REDESIGN OF PORTABLE GAS CUTTING MACHINE

DIPLOMA PROJECT
SUBMITTED IN PARTIAL
FULFILMENT OF THE
REQUIREMENT OF THE
POSTGRADUATE DIPLOMA
IN INDUSTRIAL DESIGN

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FOR THE POSTGRADUATE DIPLOMA
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1. INTRODUCTION

In recent years, oxy-cutting has come to the fore, consuming a lion's share of all the oxygen used by the welding and cutting industries.

Among the processes for preparing plate material for welded fabrication, flame cutting takes a prominent role in almost any engineering industry, including metal making, shipbuilding, boilermaking locomotive building, building construction etc.

Based on semi automatic and automatic machines, it has brought with it unprecedented production rates.

The basic trend in today's flame technology is towards the ultimate in process mechanisation, the use of special purpose equipment of high efficiency, automatic process monitoring and control.

In India, today, numerous type of cutting machines are available, ranging from simple hand steered blowpipes to most sophisticated, special purpose profile cutting machines using photo-electric cell.

A tractor run, portable gas cutting machine, used for straight and circular cuts is one type of machine in the range, which is low cost and versatile. It has application in general engineering, construction and fabrication etc. Whats more, the machine is cheap enough to fit the budgeta of small scale industries which are incidently , rapidly forming the backbone of the industralisation program of our country.

The low cost and simplicity in production should enable the small scale industries also to produce it, thus creating competition and improving the design or bringing down the cost even further. Ironically, this is not so. There are very few manufacturers in this line and they have the market all to themselves. The buyer (?), thus has to do with whatever quality he can get and pay whatever he is asked to which incidently is unjustified. This can be seen from the fact that, Indian Oxygen Limited (IOL) is the only large scale manufacturer of the machine.

The machine, therefore, has to be redesigned keeping in view all the important aspects of aesthetic, economic, functional and ergonomic

and
~~with~~ improving the dependability, so that it can be made competitive not only in the domestic market but also in the international one.

2. PROBLEM STATEMENT

The existing portable gas cutting machine needs a re-design on many accounts.

In order to take care of the drawbacks in the existing machines, and therefore to augment the feasibility of the machine, important aspects like functional, structural, ergonomic, aesthetic, low cost etc. would be emphasised.

3. INFORMATION AND DATA COLLECTION

3.1 Flame Cutting

The process of flame cutting consists of heating the steel plate along a predetermined path, to combustion temperature (about 900°C) causing rapid oxidation by supplying a jet of pure oxygen, and blowing away the iron oxide thus formed and any molten iron particles under the pressure of the oxygen jet. The heat freed by the chemical reaction helps in the preheating of further portions to be cut, and less heat is required to continue cutting after a start has been made, then is required for starting the cutting operation.

Only those materials can be flame cut whose combustion temperature is below their melting temperature, as otherwise the material would melt away before oxidization and a clear cut edge could not be obtained. It is also important that the melting temperatures of the oxides lies below that of the parent material. Nonferrous metals cannot, therefore, normally be flame cut. Cast iron and stainless steel need special procedures and even then a flame-cut edge of the same quality as with steel is difficult to obtain.

When the flame-cutting process was originally developed at the beginning of the century, hydrogen was used, as fuel gas, but to day acetylene is the fuel most frequently used. Coal gas and propane are also often used.

3.2 Data Collection

The project commenced with data collection from a literature survey, and from manufacturers sellers and users through questionnaires and discussion.

Date collection consisted of the following:

3.2.1 Literature survey of magazines, books on gascutting and welding from Central Library of I.I.T.Bombay. These books and magazines yielded useful information about different types of cutting machines ranging from simple hand operated ones to highly sophiticated ones working on photo cell. We will discuss some of the commonly used in brief.

3.2.1.1 Blow pipe

A simple hand operated cutting blow pipe working on oxy acetylene is shown in the figure 1. It provides the oxy-acetylene

