DESIGN OF ELECTROENCEPHALOGRAPH

JAYANTO BOSE

INDUSTRIAL DESIGN CENTRE
INDIAN INSTITUTE OF TECHNOLOGY, BOMBAY

1975

49

Design of Electroencephalograph

Diploma Project

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

by

Jayanto Bose

Industrial Design Centre
Indian Institute of Technology
Bombay 400 076

1975

Guide : Prof. S. Nadkarni

Co-guide : Mr. U.A. Athavankar

Approval Sheet

Diploma Project entitled
'Design of Electroencephalograph'
by Jayanto Bose is approved for the
Postgraduate Diploma in Industrial Design

Guide .

Chairman .

Examiners .

.

ACKNOWLEDGEMENT

My most sincere thanks are due to my guide, Prof. S. Nadkarni, for his keen interest and guidance throughout this project.

Thanks are also due to Prof. Y.N. Bapat, Head, Aeronautical Engineering Department, I.I.T. Bombay, for having suggested this project, and Mr. Sonabatti, Technical Director, APLAB Electronic Instruments Limited, for the time he so generously gave for discussion and guidance.

Thanks are also due to the doctors and staff connected with the different EEG instruments at K.E.M. Hospital, Bombay, for their patience and interest in my work.

I must also gratefully acknowledge the help and guidance which was always forthcoming from the faculty of this Centre.

I am grateful to the workshop and office staff who have helped immensely to see this project through.

Jayanto Bose
17 March 1975

CONTENTS PAGE NO.

1.0 INTRODUCTION

In the last couple of years electronics in general and medical electronics in particular has made fantastic progress. Progress which even a few years ago would have been unthinkable.

Miniatureization has made it possible to bring under control tremendous amount of power, computation and highly complex controls to one's fingertips and in a package which may occupy only a portion of an ordinary desk-top. A single operator can now control an atomic reactor, the production of a steel plant and can literally monitor the life of a human being in its physical aspects. The degree of complexity and compactness in medical electronic equipment has resulted in their very wide use in hospitals today. An operation theatre for example is nowadays crammed with extremely sophisticated instruments each of which performs a vital function.

However, in the highly expensive development programmes of these instruments what considerations are given to the persons who sit behind the control consoles day after day with their eyes glued to gauges and dials and their hands and feet performing various functions almost continuously? What considerations are given to correct working heights, sitting or standing postures or human factors in general?

1.1 Need for Redesign

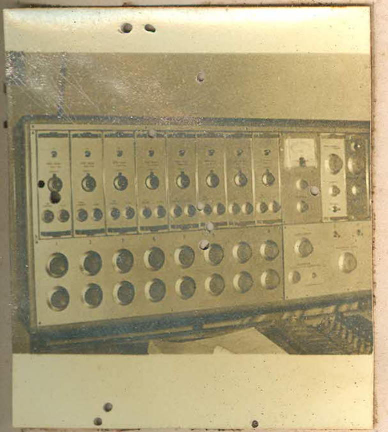
The Electroencephalograph is a precision, high quality instrument used mainly to monitor and record electrical impulses from the brain. It is used normally before any treatment, surgical or otherwise, is specified. It can be used to verify and locate the exact position of a tumour in the brain. It can also be used for the treatment of Epilepsey, Organ Neurosis and Pschycosis and other mental disorders to find out if actual brain damage has occured. Likewise it is used to find out the extent of brain haemorrhage in case of accidents. The instrument may also be used as a Poly-physiograph where in addition to monitoring a certain portion of the skull it can also record respiration, electrocardiograph, etc.

An important fact to remember is that the instrument is not automatic and what it produces will depend on a large extent on the natural ability and training of the person who operates it. This may seen too obvious to need emphasis. The amount of training required of the operator is equivalent to that needed for the operation of heavy duty X-Ray equipment. Though not immediately dangerous like X-Ray, incompetent Electroencephalography can be disasterous. This is because if the operator is not absolutely alert a certain curve may be recorded which may be due to the accidental movement by the patient. This may lead to wrong conclusions by the doctor if not immediately cancelled out by the operator.

Considering the above factors there was a need to provide the operator with a well-designed machine so that he could operate it efficiently. Most models in use today do not satisfy this criteria. The main accent, therefore, has been on redesigning the machine from the point of view of ergonomics and human factors. Ideally this sort of study should have preceded the development work carried out on this instrument by a couple of Indian manufacturers. However, the work is so vast that it calls for a team work and was, therefore, beyond the scope of this project.

1.2 An Ergonomical Approach

A usual ergonomical analysis of a product is comparable to the treatment by guesswork of a chronic disease. Neither is able to make a definite treatment because of an unawareness of the basic mechanism and structure of their respective subjects.

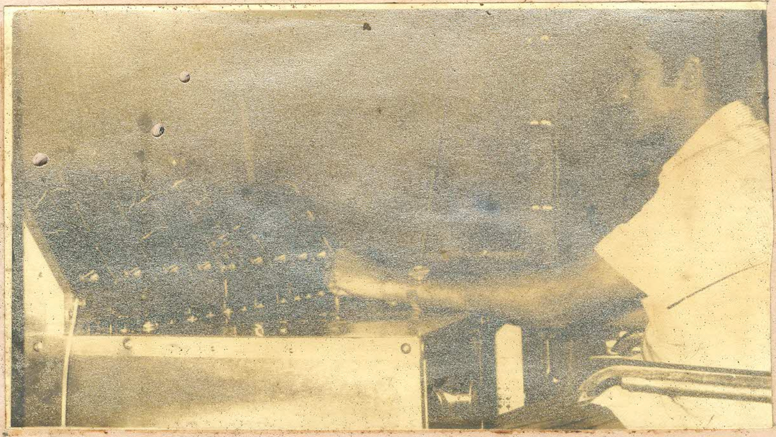


Such an ergonomical analysis operates within an existing engineering design. It accepts the structure and mechanism as limits within which its solution must be developed. It does not attempt to question the validity of these limits nor formulate new ones. Thus the result is a product which is a conglomeration of engineering and ergonomical elements functioning at a low level of efficiency.

Admittedly, most products do not require a high order of efficiency. We can afford to be satisfied with for e.g., ergonomically designed control panels. They are a significant improvement over the engineer designed panel, the increase in efficiency may even be measured in hundreds of percent.

This sort of treatment is, however, not enough and significantly more can be done. What is required is a more definitive approach, an involvement with the whole product. This sort of solution should be based upon the effect of a complete product on the user. As such ergonomics cannot be separated from engineering. When their manifestation is accorded aesthetic qualities the result is greater user acceptance.

A designer using this approach works with an intutive sense of materials, for structure, for the economics of use, maintenance, replacement, and for the organisation of elements into significant sensory patterns. It requires a working knowledge of engineering, economics and aesthetics in addition to ergonomics. A definitive treatment should necessarily precede the engineering design for the best results.



2.0 PROBLEM STATEMENT Redesign of the "Electroencephalograph (EEG) Machine" to be used in hospitals and large clinics.

3.0 INFORMATION

3.1 Manufacturers of existing products

There are at present 2 Indian manufacturers of this equipment. Of these M/s. Aplab Instruments is at Bombay while the second the Electronic Corporation of India Ltd.(ECIL) is at Hyderabad. While the former intends manufacturing a 13 channel EEG instrument, the latter is manufacturing a 8 channel one. A large number of these instruments are still imported.

3.2 Users

The EEG instrument is used very widely in hospitals and large clinics. They are used mainly in the Neuro-Surgery and Psychiatry departments although there is usually a separate EEG section which caters to the need of other departments. These instruments usually have a capacity from 12 to 16 channels.

There are a number of imported portable 6 to 8 channel EEG instruments available. Some of these are used in clinics who do not want to invest in a larger machine. An obvious disadvantage is that the smaller machine takes almost twice as long as a larger one to cover the entire skull and hence not very suitable for hospitals where the demand for this instrument is large.

On an average day an EEG machine in a busy hospital takes care of at least 7 to 8 patients, each examination involving between 1 to 1½ hours. Hence the instrument may be used continuously for almost 12 hours in routine EEG examinations.

In addition to the above use, the EEG machine is sometimes used for 12 hours or more continuously to monitor a patient even while he is asleep. Needless to say, an operator has to be in attendance. The EEG is now increasingly used in operation theatres when major brain surgery is going on.

