

SAFETY EQUIPMENT FOR WELDERS

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1973

safety equipment for welders

diploma project 72-73

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Design of safety equipment for welders

Diploma project

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

by

Liladhar Jethwa

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1. Problem statement

Design the safety equipment for welders

2. Introduction

Every industrial establishment, small and large, is now equipped with welding appliances. Welding has become one of the principal means of fabricating and repairing metal products. Modern welding methods date from the discovery of electric arc by Davey in 1912. In 1881 electric welding was first brought into use. The first practical torch having an oxy-acetylene flame for welding was used by Fouche & Picard in 1901. This method was first applied in 1903.

The vast expansion of welding processes used in industry can be judged by the amount of welding material used every year. In the U.S.A. in 1937 five billion cubic feet of oxygen and two billion cubic feet of acetylene were used for welding. In the same year 155, 310, 000 pounds of welding wire was also used.

Welding finds extensive use in the following industries - aircraft and rocket, automotive, railroad, shipbuilding, containers, furniture & fixtures, industry machinery, personal service machinery, building & bridge construction, maintenance, etc.

Welding is subject to greater hazards than any other manual or manufacturing activity, and these may lead to serious accidents not only for the workman himself, but also for those in his vicinity. For this reason safety regulations for welding have been framed by all the countries of the world.

Due to the nature of the process, the welder's body and clothing must also be protected from radiations and burns caused by flying globules of molten metal. The arc, in addition to being very bright, is a source of infra-red and ultra-violet light which is injurious to eyes and skin. The fumes also cause some problem.

3. Problem definition

Safety equipment for welders, as such, can be resolved into a broad spectrum of accessories. The enormity of scope and the large time needed for the study could not be fully visualised at the initial stages. At the time of gathering information it was decided that the work should be confined to faceshield, helmet and goggles only, nevertheless further study can be carried out for the remaining safety gadgets viz., gloves, apron and boots, should such a need arise.



4. Information

4.1

In all welding processes the welder has to protect himself against the hazards of -

. Dazzling flashes

While striking the arc the welder is unable to see the job in its blinding light, caused by the immense heat.

. Infra-red radiation

The invisible infra-red rays can be absorbed by the unprotected eyes and transformed into heat energy. This heat damages eyes lens as well as retina.

. Ultra-violet rays

The invisible ultra-violet rays cause corneal corrosion and welders then complain of chronic soreness, burning of the eyes, Lachrymation (watering of the eyes) and photophobia. Excess ultra-violet light can cause an effect similar





to sun-burn on the skin and a condition known as 'arc eye'.

. Flying hot particles

Usually the molten flux and the metal itself spatter for a considerable distance around the article being welded. The spattering consists of tiny hot particles.

. Fumes

Most of the fumes (non-poisonous) arising from welding of iron or steel consist of finely divided particles of iron oxide and some of these inhaled by the welders may remain in the lungs.



4.2

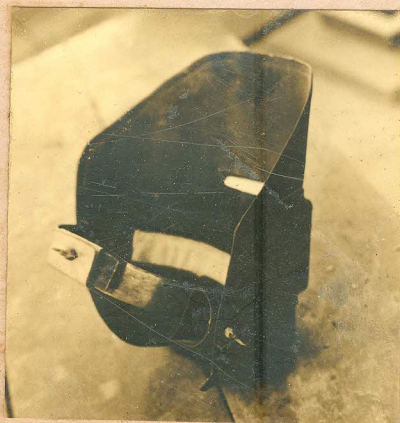
For the protection of welder's eyes & face
following safety-wares are in vogue -

Welding techniques	Safetywear	Use
Gas welding	G	
Thermit welding	G	
Flame cutting	G	Commonly used
Hard surfacing	G,H	
Carbon arc welding	G	
Unshielded arc welding	H,HS	
Inert-gas carbon-arc welding	G	
Metallic inert-gas welding	H	
Tungsten inert-gas welding	H	Not in vogue
Atomic hydrogen welding	H	
Submerged arc welding	H	
Plasma arc welding	H,HS	
Pulse arc welding	H	

G



H



HS



4.3

Salient points of Indian Standard Code of practice for safety and health requirements in electric and gas welding and cutting operations (First Revision IS 818 - 1968).



- . The material used for the protective equipment of the eyes should be heat resisting, non-ignitable and impervious to the harmful rays.

- . Minimum amount of metal should be used in the construction. Metal rivets should not be used unless one end is covered by an insulating material.

- . The adjustable band of the helmet should be made as far as practicable from an insulating material with non-absorbent properly.

- . Caps or shoulder covers made of leather or other suitable material shall be worn during overhead welding or cutting operations. Leather skull caps may be worn under helmets to prevent head burns.

- . Where there is exposure to sharp or heavy falling objects, hard hats or head protectors should be used.

- . All welding and cutting operations carried out in confined spaces shall be adequately.

ventilated to prevent the accumulation of toxic gases or possible oxygen deficiency.

. Employment of persons under 18 years of age shall be prohibited in gas or arc welding. All welders and workmen engaged in welding shall be thoroughly examined periodically.

4.4

Two types of welding shops are in existence at present -

- . The welding shop, or department, attached to some factory or manufacturing establishment.
- . The independent welding shop jobbing which specialises in repairing and fabricating metal structures by the various methods of welding.

4.5

The welders rarely use aprons and boots because of hot climate and indifference towards safety regulations. They wear the uniform prescribed by the employer.





4.6

For the inspection work, helmets have to be lifted up as nothing is visible through the tint glass in the absence of arc. This also provides the welder with much needed draught of air. For this very purpose, the welders lift the helmet frequently even when no inspection is involved.

4.7

The top cover glass (costing 20 - 30 paise) is replaced intermittently (usually after 5 - 7 days) because it becomes dirty from smoke and fumes and becomes pitted from weld spatter. The inside glasses are changed after long use.

4.8

Portable electric grinders are used to grind the finished welds prior to painting. These are also invaluable for preparing metals for welding and for cleaning finished welds.

Goggles are used for protecting eyes against the flying particles.

4.9

Goggles are frequently used in operations like gas welding, flame cutting, slag cleaning, grinding, chipping, etc. Tint glass and cover glass are housed in threaded cups.



4.10 .

During their work welders carry following articles -

- . Helmet, handshield or goggles as required
- . Gloves
- . Electrodes (usually in a box)
- . Chipping hammer
- . Steel brush

4.11

Welders work in two shifts each of eight hours. During heavy work-load they operate for 3 to 5 hours without a pause.

4.12

Usually personal protective equipment manufacturing is carried out in small scale industries but they are marketed by larger companies. However, the following companies market the safety equipment manufactured by them -

- . Indian Oxygen Limited
- . Joseph Leslie & Co.
- . Universal Industrial Corporation
- . Vishwabharati Trading Co.

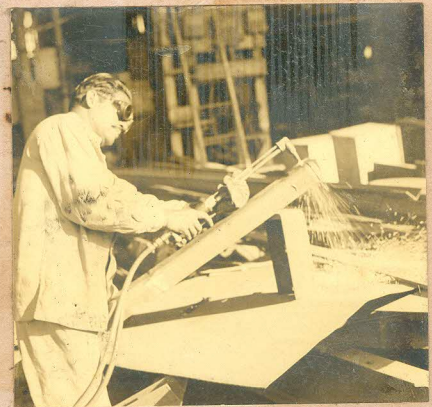
4.13

The existing market prices of headwears are as follows -

Helmets of F.R.P.	- Rs.80.90
Helmets of vulcanised fibres	- Rs.40.50
Handshield of vulcanised fibres	- Rs.25.30
Goggles	- Rs.20.25

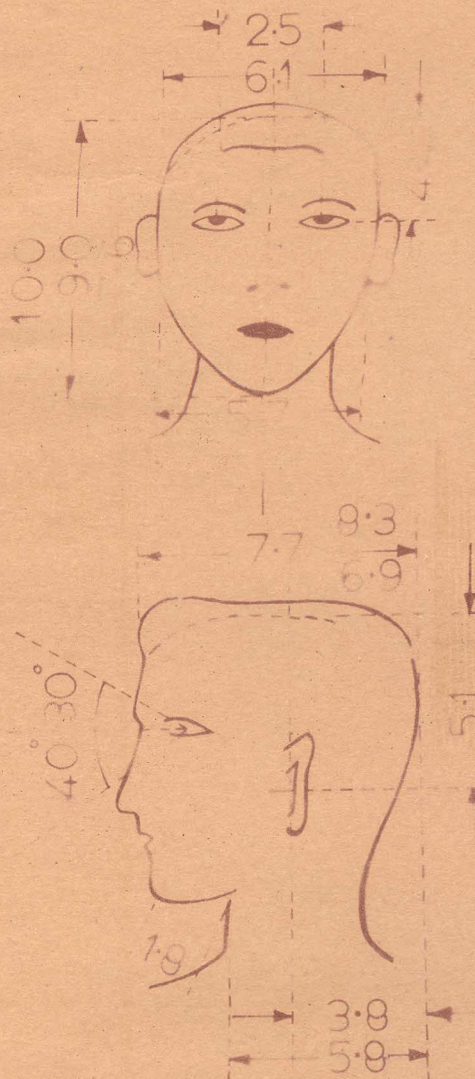
4.14

These days, goggles are usually made of bakelite and they have a fastening elastic strap. They find extensive use in gas welding and flame cutting.



