DRAFTING TABLE

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Design of Drafting Table

Diploma project

Submitted in partial fulfilment of the requirements for the postgraduate diploma in Industrial Design

by

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Diploma project entitled 'Design of Drafting Table' by Khirod Chandra Mahapatra is approved for the postgraduate diploma in Industrial Design.

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Examiners

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My acknowledgements to

Different design offices in Bombay

The Raja Bahadur Motilal Poona Mills Ltd, Poona

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Staff of Industrial Design Centre

Shri M. Chattopadhyay

Shri U.A. Athavankar

All technical staff and my friends

Contents.

1. Problem Statement

Redesigning of the Drafting Table as a device to simplify and accelerate drafting work.

2. Introduction.

2.1 Designers everywhere must be aware of the great changes taking place in the drawing office. Drafting is rapidly becoming a new technology. The drawing office environment, which has hardly changed in the past half century, is undergoing a revolution. The employment of advanced electronic equipment and automated drafting machines within the drawing office has given rise to the creation of an atmosphere much more in keeping with the draftman's important role in industry today.

Quality and reliability standards of products have become more rigorous and manufacturers have been faced with the problem of needing to reduce overhead cost drastically. Lowering standards of accommodation in the drawing office, coupled with the feeling of not being paid a salary proportional to the importance of their contribution to the company's success have resulted in trained draftsmen leaving the drawing office for other related fields. These factors gave rise to the need to automate the traditionally manual methods of drawing office in order to reduce to a minimum the lead time required between the

conception of an idea and its production reality. And drafting machine as a device plays a dominent role in it.

The fuller utilization of the higher abilities of draftsmen is a major challenge today. To meet this challenge, ways and means are needed of reducing the time and effort required to make drawings. Among these ways and means are the use of simplified drafting machines and methods, elimination of non-essential and exclusive use of drafting aids and time savers.

Unlike in foreign countries, India cannot go for computer aided drafting machines because of the high capital cost involved in it. The majority of drawings required by industries today in India are still produced by manual methods and this situation is likely to continue for some time.

Most of the drafting machines manufactured in India today are so expensive that an ordinary designer can never afford it. Also no human consideration has been taken into account in the available drafting machines which results fatigue for the user. The unnecessary floor area taken by its bulkness and complicated operational sequences makes the product still worst. After studying the aforesaid problems,

the redesigning of the drafting table was felt a long due.

2.2 Problem Background :

As applied to the design and manufacture of individual products, drafting has contributed much to the material wealth of the present era. But paradoxically, while it helped to improve manufacturing and promote progress, drafting itself remained relatively unchanged. It still employs today virtually the same amount of time-consuming elaboration of details as it did at the time of its inception.

The history and origin of drafting table as an out standing instrument of communication, however, remains a mystery. No one knows who first used a drafting table. But probably the increasing use of consumable products in the sixth century furnished the impetus to the development of drafting table and drafting practices as a means of planning and design methods. The first drafting table was then a simple wooden board to provide a flat working surface.

During the world war drafting table developed tremendously with new technical changes and innovations, and it has been keeping pace set

for it ever since. The trend in the modern drafting table design in recent years have been of such radical nature that it is very difficult to categorize them. In this age of specialization, in order to meet each individual type of service, they are classified into types like industrial, architectural, designing, topographical, engineering, military and so on.

The highest type of drafting table today is the automated computerized drafting machine. Automated drafting machines show considerable promise in speeding up the process of drawing. But unfortunately, the computer equipment industry still have a long way to go before the day arrives when all the different types of manufacturer's equipment is interchangeable. Now one would expect as time goes on that the equipment employed in computer aided design technique will become less expensive and will spread throughout industry.

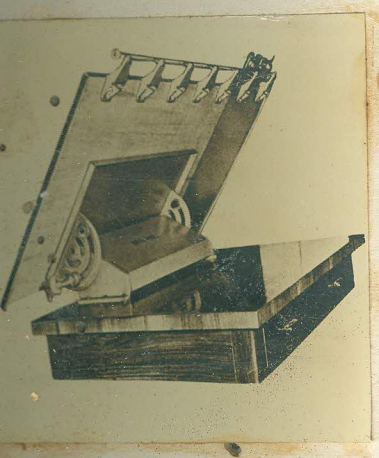
3. Information :

3.1 Existing drafting machines and types :

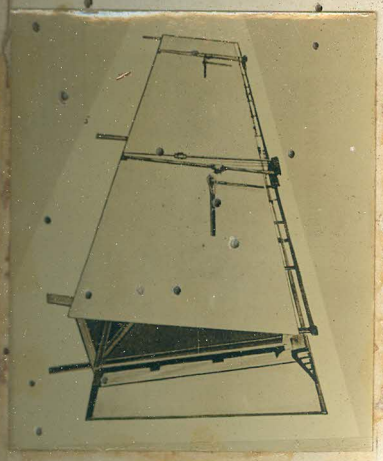
Travelling Trolley type by 'Pittie' occupies no space by stand as it is built inside the reference table. The drawing board is fully counter-balanced and can be adjusted and locked in any desired position. Horizontal and vertical guideways are both manufactured from ground stainless steel bar. All rollers are on ball bearings to assure consistent accuracy. It is provided with a reference tray and mobile spot lights are provided with an extra cost.

Drawing board size: Standard: 100 cm x 160 cm
Special : 100 cm x 200 cm.

Universal drafting machine by 'Pittie' has a tubular frame stand. The drawing board is fully adjustable for both angle and height. It is counter-balanced for easy adjustment and a full length pedal can lock the board in any desired position. Drawing board size: 100 cm x 150 cm, 76 cm x 107 cm.



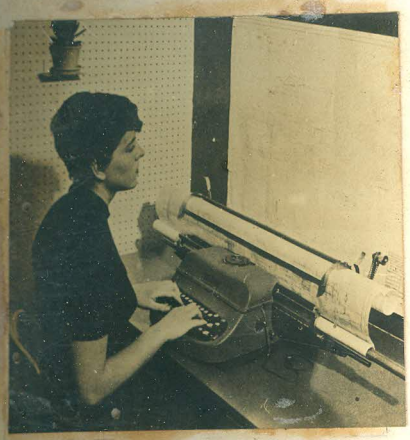
The mini-drafter and Bench Mounting Drafting Machine by 'Pittie' is ideal for drawing offices producing small drawings. It can be mounted on existing table or filling cabinet. Only angular movement counter-balanced by tension



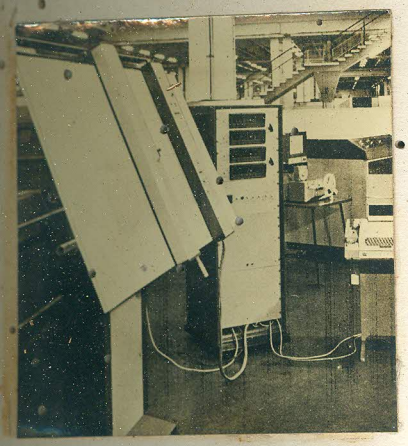
spring is provided im B.M. Drafting machine. Drawing board size: 76 cm x 107 cm.

The special drafting machines are specially executed in widths of 125 cm or 200 cm above 2 metres long to any desired length in multiples of 1 metre. These drafting machines can be supplied with drawing boards mounted either on one side or both sides of the frame and are fixed in position.

The Vari Typer : To reduce the time involved in lettering drawings, some industrial drafting rooms are equipped with a special lettering machine called the Vary-typer. It is used for filling in bills of materials, specifications, schematic diagrams, notes etc. The machine is operated much like a type writter. Electrically controlled impressions permit uniform clear and sharp composition of type directly on drawings.



Plan Hold Corporation has introduced a Semi-automatic drafting table with a spring loaded base which allows finger tip control of height adjustment. It can be used as a desk at the lower height (30 inches) and as a drafting table with heights adjustable to 36-3/4 inches. The top can be tilted to nine different positions.



The automated computerized drafting machine has a precision table with a drawing area from 4' x 4' to 6' x 20', a travelling beam and carriage which moves the drawing device and servodrive motors to control the movement of the system. The drawing board holds one or several stylus which may be either a capillary pen or a metal scriber. Only one stylus is in operation at any given time.

3.2 Informations from manufacturers and dealers :

Types: The available drafting machines in the market are under the trade name of mini drafter, travelling trolley type, Universal Drafting Machine, Bench Mounting Drafting Machine and Special Drafting Machine.

Model types	Drawing board size in cms.
Model SMW II	- 100 x 150 (standard)
Model TS	- 100 x 200 (special)
Model TS	- 100 x 150 76 x 107
Model TM	- 76 x 107
Model TT	- 76 x 107

Pantograph Models	For Drawing Board size in cm
Model PP-1	- 100 x 150
Model PP-2	- 76 x 107
Model PP-3	- 76 x 107

Patterns of division of reduction scales in metric graduation are available in 1:10, 1:50, 1:1 and 1:5. Any other graduation can be supplied on demand. While ordering type of protractor head and type of scale is indicated.

Price: It ranges from Rs.45/- for a mini-drafter to Rs.3000/- for the Travelling Trolley

Type of Drafting Machine.

Manufacturer is Raja Bahadur Motilal Mills Ltd. (Pittie), Poona and the selling agent is Macneill and Barry Ltd., Bombay.

Rate of production is according to the job orders.

Capacity for designing of the machine are decided from the available standard sheet metals and wood sizes available in the market. No limitation in design as well as in application due to easy availability of material.

Form and colour of the machine is based purely on technical design. No special thoughts are given on colour and appearance of the machine.

Buyers are mostly drawn from educational institutions (particularly engineering colleges), design offices of industries and other consulting design offices.

Buyers usually ask for guarantee and a guarantee of one year is generally given by the manufacturers.

Very occasional complaint from customers.

The dealer does not sell spare parts ~~of~~ except scale and protractor head.

There is little fluctuation in sale. The sale price includes accessories like scale, protractor head and the reference table. Mobile spot lights are provided with an extra cost depending upon the types demanded.

