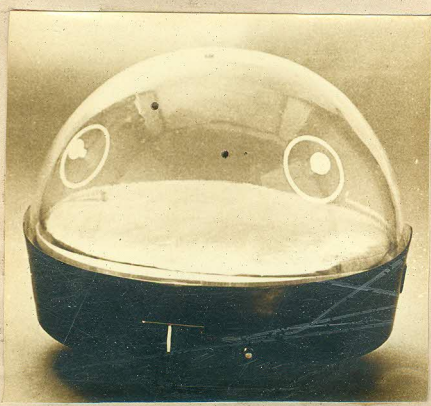
Initially a rectangular shape was

selected, but it was found out that this shape does not solve any functional problems, especially that of heating. This is uneconomical from the structural point of view though it is economical and easier to manufacture. It is not suitable from the ergonomical point of view.

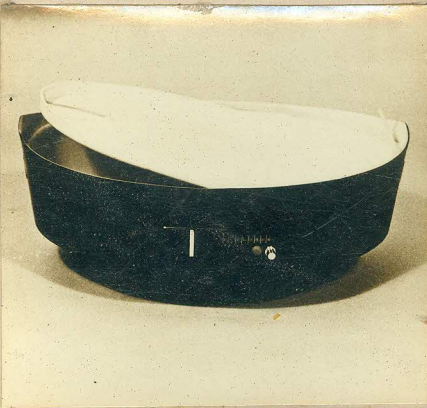
So an oval shape was selected which solved many problems but raised constructional and manufacturing difficulties.

So a golden mean was reached by the selection of circular shape.

The final design has the following features



Hood - It is made up of transparent polystyrene and has a domical shape which is formed by forming process. It is made into two halves which slide one above other. The outer portion serves as an opening while inner portion has two holes which act as a restricted access to the infant for nursing. It also helps in retaining heat and radiating it on the infant by the virtue of its shape. It holds more air volume as compared to its

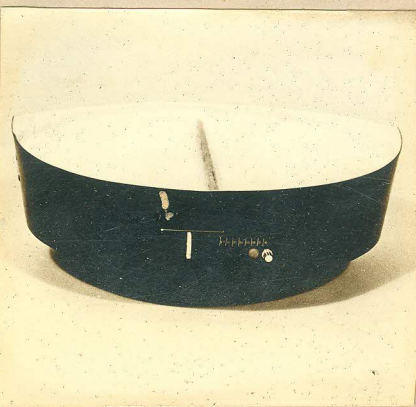


surface area. It helps in maintaining oxygen dome.

Bed - Incubator bed is made out of thermocole balls which is easy to clean and maintain. It is quick drying and allows air circulation within. It is warm and comfortable. It is circular in shape.

Bed-dish - is made out of aluminium sheet by forming method. It also facilitates tilting through $\pm 15^\circ$ and takes its support on the base.

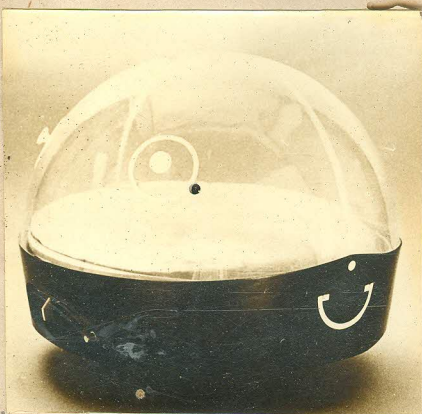
Base - Incubator base is made up of aluminium sheet by fabrication process. The joining is done by synthetic adhesive to make it air tight. It has a shape of a frustum which has smaller diameter at the bottom. It supports the whole unit.



Heating system - heating system is situated exactly below the infant bed. It comprises of 4 bulbs as a heating element, the heating of which is controlled by a Rheostat by increasing or reducing the voltage. The whole system is situated in a aluminium box with an asbestos lining from inside.



Ventilation system - Incubator has an air inlet at the rear side of the base. The air is passed on the bulbs and enters in infant chamber along the periphery of the bed. It has an outlet in the incubator hood which is adjustable to give 10 to 15 air changes per hour.



Control panel is situated on the front portion of the base. It is sunked to give protection to the thermometer. The sliding indicator when matched with the mercury column gives the required temperature. Thermometer has seven positions to adjust. The thermometer when adjusted to give 30°C temperature any position of indicator which matches with the mercury column ensures inside temperature of 30°C . Same is true of any selected position of a thermometer for 32 , 35 or 37°C etc.