4.15

Human measurements for the average adult male
from, 'Designing for people' by Henry Dreyfuss,
Simon and Schuster.



Average Weight	153 lb. (202.0-118.0)
Left Handed	6.6 %
Colour Blind	3.5 %
Hard of Hearing	4.5 %
Wear Glasses	43.6 %

4.16 Material Information

Handsheld - Black vulcanised fibre sheet, F.R.P.

Helmet - Black vulcanised fibre sheet, F.R.P., Polypropylene

Safety hat - Aluminium, bakelite, polypropylene, F.R.P., polycarbonate

Lens carrier - Wood, rubber, F.R.P.

Handle of handsheld - Wood

Material	Heat resistance F	Density gm/cu cm	Tensile strength psi	Comp. strength psi	Price Rs.	Processes	Remarks
B.V.F.	225	1.0-1.5	6000-8000	20000-30000	6/sq.ft for 1/8" thickness	Cutting, bending, riveting.	Production rate very slow.
F.R.P.	350	1.5-1.9	12000	40000	70/sq.m. for 1 mm (including process cost)	Contact moulding.	One piece/mould/ one day.
Polypropylene	250	0.910	5000	6000	12/kg.	Injection moulding.	Higher mould cost. Production rate very fast.
Aluminium	300	2.70	12000	14000	4/kg.	Pressing, die casting.	-
Rubber • natural • butyl	200 300	0.92 1.25	3000	4000	4-5/kg.	Comp.moulding, Injection moulding.	-
Polycarbonate	275	1.2	9000	11000	40/kg.	Injection moulding	-
Bakelite	175	1.3	6000	12000	7/kg.	Comp. moulding	-
Nylon	480	1.14	11000	13000	36/kg.	Injection moulding	-

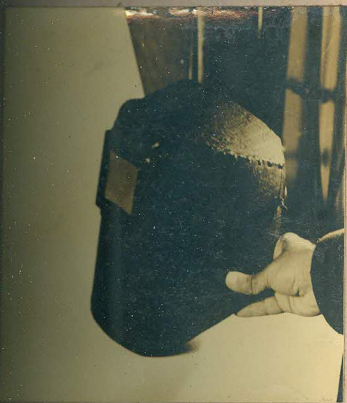
5. Analysis

For the analysis work a number of helmets, handshields and goggles of Indian and foreign make were studied.

5.1 Structural analysis

5.1.1

Structurally a helmet consists of a shell, an adjustable band and a lens holder. The lens holder houses the tint glass along with two protective glasses on either side. The latter are changed from time to time.



5.1.2

The rounding of helmet at the chin creates difficulty in the breathing. On the other hand it prevents, to some extent, injury from flying particles.





5.1.3

One fastening device consists of two separate straps locked by a fly-nut. But every time an adjustment is to be made the helmet is to be taken off. The other strap encircling the head has no adjusting facility. With gloved hands rotating the small fly-nut is difficult.



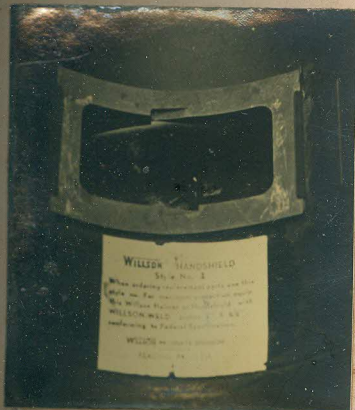
5.1.4

In one helmet the strap encircling the chin is not of any use as there is no adjusting facility.



5.1.5

The tint glass is sandwiched in between two protective glasses and the inner glass is fixed by two fly-nuts. But fly-nuts fail in providing a good grip. Often paper packing is provided. The lens and glasses do not snugly fit in the hand-made wooden frame.



5.1.6

In one arrangement the spring steel frame is pulled up and glasses are placed, but when the frame is pressed back, top glass is likely to break. On the positive side it provides a good grip.



5.1.7

Very often adjustable bands are removed and the helmet is used as a handshield. For this a temporary wooden handle is fitted to it.



5.1.8

Handles behind the front screen protect the hand from heat radiation. Handshields with protruding handles occupy more space. This aspect becomes more glaring when the work is to be carried out in a limited space.



5.1.9

The provision of two separate lenses (to accommodate the bridge of the nose) restricts the area of vision. The fastening band loses its elastic property after some time.



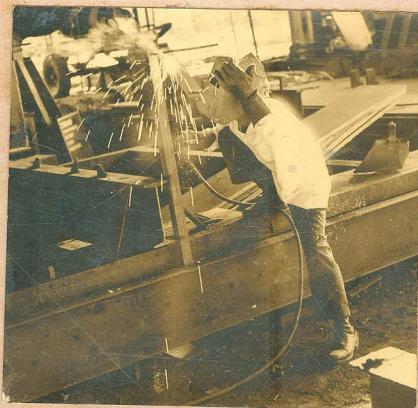
5.1.10

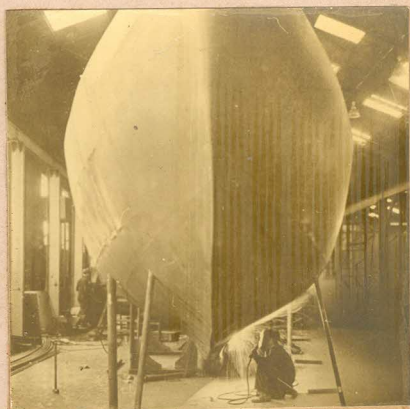
The thread fastening the suspension to the helmet is exposed hence it quickly wears out. The suspension itself, made of cotton strips and the foam cushioning get spoiled due to sweat.

5.2 Functional analysis

5.2.1

A study of the use of safetywears by the welders in different postures was carried out. The choice of posture is governed by the position of workpiece i.e. flat, horizontal, vertical, overhead and lying etc. Often objects whose positions cannot be frequently changed because of its bulk, setting time and handling difficulties demand that the welder should carry his work in inconvenient postures too.





5.2.2

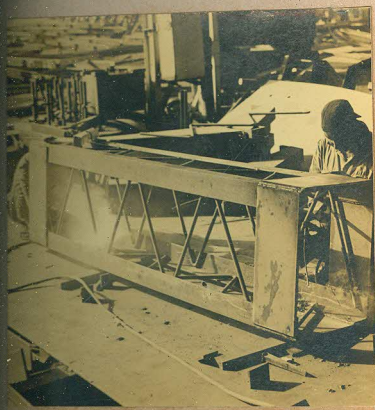
Mode of working -

- . Study of the marked welding area, drawing, etc.
- . Adjustment of welding machines like transformers, motor generators, rectifiers, etc.
- . Wearing gloves and helmets
- . Fixing of electrode in the electrode holder
- . Striking the arc
- . Running continuous beads
- . Intermittently checking the quality of weld
- . Replacement of electrodes
- . Slag removal by chipping
- . Dragging of cable, carrying electrodes
- . Switching off the machine, keeping all the welding accessories in respective places.