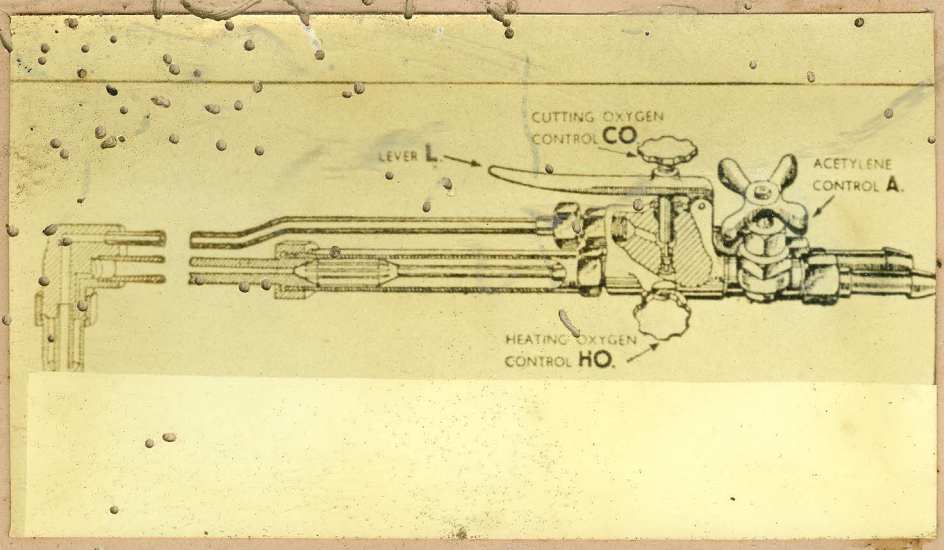

CUTTING OXYGEN
CONTROL CO.
LEVER L.
ACETYLENE
CONTROL A.
HEATING OXYGEN
CONTROL HO.

fig 1

flame which heats up the material up to combustion temperature, and it supplies the oxygen jet which is thrown on to the part to be cut. The mixed gasses for heating flame leave the blow pipe through numbers of orifices surrounding a central nozzle opening which supplies the cutting oxygen jet.

Valve hand (A) serves for controlling the acetylene supply, handle (HO) for adjusting the flow of the heating, handle (CO) for adjusting that of the cutting oxygen. Heating and cutting oxygen are both taken from the same oxygen supply which is divided by the valves controlled by handles (HO) and (CO). After the gas supplies have been adjusted, the operator heats the material to be cut, with a neutral oxy-acetylene flame pressing down lever (L) in order to cut off the cutting oxygen supply. After the material has reached the required heat, the cutting oxygen is turned on by a allowing lever (2) to go up, and the oxygen jet passes through the flame.

3.2.1.2 The efficiency of the cutting operation of the quality of the cut can be greatly improved by guiding the blowpipe