5.1.0. Salient features of the design.

1. Use of inexpensive and easily available materials.
2. Easily replaceable heating element.
3. Construction permits easy changing of elements and also facilitates dismantling and cleaning it easily.
4. Provision of complete and clear infant view. Observation from a longer distance.
5. It is easy for nursing infant.
6. Reduces the risk of over heating.
7. Control is safe and simple.
8. Tilting is very easy.
9. It avoids a sharp corners and edges.
10. Use either as open type or closed type.
11. Simple form which reduces production cost and make it better looking.
12. It can adjust with other hospital equipments.
13. The visual bulk is reduced by the use of colour scheme and form.

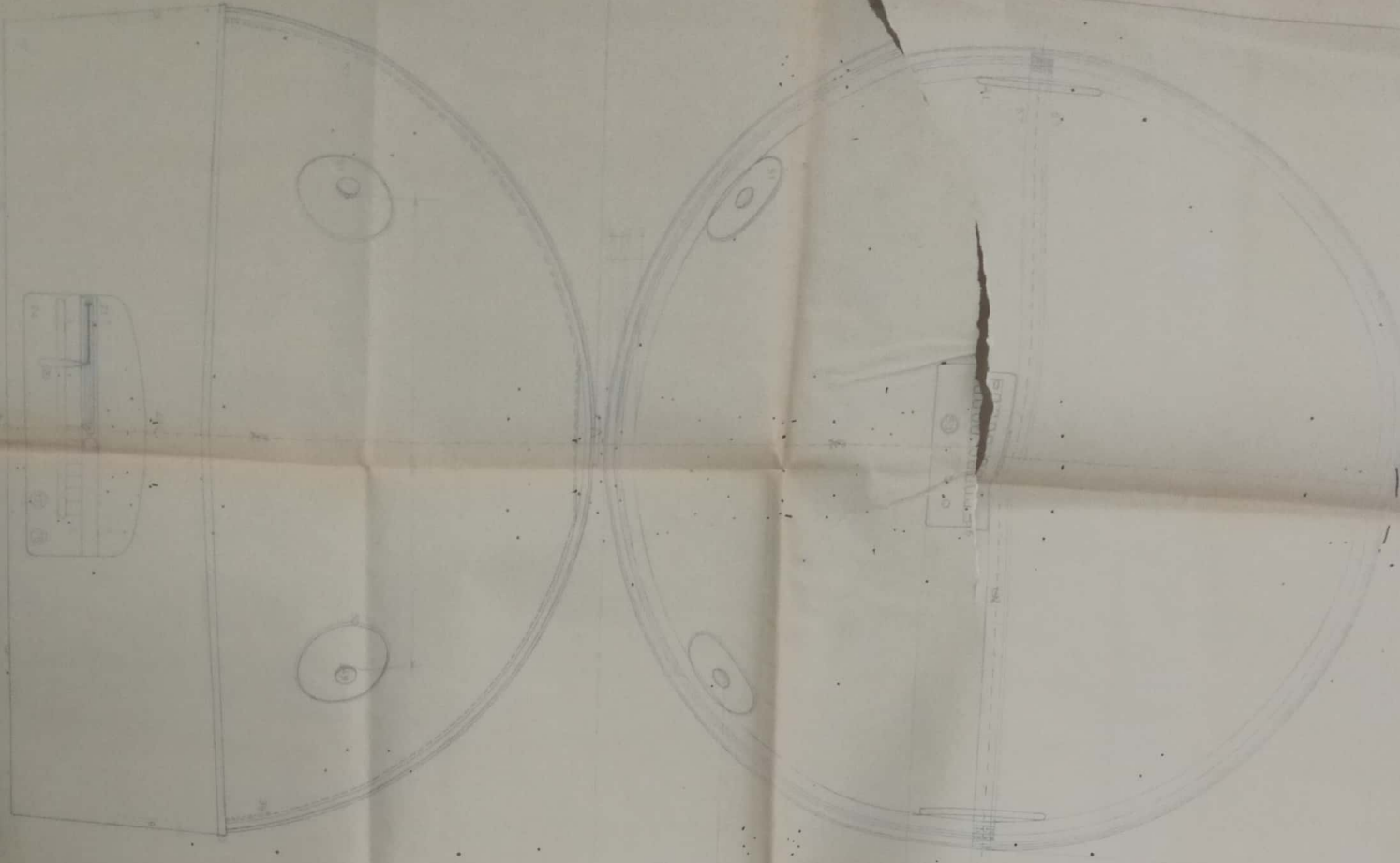
. Bibliography

1. The Premature Baby
2. Prematurity
3. Incubator Design

V. M. Crosse.

Beryl Corner.

