REDESIGN OF pH METER

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1975

Redesign of pH Meter

Diploma Project

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

by

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Approval Sheet

Diploma Project entitled

'pH Meter'

by E. Jyothi John is approved for the

Postgraduate Diploma in Industrial Design

Guide .

Chairman .

Examiners .

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Guide : Mr. M. Chattopadhyay

Co-guide : Prof. S. Nadkarni

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I am grateful to the Workshop Staff, Photo Studio Staff and Office Staff for the help they rendered in completing my various jobs successfully.

I am thankful to my friend Mr. B.N. Prabhu, Chemistry Department, and ELICO Pvt. Ltd., for their help.

CONTENTS

1. INTRODUCTION

1.1

The dawn of the modern civilization is characterized by the electronic industry. During the last few decades electronics has made tremendous advances. Electronics did not spare to enter into any of the human environment like laboratories, houses, etc. The major portion of the laboratory instruments are mostly electronic in nature..

1.2

pH Meter is one such among the vast array of electronic instruments. The adherence and determination of certain pH values is very important particularly at catalitic processes. Some important fields of application are

Chemical Industry:

Esterification of alcohols
Fatty acidsynthesis
Aldol dimerisation
Refining of gasolines
Manufacture of glue and gelatine
Stabilization of latex
Production of cellulose

Neutralizing processes

Production of various plastics

Penicillin production

Production of emulsion, etc.

Foodstuff Industry:

Sugar manufacture

Soap manufacture

Canned foods etc.

Light Industry:

Miscellaneous processes in textile industry:

Cleaning baths

Bleaching baths

Dying baths

Washing waters, etc.

Miscellaneous processes in leather industry:

Washing

Lime alcalinity measuring

Deliming

Bating

Tanning

Bleaching

Dying, etc.

Miscellaneous processes in paper industry:

Water preparation

Sulphite leaching, etc.

Heavy Industry:

Ore dressing

Gas making - scrubbing

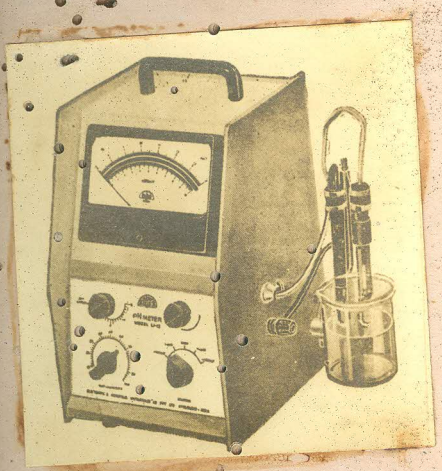
Water purification

Electroplasting, etc.

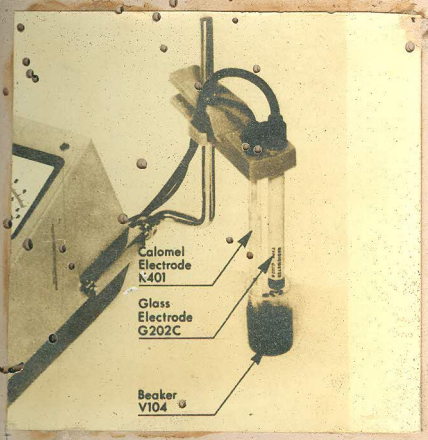
In addition to these, there are numerous other fields of application of pH meter . For example, it can be advantageously be used in the pH control of boiler feed water or in sewage clarification.

1.3

In short, pH meter has varied applications and determination of pH value of solutions is very important. Man always seeks ease and comfort and does not want to waste time and energy. Quick and accurate operation and reading of an instrument is essential for him.



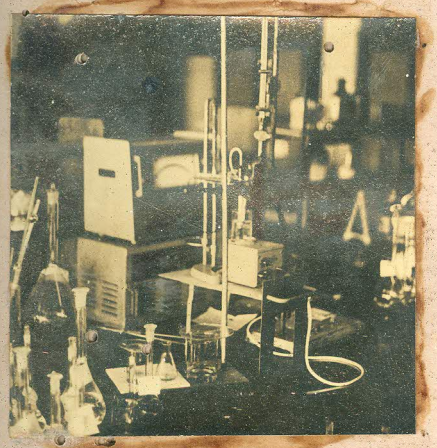
If we look at some of the existing pH meters we notice that most of the instruments have a vertical front panel in which case the reading of the scale is difficult when the instrument is placed on the table. Some instruments have improperly inclined front panel, the inclination of which is not adequate



for proper reading. Some models have about 16 screws on the front panel which give a bad appearance to the meter. The designers' approach to design of clips or holders for electrodes was always the same. They never deviated from their usual trend so as to include a factor of safety of the electrodes. No colours were used to differentiate different ranges.

In broad sense they never endeavoured to apply human engineering to their products.

1.4



It is absolutely necessary to minimise the space on laboratory tables by proper arrangement of an instrument and its accessories because much space is occupied by the bottles containing solutions, beakers, stands, etc.

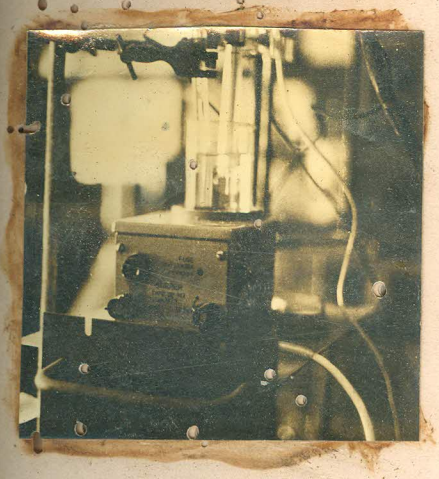
1.5

It is also necessary to see that no wires pass across the working space . Some instruments do not have such an arrangement.

1.6

In my design I tried to solve all the problems from a different angle. I used a simple means for supporting the electrodes which can be moved up and down without use

of any clips. The electrode holder passes through the instrument which is supported on a stand thereby saving space and making it easy for operation.



Small stirrers can be easily put directly under the electrodes without any extra space and the electrodes can be adjusted to the required height.

The acidic range is between 0 - 7. The basic range is between 7 - 14, 7 being nutral. Hence, to differentiate between different ranges I used different colours.

A knife-edged pointer is used to reduce parallex error.

The knobs are designed with ergonomic considerations.

2. PROBLEM STATEMENT

2.1 Redesign of pH Meter

2.2

The emphasis would be on the following points.

2.2.1

The system should be, as far as possible, economical.

2.2.2

Materials and processes should be appropriate.