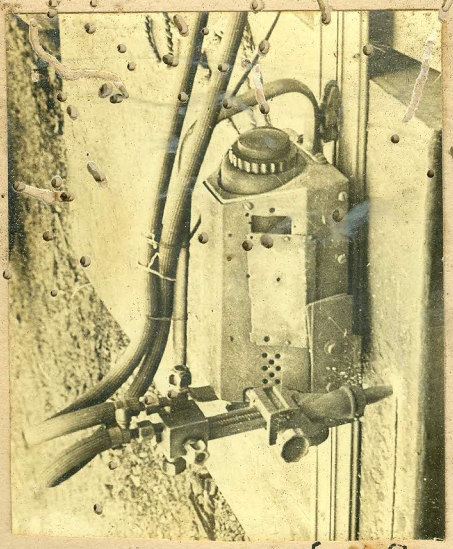


fig 2

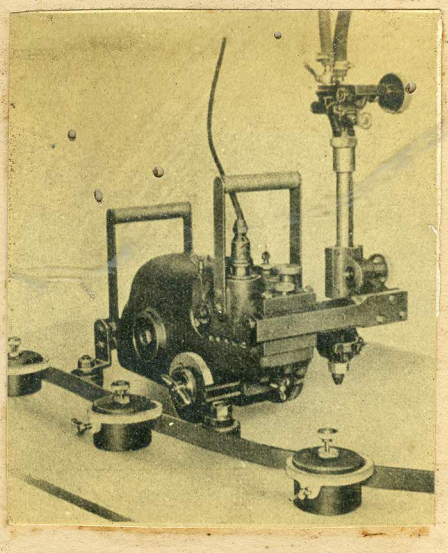


fig 3

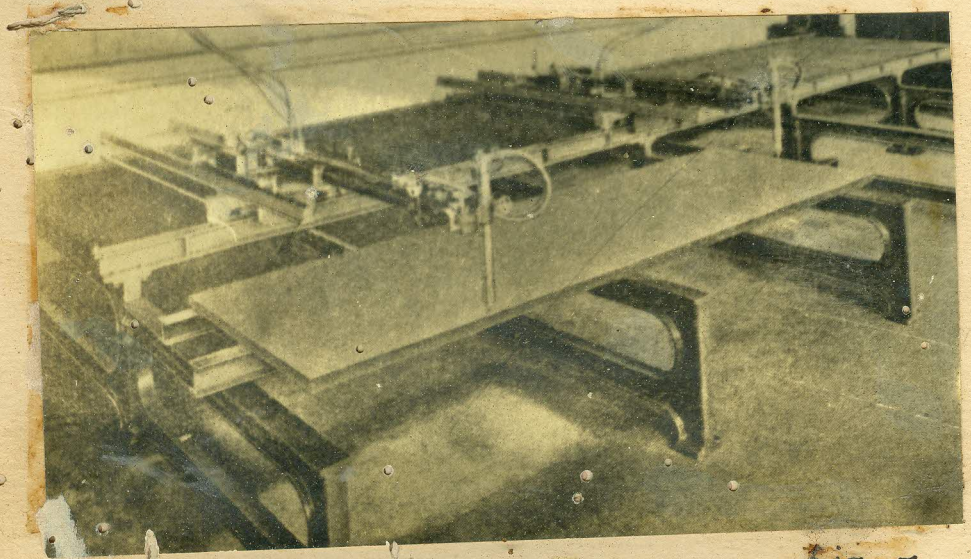


fig 5

mechanically , instead of relying upon the obviously varying steadiness of the operator's hand. Portable blowpipe carrying apparatus is often supported by the plate itself to be cut (fig.2) and guided either by a template in accordance with the desired profile to be produced (fig.3) or in case of cutting circular shapes by a radius bar (fig.2).

fig 4

3.2.1.3 Portable cutting machines may also be supported and guided by a rail arrangement (fig.4). A small electric motor and a speed change device drive the wheels which give the machine the required cutting speed.

3.2.1.4 For cutting plate components covering a large area, profiling machines of the type shown in fig 5 have been developed. Here the cutter slide carries at the rear end the motor-driven tracer roller, and at the front end the cutting blowpipe, templates being fastened to the table in the rear of the photo, and the cutter carrier following their profile through its two-dimensional sliding arrangement.

3.2.1.5 For cutting smaller components panto-graph machines (fig.6) are used. In these

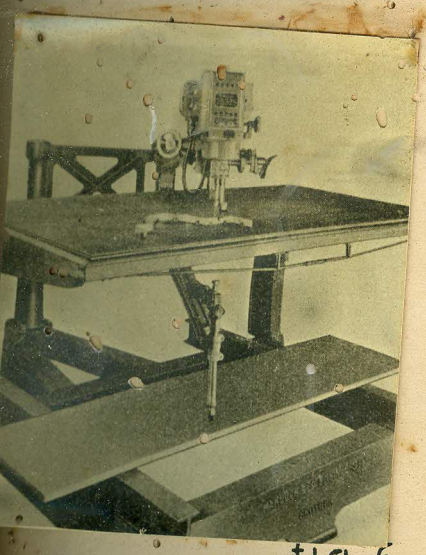


fig 6

machines, a template guides the pantograph arms in parallel, more than one component can be reproduced from one template.

Magnetic rollers, or twin roller are used for holding the guiding device in contact with the guiding template and feeler fingers or tracers are used for hand guiding the pentograph arm along the outlines of a template or a drawing.

3.2.1.6 The tracing mechanisms employed in stationary cutting machines may be of the mechanical, eloctromagnetic, or photo cell type.

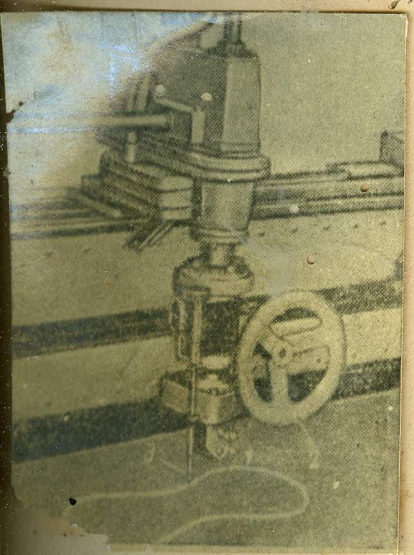


fig 7

Mechanical tracing heads are usually moved by hand around a drawing or the contour laid out on the plate, and the torch follows the profile (fig.7).

The head has a knurled guide roller I which travel over the tracing table and moves the torth carrying arm. in the desired direction. When cutting from the drawing, the roller is guided by a handwheel 2. The head has an index 3 whose point is directed along the drawn profile.

Magnetic tracing heads depend for their operation on steel templates. The key part of a magnetic tracing head is a steel knurled magnetised roller driven by an electric motor. The roller adheres to the steel template along which it moves. The torch coupled to the tracing head describes the motion of the roller. The drawback of magnetic tracing heads is that they require a large number of steel templates which adds to cutting costs and take up storage space. These drawbacks are non existing in photo-electric heads.