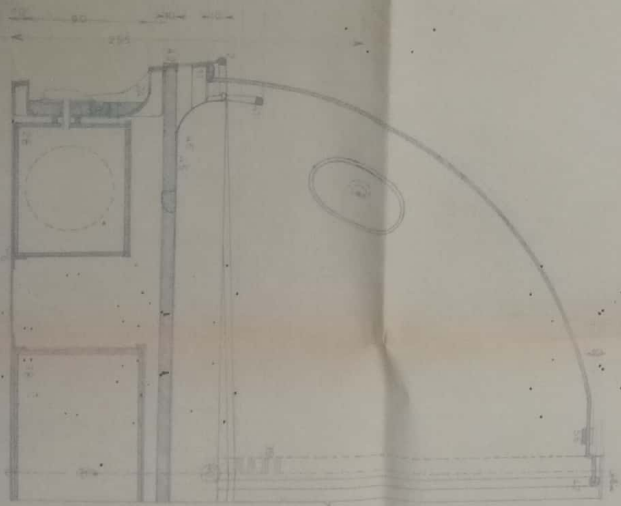
K. K. Trivedi.



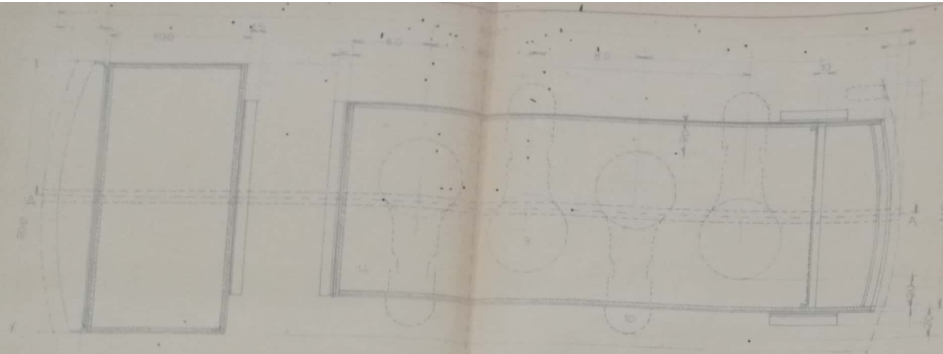
FRONT VIEW

SECTION A-A

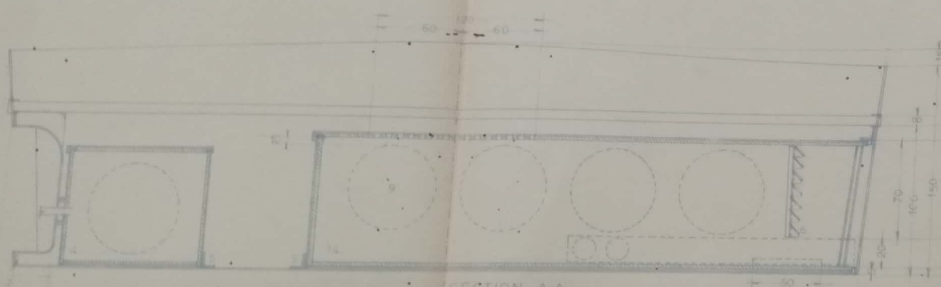
PLAN



NO.	DESCRIPTION	QTY	UNIT	REMARKS
1	FLAT FLANG	1	PC	
2	FLAT FLANG	1	PC	
3	FLAT FLANG	1	PC	
4	FLAT FLANG	1	PC	
5	FLAT FLANG	1	PC	
6	FLAT FLANG	1	PC	
7	FLAT FLANG	1	PC	
8	FLAT FLANG	1	PC	
9	FLAT FLANG	1	PC	
10	FLAT FLANG	1	PC	
11	FLAT FLANG	1	PC	
12	FLAT FLANG	1	PC	
13	FLAT FLANG	1	PC	
14	FLAT FLANG	1	PC	
15	FLAT FLANG	1	PC	
16	FLAT FLANG	1	PC	
17	FLAT FLANG	1	PC	
18	FLAT FLANG	1	PC	
19	FLAT FLANG	1	PC	
20	FLAT FLANG	1	PC	
21	FLAT FLANG	1	PC	
22	FLAT FLANG	1	PC	
23	FLAT FLANG	1	PC	
24	FLAT FLANG	1	PC	
25	FLAT FLANG	1	PC	
26	FLAT FLANG	1	PC	
27	FLAT FLANG	1	PC	
28	FLAT FLANG	1	PC	
29	FLAT FLANG	1	PC	
30	FLAT FLANG	1	PC	
31	FLAT FLANG	1	PC	
32	FLAT FLANG	1	PC	
33	FLAT FLANG	1	PC	
34	FLAT FLANG	1	PC	
35	FLAT FLANG	1	PC	
36	FLAT FLANG	1	PC	
37	FLAT FLANG	1	PC	
38	FLAT FLANG	1	PC	
39	FLAT FLANG	1	PC	
40	FLAT FLANG	1	PC	
41	FLAT FLANG	1	PC	
42	FLAT FLANG	1	PC	
43	FLAT FLANG	1	PC	
44	FLAT FLANG	1	PC	
45	FLAT FLANG	1	PC	