One of the latest use of the EEG machine is to determine when exactly a patient is clinically dead. Mere stopping of heart-beats is no longer accepted as proof that the patient is dead. Therefore, in the latest technique after the patient's heart-beats have stopped he is connected to a artificial respirator and an EEG taken immediately. After waiting for another 30 minutes another EEG is taken. If the recordings produced are absolutely flat, then it is concluded that the brain has stopped functioning and there is no possibility of reviving the patient.

It can easily be seen from the various usess the instrument is put to that not only must it perform without a flaw but it is imperative that the operator must have a degree of comfort to enable her to operate the instrument efficiently and without undue physical strain.

3.4 Principal parts of the Unit

- Pre-amplifiers
- Power-amplifiers
- Paper recording unit
- Controls and gauges for monitoring and testing.

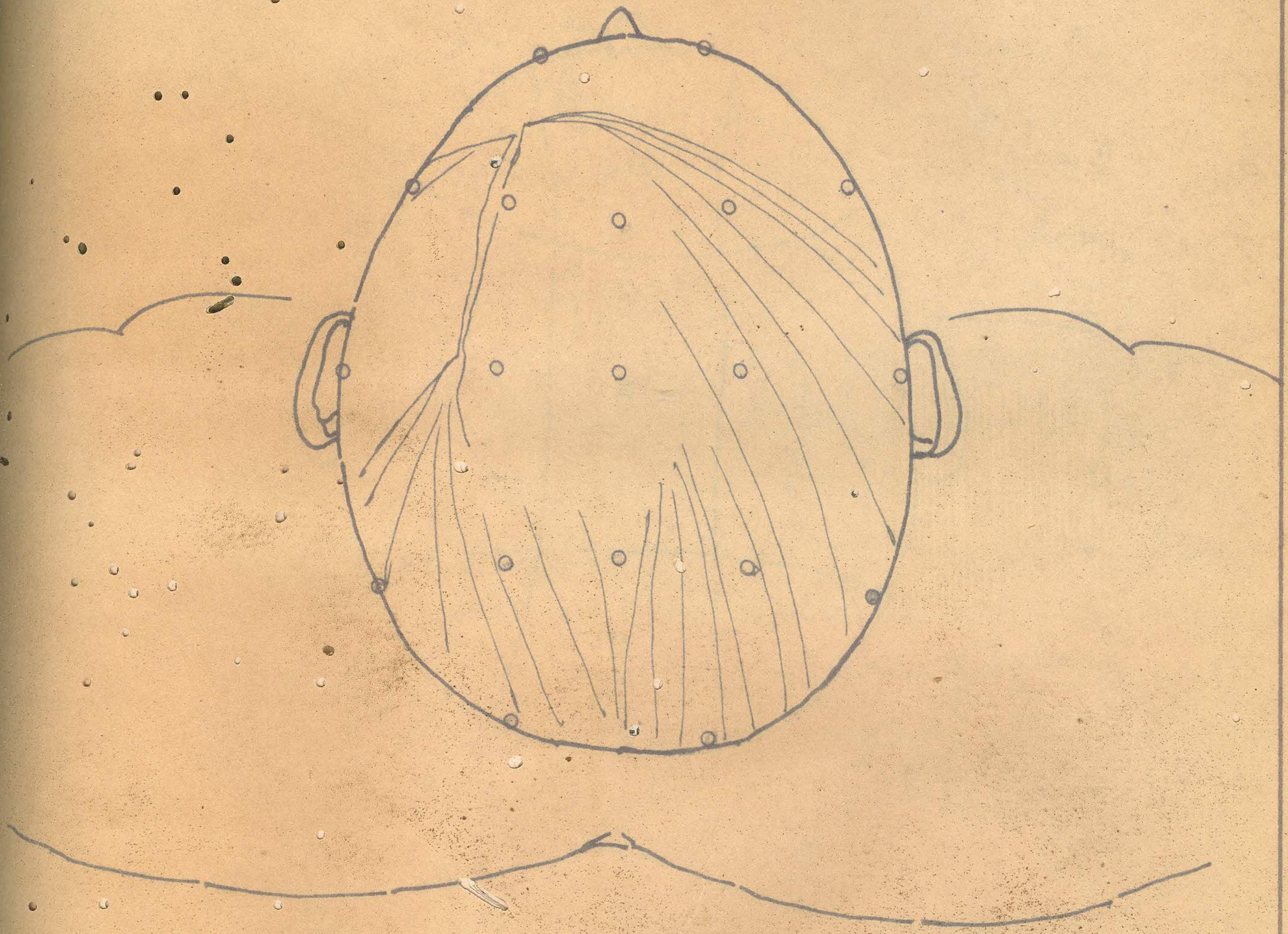
3.5 Normal operations & their sequence

3.5.1

The instrument has first to be caliberated.

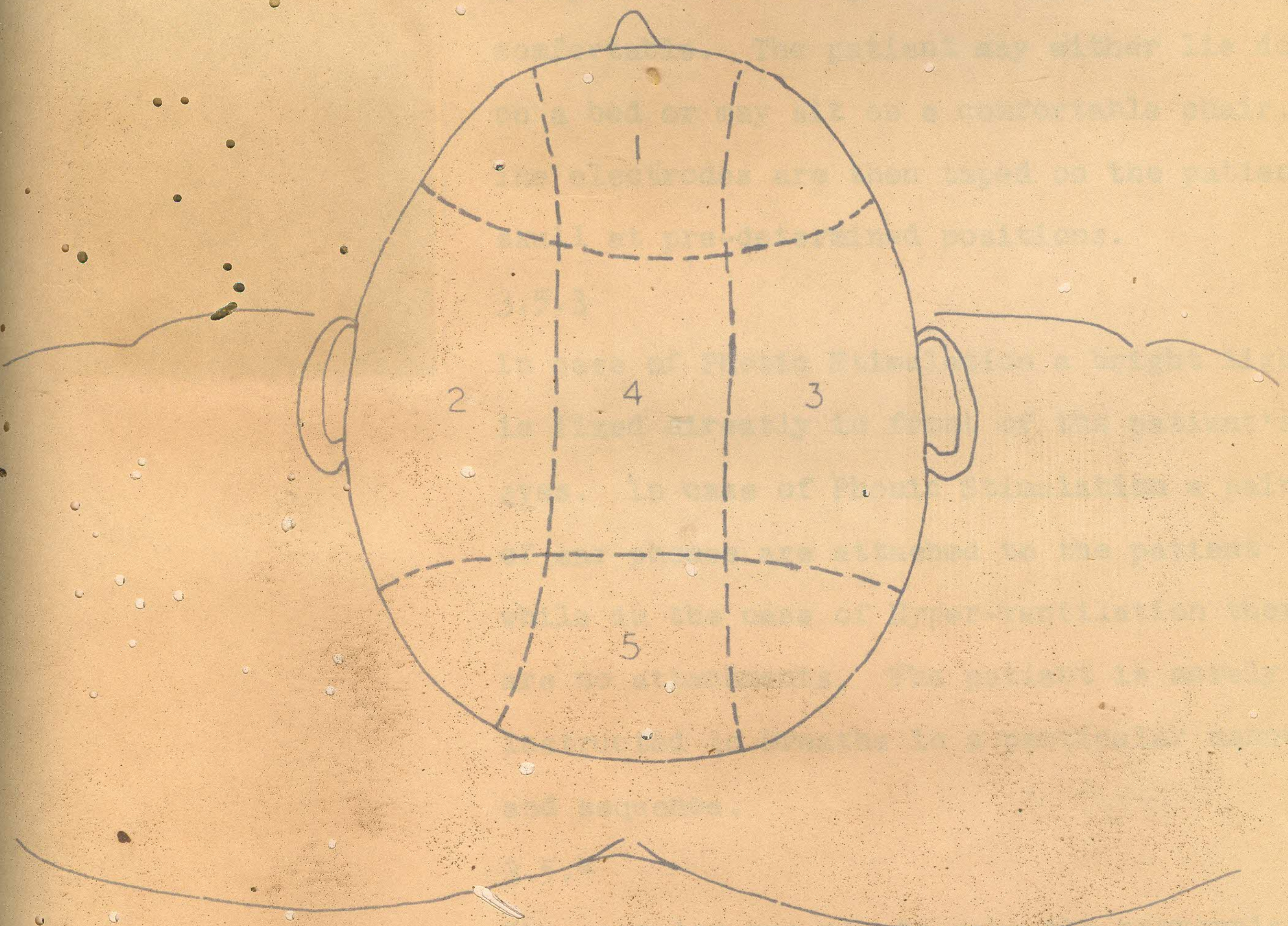
To caliberate

- the instrument has to be grounded.
- the AC cable should be plugged to an outlet having properly rated alternating current.
- the pre-amplifier master switch and individual pre-amplifier switches are switched on.
- the master AC switch and individual power amplifier switches are switched on.
- the caliberator switch is switched on.
- the power amplifier controls, filter and equalising switches are set.
- the proper flowing of ink in pens is checked and paper slotted through the pens. The master writer switch is turned on and as paper starts to run the individual writer switches are switched on. The result should be a perfectly straight line on all channels.
- the paper speed is set at 30 mm/sec.