Automatic photo-electric tracing from full size drawings may be employed on any flame-cutting machine. For example it can be used on the machine shown in fig.7 fitted with a mechanical tracing assembly and a photo cell scanning unit, which automatically follows the contour of a drawing and guides the mechanical head which is rigidly coupled to the torch.

3.2.2 Manufacturers

In India, there are very few manufacturers of portable gas cutting machines. In Bombay, besides Indian Oxygen Limited which is the

only large scale manufacturer of this machines, there are two manufacturing industries viz. Twinkel Machine Manufacturer at Marol and Advani Oerliken at Mulund. Twinkle Machine Manufacturers did not oblige us as they did not like to discuss the aspect of manufacturing, major problems etc. They manufacture about 3 to 5 machines a month as per the orders. The portable machine, Cougher which they manufacture are made to order and are mainly sold to local market. I.O.L. could not give us the necessary information as they manufacture machines in Calcutta. The company makes about 100 to 200 machines a month mainly for Indian market. The design of their machine , CHEETAH is done by a British company, British Oxygen Company. CHEETAH is a tractor run solid state speed control portable machine runs on fabricated rails. The motor, gears, wheels and the electronic elements are housed in a sheet metal enclosure.

3.2.3 Sellers

Sellers from various places in Bombay like Ghatkopar, Lohar Chawl, Mahalaxmi, etc. were interviewed. According to them next to oxy-acetylene blowpipes, the common sold

item was tractor run portable gas cutting machine. They sold about one to eight machines a month. Due to the low cost, versatility and general purpose use even small fabrication workshops bought this machine not minding its cost for they would like to buy fairly reliable and reputed machine. According to the sellers, most of the buyers opted for CHEETAH which is sold at Rs.4000/- excluding other accessories like hose nut spanner, nozzle nut spanner, 2 meter long fabricated steel track, circle cutting attachment etc.

3.2.4 Users

Some of the users interviewed were I.I.T. Workshop employees, Famous Cutting Works at Marol, and Dockyard. Photographs were taken of various machines used by these users. These machines are Cougher-12 manufactured by Twinkle industries, Marol, Cheetah, and Pug which is the earlier desig of cheetah.

Most of the old companies are using Pug. Newer companies go for Cheetah because of company's reputation. The machines are usually in use for a period of 10 to 20 years. There is one user at Marol who has been using Pug for 20 years. Industries who mainly do

fabrication work, use the machines around 2 to 4 hours a stretch. Their main complaint is so far function is concerned, is that the motor starts showing unsteadiness after an hour's use. Resistors need replacing after 2 to 5 years. They have enough operating and ergonomical problems with the machines. All these problems will be discussed in the followin chapter.

4 ANALYSIS

Data collection made with the help of the interviews we had with manufacturers, sellers and users through the quentionnaire designed, and the photographs of the machines helped us to study the various features of the machines, functional, structurel, ergonomical, visual and servicing problems in the machines.

4.1 Structural analysis

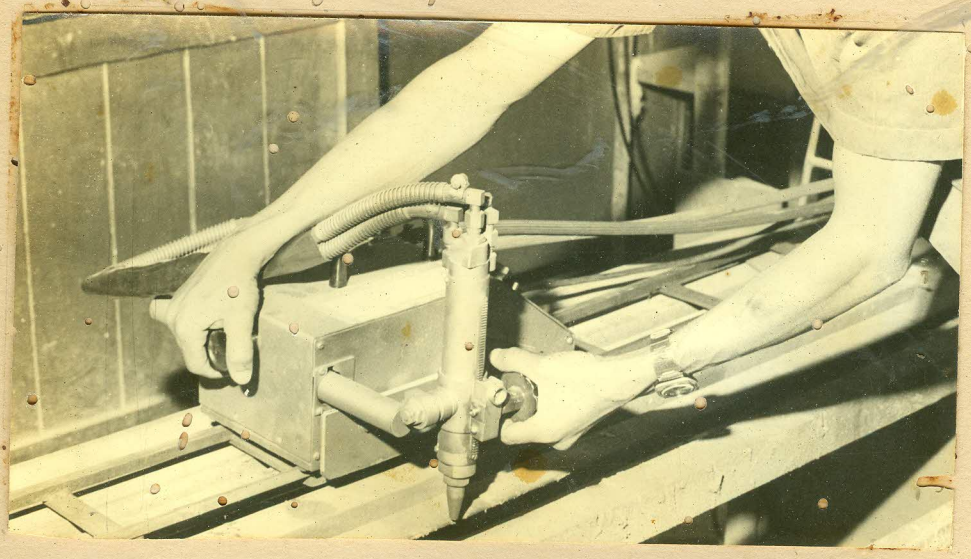
4.1.1 Vertical adjustment knob made out of bakelite gets destroyed in a short period due to the heat from the burner.