2.2.3

It should be easy for manufacture.

2.2.4

There should be ease of servicing.

2.2.5

There should be saving of space on laboratory tables.

2.2.6

The housing should be constructed from standard sheets available in the market for optimum size of the housing with maximum scrap so as to get 25% of the original cost of the material.

2.2.7

Great rewards of ergonomics should be achieved.

2.2.8

It should be possible to place a stirrer below the electrodes without occupying extra space.

3. WORK DONE

3.1

Before the designing work, data is collected from the manufacturers, sellers and users of pH meter. This is done through questionnaires, discussions and visits.

3.2

Some available pH meters in the market are analysed from the point of view of structure, function, form, cost, etc.

3.3

After data collection and careful analysis, is enanciated an hypothesis of design requirements.

3.4

Synthesis is the next step wherein all possible solutions are worked out based on materials and processes.

3.5

In the next stage the best solution is selected by evaluation.

3.6

The project work ends with a pH meter model.

4. DATA COLLECTION

4.1

As a part of data collection, literature survey is made which includes magazines, books, pamphlets prepared by some industries. Useful information from this is noted down.

4.1.1

The pH meter and its glass electrodes should be carefully shielded to reduce disturbances from moving fields during the measurement. However, the lower part of the glass electrodes, must necessarily be unshielded, thus leaving open a space between the surface of the test solution and the shield of the electrode. Electrostatic fields may move along this exposed space and cause the meter needle to fluctuate. This can be avoided by immersing the electrodes at least 25 mm into the sample, which will act as a shield.

4.1.2

An efficient precaution to avoid disturbances is to treat the tables, floors, coats, etc. with an antistatic solution.

4.1.3

The mounted electrodes should never touch the bottom of the beaker.

4.1.4

Most common beakers used in the laboratories are 50 ml., 100 ml. and 200 ml. for measurement of pH value of solutions.

Capacity	Height	Diameter
50 ml	50 mm	45 mm
100 ml	65 mm	55 mm
200 ml	75 mm	55 mm

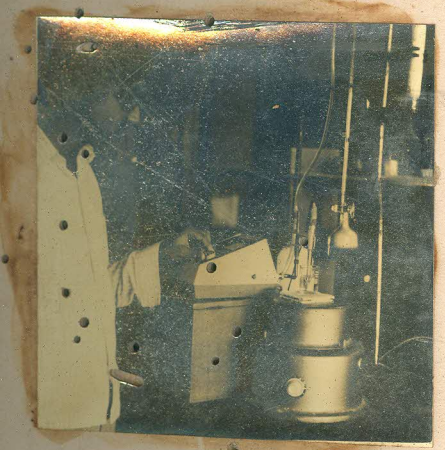
4.2 User:

Following difficulties were observed during the operation of the meter.

4.2.1

The users have to bend to read the scale which is straining. Though some instruments have inclined meter, the inclination is not enough for quick and accurate reading.

4.2.2



The operators use wooden blocks on which the instrument is put for convenient operation and reading.

4.2.3

Though some instruments were provided with handles, the users never used them.

4.2.4

The instrument is set up in one position

permanently.

4.2.5

Some instruments which have handles on the front panel don't have room for fingers to be put in.

4.2.6

Users dip the electrodes in the solution and lift them by clip or holder to remove the beaker.

4.2.7

The users want to avoid parallax error which is not provided in some meters.

4.2.8

Some instruments have instructions on the front panel, where a leaflet would do. None of the users want instructions on the front panel. Large portion on the front panel is occupied by the instructions and provides unutilized space inside the housing.

4.2.9

The users are ready to pay slightly more for a better instrument.

4.3 Sales and Service

The cost of one pH meter varies from Rs.2000/- to 3000/-, hence the sellers want

good models.

4.3.2

The sellers are sure that the customers would pay more for a good stand.

4.3.3

The customers ask for new models with improvements over the existing ones.

4.3.4

They usually complain of servicing because they have to unscrew a number of screws before the chassis is taken out.

4.3.5

The customers want light weight instruments though they do not want a portable model.

4.3.6

The instrument is packed in corrugated cardboard cartons and transported in wooden crates. Grass is sandwitched between the cardboard and the instrument.

4.3.7

The major buyers are the pharmaceutical and chemical industries, universities and affiliated colleges.

4.4 Manufacturers

4.4.1

The housing of the instrument is aluminium in all cases.

4.4.2

Small-scale industries manufacture the housing by simple shearing, bending, screwing, rivetting, etc.

4.4.3

Manufacturers of large scale preferred aluminium die casting.

4.4.4

In small-scale industries they produce about 500 pieces per year and in large-scale it could be in thousands.

4.4.5

Operational elements are generally purchased by small-scale industrialists. Large-scale industrialists produce standard types of knobs for different instruments. They may use the same type of knobs for pH meter.

4.4.6

The instruments after manufacture are stacked up in stores.

4.4.7

The cost of housing varies from 1 - 4% of the cost of the instrument, hence relatively less care is given for its manufacture.

4.4.8

The manufacturer keeps changing the layout hence, tries to come out with a new model every 5 years.

4.4.9

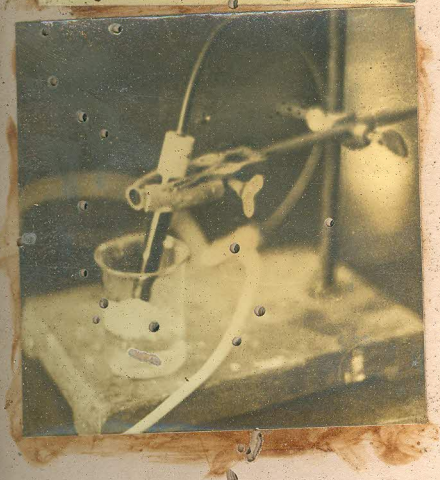
The life of the instrument may vary from 5 - 10 years.

4.4.10

Almost all the instruments have the stand fitted on the side of the instrument.

4.4.11

In other cases, bush with screws is used.



4.4.12

The support for the clips is a steel rod.

Electrode holders or clips made by some manufacturers are not reliable. Hence, test tube holders are used in the laboratory instead of them.

5. ANALYSIS

5.1

The size of the instrument is governed by the circuitary part. The housing becomes bigger with a circuit using tubes. With transistors and integrated circuits the sizes would be reduced.