46	FLAT FLANG	1	PC	
47	FLAT FLANG	1	PC	
48	FLAT FLANG	1	PC	
49	FLAT FLANG	1	PC	
50	FLAT FLANG	1	PC	
51	FLAT FLANG	1	PC	
52	FLAT FLANG	1	PC	
53	FLAT FLANG	1	PC	
54	FLAT FLANG	1	PC	
55	FLAT FLANG	1	PC	
56	FLAT FLANG	1	PC	
57	FLAT FLANG	1	PC	
58	FLAT FLANG	1	PC	
59	FLAT FLANG	1	PC	
60	FLAT FLANG	1	PC	
61	FLAT FLANG	1	PC	
62	FLAT FLANG	1	PC	
63	FLAT FLANG	1	PC	
64	FLAT FLANG	1	PC	
65	FLAT FLANG	1	PC	
66	FLAT FLANG	1	PC	
67	FLAT FLANG	1	PC	
68	FLAT FLANG	1	PC	
69	FLAT FLANG	1	PC	
70	FLAT FLANG	1	PC	
71	FLAT FLANG	1	PC	
72	FLAT FLANG	1	PC	
73	FLAT FLANG	1	PC	
74	FLAT FLANG	1	PC	
75	FLAT FLANG	1	PC	
76	FLAT FLANG	1	PC	
77	FLAT FLANG	1	PC	
78	FLAT FLANG	1	PC	
79	FLAT FLANG	1	PC	
80	FLAT FLANG	1	PC	
81	FLAT FLANG	1	PC	
82	FLAT FLANG	1	PC	
83	FLAT FLANG	1	PC	
84	FLAT FLANG	1	PC	
85	FLAT FLANG	1	PC	
86	FLAT FLANG	1	PC	
87	FLAT FLANG	1	PC	
88	FLAT FLANG	1	PC	
89	FLAT FLANG	1	PC	
90	FLAT FLANG	1	PC	
91	FLAT FLANG	1	PC	
92	FLAT FLANG	1	PC	
93	FLAT FLANG	1	PC	
94	FLAT FLANG	1	PC	
95	FLAT FLANG	1	PC	
96	FLAT FLANG	1	PC	
97	FLAT FLANG	1	PC	
98	FLAT FLANG	1	PC	
99	FLAT FLANG	1	PC	
100	FLAT FLANG	1	PC	