4.1.2 Similar problem is experience with the front horizontal adjustment knob.

4.1.3 For circle cutting a trammel bar is attached to the machine base. The machine then moves on a castor ball. This castor ball gets rusted and jammed causing problems during circular cutting. Frequent replacing of this becomes necessary.

4.1.4 The carrying handle is of a weak design. The handle is fixed on to the 16 guage steel sheet with the help of two small screws.

4.1.5 Rails show vertical warping due to the heat from the burner and the sheet being

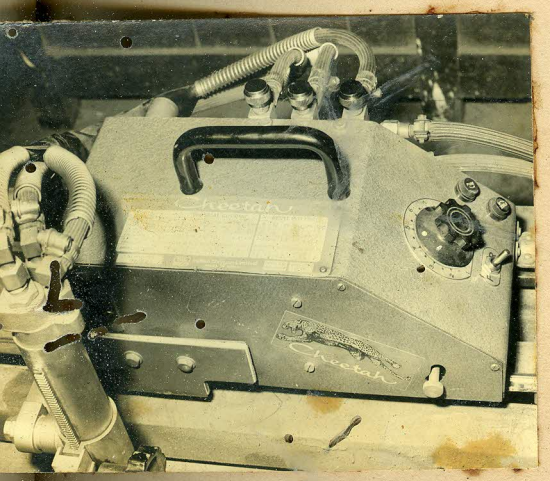



Cheetah
VERTICAL CUTTING
BEVEL CUTTING
Indian Oxygen Limited

cut. The machine thus appears unbalanced.

4.1.6 The distance between the rivets used to fix the data panel on the body is so much that the panel does not remain firmly flat in place. The panel shows inclination towards bulging and also gets torn apart.

4.1.7 The electronic control sometimes behaves erratic which may be due to the heat. The burn outs of the coil usually occur due to surge voltages or currents.

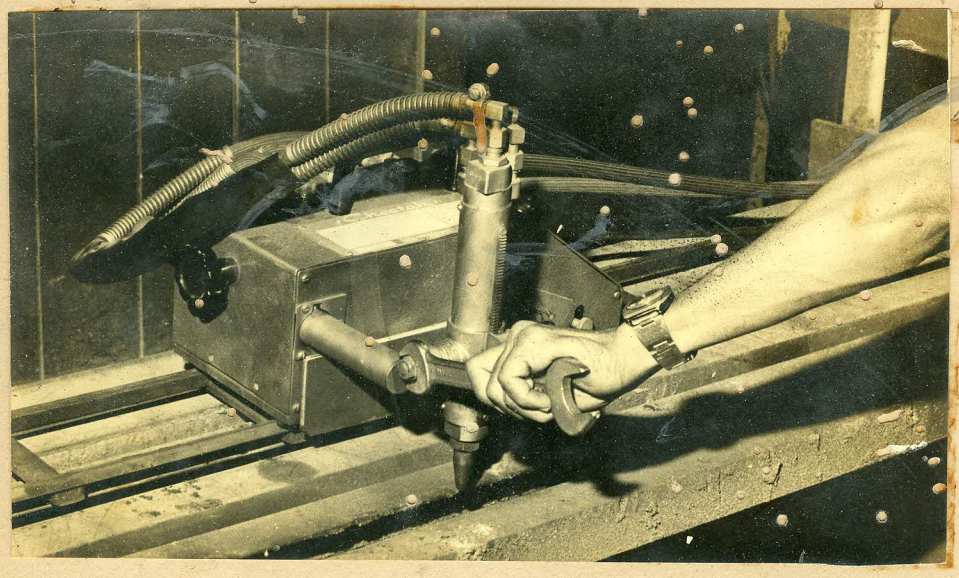


4.2 Ergonomical and Functional Analysis

4.2.1 The control areas on the machine are dispersed in an apparently illogical manner, with little attention to the operator's position and the ease of operation.

4.2.2 Access to simultaneous operation of both the vertical and horizontal adjustment knobs is inconvenient. Operator has to inconveniently extend his arm round the protruding elements like the hoses, cutter etc. in order to reach the horizontal adjustment knob.