5.2

The dimensions of the major components coming in the tube version are

Transformer : 80 mm in length
75 mm in breadth
100 mm in height

Condensers : 40 mm in dia, 55 mm long
25 mm in dia, 80 mm long

5 Tubes : 20 mm in dia, 70 mm long

2 Ten-way leg boards: 95 mm x 50 mm

Rotary switch: 50 mm in dia, 45 mm long

3 Potentio meters: 45 mm in dia, 20 mm long

All these with other components are to be arranged on the chassis 250 mm x 230 mm.

5.3 Cambridge pH Meter

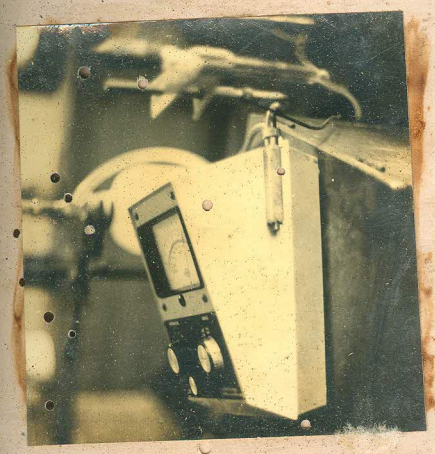
Dimensions	-	400 mm L x 250 mm B x 220 H
Material used for housing	-	Wood
Number of knobs	-	3
Material used for knobs	-	Bakelite
Front panel	-	Sheet metal
pH & mV range	-	0 - 14 pH No mV scale
Finish	-	Varnished
Scale length	-	130 mm
Dial and pointer	-	Circular dial. No knife edge or mirror
Type of clip or holder	-	Nil
Temperature compensation	-	0 - 100 °C
Weight of the instrument	-	7 - 8 kgs.

5.4 Universal pH Meter

Dimensions:	-	340 mm L x 220 mm B x 260 mm H.
Material for housing	-	Die cast aluminium
Number of knobs	-	4 similar knobs
Material used for knobs	-	Bakelite
Front panel	-	Sheet metal (Al.)
pH and mV range	-	0 - 8 pH, 4 - 14 pH 0- 1600 mV (8 steps) 0 - (-)300 mV

Finish	-	Spray painted
Scale length	-	150 mm
Dial and pointer	-	Rectangular dial 180 mm x 90 mm. No mirror or pointed knife edge. The pointer is a fine wire. Shiny metal is used in place of a mirror.
Type of holder or clip	-	Heavy perspex block, injection moulded.
Switch	-	Phenolic with a plastic glow lamp.
Temperature compensation	-	0 - 85°C
Weight	-	7 Kg.

The instrument is provided with die cast aluminium handles on front with no room for finger to insert and lift the instrument.



5.5 Radiometer pH Meter, Type pHM29

Dimensions	-	150 mm L x 230 mm B x 120 mm H
Material for housing	-	Die cast aluminium
Number of knobs	-	3
Material of knobs	-	ABS
Front panel	-	Anodised aluminium sheet
pH & mV range	-	0 - 8, 4 - 14 pH, 0 - 700 mV, 0 - (-300) mV
Finish	-	Spray painted
Scale length	-	140 mm

Dial and pointer	- Rectangular dial. Mirror-backed scale.
Type of holder or clip	- Polypropelene, injection moulded and machined.
Temperature compensation	- (-)10 to 100 in steps of 5

5.6 Elico pH Meter LL10

Main dimensions	- 390 mm L x 430 mm B x 165 mm H
Material for housing	- Aluminium
Number of knobs	- 4
Material for knobs	- Bakelite
Front panel	- Black anodised panel
pH and mV range	- 0 - 7, 7 - 14 pH 0--1000 mV, 0 - (-)1000 mV
Finish	- Spray painted
Scale length	- 120 mm
Dial and pointer	- Rectangular dial. Mirror-backed scale
Type of holder or clip	- Steel clamp holder with spring material on a fixed stand.
Temperature compensation	- 0 - 100°C
Weight	- 7 Kg.

6. HYPOTHESIS

6.1

To redesign a pH meter so as to include an easily movable electrode holder.

6.2

The instrument must be mounted on a stand to make it convenient for reading and operation leaving a working space below it.

6.3

Aluminium should be ~~reaubed~~ as material for housing as it is a good shield and holder of cheap plastic injection moulded.

6.4

No handles are required as it is not a portable model.

6.5

It should be easy for packaging and transport.

6.6

The instrument should be simple to look at.

6.7

It must be stackable.

6.8

The housing must be constructed from standard aluminium sheets,(8'-0" x 4'-0")2.43 and (8'-0" x 3'-0") .91 M. for optimum size of the housing with economy.

6.9

The scale should be designed for a reading distance of 600 mm.

6.10

Knobs should be convenient for operation.

7. SYNTHESIS

7.1

There cannot be a single solution to a problem but many which can be worked out. During the designing process of pH meter number of possible solutions were arrived at.

7.1.1

Providing a separate compartment for the circuit part and another for the electrodes with the beaker which could be inserted from the top and bottom respectively.

7.1.2

With extended bottom part of the front panel below the meter in such a way that the meter and the controls could be shifted to one side and the beaker and the electrodes to the second half.

7.1.3

Providing a sliding part for the electrodes with holder on one side of the instrument.

7.1.4

Putting the electrodes and the beaker in a box such that the upper hinged part of the box fitted with the electrodes could dip into

the bottom part thereby dipping the electrodes in the solution.

7.1.5

The next approach was to include a stand for the instrument on which it could be mounted. The electrodes are suspended by means of a simple holder which could be moved up and down easily while putting test solutions under the electrodes.

7.1.6

The first solution posed a problem of spilling the solution in the housing.

7.1.7

The second one required more space than normally required.

7.1.8

The third one needed slightly extra joinings for the sliding part.

7.1.9

The last one was found to be the best arrangement which could be occupying minimum space. It was found to be easy for operation. Electrodes are held by a holder which could be pushed up and down while placing the beaker and taking it away.

8. DESIGN DECISION

8.1

The pH meter would include the following features.

8.1.1

It would take a rectangular shape because rectangular shape is the simplest of all the forms and easy for construction. Other forms would involve higher costs. It can also be stacked up easily.

The housing is divided into four parts.

The upper part covering the sides.

The front panel

The rear panel

The bottom part (chassis)

The front panel consists of slots for the meter, switch and four similar holes drilled for the knobs. The rear panel is provided with a grill for cooling. The mains are connected to the transformer from the back.

8.1.2

The stand is constructed with wood and ~~alumi-~~ M.S.
~~nium~~ channel. The aluminium section is bend twice at right angles and allows the cheap plywood pieces to be inserted in and screwed.