3.3 Information from users :

Grade of operator - skilled and educated.

No. of operators - usually one, but in architectural drafting several persons may work.

Fatigue every 2-3 hours due to continuous bending or standing. Horizontal and inclined position of the table causes pain at backbone, knee and leg joints.

Most of the draftsmen and designers work on it continuously for 6 to 8 hours a day. They prefer not to work during night because of strain put on eye.

Visual difficulties due to the creation of shadow at night time. The spot light causes glare and reflection. Readability of the scale is poor because the graduations are often faded out.

Sufficient space for leg operation is also not given which hinders the easy movement of the legs and causes pain.

The position of the cabinets and shelves is inconvenient for quick and easy operation and does not provide proper space for keeping drawing and tracings.

User often changes position due to various cycles of operation.

The lever and foot pedal mechanism for changing the inclination of the board requires sufficient force and causes physical fatigue.

They have no special comment on the form, colour, size of the product and the office environment.

The vertical guideway often tears or spoils the ink rendered tracing or drawing sheets.

Majority of the users prefer to have special arrangements for holding the drawing sheets and tracings on the board instead of using cellophane tape all the time.

For rough calculations, sketches, they prefer to have some additional space provision on the board.

The stool is not suitable for the position of the errect and comfortable seating. The backrest to be given so that backbone should not be affected.

3.4 Human Engineering data and informations :

3.4.1 Static muscle load in different work positions:

The static muscle load in different work position (an electromyographic study) by. Sven Carlsoo deals most of the postures required for drafting practices and shows the following results.

The standing body posture present a gravity problem. In the symmetric standing posture at rest the centre of gravity of the body lies roughly in the first sacral vertebra. To balance the body and its various segments, muscles must be active in order to counter act the effect of the force of gravity on the different joints without causing fatigue. All possible postures are shown in fig.1.

Of all these postures examined, the standing symmetric rest position appears to require the least muscular effort for counterbalancing the effect of gravity on the various parts of the body.

The distribution of the weight of the body on the foot would seem to be the prime factor in determing the load borne by the muscles of the lower leg. The minimum loading of

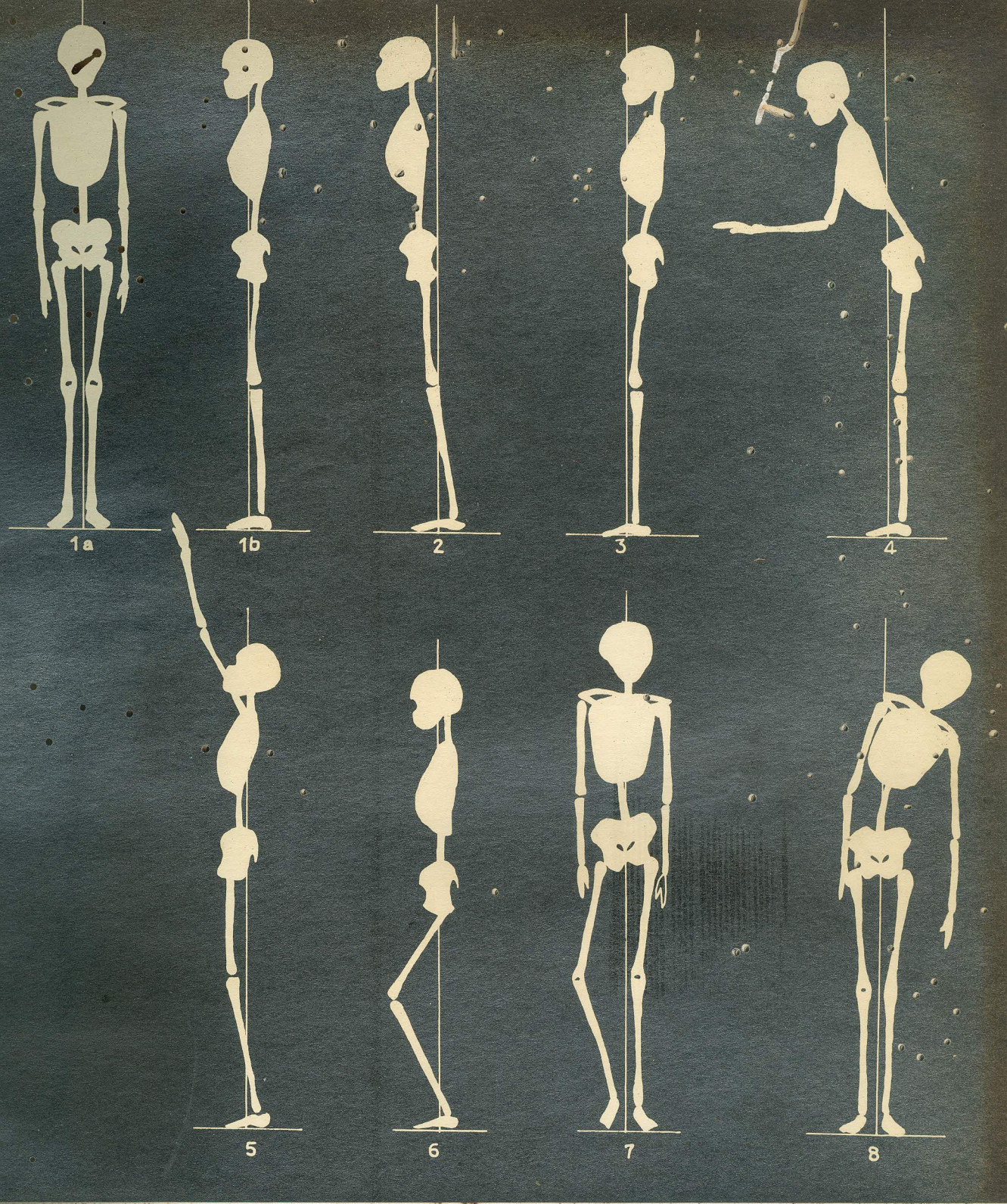


Fig.1:Static muscle load in different work positions.

1. Symmetric standing rest position
2. Forward leaning position
3. Backward leaning posture
4. Slight stooping posture
5. Backward bending posture
6. Knee bending posture
7. Asymmetric standing rest position
8. Lateral bending posture

these muscles occurs in the symmetric standing position.

3.4.2 Horizontal work surface :

Many types of mannual activities are carried out on horizontal surfaces such as tables, desks, etc. For such work surfaces, the 'normal' and 'maximum' areas have been proposed by Barnes with normal work area proposed by Squires superimposed to show differences. Fig.2 shows the details of the work surfaces.

Normal area: This is the area that can be conveniently reached with a sweep of the forearm, the upper arm hanging in a natural position at the side.

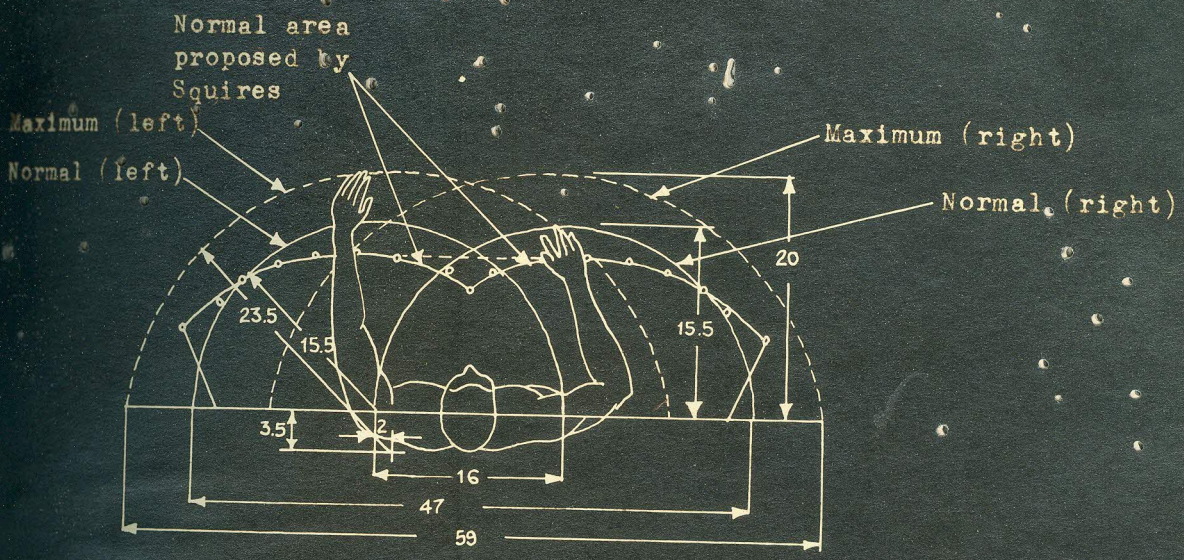
Maximum area: This is the area that could be reached by extending the arm from the shoulder.

3.4.3 Work surface height :

Some experimental evidence relating to work-surface height for persons working in standing posture comes from a study by Ellis. Work surface height in relation to arm length, distance from floor, and distance from elbow as used in study by Ellis is shown in Fig.3.

It gives the six level of working surface expressed in terms of arm length (specially the

Fig. 2 : Horizontal work surface



Dimensions in inches of normal and maximum working areas in horizontal plane as proposed by Barnes, with normal work proposed by Squires superimposed to show differences.

Fig. 3 : Work surface height in relation to arm length, distance from floor, and distance from elbow, as used in study by Ellis.

	WORK-SURFACE HEIGHT					
	1	2	3	4	5	6
% of arm length from fingertip	-10	+10	+30	+50	+70	+80
Average inches from floor	25.9	31.3	36.6	42.0	47.4	52.7
Average inches from elbow	-18.9	-13.5	-8.2	-2.8	+2.6	+7.9

percentage of arm length above or below the finger tip), distance from floor, and distance from the elbow. The fourth level averaged about 3 inches below the elbow. This was about 42 inch above the floor.