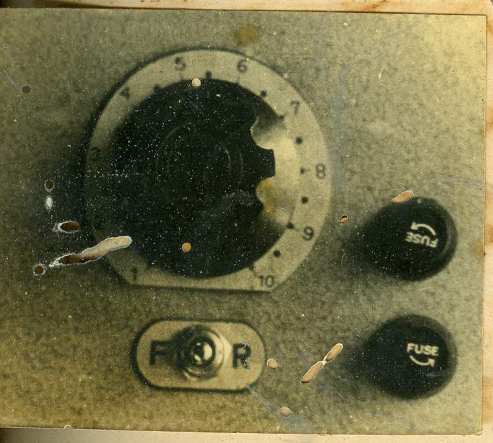
4.2.3 Same problem is experienced in operating both the regulator and the horizontal adjustment knob.



4.2.4 Vertical adjustment knob is positioned perpendicular to the machine, which makes the operator position his hand in an awkward position while operating it.

4.2.5 Accessibility to fix the bevel angle by tightening the swivel nut with the help of the spanner is also poor.

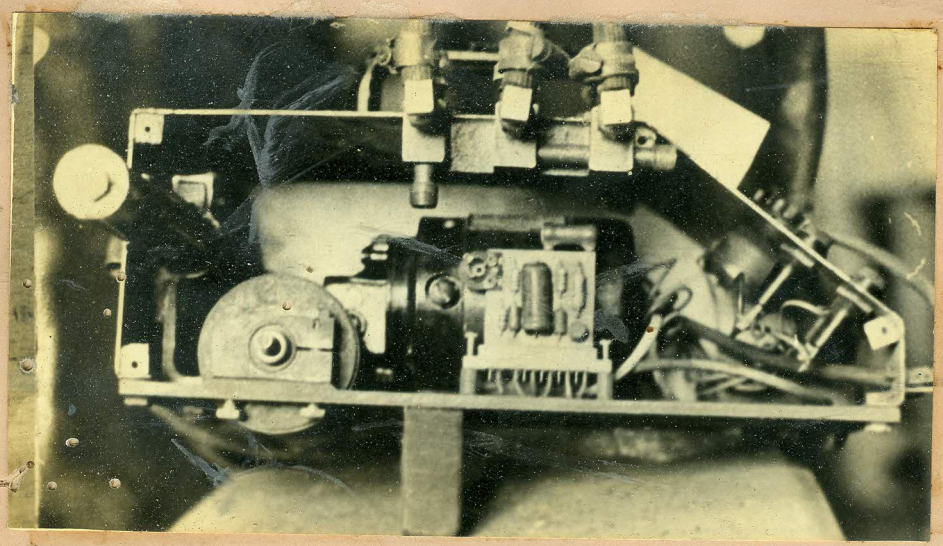
4.2.6 Speed regulator knob has unnecessarily been given intricate detailings. It also seems to be moving easily with slightest effort giving the user a sense of unreliability.



4.2.7 Toggle switch for reverse and forward control of the motor comes in the way of the operator while operating the speed regulators. Off position is also not indicated on the forward-reverse switch.

4.2.8 The three valves of the valve block have been colour - coded. However, these colours were found to have faded on the older machines, so that all the knobs appeared to be of the same colour. A more permanent and distinct identification of valves is necessary.

4.2.9 Too many projecting screw heads on the underside of the machine, as well as on



the sides, create a slight confusion when the machine has to be opened for servicing.

4.2.10 Opening one side panel does not give complete access to all the inside components.

4.2.11 The position of the handle is not convenient for tilting the machine up for access to the under side of the machine.

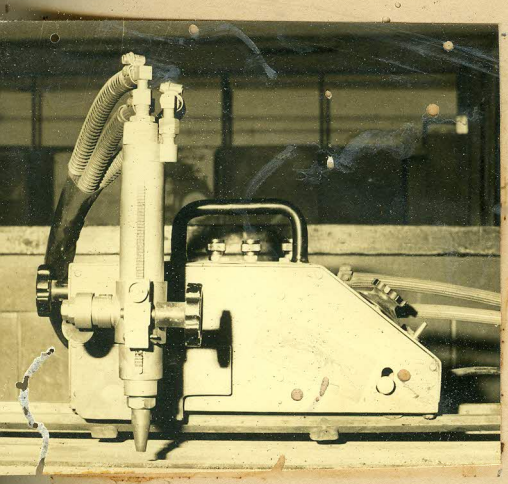
4.2.12 The orientation of the data panel need repositioning since the present orientation is not accessible while setting the speed and pressure control.

4.2.13 Areas of non operating elements and operating elements are not defined, and hence need re-shuffling.

4.2.14 Components inside the machine also need rearrangement for the sake of convenience during repair or replacement.

4.3 Visual Analysis

4.3.1 The overall form of the machine is bulky, non-unified and ill-logical with knobs, switches, screws and other protruding elements over the body causing visual disharmony.