It provides sufficient strength for taking the load of the instrument. No screws will be visible from the front side. The stand provides a working space below the instrument. It looks neat.

8.1.3

The electrode holder is made from thin extruded Al ~~injection moulded polythelene~~ with a screw ~~and a nut~~. It is cheaper to manufacture. The upper part of the holder consists of a knob(threaded) for lifting the electrodes. The holder is of such a length that the electrodes will be 15 mm above the bottom of the beaker which assures safety to the electrodes unlike the other clips or holders in which there is a possibility of breakage of electrodes due to slipping. An important thing is that the electrodes should be dipped at least 25 mm in the solution. The standard beakers are of 50 - 75 mm in height. Leaving the electrodes 15 mm above the beaker base the electrodes would dip more than 25 mm in the solution, which is essential. The electrode connections are taken from the top cover of the instrument. Hence, no wires will come in the working area. The holder does not require any

spring or spring material which would otherwise complicate the manufacture. The removal of the holder is simple as it can be taken out from the top. The holder does not require any stand as it rests on the top cover.

8.1.4

The scale is graduated from 0 - 7 pH and 7 - 14 pH ranges. The dimensions of the dividing lines and line thicknesses are calculated on the following lines for a reading distance of 600 mm.,(a) for pH scale.

Major dividing lines = a/90 = 6.6 mm
Intermediate dividing lines = a/120 = 5 mm
Minor dividing lines = a/200 = 3 mm
Height of letters = 3 mm
Line thickness = a/5000

On similar lines mV scale is caliberated. The scale is given two ranges, 0 - 7 pH and 7 - 14 pH. The first one is the acidic range and the second one is the basic range. Hence, to differentiate two ranges, two colours are used on the scale. The value 7 pH is neutral which is differentiated by a third colour.

8.1.5

There are two different methods for reducing the parallax error. Providing a mirror or knife-edged pointer with the scale. The second one is cheaper which reduces the cost of the mirror and its fixing. Hence it is chosen.

8.1.6

From data collection it was found that almost all the users want to operate the meter in sitting position. Hence, it is designed for operation in sitting position.

8.1.7

The size of the laboratory table is 900 mm and the stool is 750 mm. The stand is 200 mm in height, the meter mounted on it is 170 mm. The sitting height of the operator is 750 mm and his line of sight is 585 mm from the seat height. With this arrangement the front panel would fall within 38 degrees from the line of sight which is a desirable consideration and the meter would be approximately at the high level.

8.2

Very often control knobs and dials occupy an important place; the front panel of an

appliance or electronic equipment. Hence it is necessary that they should actively contribute to the aesthetics of complete design package. But when a designer is considering components to be utilised with a new product, knobs and dials are relegated to minimal importance. Normally people think that all knobs are similar. It was thought to dismiss the idea. Reviewing the standard control knobs on the market we would definitely come to a conclusion that all knobs feature straight knurling on the side of the gripping surface with knurling varying from coarse to fine having the same general appearance. To diverge from this usual trend, knobs were designed with smooth finish on the side, with four equally spaced grooves to provide an adequate grip for the fingers. As the grip was not sufficient it had to be changed over to the conventional type with straight knurling on the sides.

8.2.1

Types of control functions

1) Activation - On - Off

2) Discrete setting - Setting at any one of 3 or more separate positions.

3) Continuous control - Constant control varying along some quantitative continuum.

4) Quantitative setting - Individual setting at any position along a quantitative continuum.

Rotary selector switch is used for discrete setting. Knob is used for continuous control or quantitative setting.

8.2.1.1

Rotation knobs

Thumb and second finger = 16 mm ∅

Thumb and third finger = 9 mm ∅

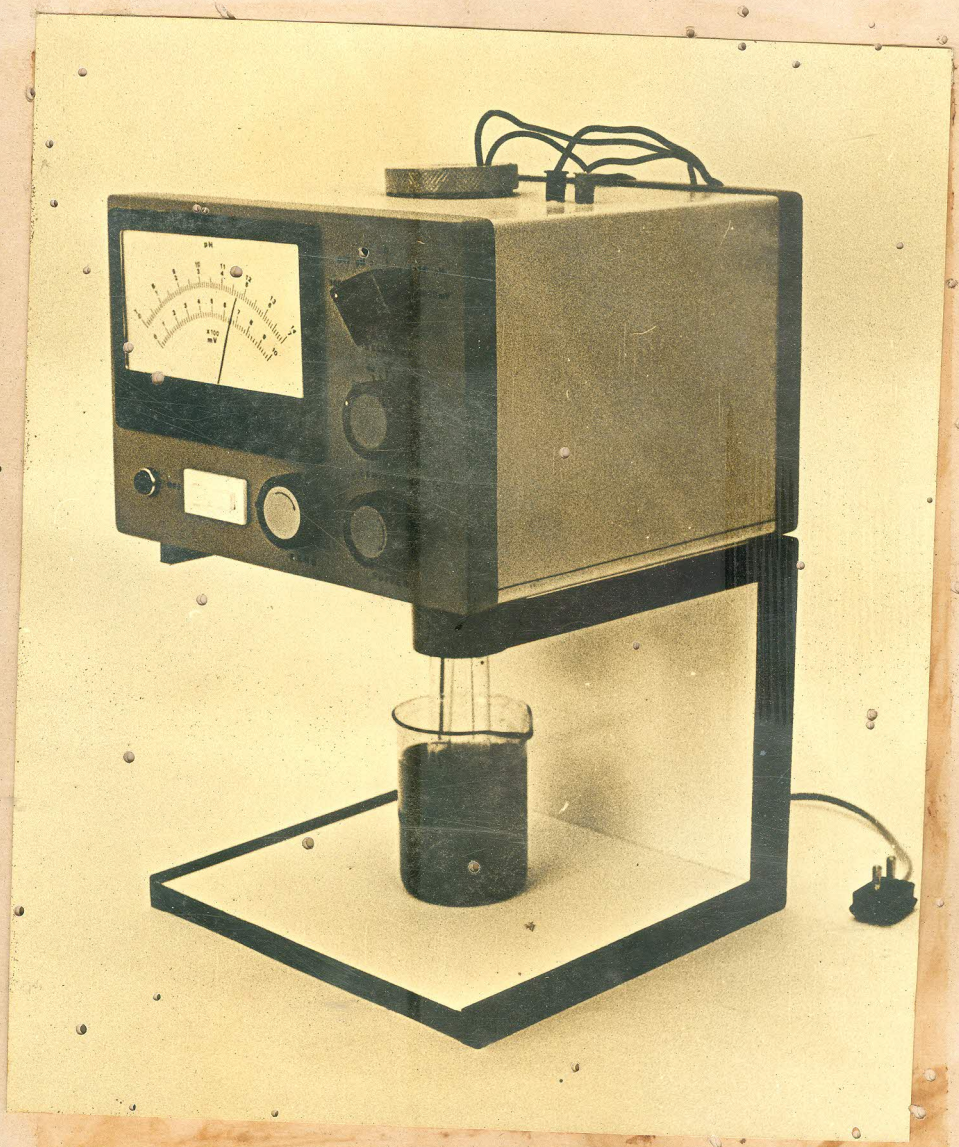
Thumb, first and second finger = 38 - 51 mm ∅