3.4.4 Where the work place is to accommodate the individual in both a seated and a standing position, it has been proposed that the optimum visual and manual areas will be achieved for a range of individuals if the pertinent dimensions (eye height, elbow height etc.) of average personnel are utilized rather than dimensions of extremes.

3.4.5 Illumination standards recommended by the Illuminating Engineering Society for several selected types of situation and tasks recommends illumination of 200 foot candles for detail drafting practice.

3.4.6 Effect of glare :

Glare affects visual performance and also visual comfort. The effect of glare on visual performance is shown as a percentage of the visual effectiveness that would be possible without the glare source.

It has been found out that with the glare source at a 40° angle, the visual effectiveness

is 58 per cent, this being reduced to 16 per cent at an angle of 5 degrees.

3.4.7 Direct glare can be minimised by reducing the brightness of light sources, by placing the light sources out of the line of vision, by increasing the brightness of areas around the glare sources. Reflected glare can be reduced by keeping the brightness of individual light sources reasonably low, by providing good general illumination, by diffusing light, by proper positioning the light sources and by avoiding the use of glossy surfaces.

3.4.8 From investigations into the speed of working with various types of drawing equipment and the effect of drawing office working conditions upon the health of daughtsmen, various results were found out. The results are shown in Fig.4 as percentage of injuries to health. The result shows that standing position is best for working on drafting table having the drawing board adjustable for height and angle.

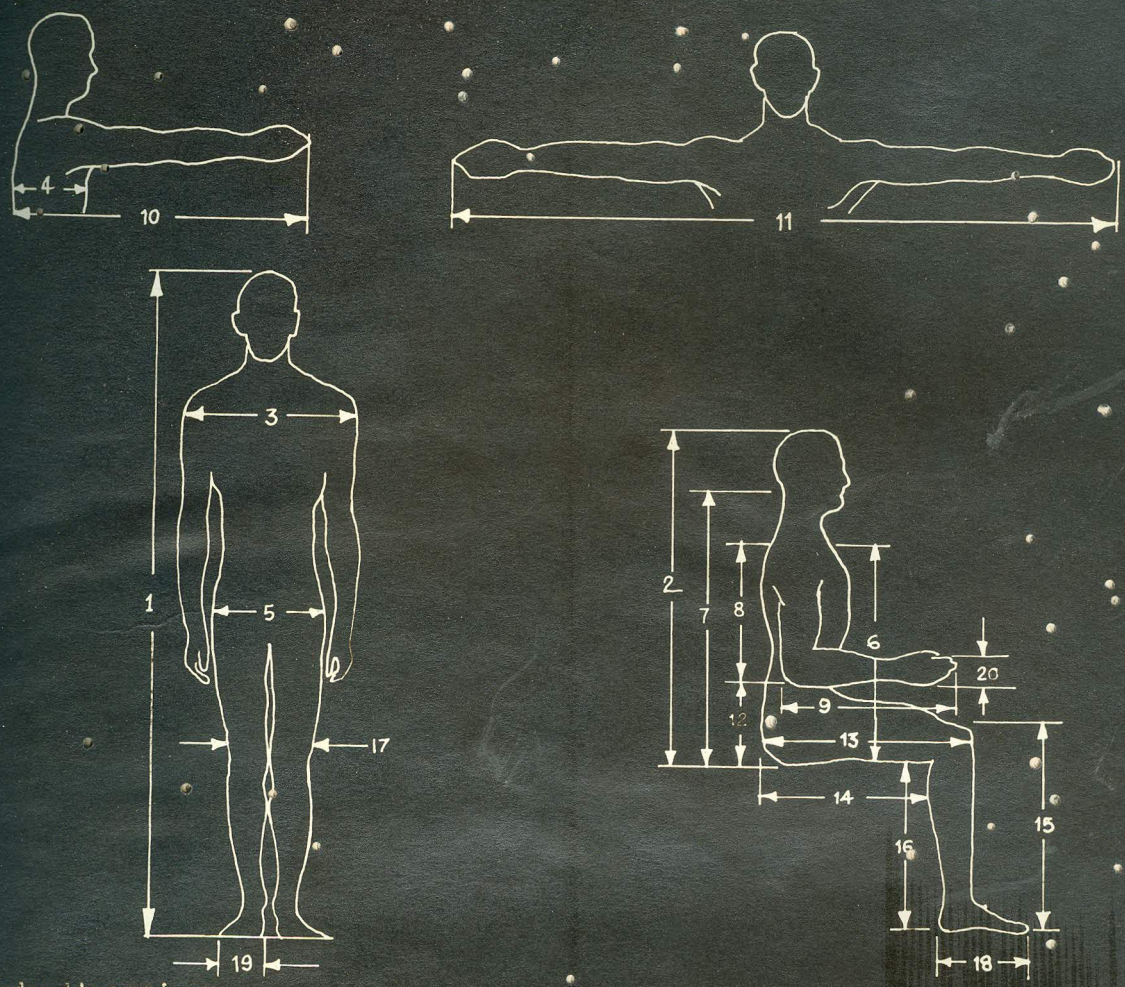
3.4.9 Anthropometric data required for the design of drafting table is shown in Fig.5.

From investigations by a scientific institute into the speed of working with various types of drawing equipment and the effects of drawing office working conditions upon the health of draughtsman, the following test results were obtained.

Fig. 4 : Percentage of injuries to health

INJURIES	HORIZONTAL DRAWING BOARD		DRAWING BOARD ADJUSTABLE FOR HEIGHT & ANGLE	
				
	SITTING	STANDING	SITTING	STANDING
Headache	52	47	36	31
Constipation	29	44	22	14
Colds & Bronchitis	38	59	29	21
Backache	14	50	24	14
Foot trouble	10	31	18	27
Mean value	29	46	26	22

Fig. 5:Selected Body Measurement for Adults.



Some body dimensions

1.Height
2.Sitting height:erect
3.Shoulder breadth
4.Chest depth
5.Hip breadth:standing
6.Shoulder height:sitting
7.Back height
8.Shoulder elbow
9.Forearm-hand
10.Arm reach
11.Arm span
12.Elbow height:sitting
13.Buttock -knee
14.Seat-length
15.Knee height:sitting
16.Seat height
17.Knee breadth
18.Foot length
19.Foot breadth
20.Hand breadth

Body dimensions in mm.	Male	Female
Forearm length	486	379
Forward arm length	876	691
Shoulder breadth	430	320.
Seat height	450	360
Knee height	547	448
Shoulder elbow	385	297
Hip breadth	340	350
Buttock knee	580	550
Seat length	470	450
Shoulder height	630	570

4. Analysis :

4.1 User:

Broadly speaking everyone working with the drafting table can be classified into one of two groups, the amateurs and the professionals. The former are mostly from commercial designing and art fields. But the professional is essentially interested in the total aspect of the product. They are generally constituted of Industrial Draftsmen, Architects, Designers, Topographers, Engineers, Professional students and teachers.

Users are mostly educated and conversant with the drafting practice.

Ninety per cent of users are constituted of males, whereas females constitute only 10 per cent, mostly drawn from architecture and design fields.

4.1.1 Primary need: To save effort and time in drawing.

4.1.2 Secondary need: To speed up the process of preparing drawings by eliminating the need for separate instruments.

To draw precisely and correctly.

4.2 Structural analysis :

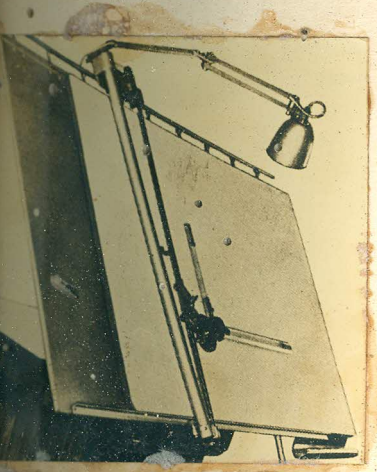
The structure of the drafting table is the natural outgrowth of a need for supporting the drawing board at varied angle and height. Also the structure combines in one unit the functions of the straight-edge, protractor, triangle, scale and elliminates effort and time.

For the sake of detailed analysis the conventional type of drafting table 'Travelling Trolley Type' manufactured by Raja Bahadur Motilal Poona Mills Ltd. has been chosen. The following are the main parts of the drafting machine.

Drawing board :

The drawing board is mounted on the stand by means of two pressed sheet metal plates screwed from the back. These two plates are connected to the horizontal M.S. pipe joining the two vertical columns of the stand. Also to each pressed plates at the back are connected two friction plates having grooves to allow angular movement to the board.

The drawing board is made of white pine of several pieces glued together having plywood surface coverings on all sides. A thin layer of PVC is glued to the working surface of the.



board.

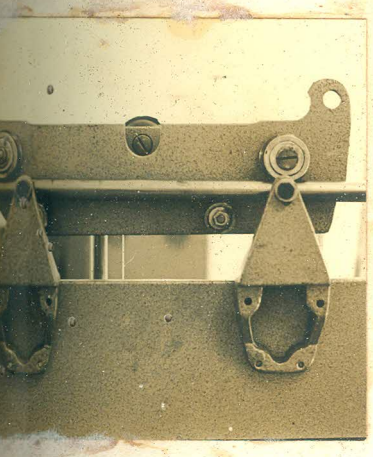
Over all dimension of board: 100x150x2.5 cms.

The bottom edge of the board is connected length wise to an aluminium angle plate which guides the rollers attached to the vertical guideway. Nine cast iron attachments are connected to the top of the board which supports the horizontal guideway.

Two additional small trays having V-berds are also attached to the bottom edge of the board by means of screws.

Reference tray:

The reference tray is attached to the left side of the drawing board by means of seven screws. It consists of a flat sheet metal of 40 x 104 cm size (16 gauge) having 90 degree bends at three sides in different directions. Two of the attachments holding the horizontal guideway are also screwed to it. Also a portion of the angle plate of the board extends on it.