5.2.3

In overhead welding, the kneeling position of the welder causes strain in the thigh and the neck leading to fatigue. If the mask slides the welder has to hold it with one hand in this process.



5.2.4

In the case of structural welding, as for example - welding of roof trusses and objects with irregular contours the welder has to acquire postures according to the limitations placed by space, protruding bars, accessibility, etc.



5.2.5

Working at an elevated point the welder has to rest his shoulders, buttocks or hand against some rigid support in order to maintain balance. This aspect becomes more glaring when the welding is carried out at outdoor sites.





5.2.6

The top portion of the helmet does not protect the head fully in overhead welding against flying globules. Welders use cotton skull caps or handkerchieves under helmets to prevent head burns.



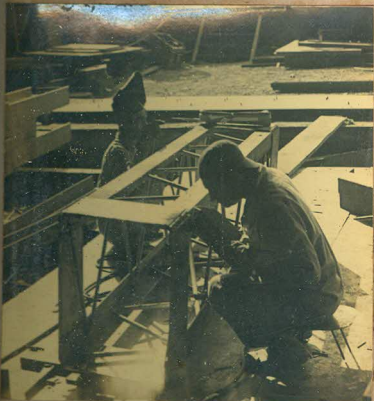
5.2.7

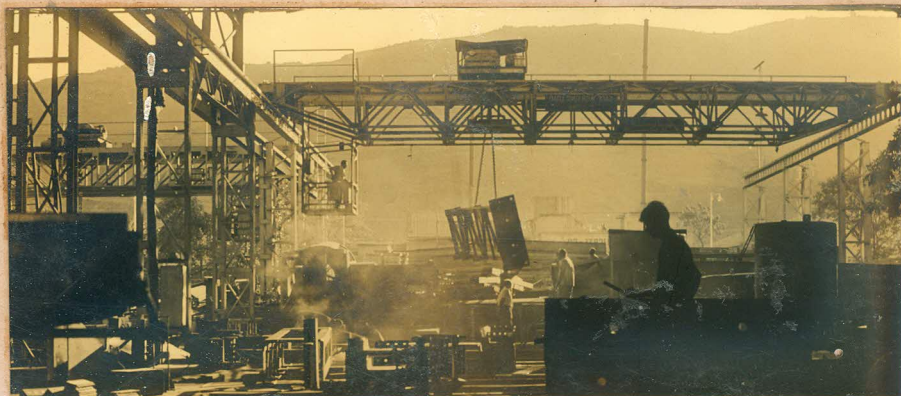
Welder's both hands are engaged when filler rods and flux coated electrodes are used. In such cases the handling of helmet is reduced.



5.2.8

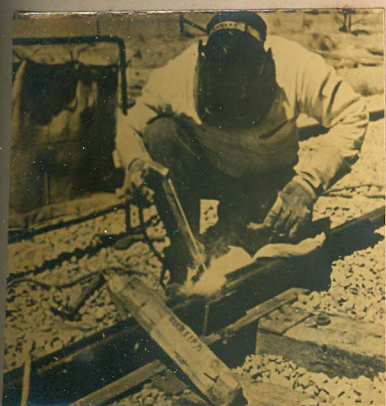
Working as a team on the same job some of the welders have to raise the mask for inspection and removal of slag, thus exposing themselves to flashes and flying particles.





5.2.9

In welding organisations, material in the form of sheets, angles, rods etc. is shifted from corner to corner by overhead cranes. Welders work in unsafe condition due to exposed sharp edges and accidentally falling objects.



5.2.10

In outdoor welding like site construction work, pipe welding etc. welders do not have any protection against sun.

5.2.11

In small weld the welder himself removes the slag by chipping with his helmet raised. He does not have any protection against flying particles.

5.2.12

The welder has to frequently raise his helmet for the following petty works -

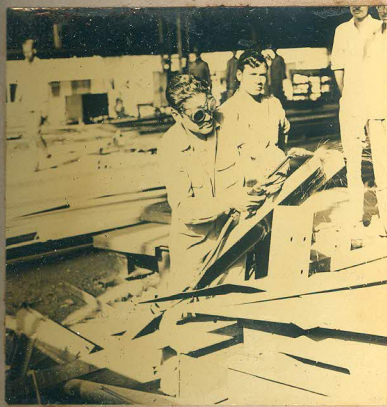
- . removal of electrode stub
- . fixing of new electrode
- . bending of electrode
- . inspection of weld
- . slag removal by chipping
- . dragging of the cable
- . to act upon warning calls



In this way the welder is deprived of helmet's protection for about 8 to 10 minutes in an hour.

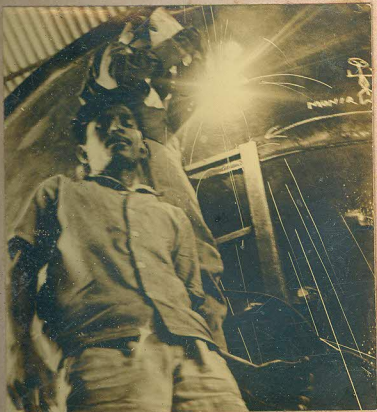
5.2.13

Due to the elastic band the goggles cup the eyes fully, leading to lack of ventilation in that region. This further increases the discomfort as mist is formed on the lenses blurring the vision.



5.2.14

The use of a helmet is a must while the welder is on the rungs of a ladder, a freehand in such a situation helps in balancing. Usually a helper behind him carries electrodes and drags the cable.



5.2.15

In long run adjustable bands made of vulcanized fibres and elastic straps of goggles become damp due to sweat and might rot.

5.2.16

The existing vulvanized fibre sheet face-shields and helmets are painted afterwards. In long run paint layer starts peeling off leaving an ugly surface.

5.3 Formal analysis

5.3.1

The aesthetic value in protective devices of welders is lacking because of following reasons -

- . These are fully function oriented items.
Provision of safety is the ultimate object.
- . These are very roughly and carelessly used.
Always exposed to radiation, sun, dust, etc.
- . Being nobody's personal property fail in developing the feeling of possession.
- . Limitation of materials and processes.
- . No competition in the limited market.
- . Users are not much reactive against the existing design and thus manufacturers are reluctant to effect any improvement.

5.3.2

The hollow and round form of the helmet makes it unstable while kept inverted on a plain surface. Because of its hollow shape welders very frequently keep gloves, wire brush, hammer, etc. inside it.



5.3.3

Exposed rivets on the outer surface, sharp formal transition above the window, naked and warped edges and ugly lens holder fitting spoil the overall appearance of the handshield and helmet.

5.3.4

Black colour having low reflectivity, is not the only suitable one for helmets and handshields.



[illegible]

-
- A close-up photograph of a wooden surface, likely a boat hull, showing a circular metal fastener or plug. The wood grain is prominent, and the fastener has some text or markings on it.





5.4 Socio-economical analysis

5.4.1

Being nobody's personal property a helmet has to be the victim of rough handling from the negligent welders. Often a helmet can be seen to be taken off and thrown carelessly on the floor, it being abraded heavily in the process. More often a helmet is used as a bowl for keeping gloves, goggles, electrodes, chipping hammer, brushes, etc.



5.4.2

Welders are often indifferent towards the well-being of helmets, as its replacement does not cost them anything. Sometimes for reasons of fitting and conformity, they may have some attachment with it, so they pring their names on their helmets despite the orders not to do so.



5.4.3

The welders show indifference towards safety rules for want of safety mindedness, however, they follow a few rules more for reasons of their own comfort than for those of safety. In the absence of strict governmental control, the employers too, make little effort to ensure the compliance of safety rules by the workers.

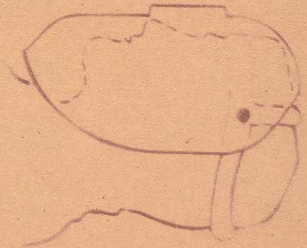
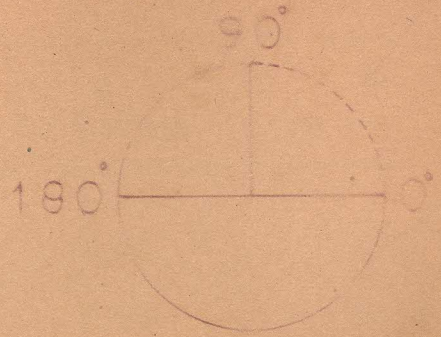
5.4.4

The marketability of safety equipment largely depends upon the reputation of the seller. A buyer can pay more if he is satisfied about the quality of the goods.