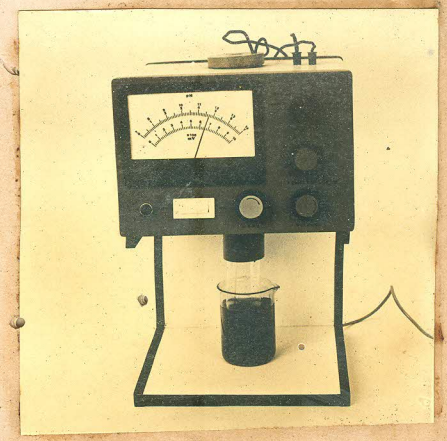
38 - 51 mm is a good size offering smooth operation and accurate adjustment. 75 mm or more require operation by wrist movement. Knobs greater than 120 mm become difficult to hold easily to produce the adequate torque. Hence, the diameter of the knobs is taken as 35 mm which are suitable on the front panel.

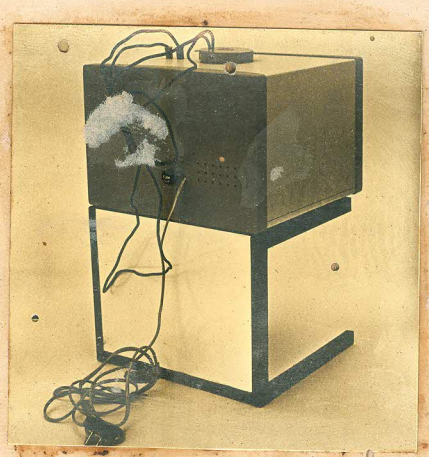
The knob's height for finger tip operation.