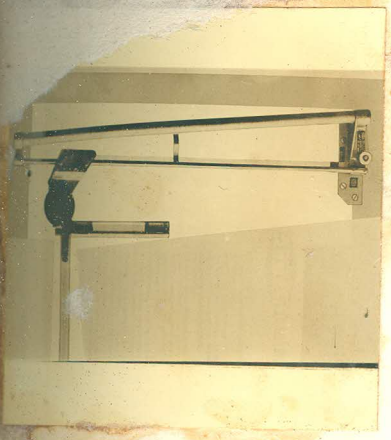
Horizontal guideway :

The horizontal guideway is a ground stainless steel bar of length 174 cms attached to the top of the drawing board by means of nine cast iron attachments. The attachments are connected

to the guideway by standard nuts and keeps it parallel to the length of the board. The guideway ends are provided with two circular nylon washers. The travelling trolley fits to it through four rollers.

Vertical guideway :

It is also a ground stainless steel bar of length 115 cms and dia. 1.5 cms. This is fitted to the travelling trolley by means of two screws at the top and remains at 90 degrees to the horizontal guideway. The four rollers of the protractor head attachment runs on it in upward or downward direction.



Travelling trolley:

It consists of a M.S. pipe of 3.5 cm dia. and 115 cms length and runs on a track mounted on top of the board by means of a trolley unit.

Both the ends of this pipe are attached to the vertical guideway bar. The lower end of this pipe has a roller on ball bearings and runs on the aluminium angle plate attached to the bottom of the drawing board. A bend welded plate also joins the middle with the vertical guideway.

The top end of the pipe is attached to another casted trolley unit having two parallel plates. The bottom plate has got four rollers which runs

on the horizontal guideway bar. The upper plate contains a nylon pulley on which a nylon string passes, and connects the protractor head at one end, other being fixed to another pulley inside the main M.S. Pipe.

Protractor head :

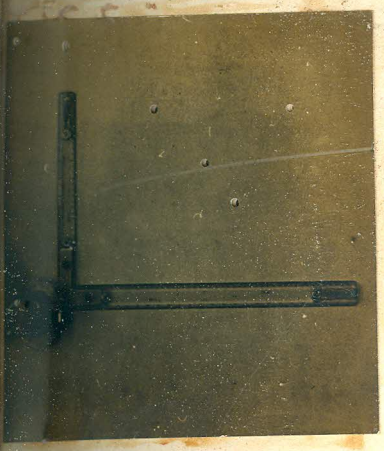
It has got a circular anodized aluminium plate of dia. 12 cms mounted on another circular aluminium plate having 11 circular grooves along one side of its circumference.

The upper plate has got graduation of zero degree to 60 degrees anticlockwise and zero degree to 90 degrees in clock wise direction having the zero line coinciding the 45 degree line between both the scales. This protractor has got a knob at the middle made of U.F.resin.

The protractor is attached to another plate having four rollers and runs on the vertical guideway. The plate has two dove-tailed levers. The nylon string passing through the pulley of the travelling trolley attachment is also fixed to it.

Scales :

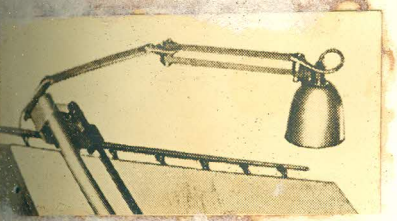
Two scales at 90 degrees to each other made of perspex are connected to the protractor by means



of another aluminium plate. This plate connects both the horizontal and vertical scale to the protractor and has a lever. This lever is connected to the protractor knob by means of a spring. Both the scales are having an index head - its zero coinciding the zero of the protractor in normal position.

Both the scales are having metric graduations on it. The pattern of divisions of reduction scale on both the scales are 1:2.5 on the outer side and 1:1 on the inner side.

The vertical scale measures 30 cms where as the horizontal scale measures 50 cms.



Mobile spot light :

It has a base made of pressed sheet metal forming two bends of 90 degrees at the ends. These two bends are fitted to the travelling trolley by means of a knob. The base has a vertical column holding two link arms of the light. The extreme end of one of these links has provision for the holder and the reflector.

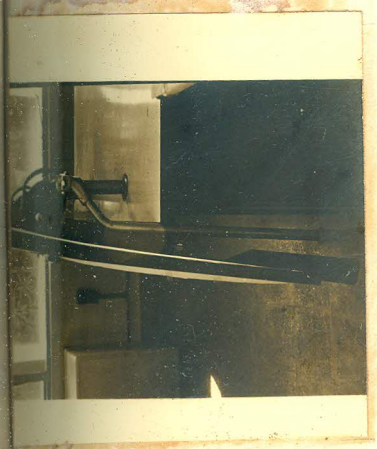
The links are made of standard aluminium square rods. The reflector is made of sheet metal spinned to the bowl and conical shapes at both ends.

Rollers :

The travelling trolley has four rollers of two sizes turned from mild steel rods. The rollers are provided with ball bearings and fitted to the travelling trolley by means of screws and nuts. The bigger size rollers run from the top of the horizontal guideway where as the small ones run from bottom.

The protractor head has also four rollers of same size and moves on the vertical guideway. The roller running on the angle plate at the bottom of the board is made of nylon.

Hand lever :



The hand lever is made of standard G.I. pipe. having a bend of 135 degrees at one end. A groove at one end of the lever accommodates the link rod passing through the horizontal pipe joining the two vertical columns of the stand. The operating end of the hand lever is fitted with a handle made of P.V.C.

Reference table :

The reference table has a formica table top and inside is made of teak and plywood.

The table top is bolted to the stand from the bottom. It has got two holes through which the vertical columns of the stand passes.

Over all size of table top: 76x122x4 cms.

The table has also got two cabinets made of teak and plywood with locking arrangement on one side and open shelves on the other. These cabinets are fitted to the four legs of the stand by means of another teak wood plank. From inside, the foot rest and height variation mechanism is covered by another set of teak wood casings.

Stand :

It has got two halfs made of square section pipes. Every half has a horizontal pipe to which two legs made of square pipe sections have been welded. Every half is bolted to the table top from bottom. The legs are bolted to the two planks joining the cabinets. The legs are provided with metal washers at the ends.

Foot pedal :

The foot pedal is made of standard M.S. pipes. It has a horizontal pipe fitted from both ends to the middle wooden planks connecting the two cabinets. Another pipe having two 90 degree bends is welded to it and forms the pedal unit.

To the horizontal pipe are connected the levers of the height variation mechanism through a set

of springs.

Counter weight :

It is a rectangular box made of sheet metal having one open end. A chain is attached to it from inside, the other end being attached to the end of the vertical column of the drawing board. The chain passes through a set of pulley and gear. The box is filled up with small circular cast iron pieces.

The drafting table has got two such counter weights from both sides.

4.3 Functional analysis :

The Travelling Trolley Type of drafting table is the universal type and is a high precision mechanical instrument. In the simplest sense it is used to simplify work by combining in one unit the functions of the several other drafting instruments. Combination of all these functions along with the height and angle variation mechanism of the drawing board save considerable amount of drafting effort and time.

The following are the functions of the main parts of the drafting machine:

Drawing board :

It provides a flat, rigid surface area big enough to accommodate large size drawings. The PVC layer on top of the board provides a plane and firm working surface and helps sharp clear cut pencil lines on paper.
Several glued pieces inside the drawing board prevents warpage.
It also acts as a hand rest for the person and increases the steadiness of his drawing hand.

The drawing board is counter balanced by the weight of the reference table and the counter

weights. It can be adjusted and locked in any desired position for height and angle by means of the height variation mechanism and the hand lever.

Reference tray :

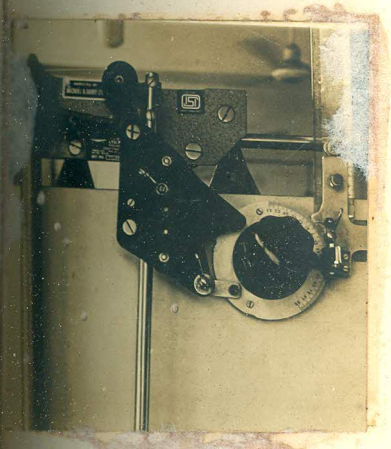
It is mainly used to hang reference drawings, standard sheets and provides space for making rough calculations.

Horizontal and vertical guideways :

Being at 90 degree to each other and mounted on rollers having ball bearings, it assures consistent accuracy to the protractor and scales for making horizontal, vertical, parallel and angular lines.

It provides means for drawing long horizontal lines throughout the length of the board by simply arresting the vertical movement of the protractor head.

The existing table fails to achieve this because the rollers are sometimes misaligned from the guide rails.



Travelling trolley :

It provides stability to the protractor head, scales and keeps the correct vertical alignment of both the guideways.

Since it operates on atrack, the length of continuous line and the distance over which views can be projected are limited only by the length of the board.

By means of the pulley and string it makes the movement of the protractor head and scale easier along the length of the vertical guideway.

Protractor head :

It provides mechanical means for moving the two scales, fixed in 90 degree relationship, over the entire surface of the board.

It replaces the traditional T-square, scale, triangules and protractor and combines their functions in one unit, which saves drafting effort and time.

By means of a controlling or index head, it allows the scale to be set at any angle. The protractor head can be swung away completely as well as lifted slightly to clear minor obstructions while fixing sheets and tracing papers on the board.

Sometimes the lever does not arrest the scale properly for which a small accidental push to the scales shift its position, thus giving

wrong angles. The exposed grooves of the protractor sometimes tear the tracing sheets.

Scales :

Main function of the scale is to provide unit of measurement for distance and provide a working face for drawing horizontal and vertical lines. It always makes 90 degrees readily available.

Mobile spot light :

During night hours, it provides illumination to the drawing surface.

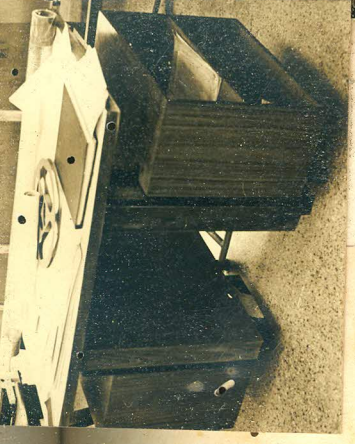
By means of the link arms and knobs, it provides adjustments in positioning and the inclination of the lamp to the vertical. The link arms also provide variation in height and distance of the lamp.