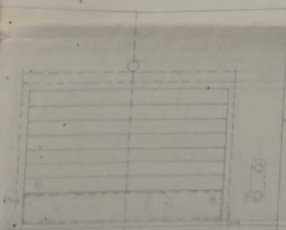
PLAN



SECTION AA

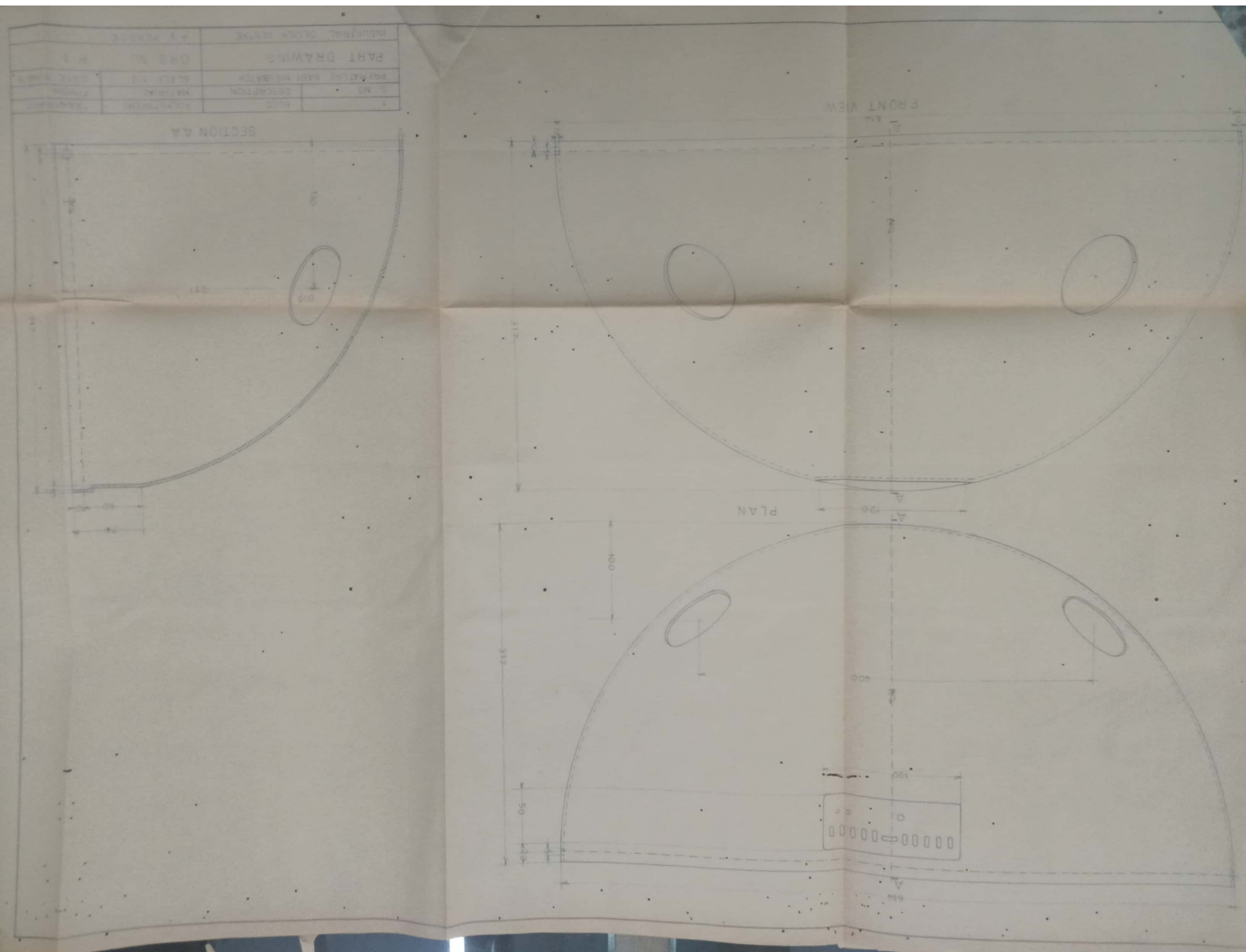


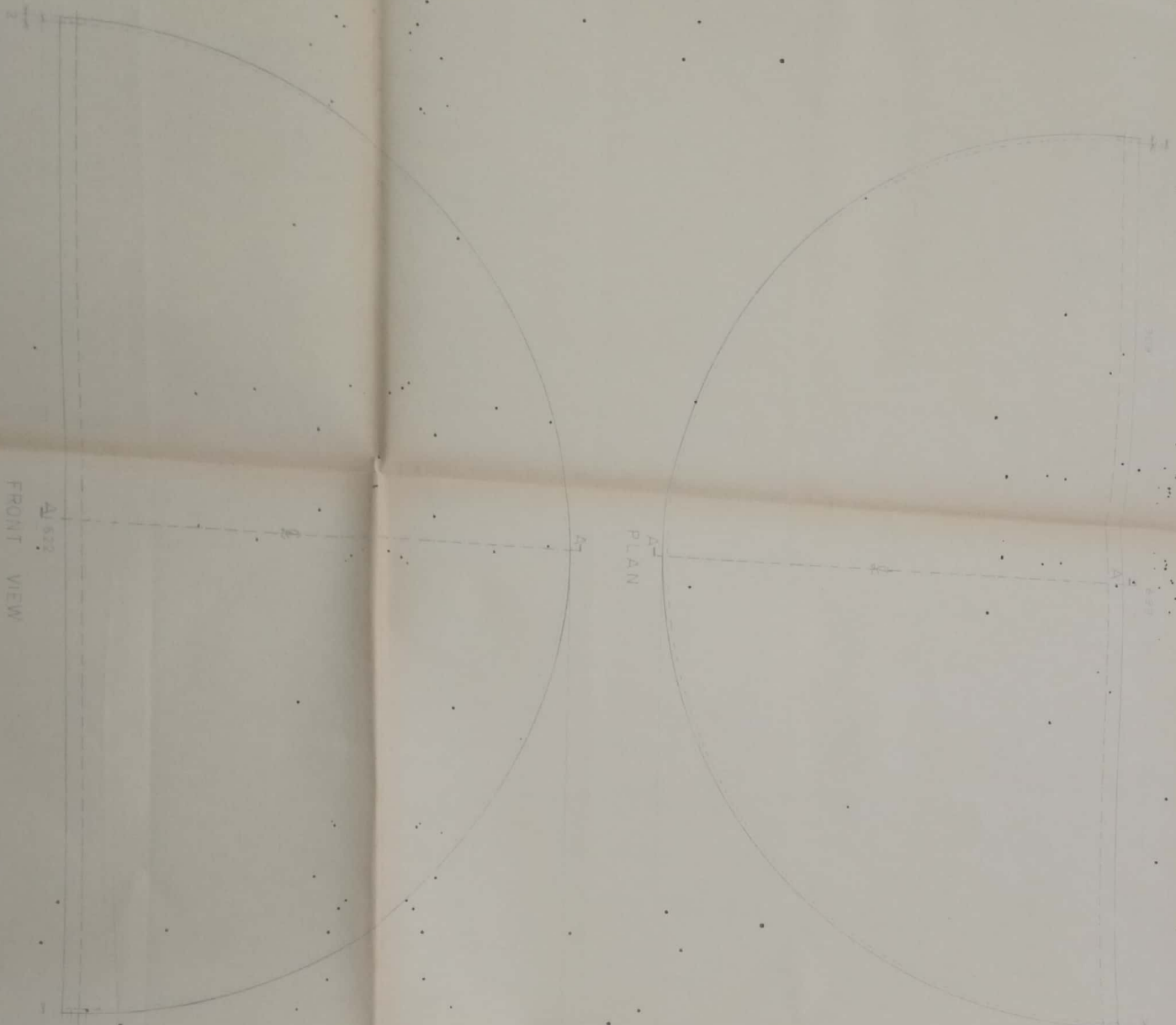
FRONT VIEW OF HANDLE



REAR VIEW

14	HEATING BOX	ALUMINUM TSM	WHITE
13	LINING	ASBESTOS	WHITE
12	SCREW 2M	BRASS	
11	AIR SEAL	RUBBER	
10	HOLDER		
9	BULB		
8	TROUGH	GLASS	
7	BALL	SPONGE	WHITE
6	VENTILATION BLIND	ALUMINUM	WHITE
5	SPACER	ALUM. ANGLE	WHITE
4	WIND-STOP BOX	ALU. SHEET 1/8"	WHITE
3	SOCKET		
2	GLASSING	ALU. SHEET 1/8"	BLACK
1	HANDLE	ALU.	CRACKLE
S. NO.	DESCRIPTION	MATERIAL	FINISH
PRELIMINARY BICYCLE INCUBATOR		SCALE 1:2	DATE: 10/1/74
SUB ASSEMBLY		DRG. NO.	A 2
INDUSTRIAL DESIGN CENTRE		P. V. RENDSE	