NORMAL ELECTRODE POSITIONS FOR EEG

① FRONTAL
② LEFT TEMPORAL
③ RIGHT TEMPORAL
④ OCCIPAETAL
⑤ PARAETAL



PRINCIPAL REGIONS OF THE BRAIN EXAMINED BY THE EEG

- the caliberation signal is introduced, a certain time is given to allow it to return to position. A second signal is now introduced.

- the machine is now caliberated.

3.5.2

The patient is brought into the room and made comfortable. The patient may either lie down on a bed or may sit on a comfortable chair. The electrodes are then taped on the patient's skull at pre-determined positions.

3.5.3

In case of Photic Stimulation a bright light is fixed directly in front of the patient's eyes. In case of Phonic Stimulation a pair of ear phones are attached to the patient while in the case of Hyper-ventilation there are no attachments. The patient is merely instructed to breathe in a particular manner and sequence.

3.5.4

The operator has now to make the appropriate electrode selection for the various channels on the main control panel.

3.5.5

The main mode switch on the control panel is now switched from caliberation to use.

3.5.6

The master writer switch and individual writer switches are turned on for use. If signal is too large the input switch is set at a lower number and vice-versa. The average peak to peak signal should be about 10 - 12 mm high, the maximum not over 16 - 18 mm.

3.6 Requirements of Users

- Noiseless operation
- All components in one unit
- Operation of the instrument in the sitting posture.
- Easy accessibility to various parts for maintenance.
- Movable unit preferred.
- Provision for fixing additional gauges.

3.7 Safety Requirements

This item should be considered from the point of view of operator safety as well as prevention of equipment damage. The main hazard is electrical. This may be due to improper electrical grounding of the instrument, high voltage leads, insulation breakdown, etc.

3.8 Cost of Existing Units

Imported units of 12 channel capacity cost above Rs.80,000/- each. Indigenous units while not yet in the market are expected to cost between Rs.60,000/- to Rs.65,000/- for instruments having similar capacity as above.

4.0 ANALYSIS

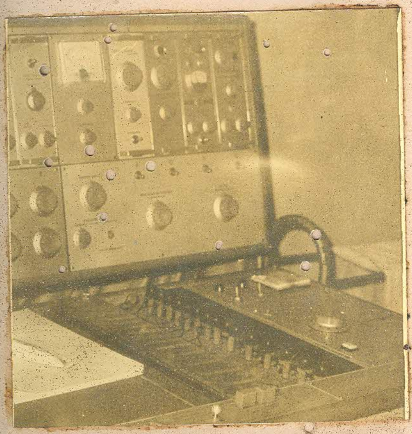
4.1 Make

- Galileo EEG, Italian make
- Grass EEG, American make

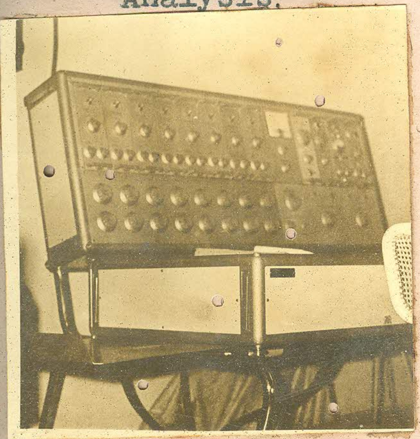
4.2 Capacity

Both models have only 8 channels. The Grass instrument is a valve set and thus has elaborate cooling arrangements. The Galileo instrument is transistorised.

This capacity is thoroughly inadequate and each instrument has to be used twice as long as one which would have had between 13 - 16 channels. This capacity is considered adequate for normal electroencephalography and is also accepted internationally. Although a few manufacturers abroad has started manufacturing EEG instruments having upto even 32 channels, these would find use only in very specialised and sophisticated diagnosis. There would scarcely be any demand for this type of instrument in this country.



4.3 Structural Analysis.



In the Galileo machine the two main structural parts are the control panel and the paper recorder unit. These are entirely separate. Each has been assembled on a framework without much consideration given to the users' convenience and maintenance. The fabricated framework of welded MS angles have panels of sheet metal screwed on to the individual frames. Both these components are fixed on to the chrome plated stand.

The Grass machine which is slightly older than the one above is a tube set. Almost no considerations is given to any other factor other than fitting the components together. It is basically a writing desk with the paper recorder unit placed on the right hand side of the operator. The control panel is very low in height. A big fan for cooling the tubes is placed near the legs of the operator. This not only creates a lot of noise but is also physically very uncomfortable. There are ample storage spaces and drawers in the instrument. These could as well have been done without, which would have made the unit much more compact. The main framework here is again of welded MS angles but all the working surfaces except the control panel is covered with decorative laminate. The metal control panel is finished in black.

In both the units mentioned above the size can be substantially reduced if the elements are properly laid out.

4.4 Functional Analysis

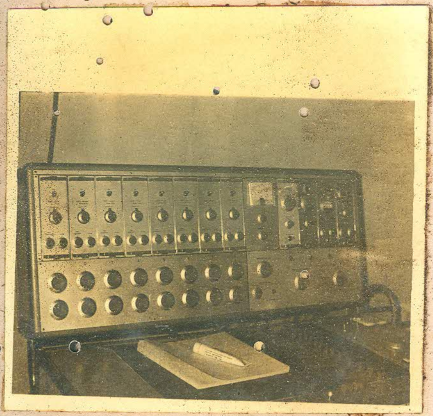
The main functional elements in both the above machines and indeed in all EEG machines, are

- the control panel which contains controls for, the various amplifiers, caliberation and testing, etc.

- the paper recorder unit which records the signal received from the amplifiers on the paper roll.

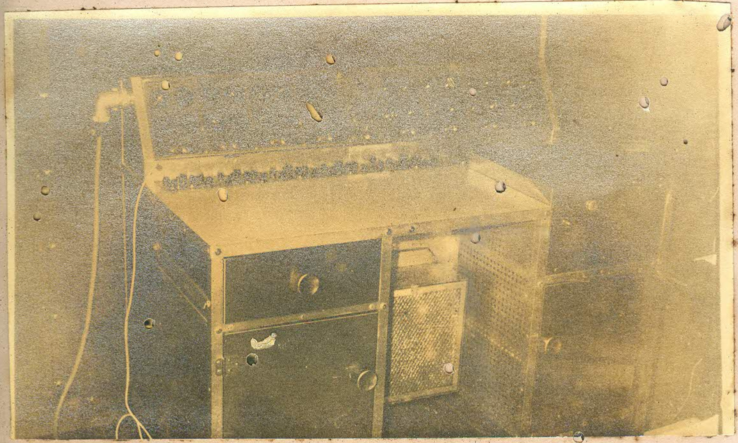
4.4.1 Control Panel

The main control panel normally consists of controls for the pre and power amplifiers, indicator lamp to show when the channel is functioning and the two electrode selectors commonly denoted as G1 and G2.



In case of the Galileo machine, as can be seen in the accompanying photographs, in addition to the controls for the 8 channels, master switches, caliberation controls as well as dials for checking line voltage are also placed. However, except for the channel controls all others are placed in a random manner on the panel. This creates confusion and reduces the efficiency of the operator at critical moments.

In case of the Grass machine, because it is not transistorised all the channel controls are not located in one panel. The main control



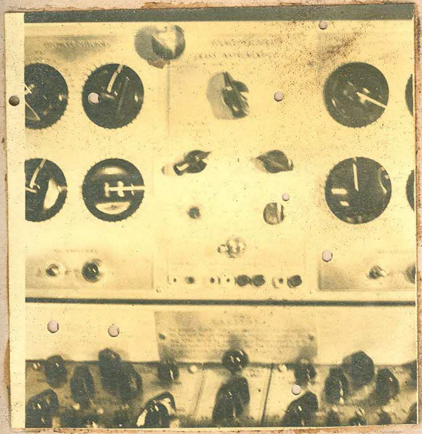
panel contains merely the electrode selector knobs. The power and pre-amplifier controls have been located on the horizontal surface as is shown in the photographs. Thus the distance from the operator to the control panel has become very large.