4.2.2 From the form of the machine, it becomes difficult to gauge which is the rear or the front of the machine. The form does not reflect sense of direction. It looks immobile.

4.2.3 The various elements do not visually relate to each other in order to lead to a coherent and unified form.

4.2.4 The control and work display areas of the machine are not properly defined.

4.2.5 The dull colours used (dull green) do not ideally suite the class of product. The colour used should give the product a definite identity, and should make the machine stand out more in the dull background of the work area.

4.2.6 The handle used on the machine looks weak and does not go with overall form, but adds to visual discord.

5 HYPOTHESIS

5.1 Machine designed would be a tractor-run, oxy-acetylene for straight and circular cuts. The cutter used would be injector type and the motion would be given by an electric motor with solid state control.

5.2 In order to reduce cost, simplicity and ease in production and assembly would be stressed.

5.3 The machine would be designed to augment accessibility to repair with minimum numbers of screws or parts to be opened.

5.4 Areas of operating elements and non operating elements would be separated to have a clear identification of functions.

5.5 Visual harmony would be enhanced by mitigating the number of parts jutting out from the body, thus reducing visual sinks.

5.6 Emphasis would be given to position operative elements so as to make the operation most convenient from the ergonomic point of view.

5.7 Attempts would be made to reduce the numbers of elements during the production.

5.8 The body will be cast in minimum number of pieces to house motor, electronic control elements and the cutter arm, reducing the bulk and thus giving the machine a compact, sturdy, sleek and reliable look.

5.9 The form should reflect mobillity and have a sense of direction.

5.10 The information display and graphics should be made easy to understand and bright for more accessibility to human eye.