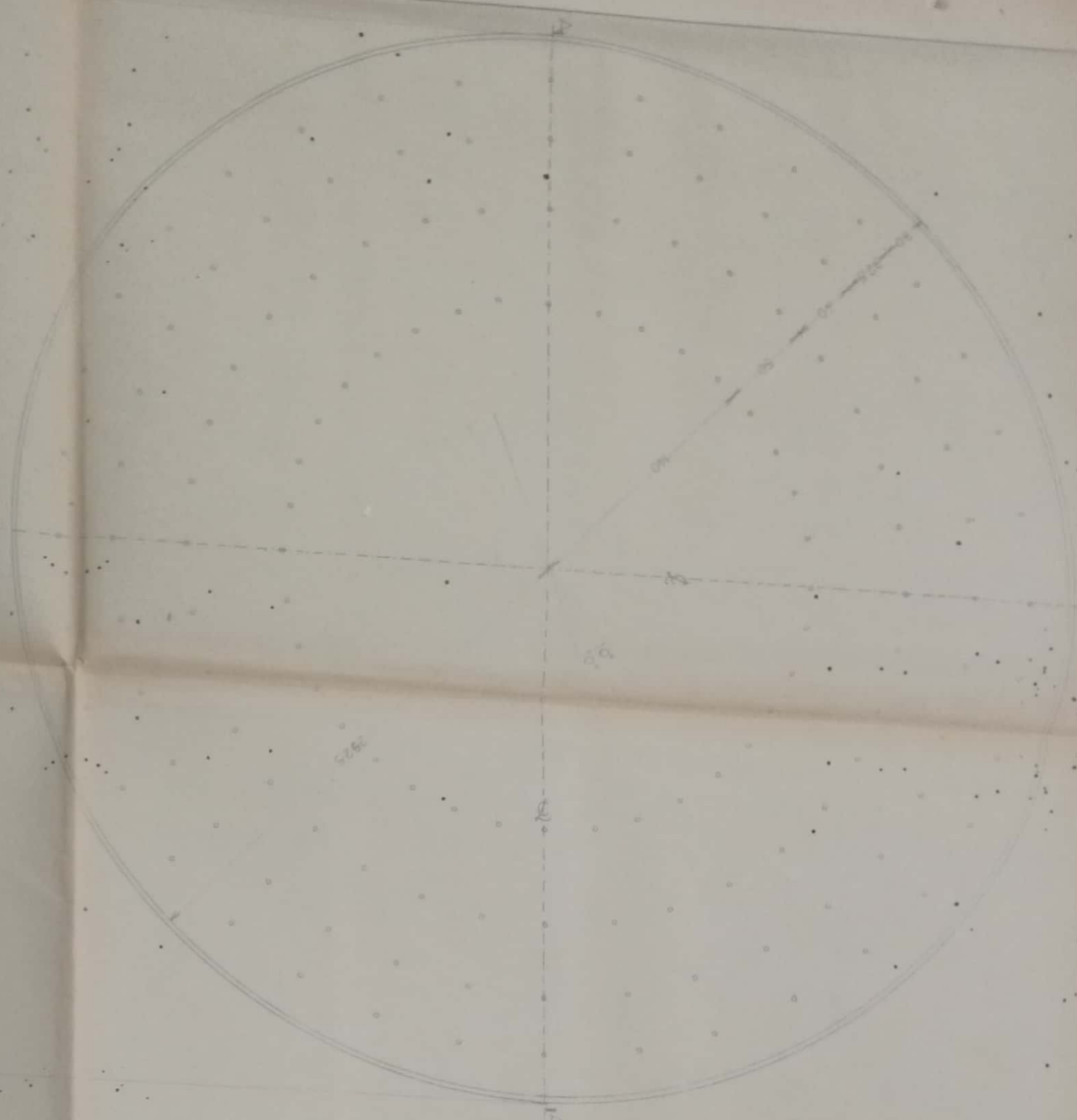


FRONT VIEW

PLAN

SECTION A-A

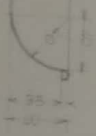
PART DRAWING			
NO.	DESCRIPTION	DATE	BY
1	INDUSTRIAL DESIGN CENTRE		
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
31			
32			
33			
34			
35			
36			
37			
38			
39			
40			
41			
42			
43			
44			
45			
46			
47			
48			
49			
50			
51			
52			
53			
54			
55			
56			
57			
58			
59			
60			
61			
62			
63			
64			
65			
66			
67			
68			
69			
70			
71			
72			
73			
74			
75			
76			
77			
78			
79			
80			
81			
82			
83			
84			
85			
86			
87			
88			
89			
90			
91			
92			
93			
94			
95			
96			
97			
98			
99			
100			