5.5

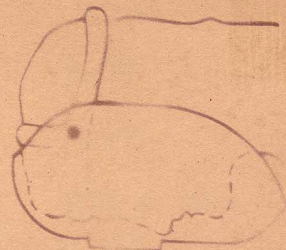
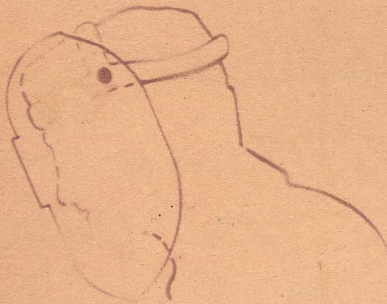
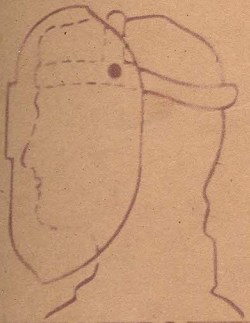
Ergonomical Study

(Positions of head)



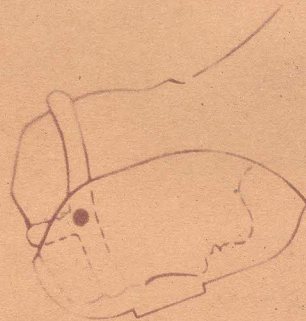
0-90° RANGE

Used on demand. Workpiece manipulated to acquire 90-180 range.



90-180° RANGE

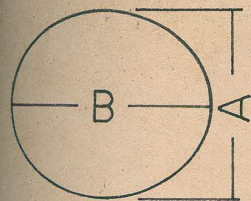
Frequently used.



180+° RANGE

Rarely used.

Skull measurement in a sample of twelve men -



	A in inches	B in inches	C in inches
1.	6.20	7.80	3.50
2.	6.25	7.90	3.55
3.	6.40	8.10	3.70
4.	6.10	7.70	3.40
5.	6.10	7.70	3.40
6.	6.15	7.80	3.40
7.	6.10	7.70	3.40
8.	6.20	7.80	3.50
9.	6.10	7.70	3.40
10.	6.20	7.80	3.50
11.	6.20	7.80	3.50
12.	6.30	7.90	3.60

average 6.19	7.89	3.49
adopted 6.20	7.90	3.50
i.e. 157.5 mm.	200.6 mm.	88.9 mm.

At extreme position of chin

X - 260 mm.



6. Hypothesis

6.1

All the headwears for the welders (helmet, handshield and goggles) should provide adequate protection against the hazards which the worker will be exposed to -

- . helmet and handshield should be able to protect the top portion of head from hot flying particles.
- . recommended grade of the filters should be used. Should be protected by cover glass from both the sides and chemically treated cover glass should be used for longer life.
- . the sides of the shield and shape should such to protect the neck and side of the head with proper ventilation.
- . all the headwears should accommodate the personal spectacles in them.
- . the handle of the handshield should comfortably come in the gloved grip and should be covered by the front portion without protruding out.

- a lifting type of lens holder which flips up instantly at the touch of the finger could protect the eyes and face from hot scale when inspecting hot welds and from flying particles of slag when chipping, grinding, etc. through the clear cover glass in the stationery section.
- interior of the helmet and handshield should be coated with non-reflective black paint.
- safety hats and helmets should be of smooth design and should have no pockets or turned up edges that will hold hot globules of metal.
- safety hats should have ribs to strengthen the section; these also distribute the impact of falling objects.
- instead of two separate lenses in the chipping goggles, one piece lens could give an ample view of the workpiece.



6.2

Welders should use safety hats for their protection from electrical hazards, exceptional impact, penetration protection and exposure to sun.



6.3

All these safetywears should provide maximum comfort and should have minimum weight compatible with protective efficiency.

6.4

Due to these equipment there should be no restriction of essential movements or work objectives.

6.5

All head safetywears should have some interchangeability giving the safe combination for each job (like gas welding, flame cutting, grinding, hard surfacing, etc.) and simplifying the stocking problem.

6.6

Safety hats and caps could advertise the welding organisation on job sites or in plants when identification is permanently visible on the fronts. To promote uniformity and team spirit, a user organisation might order for a special colour scheme of the helmet.

6.7

Following materials could be used for different headwears -

helmet - vulcanized fibre sheet, F.R.P.

polypropylene

handshield - -do-

goggles - acetates, nylons, polycarbonate
bakelite

safetyhat - bakelite, polypropylene

6.8

Helmets could be made more attractive by using green, grey or blue colour instead of black. Experiments have proved them equally efficient so far their low reflecting quality is concerned.

6.9

Should have durability and whenever possible, susceptibility of maintenance on the premises where used.

6.10

Construction should be in accordance with accepted standards for performance and materials.

7. Design decision and solution

The study revealed that the main emphasis in the design of safety equipment should be placed on, apart from safety aspect, the comfort and convenience of the user.

The non-adherence to safety rules due to the indifference of the welder and his employer towards them, places a serious responsibility on the designer's shoulders; that is, the safety aspect should be inherent in the equipment. In such a case the user of the equipment will ensure the observance of safety regulations to a greater extent.

The suggested solution consists of three main parts viz. safety hat, faceshield and goggles. Of these, the safety hat finds its use in all industries against the hazards of falling objects and sun. The remaining two have been so designed that they can be mounted on the safety hat when welding is involved.

Since the various components in the suggested solutions are interdependent, the cost may not be very welcomed with the smaller industrial establishments. The lead, under such circumstances, will have to be taken by the larger industries in using this compact set of safetywears. In due course of time the advantages flowing from such a package deal will be self-advertising and the smaller industries will follow suit.

The changes envisaged in the new design are given below:

Faceshield

1.

Glass reinforced plastic was selected as the material for faceshield because of following properties - advantages strength/weight ratio, corrosion resistance, low capital and production cost, heat resistance and insulation, versatility of shape etc.

2.

Contact moulding was suggested because of the low cost of wooden moulds and also it will

be suitable for batch production of face-shields.

3.

The faceshield attached with the safety hat protects the welder's head from flying particles and falling objects. The safety hat alone protects the welder from sun during outdoor welding. The top contour of the faceshield was so designed that on swinging upwards it would glide along the contour of safety hat and would remain there while welding is not carried out. The fixing of faceshield on the safety hat was so located that its weight will keep the hat in its position; it does not have any tendency to tilt the hat at the forward end.

4.

A lifting type of window was provided which can be flipped up at the touch of a finger and would maintain its 'open' position due to spring action. In this position of window the welder can carry out chipping, fixing and removal of electrodes, inspection of weld, etc. ; he has a clear view through the plain glass of the stationary frame. While welding the welder will collapse the window which houses the plain and tint glass in it.

5.

The fixing of plain glass in the stationary frame and the collapsible window was achieved by the spring action of wire thus making the replacement simpler with gloved hands too.

6.

The faceshield, when not mounted on the hat, can be used as a handshield too. For this, readymade handles can be quickly fixed to the shield. The handle was designed for a good grip in gloved hands.

7.

The shape of side wings and the depth of the helmet was so decided to give ample protection to the neck and the sides of the face along with proper ventilation. It also facilitates the use of personal spectacle.

8.

Two knurled knobs of suitable dimension were used for fixing of faceshield to the helmet which can be comfortably rotated with gloved hands. The tightening force was controlled by two springs placed between the knurled knob and the safety hat.

9.

One piece moulding of the faceshield and the concealed fixing arrangement of window impart an elegant look to it.

Safety hat

1.

Being a mass produced item injection moulding of polypropylene was used for the manufacturing. Such hats with shining finish can be made in some standard colours like white, yellow, blue, orange, etc.

2.

For accommodating the impression of company's name, initials or monogram by hot stamping process, a plain surface was provided in the front of the hat.

3.

Sufficient clearance between shell and suspension was provided to permit each to work in conjunction with the other to absorb impact and to dissipate its force.

4.