4.4.2 Paper Recorder Unit

The paper recorder unit on the Galileo machine has been placed almost in front of the operator. This is slightly better from the operator's comfort point of view than the Grass machine where it is at the extreme right hand corner of the operator.

4.5 Ergonomical Analysis

4.5.1 Controls



Both the machines employ a wide variety of switches and knobs. No attempt has been made, except for a little on the Grass machine, at standardization of these elements. There are a variety of graduations so that some operators who are used to one machine do not know the meaning of these on another.

4.5.2 Control Panel

In the Galileo machine the control panel is so large and so much separated from the operator

that she has to stand and operate many of the controls. Since an average examination of a patient takes 1 to 1½ hours, the operator has to keep on sitting and standing up throughout the entire period.

The Grass machine is more compact and this problem is not very acute. The main problem here is that the average operator has to stretch forward a great deal to reach frequent controls.

4.5.3 Working Height

The working height of the Galileo machine is too high for an average Indian female operator. It is so high and broad that the operator finds it extremely difficult to even operate the paper recorder unit.

The Grass machine has a lower working height and is thus comparatively easy to operate.

4.5.4 Unit Height

The height of the operator and height of the unit are also not compatible which results in obvious ergonomical problems.

4.6 Maintenance

- Regular maintenance like leak testing consumes a lot of time as the leads are not properly located.

- Maintenance is difficult because of inaccessible components and the whole unit has to be opened up in such cases.

- No provision is made to reduce the noise of the fan nor is any attempt made to locate the fan elsewhere in the Grass machine.

4.7 Formal & Visual Analysis

This analysis was conducted to examine the validity and integration of formal elements. It was also used to find the visual and perceptual functions of colour, shape and product graphics.

Good

The colour of some of the existing units is black with a few parts in a lighter colour. It can easily be seen that no thought was given on matching the colour to the environment. The overall form of most of the existing units is cubical and have sharp corners. Even though this is a simple form no thought has been given on the organisation of the various elements nor their order. This can be clearly seen by examining accompanying photographs of some of the instruments in use.

Product graphics in most cases is either non-existent or is ineffectively sited. Its location, size, colour and shade are important in so far as it projects the image and identity of the manufacturer.

5.0 HYPOTHESIS

5.1 Struetural

5.1.1

The layout or positioning of the various elements and components of the instrument should be such that there is no wastage of space without of course hampering the basic function and maintenance of the instrument.

5.1.2

The overall dimensions of the instrument have been decided primarily by taking into consideration human factors but also factors like the different ways and places the instrument has to function.

5.1.3

Material should be such that not only must it be structurally strong, light in weight but must also be easy to handle. It should not require much maintenance and for an electrical instrument must also not be a conductor of electricity.

5.1.4

Fabrication or manufacture of the material selected must be easy and economical.

5.2 Functional

5.2.1

Circuits for individual electrodes must be easily accessible and should be fitted to the control panel in the form of plug in modules in keeping with the latest trend in sophisticated electronic instruments abroad.

5.2.2

The unit should be movable as it can be used at a number of places for e.g. emergency, operation theatre, intensive care unit, etc. It should therefore be mounted on castors.

5.2.3

There should be provision for connecting auxilliary instruments like oscillioscopes and other instruments for testing.

5.3 Ergonomical

5.3.1

The instrument should be designed in such a way that the operator can sit and perform most of the operations.

5.3.2

The layout of controls serving similar purposes should be the same and wherever possible should be standardised.

5.3.3

The design of the instrument should ensure that as far as possible the line of vision be perpendicular to the panel. To avoid errors due to parallax the top and bottom sections should be mounted at an angle.

5.3.4

The most important displays and those read most frequently should be placed within the normal field of vision.

5.3.5

The most frequently used controls should be grouped in such a way that when observed in succession, the variations in both line of vision and reading distance are as small as possible.

5.3.6

All controls should be within normal grasping range. The distance between the eyes and panel should be in no case greater than the forward reach of the operator.

5.3.7

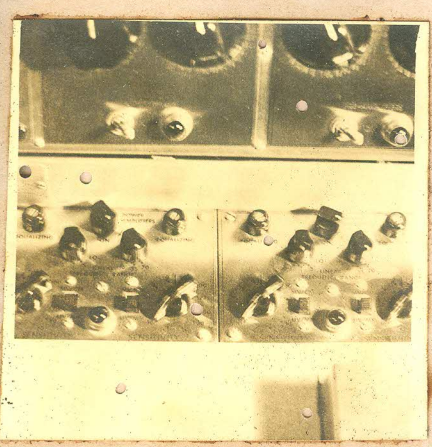
Controls should be as far as possible placed between elbow and shoulder height, within the optimum area of observation and grasp.

5.3.8

Controls operated only with the finger tips should be separated from one another by at least 15 mm.

5.3.9

For efficient lighting of the instrument panel everything possible must be done to avoid reflection from the light source or from windows.



5.3.10

Instrument housings with a glossy, reflective finish should be avoided. The main panel should have a mat finish not very light in colour.

5.3.11

The difference in illumination between the panel and its surroundings should not be too great.

5.3.12

It should be possible to open and close all access panels quickly so that trouble shooting and regular maintenance is convenient and quick.

5.4 Product Graphics

5.4.1

Functional and appropriate colours should be selected for different elements of the instrument.

5.4.2

Colour selected should be in harmony with the environment where the product will be installed. In this case a hospital or clinical environment.

5.4.3

Form should be decided keeping in view the characteristics of the material selected for the housing.

5.4.4

Disturbing elements like screw heads, weld marks, etc. should be kept to a minimum.

5.4.5

Product graphics should be effectively located.

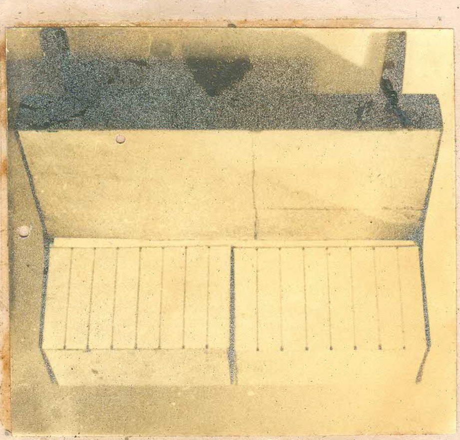
6.0 SYNTHESIS

In this chapter the various hypotheses and design criteria put forward in the previous chapters are synthesised and optimised to come closer towards the objective - design decisions.

During this phase various solutions were attempted which could satisfy various design requirements or those which could be optimised within the given constraints. A large number of sketches and rough models were constructed to find out if certain innovations could really work. By a process of synthesis these different innovations and part solutions were tried as a part of a complete design. The results of which in the form of a number of alternative solutions are given in the following chapter.

As mentioned earlier and stressed throughout the design stage, convenience and comfort of the operator was given the highest importance followed by the versatility of the instrument and an ordered organisation of the various elements. While the above factors were given the most importance, sufficient attention was also given to other requirements like ease of fabrication, maintenance, packaging and transportation, proper material selection and utilization, cost optimisation, etc.

Each solution was examined under the above mentioned heads to find out the suitability as a final design solution.



7.0 ALTERNATIVE SOLUTIONS

7.1

- In this solution the unit is split up into two smaller units. The larger unit would contain all the electronic circuits and controls for the pre-amplifier, power amplifier, electrode selectors, etc. The smaller unit would contain only the paper recorder unit.

- While the larger unit was designed for standing operations it was envisaged that the operator may sit in front of the recorder unit. Hence the working height of the latter was made lower than the former.

- Conventional MS angle fabricated framework with sheet metal panels were materials specified.

7.2

- The main principle of solution (7.1) was carried a bit further in this solution.

- While still retaining the concept of two separate units viz., the control console and the recorder unit, both of these were now designed for use in the sitting position. Both the units were to be mounted on castors so that the operator could arrange them according to her requirements.

- As both the units were to be of identical dimensions considerable cost reduction by way of standardization of elements and packaging were envisaged.

good

- Conventional MS angle fabricated frame with sheet metal panels was retained as basic materials for the unit.