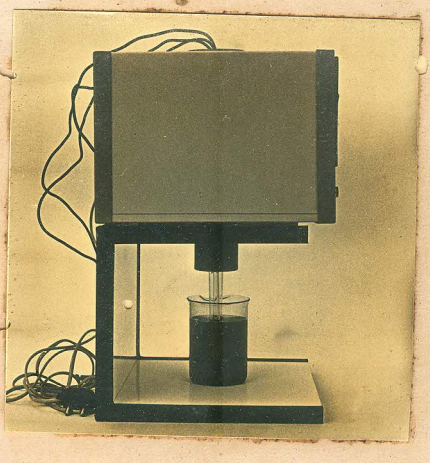
Depth min. = 12 mm

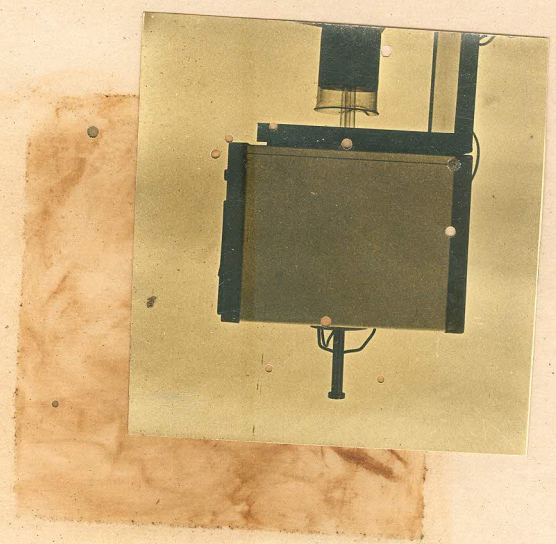
max. = 25 mm

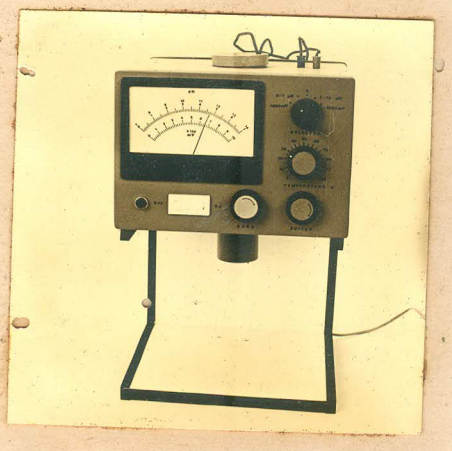


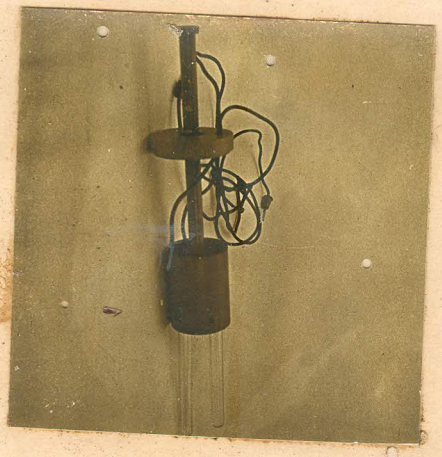


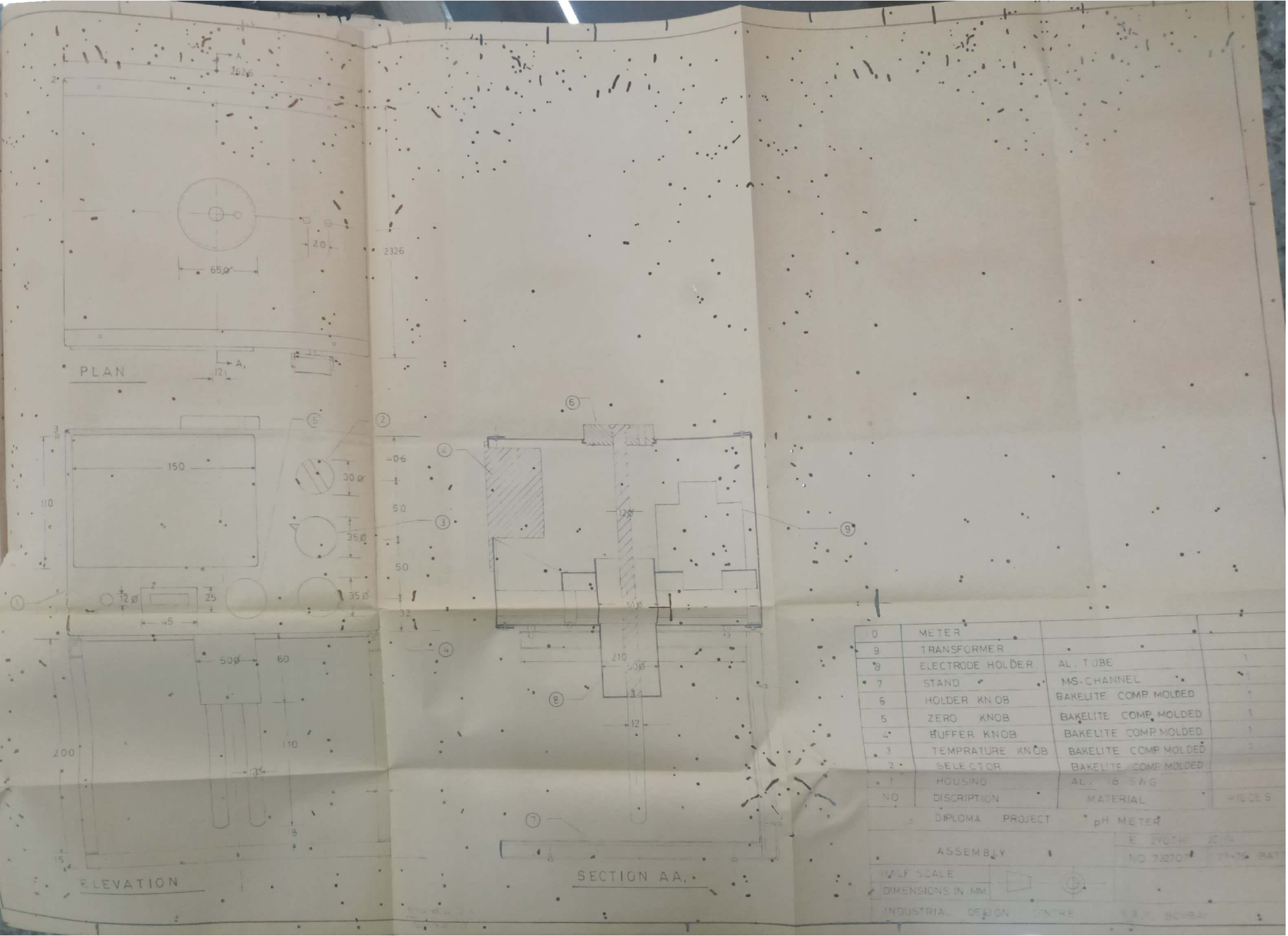


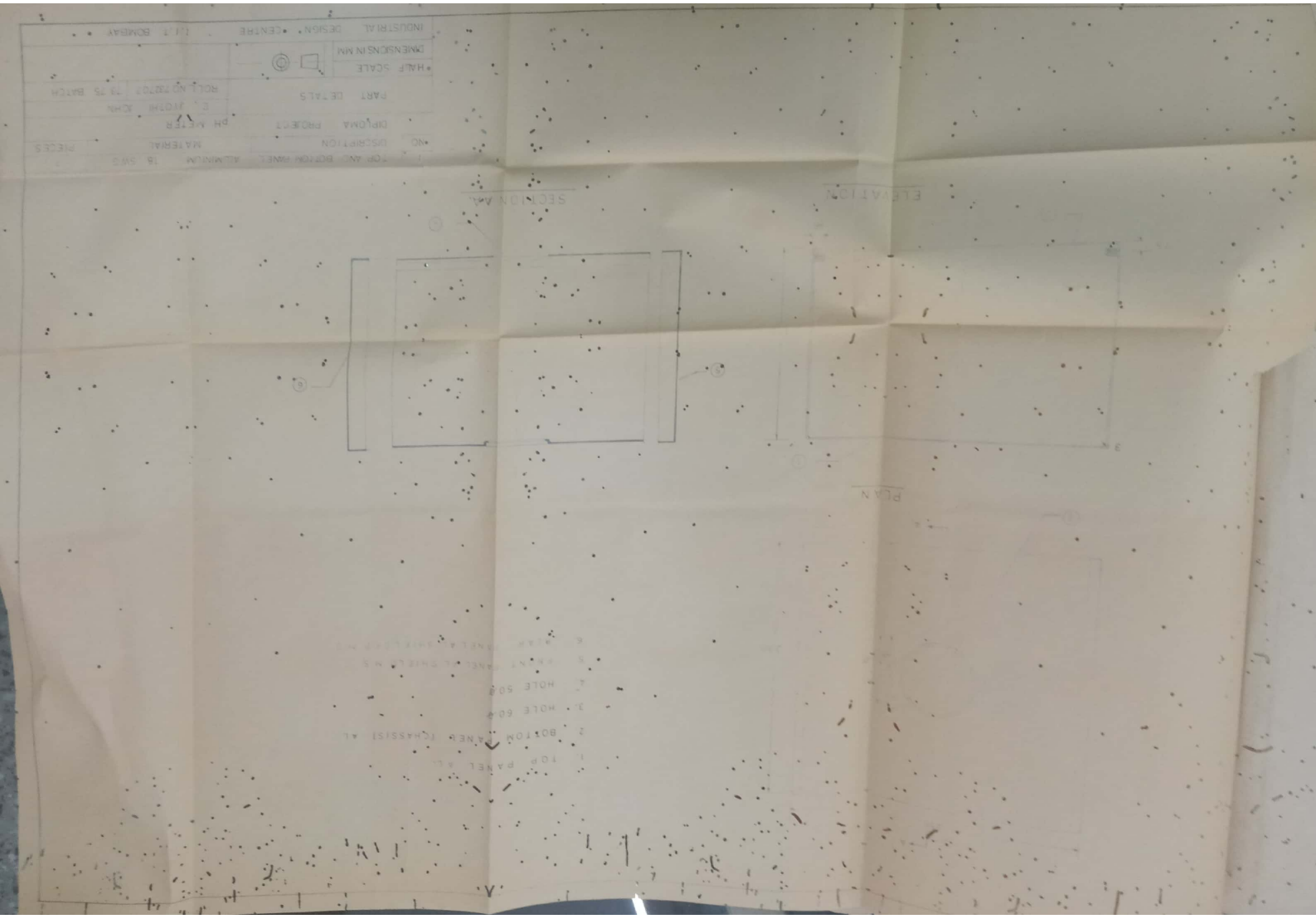


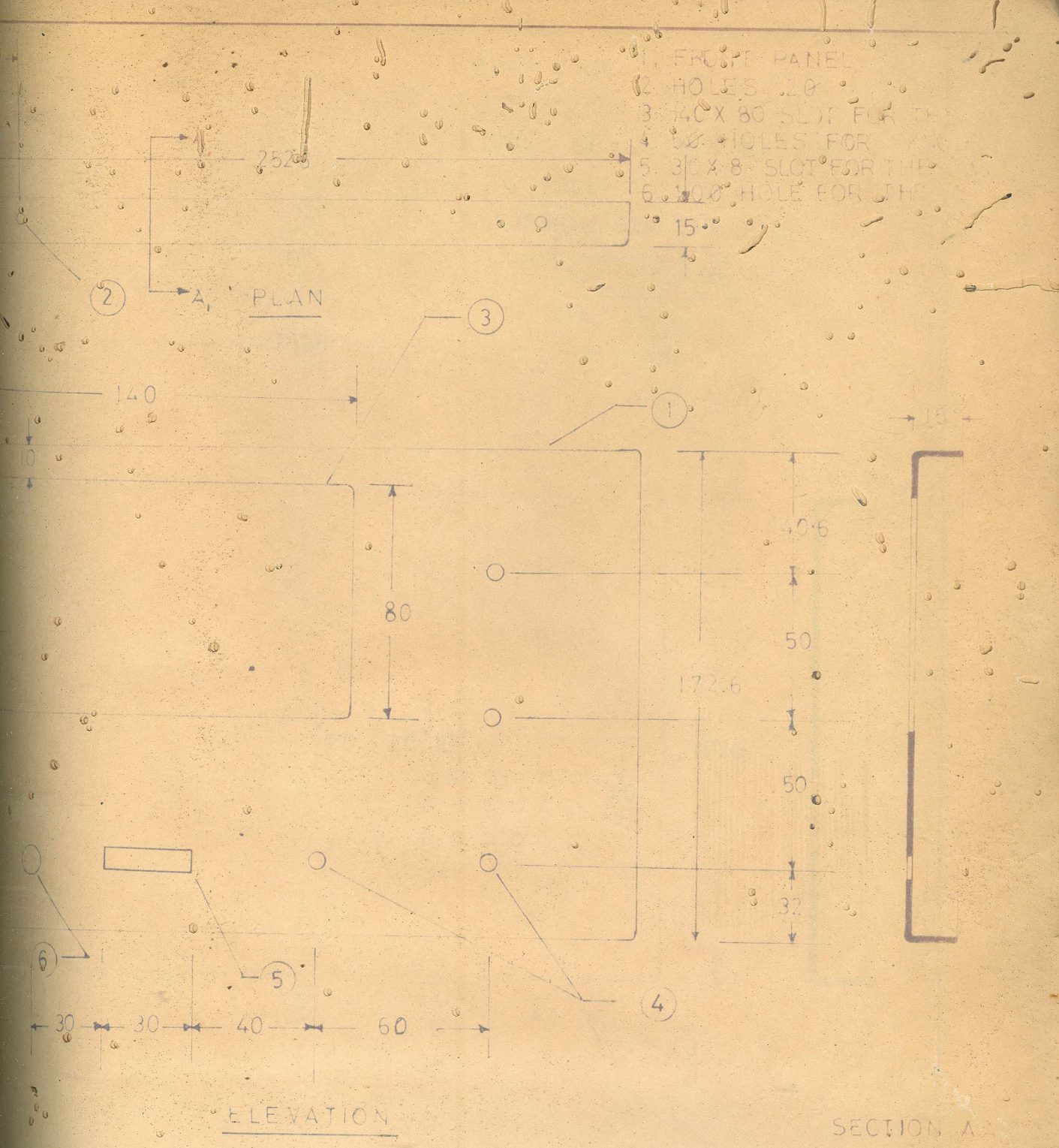












1	FRONT PANEL	MILD STEEL 18 SWG	
NO	DESIGNATION	MATERIAL	PI