Polythylene strips were selected for suspension to guard against rot, sour or mildew. Rexin covering stitched over a thin strip of foam forms the inner lining of suspension. At each headband attachment point there were three button hole selections to adjust for better comfort fit. The eight point attachment of suspension with fixed section of hat provide safe shell clearance.

5.

Suitable openings were provided on both the sides of the hat to give ample ventilation.

6.

The distribution of ribs on the hat was so designed to serve dual purpose of strengthening the section and improving the external appearance.

Goggles

1.

The facility of attaching the goggles with two side arms on the safety hat provides ample ventilation and comfort to the welder as adequate gap is present between the eyes and the goggles. This will also eliminate the problem of misting.

2.

The shape of the frame was so designed as to match with any facial contour including the personal spectacle.

3.

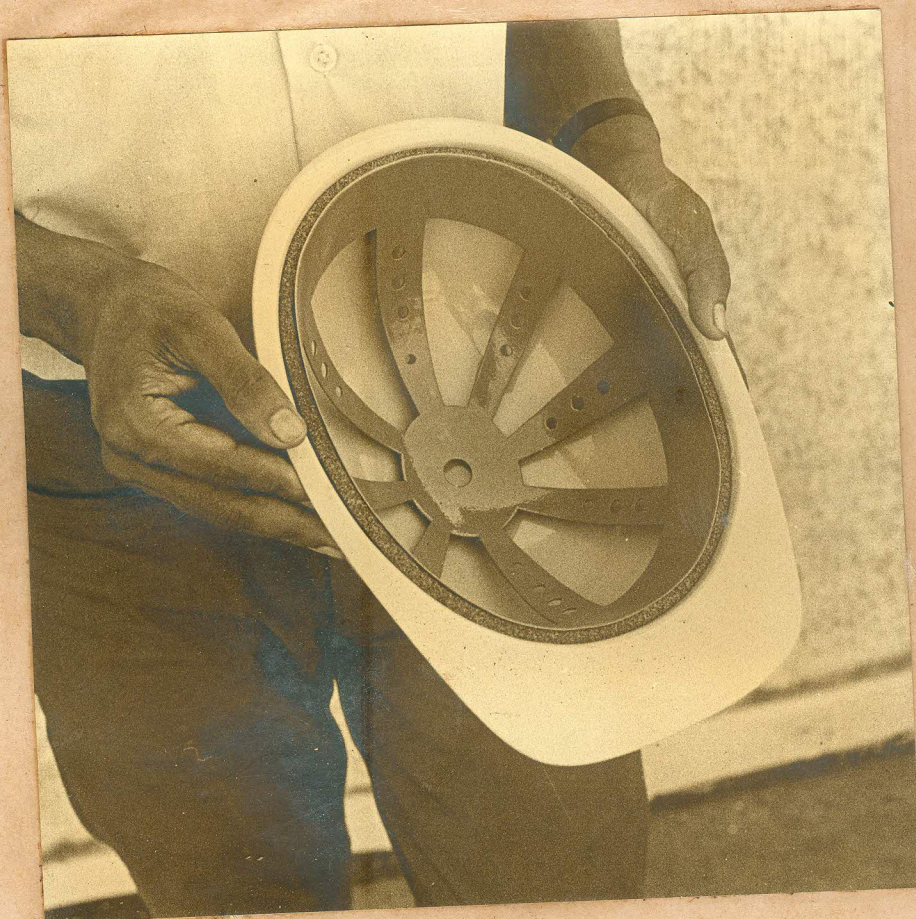
The rigid glass holder, integral with the body, was proportioned to take wide angle, one-piece lens to give an adequate view of the work piece.

4.

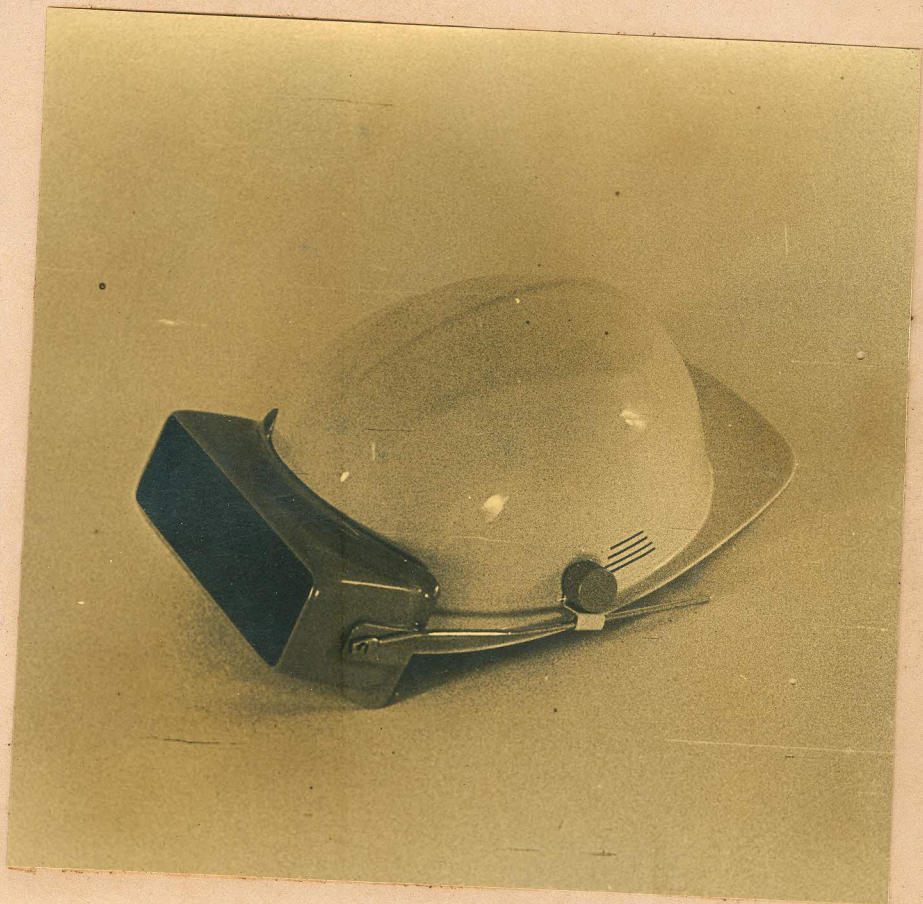
Injection moulding of flame resistance cellulose acetate butyrate was selected for the manufacturing of such goggles.