7.3

- In this solution the two smaller units of the previous solutions were unified into one larger unit.
- Instead of having one large working surface, two surfaces were preferred now. The vertical surface to house the main control panel while the horizontal to house the recorder and auxilliary controls.
- The recorder unit was integrated to the main body. Its orientation was, however, changed from the normal horizontal to one parallel to the angled control panel surface. A detachable container was placed beneath the recorder to collect paper rolls.

- It was designed for use while sitting.
- FRP was selected as the material for the top housing while retaining the metal stand of the previous solutions.

7.4

- While retaining the one unit concept of the previous solutions, both the control panel and recorder unit, the two main physical elements of the unit were placed on a well angled working surface. A collection container for the paper roll was located beneath the recorder unit.
- While looking sculptural in form, this design still satisfied the basic ergonomical principles.
- FRP was used throughout, for the base as well as the top.

7.5

- This solution again followed the principle of a single unit. The main difference from solution (7.3) was in the change of location of the paper recorder unit. This was now placed on the horizontal surface and was oriented towards the operator.

- The overall length of the unit was thus reduced as can easily be seen from the accompanying figure.

- Material selected was FRP for the top and a metal stand.

8.0 FINAL SOLUTION

The final solution has been derived from the number of alternative solutions tried before.

8.1

The basic principle of operation and recording remains the same. The electrodes pick up electrical impulses from the brain which are amplified by the pre and power amplifiers. This amplified signal is passed into the paper writer unit where it is recorded on paper.

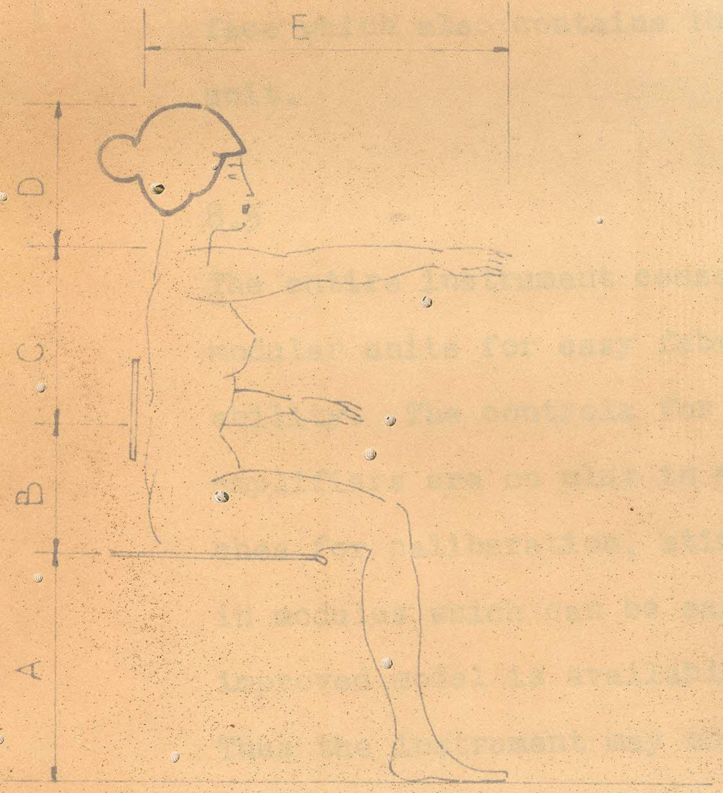
8.2

The equipment has been designed to be operated in the sitting posture and by Indian women falling in the 90 percentile range (stature 144.4 - 160.1 cm).

8.3

Controls used most frequently like the pre-amplifier, power amplifier and electrode selectors are placed on the main control panel which is suitably angled to avoid errors. The most frequently used knobs and switches are placed below the shoulder height but above

A	SEAT HEIGHT	389MM
B	ELBOW HEIGHT	212
C	SHOULDER ELBOW HT.	331
D	CROWN SHOULDER HT.	258
E	FORWARD ARM REACH	738



ANTHROPOMETRIC DIMENSIONS OF THE INDIAN FEMALE the elbow to cause the least physical strain on the operator.

8.4

Controls used occasionally like caliberation switches, stimulator control knob and paper speed controls are located on the horizontal face which also contains the paper recorder unit.

8.5

The entire instrument console is made up of modular units for easy fabrication and serviceability. The controls for the pre and power amplifiers are on plug-in modules. Even switches for caliberation, stimulator, etc. are in modules which can be easily replaced if an improved model is available at a later date. Thus the instrument may not become obsolete in a short time.

8.6

The unit is made movable by mounting it on castors. Since it is not heavy it can be moved by one person and can easily be taken to a patient's bedside if required.

8.7

The material selected for the main housing is Fibreglass Reinforced Plastic (FRP). The FRP top can be screwed securely to the metal stand and can be dismantled just as easily for packaging and transportation. No complex tools are required for assembly at destination.

8.8

FRP is an ideal material for housings of electronic components because 1) it can be moulded easily and in complex shapes without expensive tooling, 2) it is characterised by a high strength to weight ratio, 3) it has fairly good impact resistance which can easily take care of the instrument in normal use, 4) it does not corrode easily, 5) it exhibits good electrical and thermal insulation properties, 6) it is the most suitable material currently available, for batch production, 7) expensive finishing operations are not necessary after moulding.

8.9

All knobs and switches are redesigned to give a better grip and comfort.

8.10

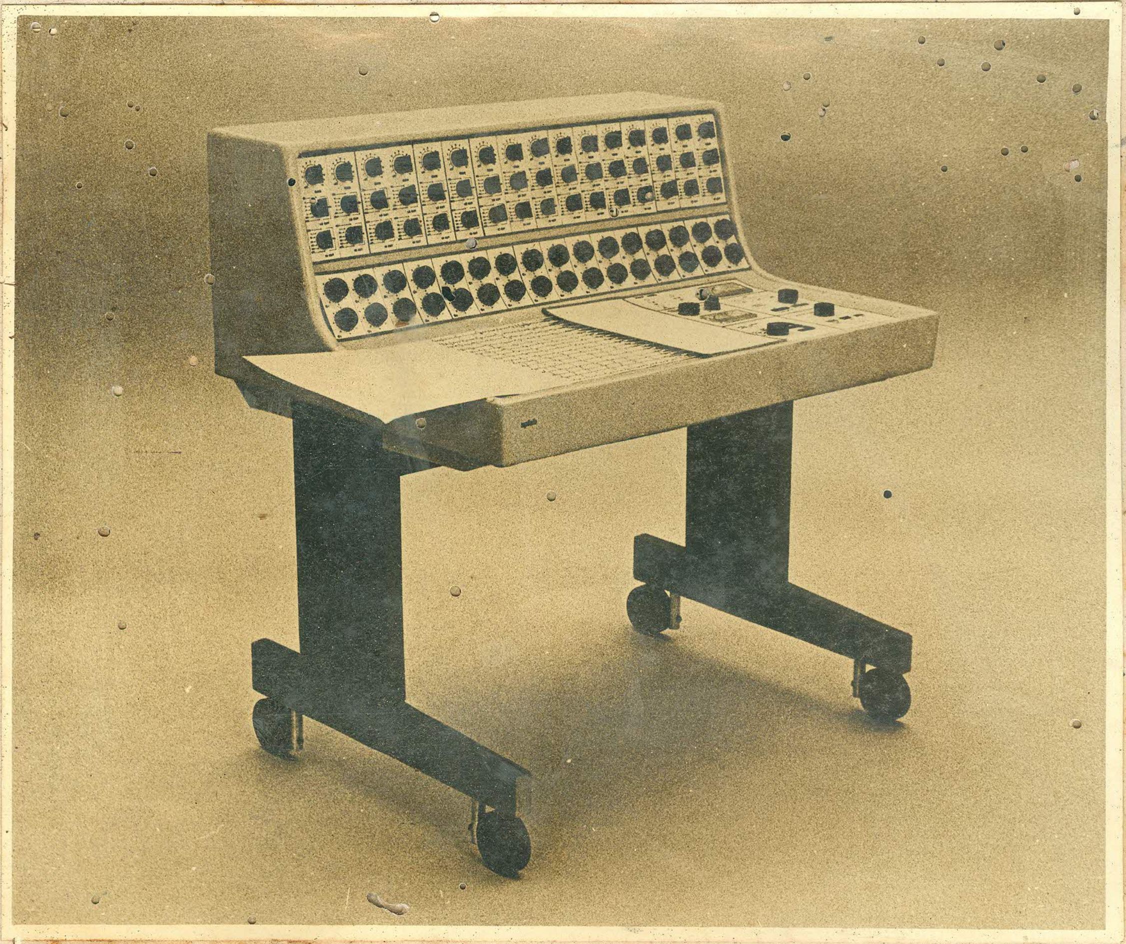
The various graduations of knobs, pointers, colour of the dial and overall shape of the panel are achieved by applying principles of ergonomics and perception.