DIPLOMA PROJECT — pH METER

PART DETAILS

E JYOTHI JOHN

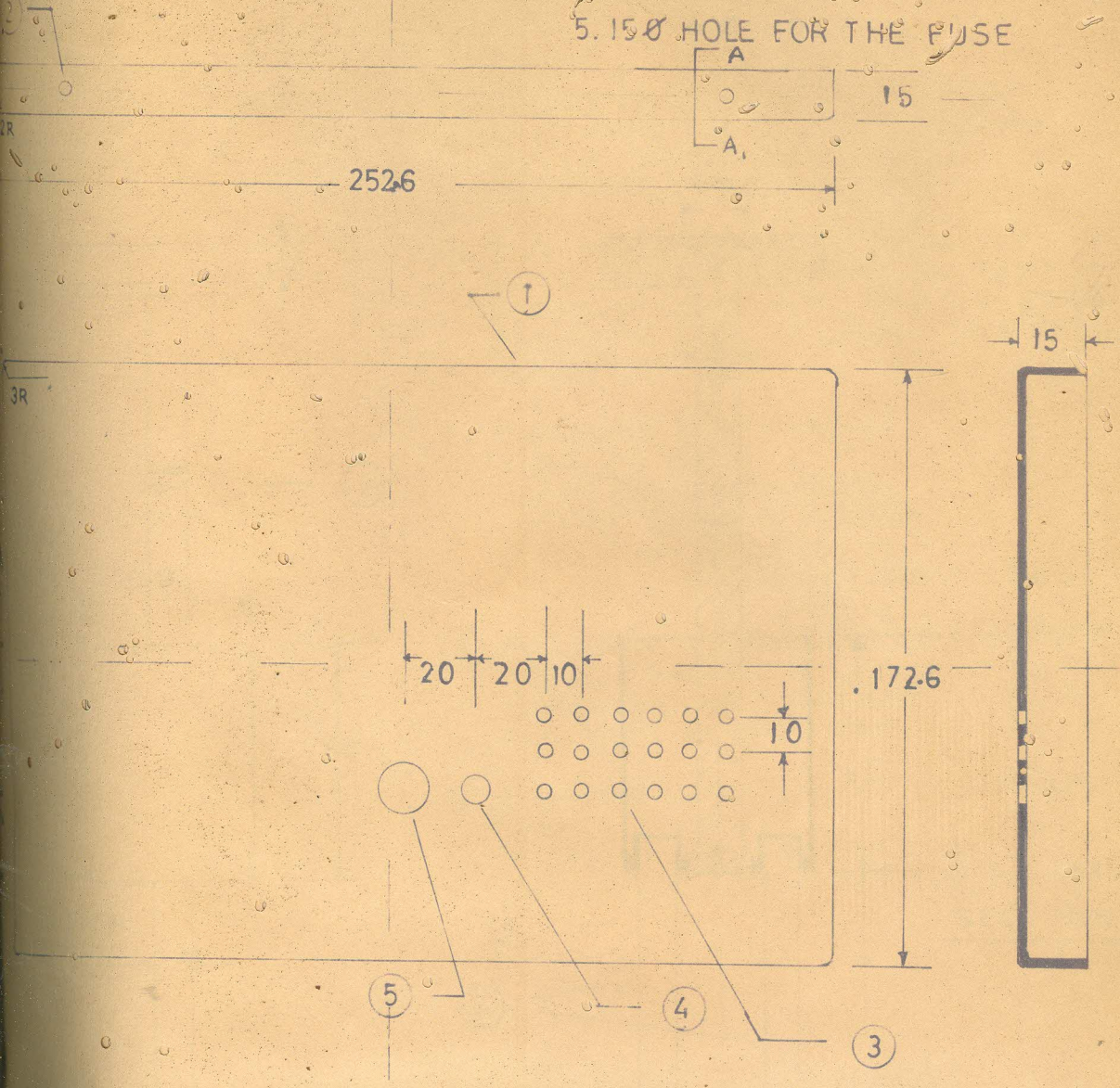
ROLL NO 732707 | 73-75 BAT

HALF SCALE

DIMENSIONS IN MM

INDUSTRIAL DESIGN CENTRE IIT BOMBAY

1. REAR PANEL
2. 2 Ø HOLES
3. GRILL 50 X 20 (VENTILATION)
4. 7.5 HOLE
5. 15Ø HOLE FOR THE FUSE



1	REAR PANEL	M.S. 18 SWG	1
NO	DISCRIPTION	MATERIAL	PIECES

DIPLOMA PROJECT pH METER

PART DETAILS