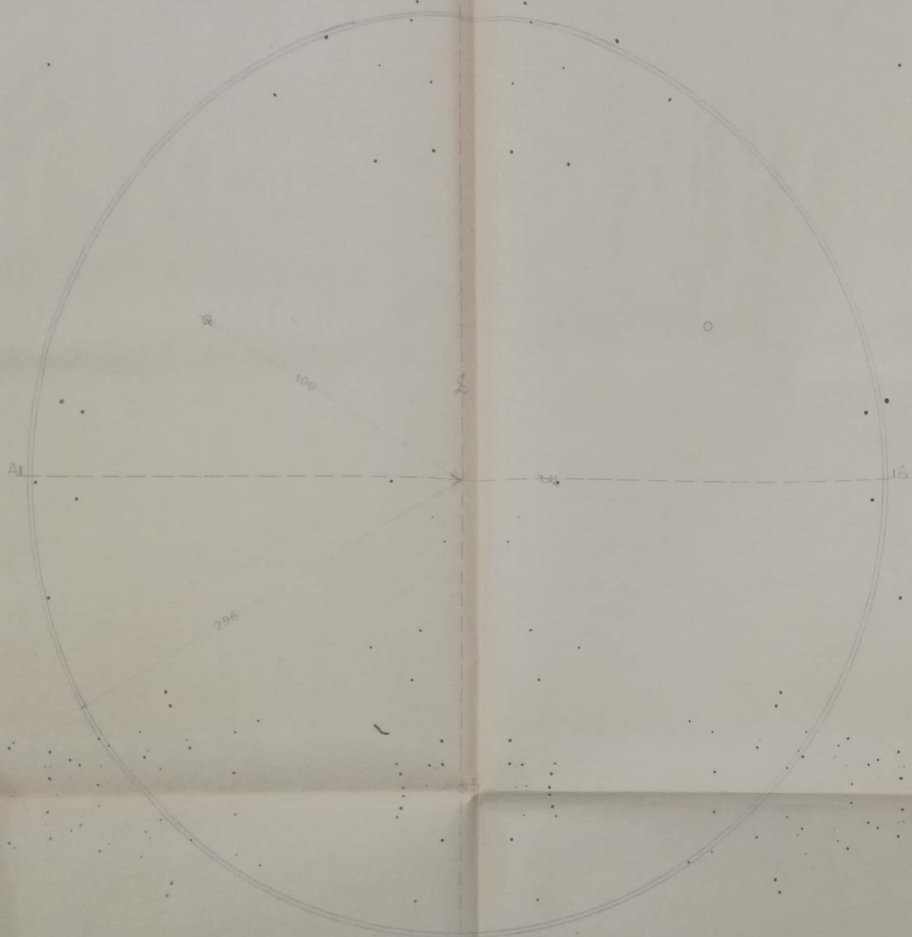
PLAN

FRONT VIEW

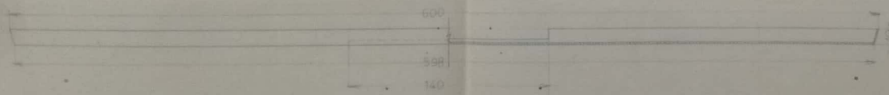
SECTION A A



1	BED TISSUE	ALL SHEET	WHITE, 20x24
2	PREPARED BY	DATE	
3	PREPARED BY	DATE	
4	PREPARED BY	DATE	
5	PREPARED BY	DATE	
6	PREPARED BY	DATE	
7	PREPARED BY	DATE	
8	PREPARED BY	DATE	
9	PREPARED BY	DATE	
10	PREPARED BY	DATE	
11	PREPARED BY	DATE	
12	PREPARED BY	DATE	
13	PREPARED BY	DATE	
14	PREPARED BY	DATE	
15	PREPARED BY	DATE	
16	PREPARED BY	DATE	
17	PREPARED BY	DATE	
18	PREPARED BY	DATE	
19	PREPARED BY	DATE	
20	PREPARED BY	DATE	
21	PREPARED BY	DATE	
22	PREPARED BY	DATE	
23	PREPARED BY	DATE	
24	PREPARED BY	DATE	
25	PREPARED BY	DATE	
26	PREPARED BY	DATE	
27	PREPARED BY	DATE	
28	PREPARED BY	DATE	
29	PREPARED BY	DATE	
30	PREPARED BY	DATE	
31	PREPARED BY	DATE	
32	PREPARED BY	DATE	
33	PREPARED BY	DATE	
34	PREPARED BY	DATE	
35	PREPARED BY	DATE	
36	PREPARED BY	DATE	
37	PREPARED BY	DATE	
38	PREPARED BY	DATE	
39	PREPARED BY	DATE	
40	PREPARED BY	DATE	
41	PREPARED BY	DATE	
42	PREPARED BY	DATE	
43	PREPARED BY	DATE	
44	PREPARED BY	DATE	
45	PREPARED BY	DATE	
46	PREPARED BY	DATE	
47	PREPARED BY	DATE	
48	PREPARED BY	DATE	
49	PREPARED BY	DATE	
50	PREPARED BY	DATE	
51	PREPARED BY	DATE	
52	PREPARED BY	DATE	
53	PREPARED BY	DATE	
54	PREPARED BY	DATE	
55	PREPARED BY	DATE	
56	PREPARED BY	DATE	
57	PREPARED BY	DATE	
58	PREPARED BY	DATE	
59	PREPARED BY	DATE	
60	PREPARED BY	DATE	
61	PREPARED BY	DATE	
62	PREPARED BY	DATE	
63	PREPARED BY	DATE	
64	PREPARED BY	DATE	
65	PREPARED BY	DATE	
66	PREPARED BY	DATE	
67	PREPARED BY	DATE	
68	PREPARED BY	DATE	
69	PREPARED BY	DATE	
70	PREPARED BY	DATE	
71	PREPARED BY	DATE	
72	PREPARED BY	DATE	
73	PREPARED BY	DATE	
74	PREPARED BY	DATE	
75	PREPARED BY	DATE	
76	PREPARED BY	DATE	
77	PREPARED BY	DATE	
78	PREPARED BY	DATE	
79	PREPARED BY	DATE	
80	PREPARED BY	DATE	
81	PREPARED BY	DATE	
82	PREPARED BY	DATE	
83	PREPARED BY	DATE	
84	PREPARED BY	DATE	
85	PREPARED BY	DATE	
86	PREPARED BY	DATE	
87	PREPARED BY	DATE	
88	PREPARED BY	DATE	
89	PREPARED BY	DATE	
90	PREPARED BY	DATE	
91	PREPARED BY	DATE	
92	PREPARED BY	DATE	
93	PREPARED BY	DATE	
94	PREPARED BY	DATE	
95	PREPARED BY	DATE	
96	PREPARED BY	DATE	
97	PREPARED BY	DATE	
98	PREPARED BY	DATE	
99	PREPARED BY	DATE	
100	PREPARED BY	DATE	



PLAN



FRONT VIEW

SECTION AA

1	FACE PLATE	ALL SHEET METAL	BLACK
S. NO.	DESCRIPTION	MATERIAL	THICKNESS
PRE-STORE	BARY INSULATOR	CLASS 1-2	1000
PART DRAWING		DRG. NO.	P. 5
INDUSTRIAL DESIGN LAYOUT		A. V. PRADEEP	