The reflector can be rotated to any required angle for spotting the drawing area.

Hand lever :

A turn of the lever permits the drawing board to be regulated to various angles.

The top can be moved to full easel position. A locking device keeps the board fixed at some required position.



Reference table :

The function of the reference table is to provide a flat working surface and counter balance the weight of the drawing board. It is used as a desk for secondary works.

Stand :

It mainly supports the drawing board and other parts of the drafting table, as well, gives stability to the whole instrument. The stand occupies no space as it is built inside the reference table.

It also supports the reference table top and the cabinets.

Foot pedal:

It acts mainly as a leverage for raising and lowering the drawing board. This is accomplished by a lever mechanism and a set of rollers which regulates the upward and downward movement of the vertical columns supporting the drawing board.

At certain angles of the drawing board, it acts as a foot rest for the user.

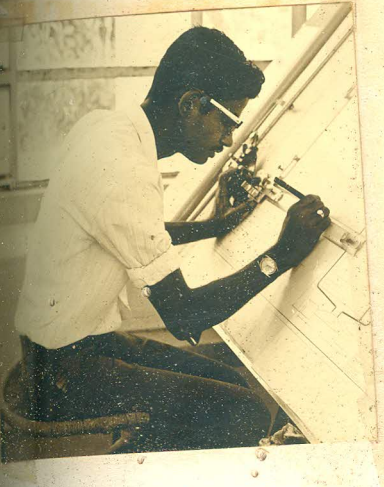
It can lock the table for any required height by simply releasing the pedal.

4.4 Ergonomical analysis :

Operation of the foot pedal for engaging and disengaging the height variation mechanism requires considerable amount of force, and at certain angles of the board does not reach the operator's legs.

Raising and lowering of the drawing board is difficult having link and lever mechanism. For such operations the drawing board has to be pressed upward or downward with considerable force resulting fatigue.

The location of the hand lever is inconvenient for giving angular variation to the board. The person in each operation has to lean forward or bend across to operate it. At the lowest height of the board, its position becomes too low for the operator. Also it does not provide a good grip and leverage for the system. Extension of the lever may hurt the operator during other operations.



The centralized control units on the protractor head allow the draftsman to accomplish the operations with his left hand leaving the right hand free for drawing. But for operations like locking the protractor head for horizontal line and angles, he has to use the

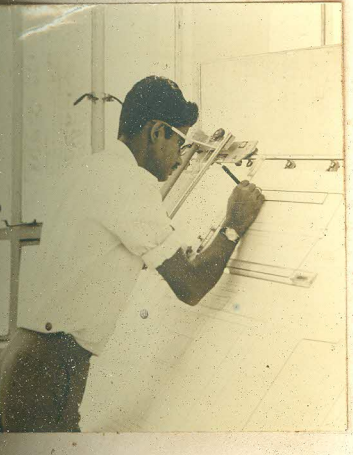
right hand, which engages both the hands.

The protractor head knob is too rigid for smooth operations and does not provide a good grip. For drawing angles, the protractor knob has to be simultaneously operated by left hand, the thumb operating the lever. It requires considerable force and hurts the thumb with its protruding and sharp edges.

The shape of the dove tail lever is unergonomical with sharp corners and small working width. They are not properly positioned.

The small trays used to keep pencils etc. unnecessarily protrudes out at the edges of the board - its sharp corners are likely to cause injury.

The position of reference tray is not correct. All the times the person has to turn left for making calculations.



The drawing table does not give all the variations in height required for convenient operation. The drafting stool serves to compensate for a considerable variation in height but it is always not the case - no standard drafting stool or posture chair is used.

In the sitting posture the person's knees

touch the board kept in vertical position. For bringing the board to horizontal position he has to shift backward.

For keeping the things in the cabinet, the person has to go round the board and bend downward.

Fastening the sheet to the board becomes difficult with cellophane tape, the scale obstructs such operation.

During night time, reflected glare occurs on the drafting table, because the area lighted is not perfectly diffusing and concentrates the reflected light in certain direction. When the person is in the line of concentrated reflected glare, it causes discomfort and affects the visual performance of the person.

4.5 Formal analysis :

The form of most of the tables are having the same basic shape like the base and drawing board and does not give much scope to change it.

The overall form of the drafting machine lacks visual unity. Various parts, knobs and handles which protrude out in all directions and a lack of consistency in the form of the different elements contribute to this visual disorganisation.

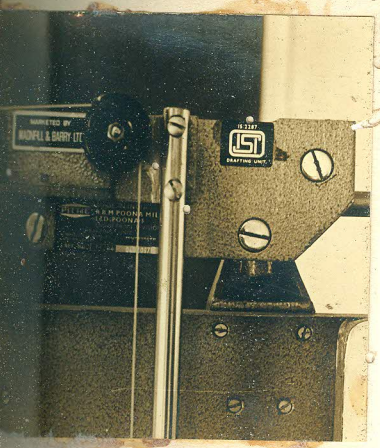
There is lack of uniform transition and juxtaposition of different forms and components which adds confussion in communication.

The system used for mounting the board is very crude and the exposed parts spoil the overall shape of the product.

Quality of finish is extremely poor. The colours used like black and grey does not go with the environment.

The whole machine is built into number of parts and they are joined with the help of screws all over, which has spoiled the overall appearance of the product.

The chromium plated dove-tailed levers and



anodized aluminium plates used in the protractor with their shining surfaces disturb the visual balance.

The name plates of the manufacturing and marketing firm have been fixed on the travelling trolley without any proper graphic lay-out. Same thing has unnecessarily been displayed on the back of the board and adds confussion.

4.6 Socio-psychological analysis :

The environmental coherence is faraway from reality with the existing drafting tables and has a negative effect on the psychology of the persons working on it.

The drafting practice is itself a mechanical process and thus results monotony to the persons.

The lowering standards of the drawing offices, and the feeling of not being paid a salary proportional to the importance of their contributionhave brought about frustration among majority of the trained draftsmen.

The challenge of the automated computerized drafting machines have given the draftsmen a feeling and fear of unemployment.

The typical communication chain in industry using traditional drafting methods do not allow the draftsmen the time and freedom to work efficiently.

5. Hypothesis :

5.1 Structural :

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

Structure should be rigid enough to hold the drawing board and other mechanism without causing vibration.

Base should be correctly levelled.

Floor area should be reduced as far as possible.

The design should be done for batch production and use of other materials should be exploited in an economical way.

Whereever possible use of screws, nuts and bolts should be avoided.

There should be permanent arrangement for fixing drawing sheets and tracings.

The reference table should be avoided but provision for keeping drawing materials should be made.

The base should be sufficiently heavy and give sufficient counter weight to the drawing board in all positions.

The drawing board should not have warpage.

The protractor head combination along with scales should have vertical and horizontal movement covering the entire surface of the board.

Graduations on protractor and scales should be proper and correct.

Scales should have bevel edges both sides.

Protractor and scales should ensure locking arrangement for any required position and give all variations for drawing angles, parallel, vertical horizontal and angular lines.

Foot pedal mechanism for height variation should be changed.

Position of light should sufficiently illuminate the entire surface of the board uniformly.

5.2 Functional :

The drawing board should accommodate all types of standard drawing sheets and tracing papers.

It should give a plane and firm working surface for clear cut pencil lines on paper.

It should not vibrate under any of the working conditions.

The drafting machine should give height and angular variation of the drawing board by simplest mechanisms.

All parts of the machine should be easily available for cleaning.

All shiny reflecting surfaces adjacent to the drawing board should be avoided.

Hand lever should be within easy reach for the person in all possible position of the drawing board. It should require less force to operate and lock the board in required position.

Provision for keeping drafting instruments, papers, sheets should be made and should have easy reach when the person is at work.

Spot light should be avoided and replaced by diffused light.

The locking arrangement of protractor and scale should be simplified.

The movement of the protractor and scale should not spoil the drawing sheet.

Location of the reference tray should be changed.

5.3 Ergonomical :

Raising and lowering of the board should be easy and quick.

Drawing board inclination should allow the person to work in standing symmetric rest position as far as possible.

It should provide the normal work area as proposed by Squires.

In the lowest position of the board, the knees of the person in sitting or standing posture should not touch it.

All knobs, levers and handles should be designed for easy and comfortable operation.

All controlling levers should be suitably placed for easy reach.

The protractor head knob should provide good grip and should ensure smooth and easy operation for all positions on the entire surface of the board.

All glossy surfaces should be avoided and the colours used should not affect the psychology of the person.

Minimum 200 foot candles should be used for illumination, preferably diffused light.

Operation of the food-pedal should not be difficult or uneasy for any position of the board.

5.4 Formal :

Overall form should be simple, visually clean and and light.

The transition of different elements should be smooth and follow function.

Form should be integrated and should go well with the environment.

All communicating informations should be displayed simply and neatly so as to be easily legible.

Quality of finish should sufficiently be improved.

Graphic layout and colours used should be clean and provide proper contrast.

Name of the manufacturing firm with other technical informations should not be displayed on or near the drawing board. It should preferably be placed at the back of the board.

5.5 Socio-psychological :

There should be environmental coherence in the system and the product.

The drafting table should be semi-automated to give a moral boost to the operator.

6. Synthesis and Communication.

The study of the existing drafting tables, drafting practices and the specific needs of the people who use them, showed that the needs of the users from armateurs to professionals vary between wide limits and the existing drafting tables do not serve their specific requirements.

It was decided to group the users according to their specific requirements and develop a system which through its different combinations and flexibility serve their needs in an economical way.

The users were divided into the following three main groups:

Group I : Users - Mainly armateurs like artists and persons from applied art fields.

Requirements - A plane surface to work

Board fixed in vertical position at working height mostly for sitting position.