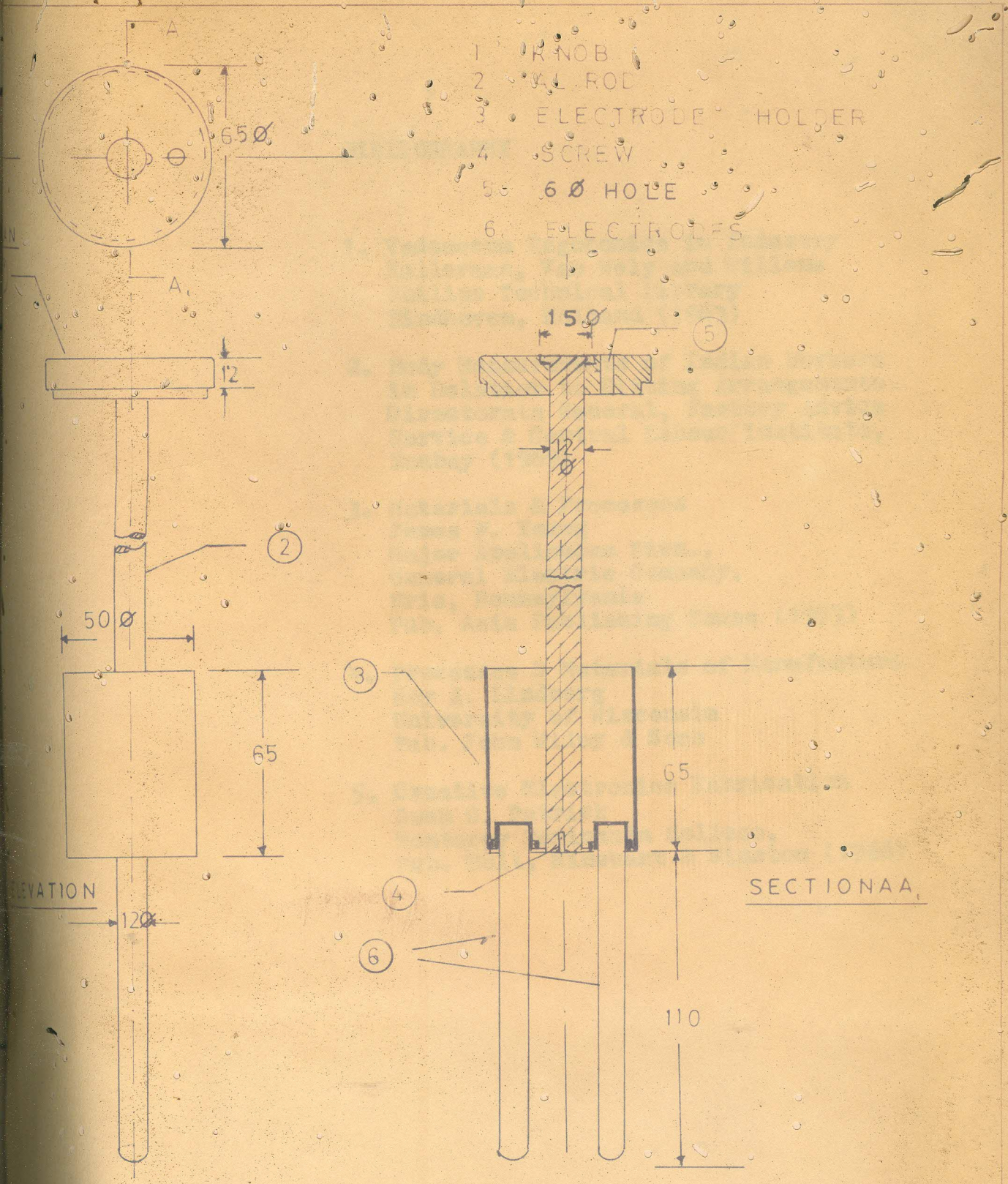
E. JYOTHY JOHN

ROLL NO 732707 | 73-75 BATCH

HALF SCALE

DIMENSION IN MM

INDUSTRIAL DESIGN CENTRE I.I.T. BOMBAY



NO	DESCRIPTION	MATERIAL	PIECES
1	ELECTODE HOLDER	ALUMIINIUM	1

DIPLOMA PROJECT pH METER

PART DETAILS

E. JYOTHI JOHN
ROLL NO 732707 73-75 BATCH

HALF SCALE
DIMENSIONS IN MM

INDUSTRIAL DESIGN CENTRE I.I.T. BOMBAY

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