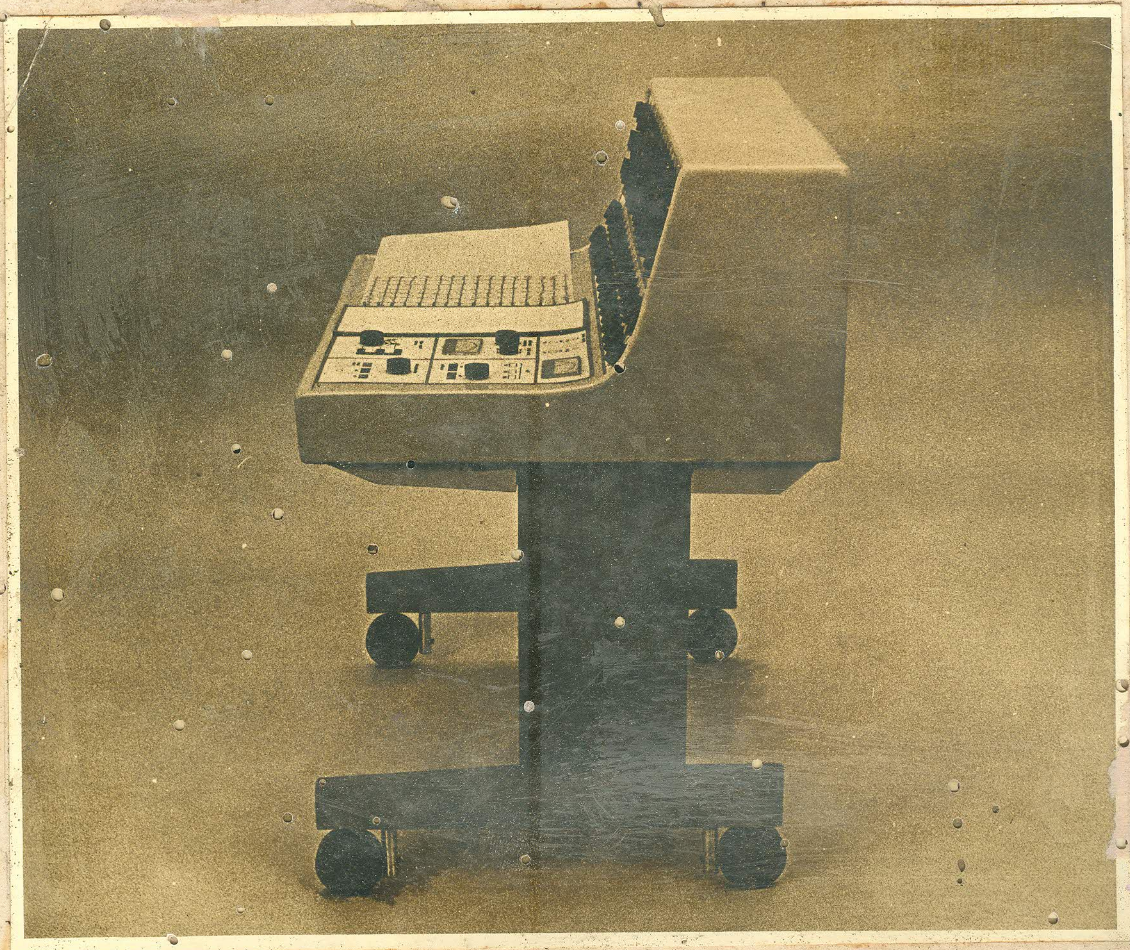
8.11

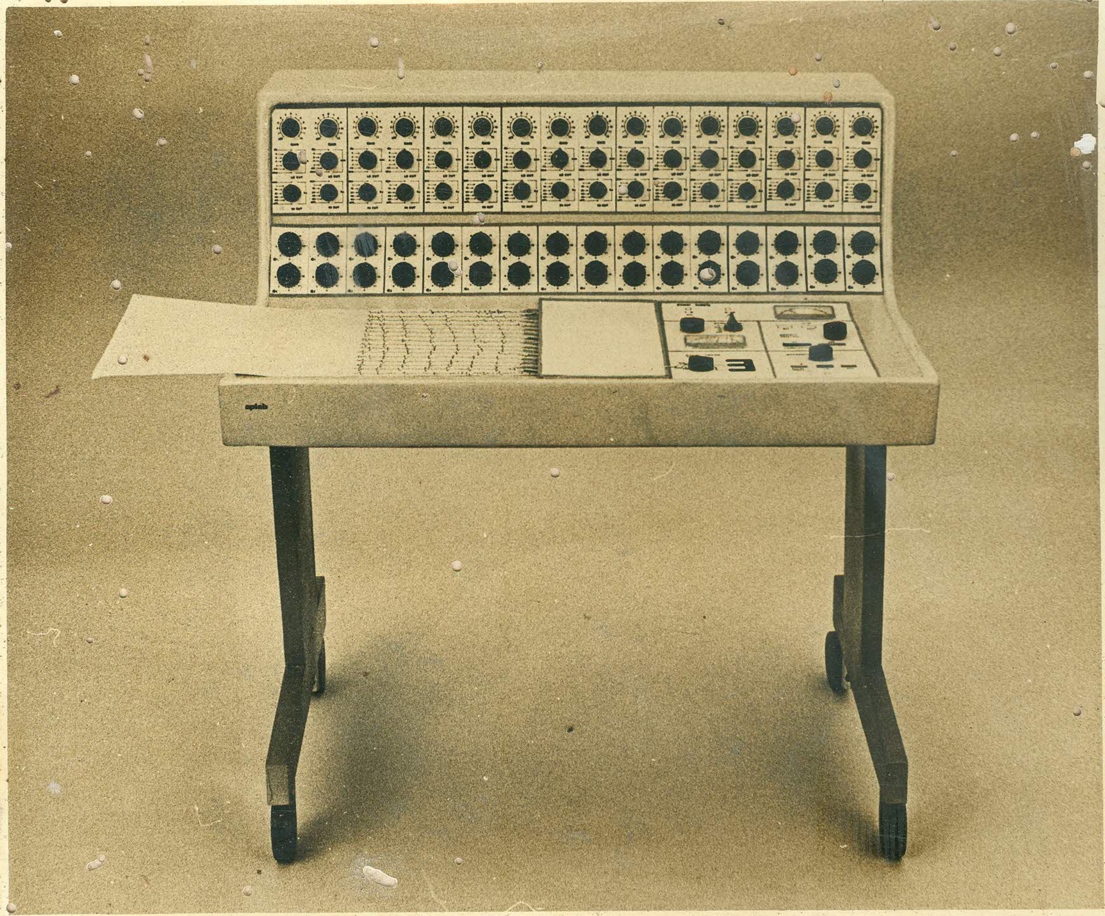
For easy maintenance access panels are located at convenient positions and can be opened easily. All normal maintenance work can be carried out this way without opening the entire instrument.