Board giving angular variations.

Minimum floor area.
Place for keeping brush, pencils, colours etc.
Pallette area.

Group II : Users - Architects, Topographers and Military draftsmen.

Requirements - Working surface to accommodate comparatively large drawings in lengthwise manner.
Board fixed in vertical position mostly for standing position.
Storage area for instruments.
Additional area for rough calculation.
Provision of light.
Precision of drafting aids for detail drawings.

Group III : Users - Mainly of specialized nature like Industrial draftsmen, Designers, Engineers of all branches, Professional students and teachers.

Requirements - A plane working surface to accommodate big drawings.

Variable position of board preferably angle and height.

Working height to suit both standing and sitting position.

Storage area for drawing aids.

Reference area for rough calculations.

Precision of drafting aids for detail drawings.

Provision of light.

Storage area for drawings and tracings.

Keeping in view the requirements of these three user groups a complete drafting table system was developed. The system consists of drawing board units, modular stand units, storage units and mounting units. All these units are standardized to give the flexibility to the requirements of the user groups through its various combination systems.

The following is a brief description of the different units of the system.

Drawing board units:

The drawing board are made of white pine of several pieces glued together having plywood coverings on both the sides. A thin layer of PVC is glued to the working surface.

The horizontal guideways are screwed to the boards from the back and holds an aluminium angle plate at the bottom. The boards have also provisions for fixing the mounting units.

Overall dimensions of boards :

Group I : 75 cms x 105 cms

Group II :100 cms x 330 cms

Group III:100 cms x 150 cms.

Modular Stand Units :

It consists of a stand unit, stand attachment-I and stand attachment-II.

Stand Unit :

It is made of standard sheet metal and square steel sections. The processes used are bending, pressing, welding. Two U-frame structures forming the legs of the stand are fitted to the top cover by means of screws and nuts. The stand unit has provision to accommodate drawer units and attach stand attachment-I.

It gives stability to the whole system and also acts as a reference table are a overall dimensions:

Top cover - 40 cm x 50 cms
Height - 80 cms.

Stand attachment-I:

It is also made of standard sheet metal and square steel sections. The processes used are bending, pressing and welding. It has a U-frame leg at one side and the other side is having a shorter frame to which stand attachment-II can be fixed. The top cover is fitted to the leg unit by means of screws and nuts. The whole unit can be fixed to the stand unit from both sides. It supports the drawing board through mounting systems. It can also accommodate a bigger drawer unit.

Overall dimensions :
To cover - 80 cm x 125 cms.
Height - 80 cms.

Stand attachment-II :

It is made of square steel sections and can be fitted to the stand attachment-I when the stand unit is not being used in the system.

Overall dimension: 33.5 cm x 61 cms.

Storage Units :

It consists of two drawer units of different sizes. The bigger drawer unit is fixed to the stand attachment-I and the smaller drawer units are fixed to the reference stand.

Overall dimensions:

Bigger drawer unit - 15 x 85 cm x 115 cm

Smaller drawer unit- 19 x 30 cm x 50 cms.

The storage units have the flexibility to be attached or removed from the system as may be necessary.

The drawer units are made of standard metal sheets and gives stability to the stand units.

Mounting Units:

There are three different mounting units for the three user groups. The mounting unit for the first group is very simple in nature. It is hinged at both ends to the drawing board and the other flat end moves along the grooves of a horizontal plate attached to the reference stand and gives angular variation of 15^{0}, 30^{0}, 60^{0} and 75^{0} to the board.

The mounting unit for the second group is of the nature of first group but only keeps the position of the board at 15 degrees to the vertical.

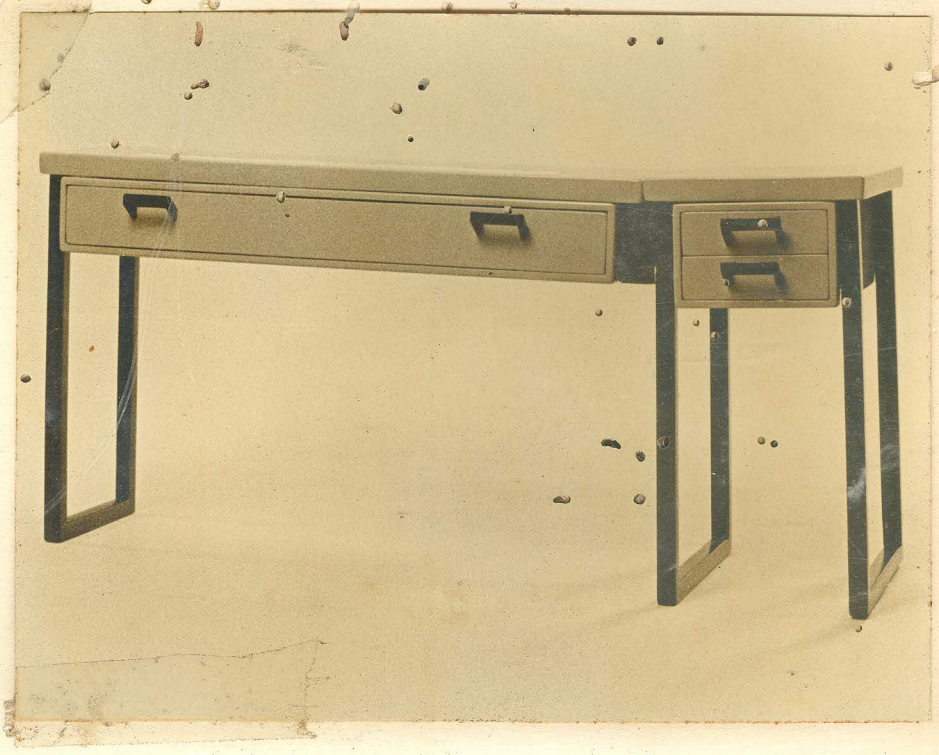
The mounting unit for the third group is of specialized nature. It consist of two friction plates made of steel castings which move around the two ends of a horizontal pipe through angular grooves and give angular variation to the board. The board can be locked to any angular position between 0 to 80 degrees by means of the handle and the lever mechanism.

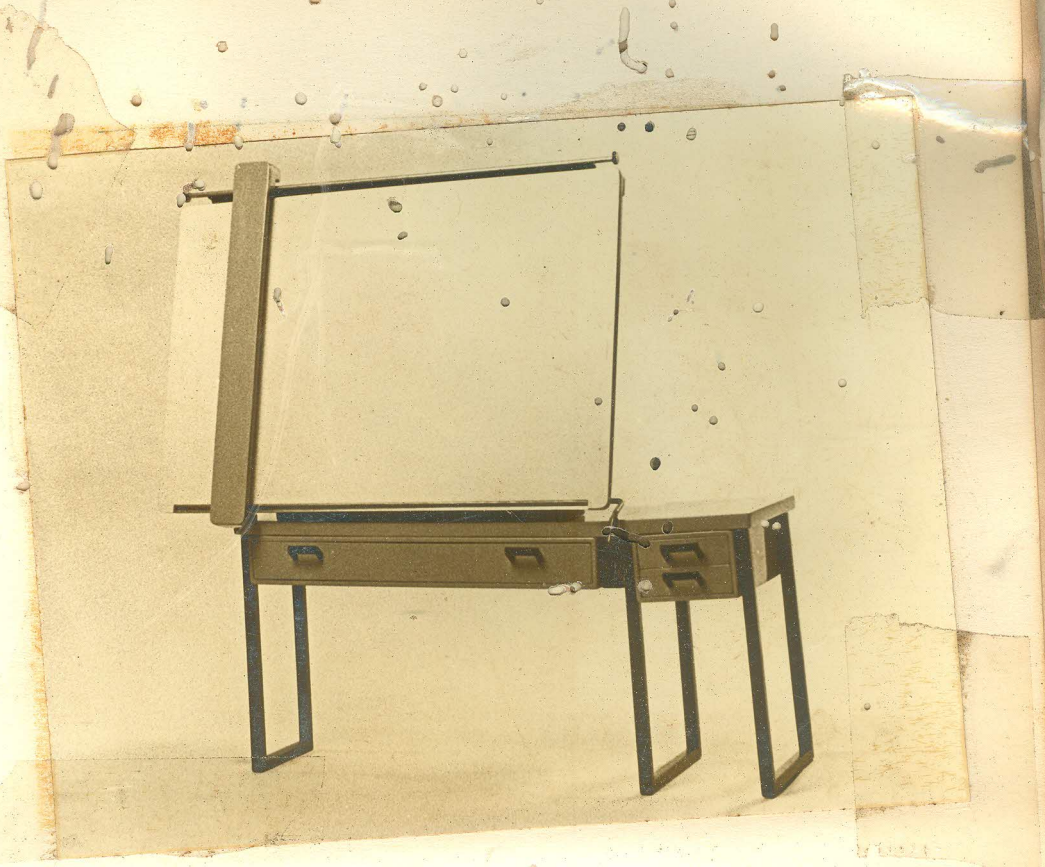
6.1 Salient Features of the Design of Group-III Drafting Table:

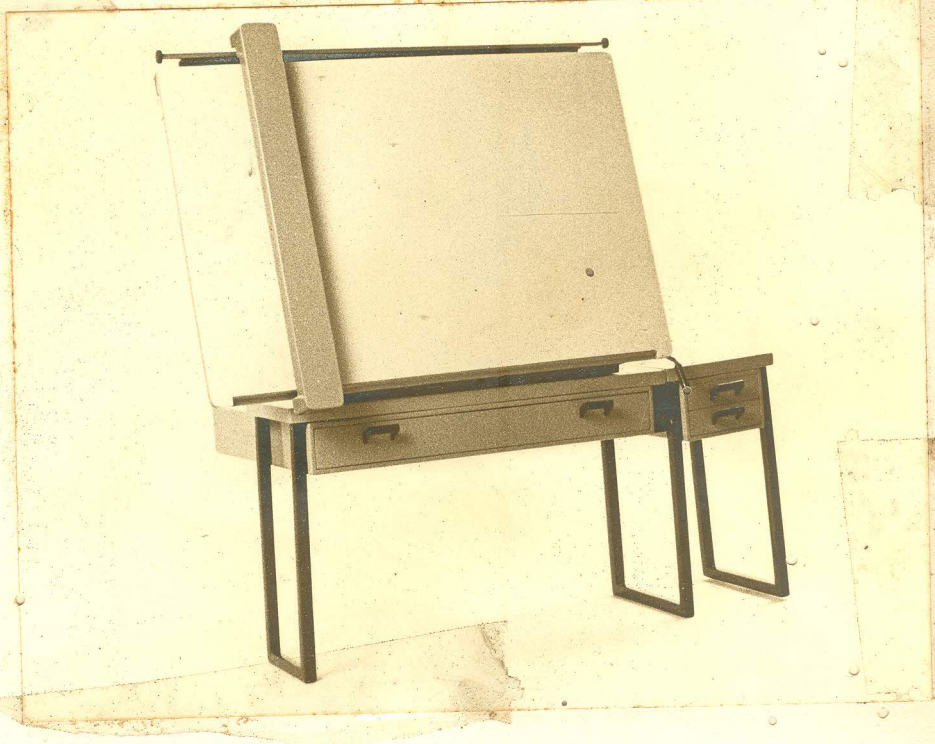
- The modular combinations of the stand and drawer units has the flexibility to add or reduce their numbers and give to the users considerable flexibility in cost reduction of the total drafting table system.
- Elimination of height raising mechanism and counter weights reduces the cost and mechanism to a great extent.
- Simplification of the stand and storage unit structures reduces the manufacturing cost and makes the total form look simple and clean.
- The sturdy and stable construction of the stand unit along with drawer units avoid vibration of the board and other elements. The structure is rigid enough to ensure reliability over a long period.
- Floor area is minimised as the drawer and stand units are built under the drawing board area.
- Maintenance cost is minimised by avoiding height raising mechanism and counter weights. All parts are easily available for cleaning.
- Reference table position at the right side of the board allows easy operations and

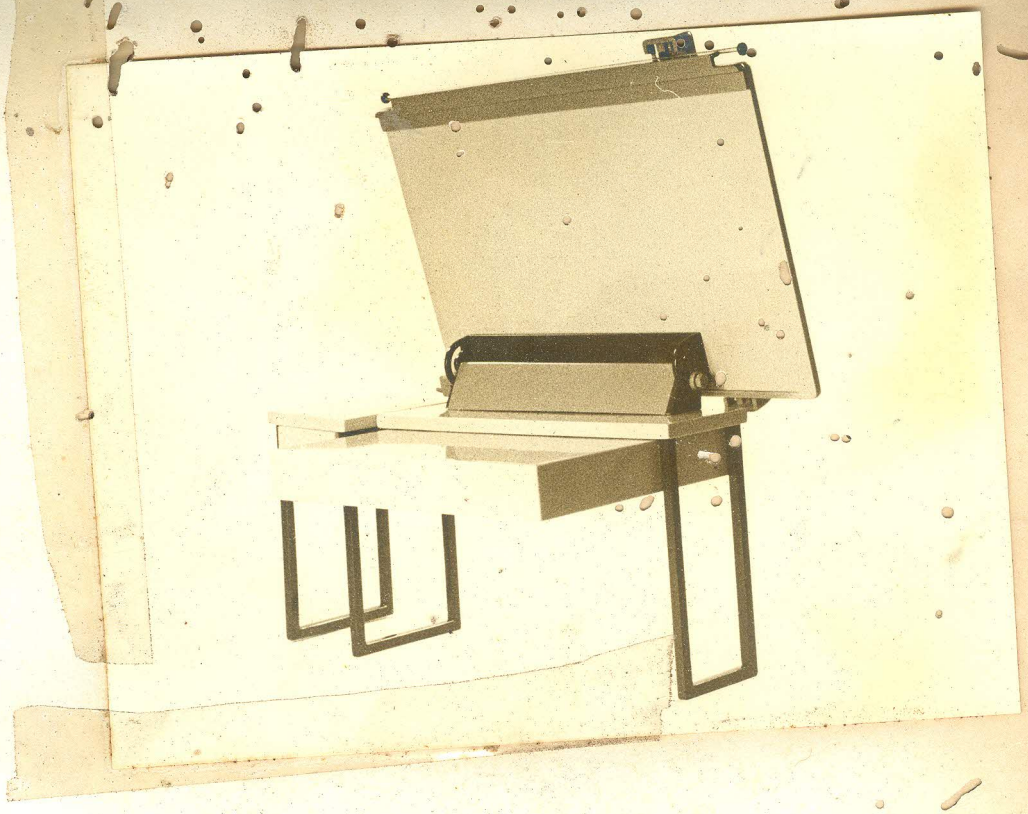
movements.

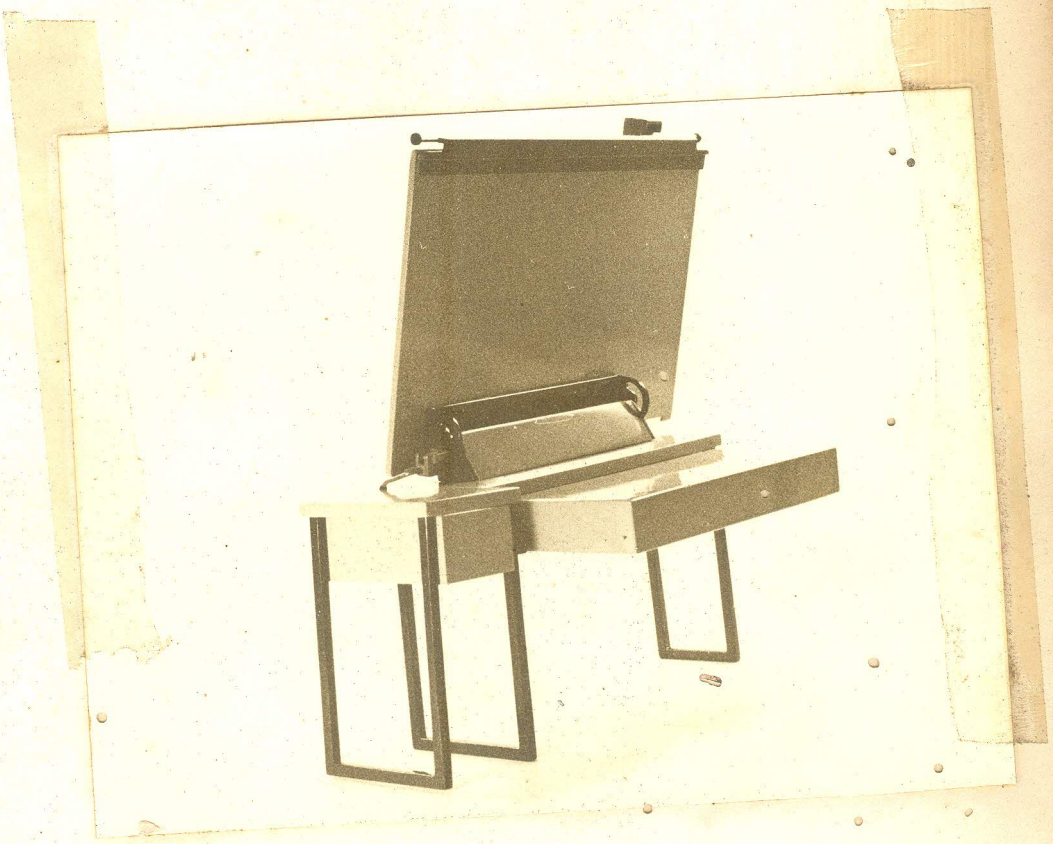
- White PVC sheet on top of the drawing board keeps it clean and gives a rigid surface for drawing firm lines.
- Hand lever is within easy reach for the person in all position of the drawing board and requires less force to operate it. Handle permits easy angular movement of the board by one hand only.
- The form of the vertical guideway is completely changed and simplified to allow easy operations. It covers the entire surface of the drawing board and does not go out of alignment.
- The drawing board inclinations allow the person to work in standing symmetric rest position without causing fatigue.
- The lower position of the board does not touch the knees of the person in sitting posture.
- In corporation of standard drafting stool or posture chair can compensate the height for reaching the top portion of the drawing board.
- In horizontal position of the board, the end being in line with the stand, does not obstruct for reaching the drawer unit.