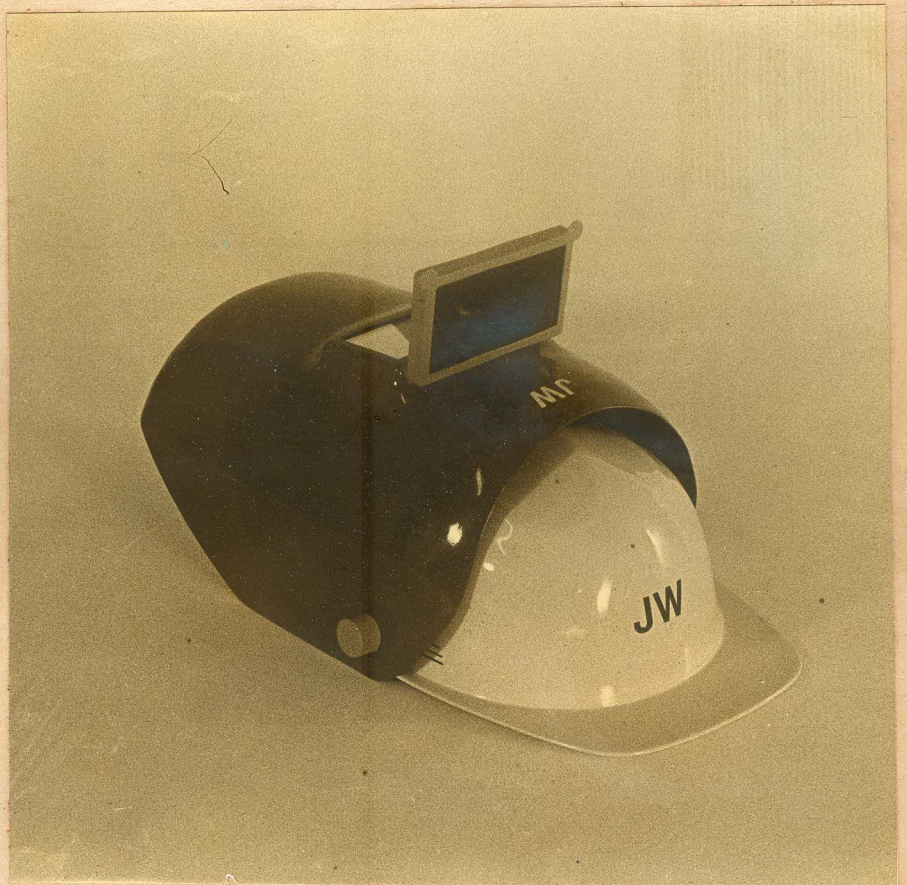
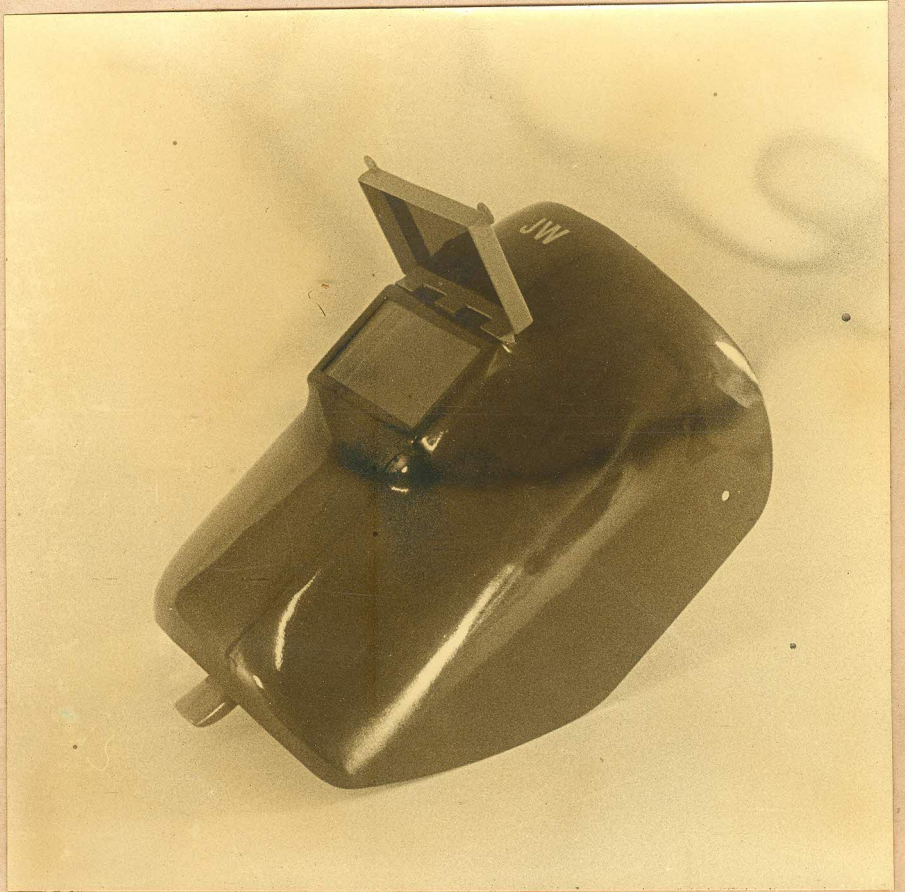
8. Communication