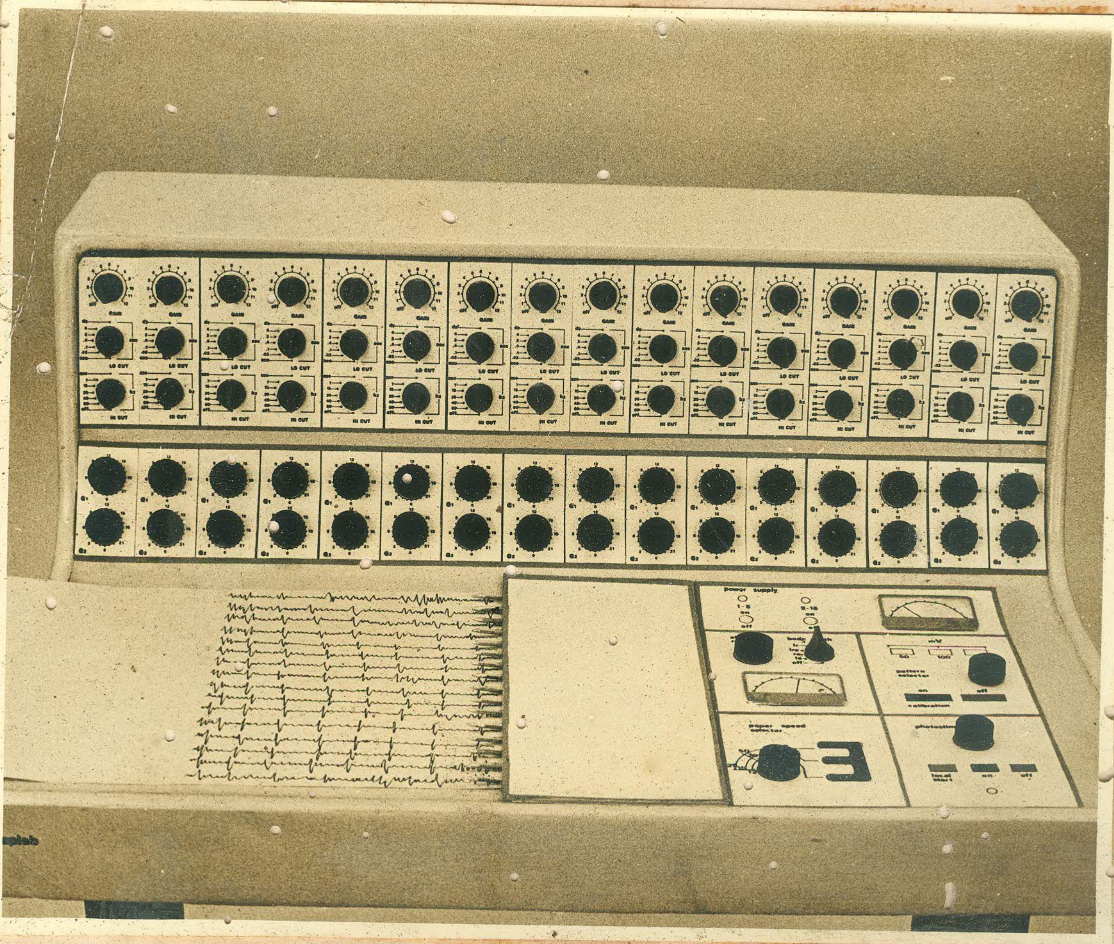
8.12

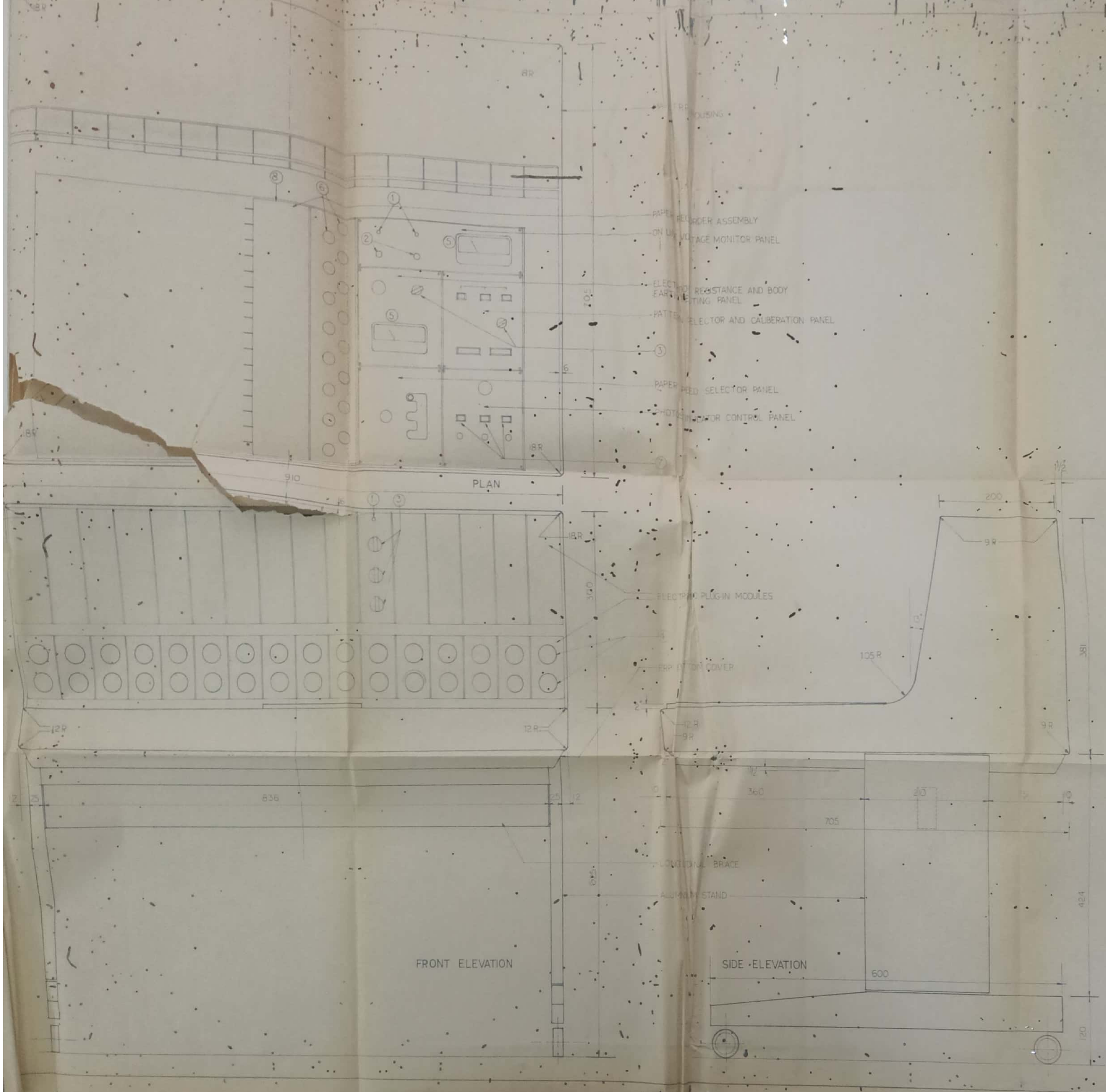
The colour scheme selected for the unit is suitable and appropriate for the environment of hospitals and clinics. The total appearance of the unit has been achieved by unifying the diverse elements and giving the unit a sense of balance and proportion.








GAIN
LO CUT
HI CUT
power supply
1-8
on
off
9-16
on
mV
50
100
pattern selector
on
off
calibration
paper speed selector
3
local start
on
off



8	DUST COVER FOR RECORDER	ACRYLIC	1
7	PUSH BUTTON SWITCH	H.I.P.S	6
6	INK CONTAINER BULB	RUBBER	16
5	INSTRUMENT DIAL 90 x 60		2
4	CIRCULAR TYPE KNOB 35Φ	H.I.P.S	35
3	BAR TYPE KNOB 30Φ	H.I.P.S	50
2	TOGGLE SWITCHES	PHENOLIC	5
1	INDICATOR LAMP	ACRYLIC	18
ITEM	DESCRIPTION	MATERIAL	NOS

DIPLOMA PROJECT — ASSEMBLY DRG.