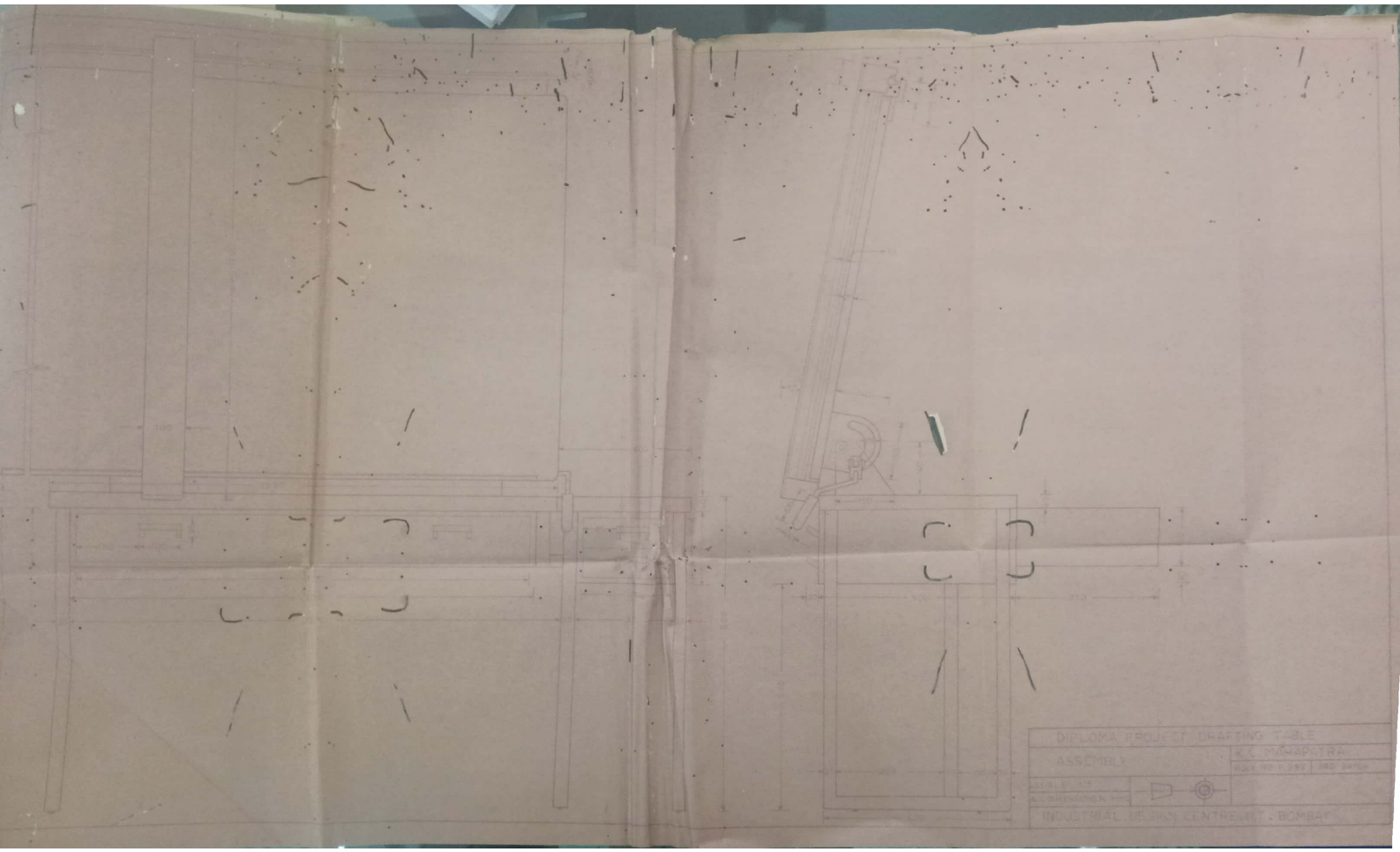


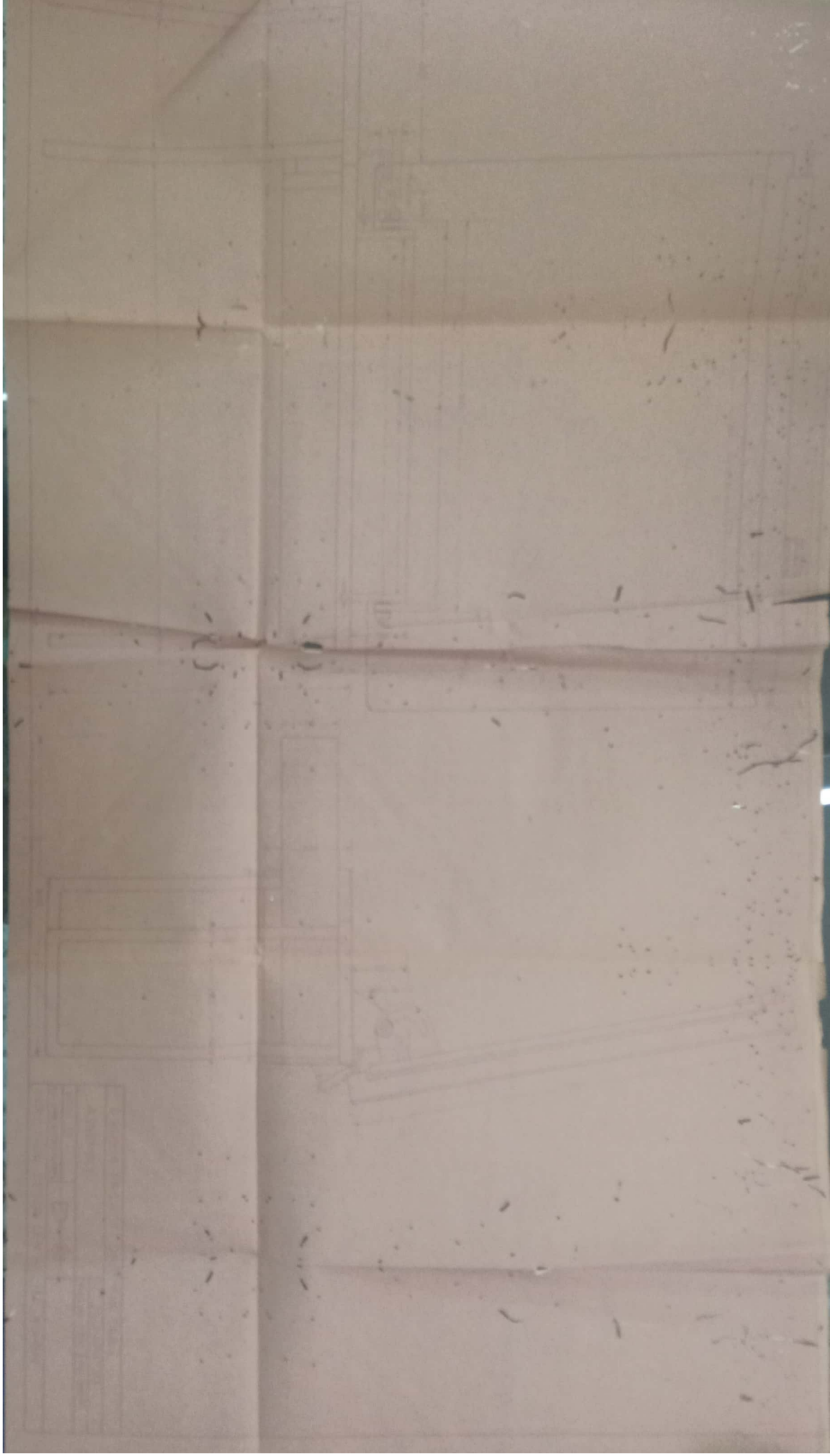


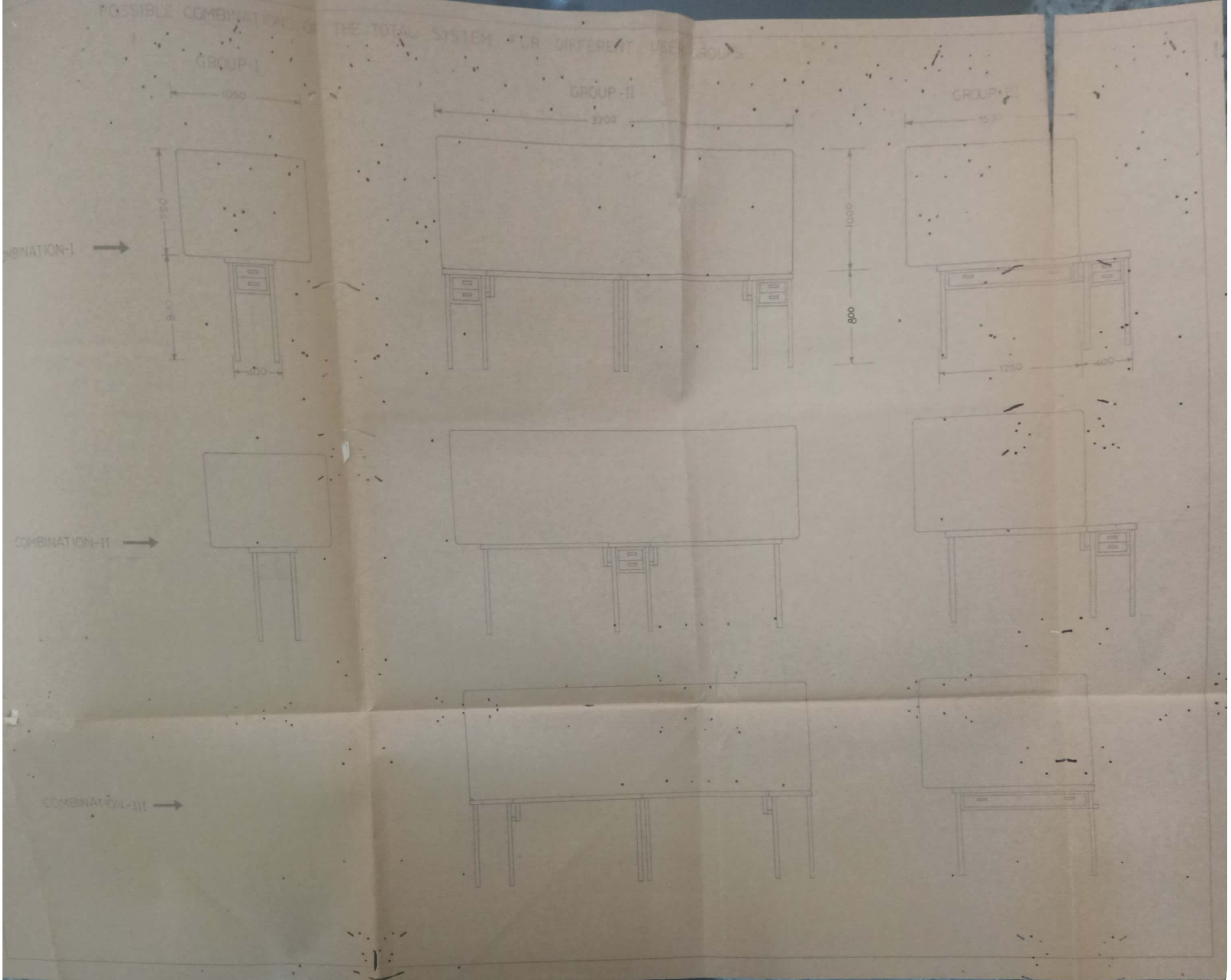












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