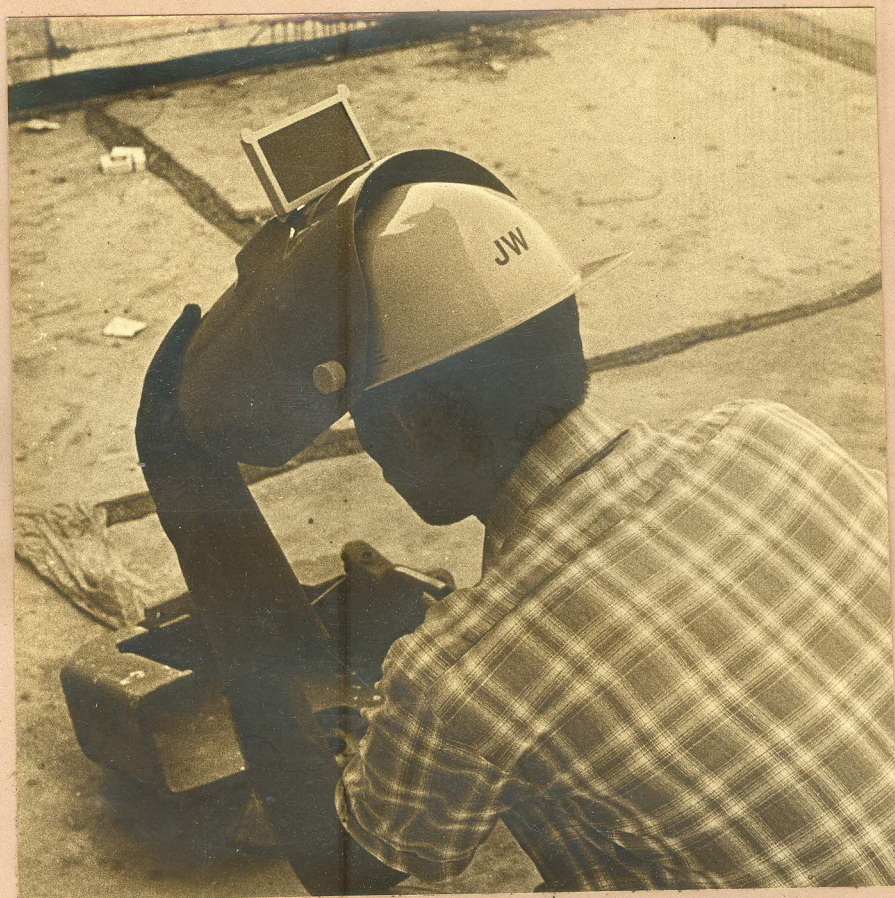
- . Photographs
- . Technical drawings

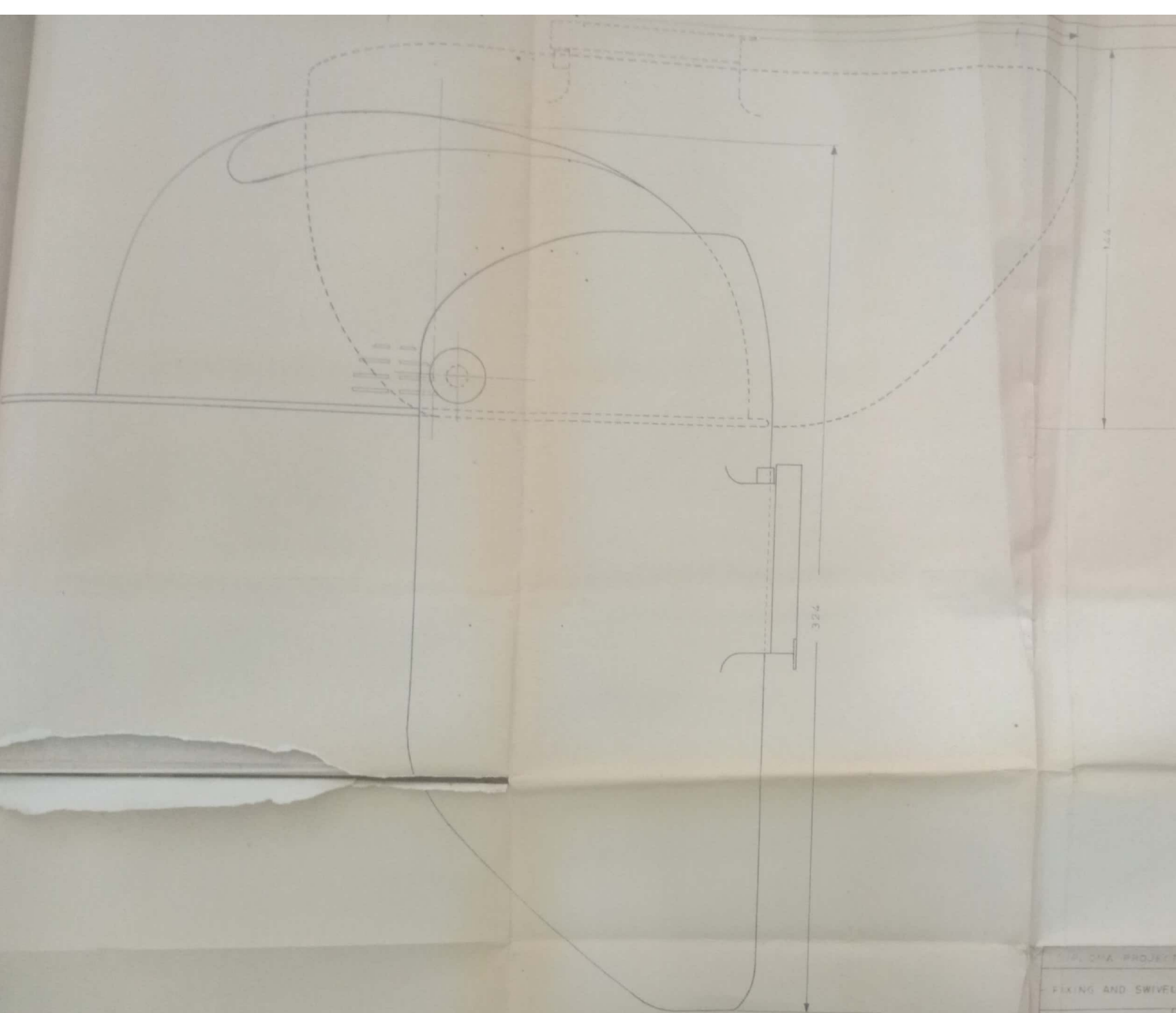


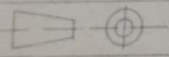
I. D. C. Library
L. L. T. Bombay.

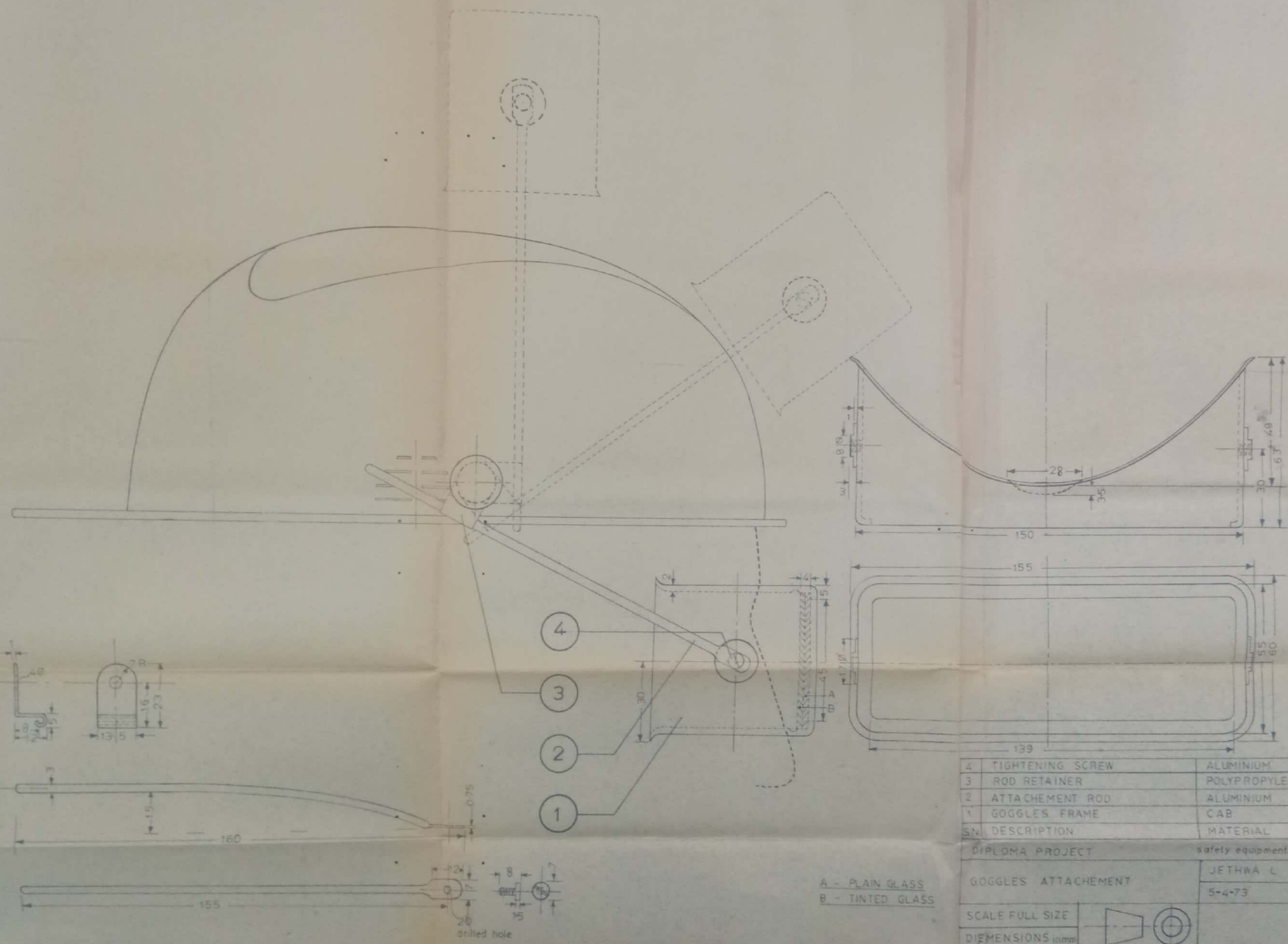








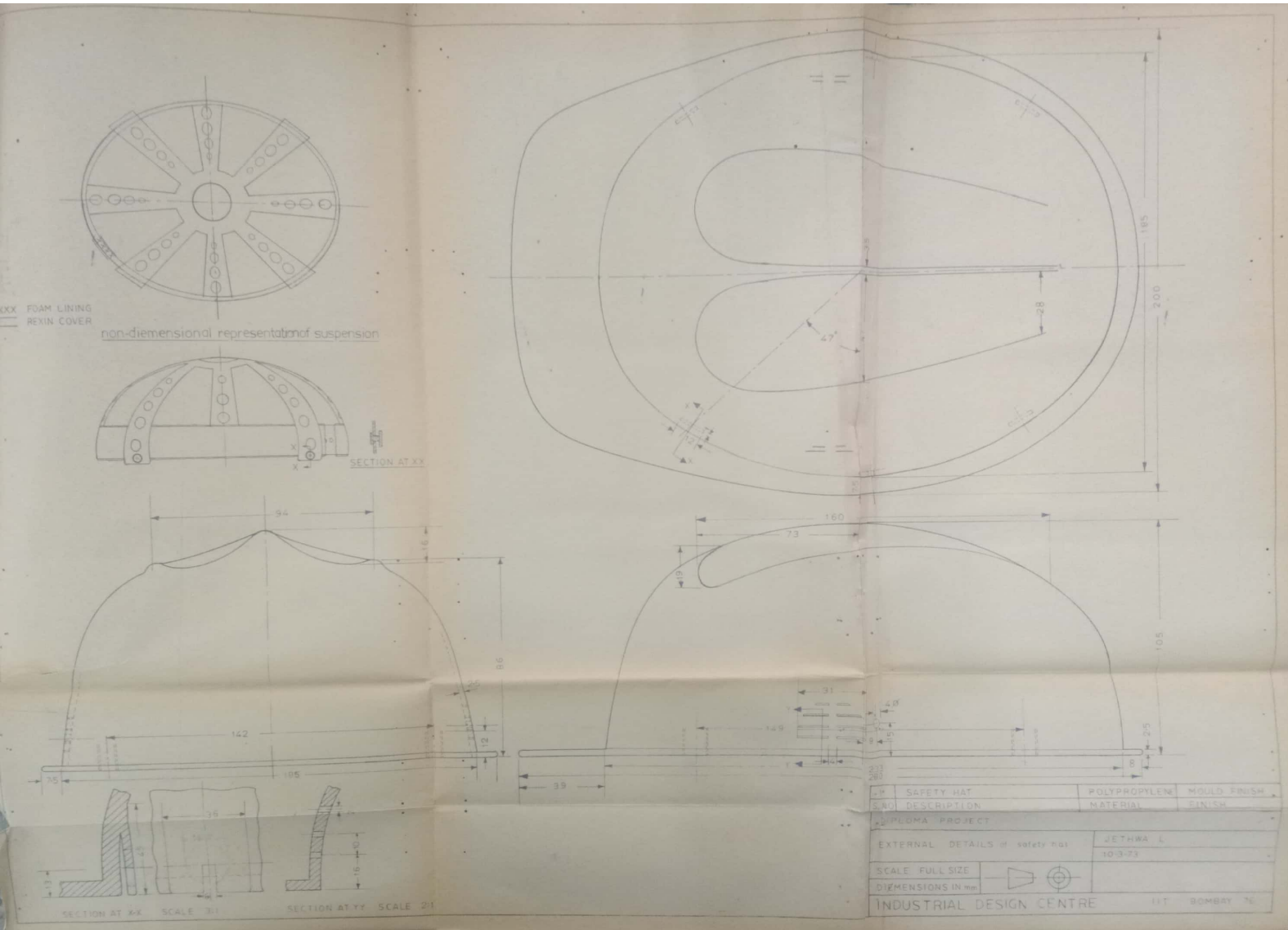
INDIA, OPA PROJECT		safety equipment for welders	
FIXING AND SWIVELLING OF faceshield		JETHWA L	
SCALE FULL SIZE		16-3-73	
DIMENSIONS in mm			
INDUSTRIAL DESIGN CENTRE		IIT BOMBAY 76	