ELECTROENCEPHALOGRAPH

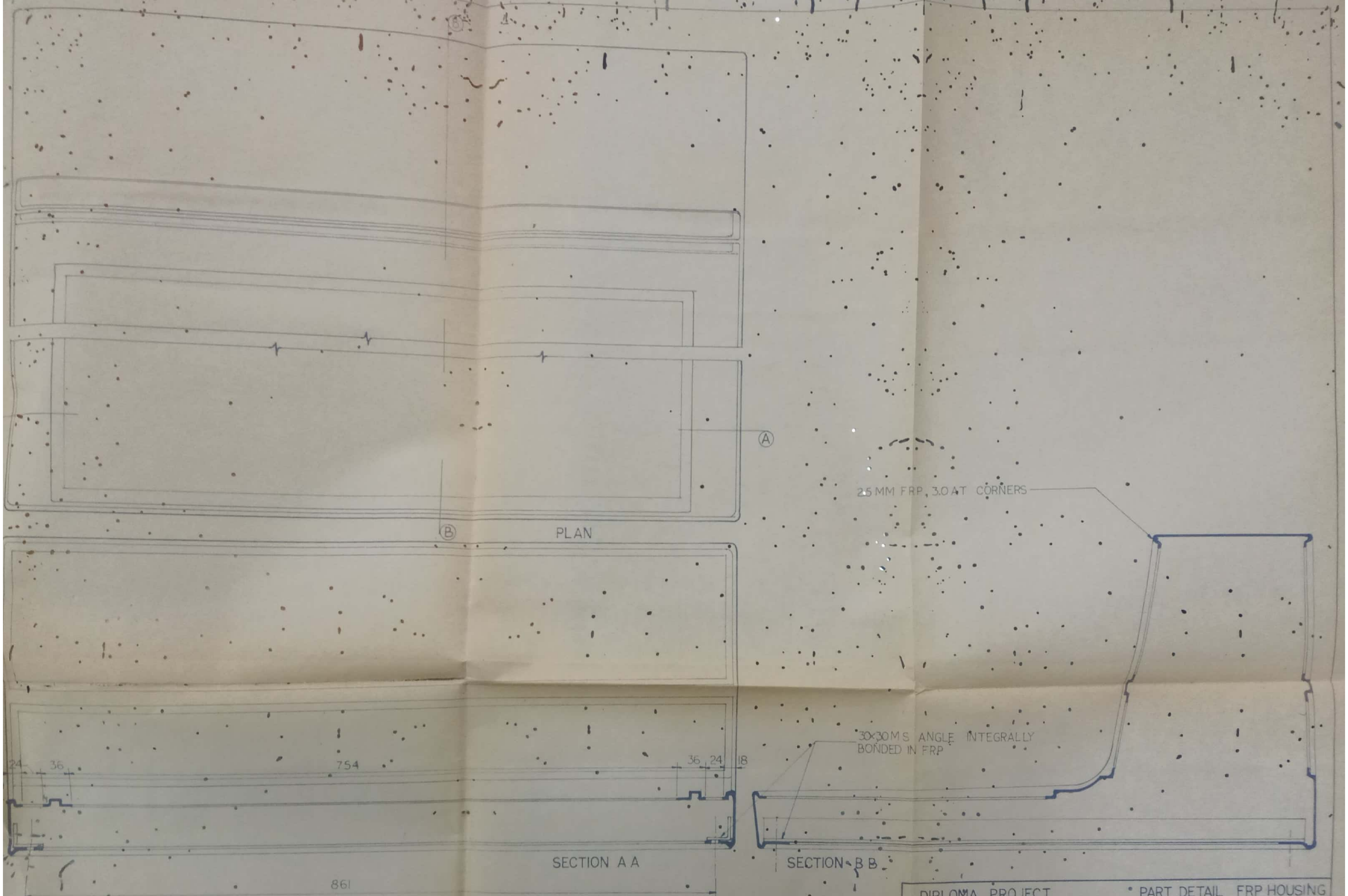
JAYANTO K BOSE 732706

FIFTH BATCH 1973-75

SCALE 1/3 FULL SIZE

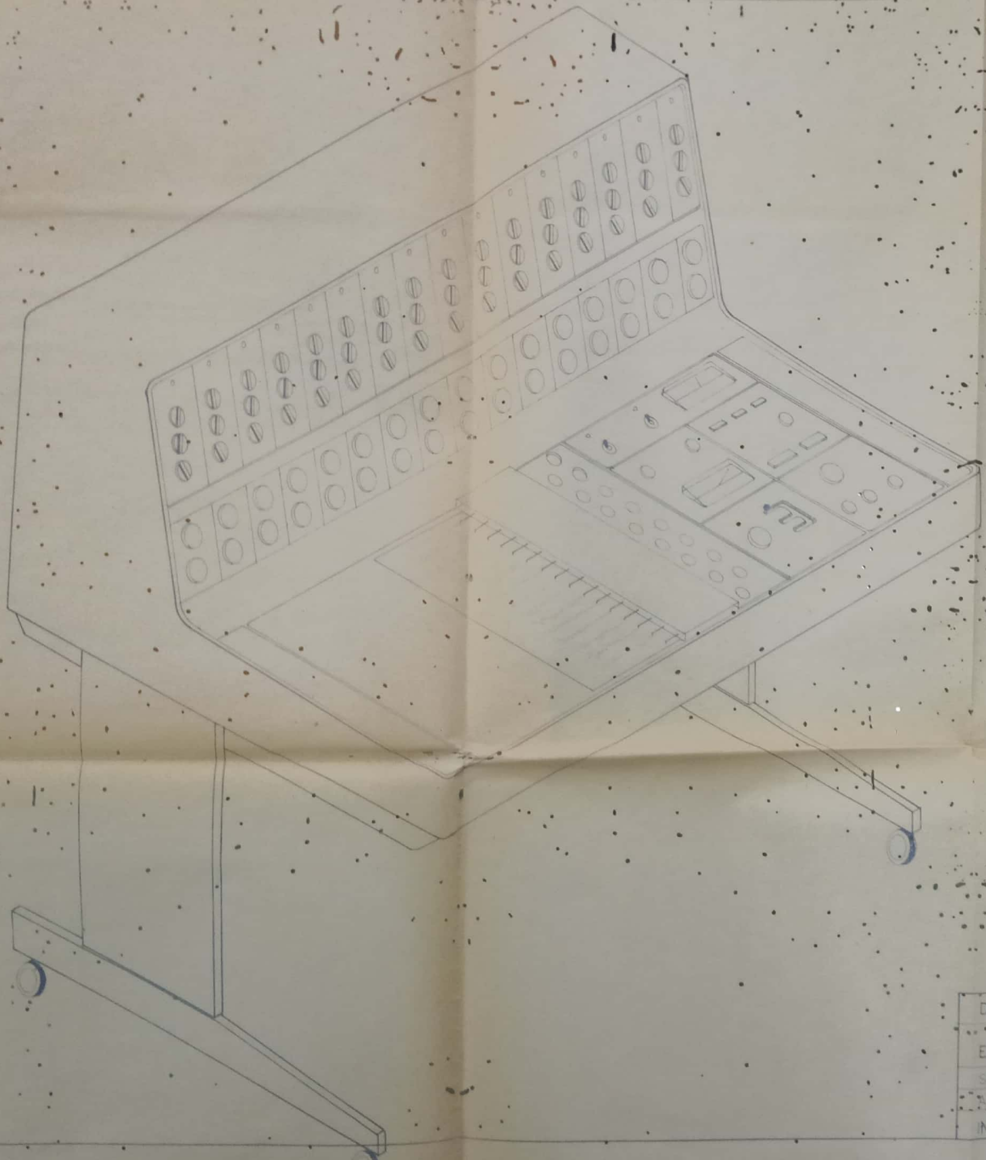
ALL DIMENSIONS IN MILIMETRES

INDUSTRIAL DESIGN CENTRE, IIT BOMBAY 400 076



DIPLOMA PROJECT	PART DETAIL FRP HOUSING
ELECTROENCEPHALOGRAPH	JAYANTO K. BOSE 732706
	FIFTH BATCH 1973-75
SCALE · 1/3 FULL SIZE	
ALL DIMENSIONS IN MILIMETRES	

INDUSTRIAL DESIGN CENTRE, IIT BOMBAY 400 076



DIPLOMA PROJECT	ISOMETRIC VIEW
ELECTROENCEPHALOGRAPH	JAYANTO K BOSE 732706
	FIFTH BATCH 1973-75
SCALE . 1/4 FULL SIZE	
ALL DIMENSIONS IN MILIMETRES	
INDUSTRIAL DESIGN CENTRE,	IIT BOMBAY 400 076

APPENDIX

BIBLIOGRAPHY

1. Journal of Ergonomics
   Vol.5, No.1, 1962

2. Value Analysis, Editype
   C.H. John, London (1970)

3. Measure of Man-Human Factors in Design
   Henry Dreyfuss
   USA., (1966)

4. Body Measurements of Indian Workers
   in relation to sitting arrangements.
   Directorate General, Factory Advice
   Service & Central Labour Institute,
   Bombay (1969)

5. Journal of Ergonomics
   'An experimental study of control consoles'
   I.E. Siegel & R.F. Brown
   Vol.1, No.3 (1958)

6. Vademecum Ergonomics in Industry
   Kellermann, van Wely and Willems,
   Philips Technical Library
   Eindhoven, Holland (1963)

7. 'Systems Approach to Engineering Problems'
   J. Korn, OEM Design
   Sept. and Oct. (1973)