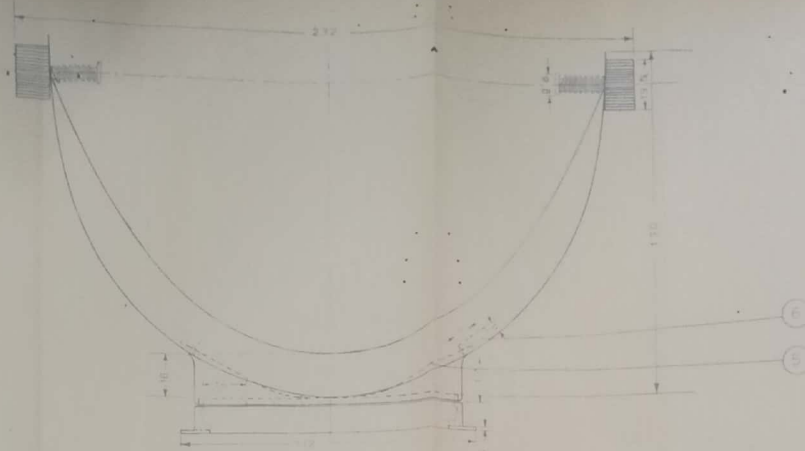
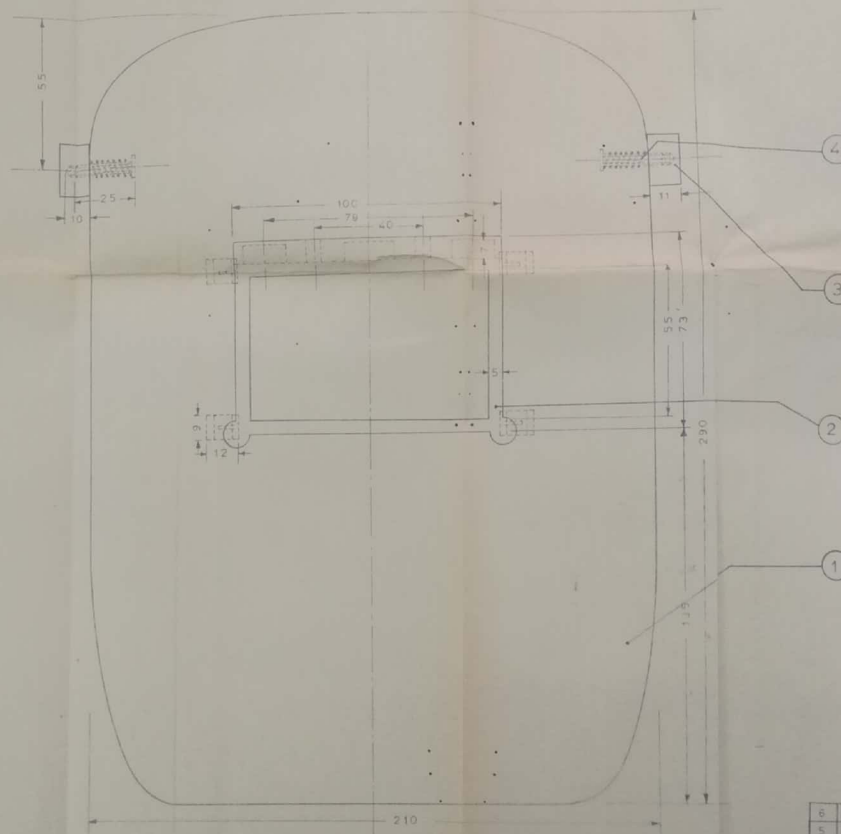
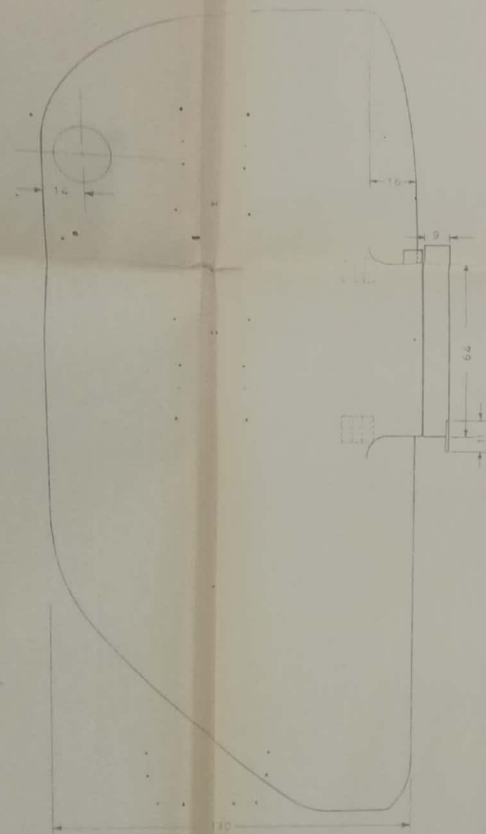


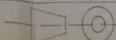
4	TIGHTENING SCREW	ALUMINIUM	
3	ROD RETAINER	POLYPROPYLENE	MOULD FINISH
2	ATTACHEMENT ROD	ALUMINIUM	CHROM PLATED
1	GOGGLES FRAME	CAB	MOULD FINISH
SM	DESCRIPTION	MATERIAL	FINISH
DIPLOMA PROJECT		safety equipment for welders	
GOGGLES ATTACHEMENT		JETHWA L	
SCALE FULL SIZE		5-4-73	
DIMENSIONS in mm			
INDUSTRIAL DESIGN CENTRE		iit bombay	

XX FOAM LINING
REYN COVER

non-dimensional representation of suspension





6	WIRE HOUSING BLOCK	FRP	
5	PRESSING WIRE	SPRING STEEL	
4	SPRING	SPRING STEEL	
3	ADJUSTING KNOB	BAKELITE	KNURLED
2	GLASS HOLDER	POLYPROPYLENE	MOULD FINISH
1	BODY	FRP	MOULD FINISH
S.No.	DESCRIPTION	MATERIAL	FINISH
DIPLOMA PROJECT		FACE SHIELD	
EXTERNAL DETAILS		JETHWA I	
		2-3-77	
SCALE FULL SIZE			
DIMENSIONS IN mm			
INDUSTRIAL DESIGN CENTRE			
BOMBAY 76			

9. Appendix

List of industrial establishments where welding operations were studied in detail -

- Kamani Metals and Alloys Ltd., Kurla
- Vikhroli Metal Fabricators Ltd., Vikhroli
- Indian Oxygen Ltd., Ghatkopar
- Surendra Engineering Works, Saki Naka
- Main Workshop, I.I.T.

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