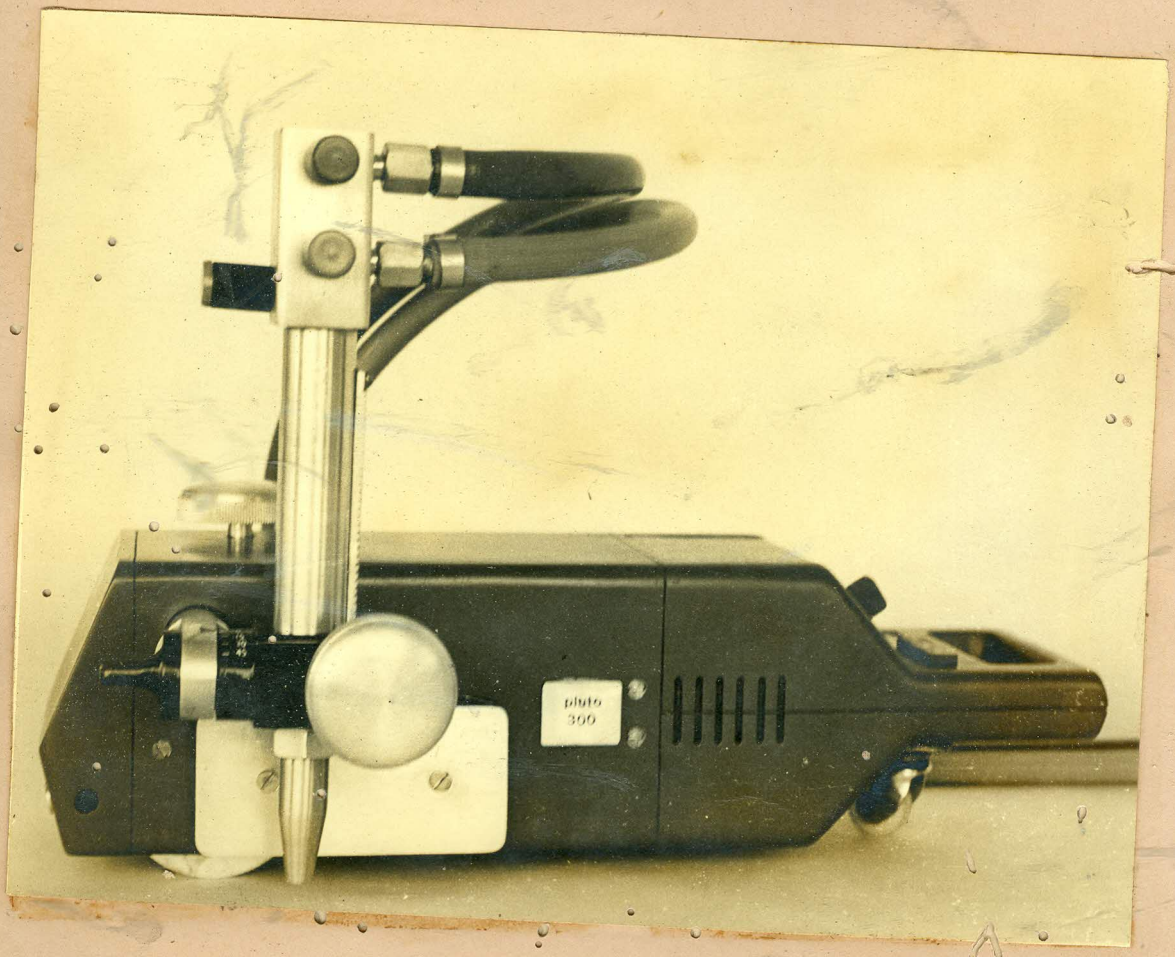
6 SYNTHESIS

Keeping in mind, all the objectives laid down, the design stage commenced with evolution of a most suitable form which would be compatible from the point of manyfacturing, functional, aesthetic and ergonomic aspects.

Several shapes of the machine were sketched out and as a result, an array of forms were derived. Three suitable forms were tried on cardboard models and finally on plaster of paris model was made in order to study the feasibility from the aspects mentioned above. Any alteration or modifications can easily be worked on plaster of paris. The model of plaster helped us to determine not only the verall form of the machine body, the castings and their assembly, but also the details of the components and their form conforming to the machine in a most suitable and logical manner.

6.1 Body

Body comprises of 4 aluminium die cast pieces with wall thickness of 3 mm. These castings are as follows:


pluto
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The motor is a 80 watt solid state controlled for connection to 220/240 volts, 50 Hz single phase.

Two slits for the wheels to pass through have been provided at the base of the motor housing. Both the wheels are held with the help of two bushing which are fixed onto the underside of the machine with the help of screws.

For the horizontal bar to pass out through the machine 2 holes of 32 mm. dia. are provided each, on either side of the motr body. The hole also have a key slot for the rack to pass. These holes provided not only the passage for the bar, but also act as ventilators for the motor.

6.1.3 End Cover

Ehd cover comprises of two identical pieces viz. Top cover and bottom cover. This cover houses all electronic circuitory and controls. Since both the pieces are identical, they can be case with one common die. The overall shape of the structure derived due to this symmetry, reduces the numbers of dies used in the castings. The handle again

forms part of the end cover and hence does not need separate fabrication or casting. The hand becomes both structurally and formally very compatible.

The pieces are held together with the help of two screws at the bottom of the handle, and 4 screws, holding the cover to the motor body from the sides. Top cover, besides providing a well defined space for Data Panel on the surface, hourses a potentiometer, reverse-off-forward switch and two fuse holders.

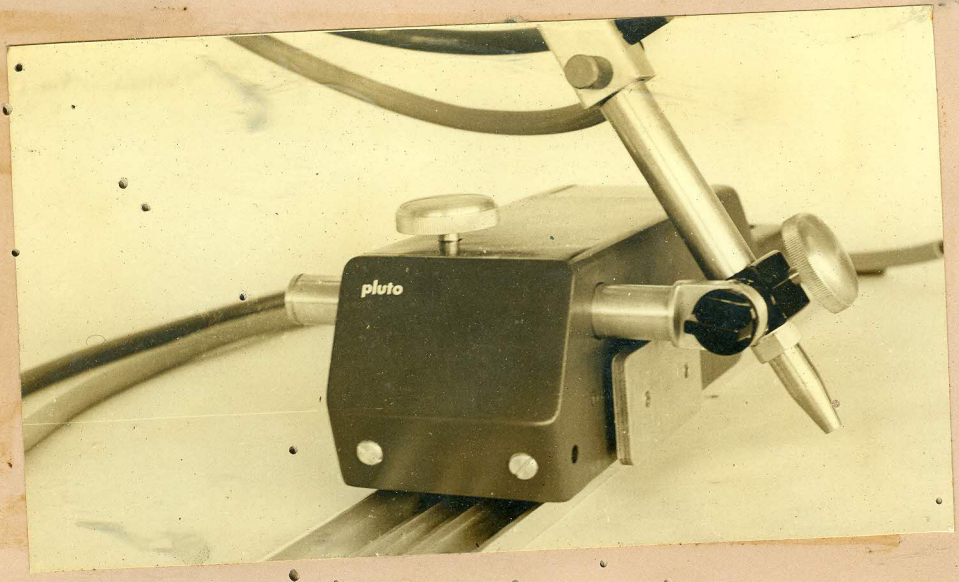
Bottom covers is the housing for the solid state circuitory , consisting of elements like silicon control rectifiers , resistors, etc. Caster wheel is fixed on to the bottom of the cover with the help of 4 screws.

6.2 Cutter

Cutter consists of 3 main parts , valve block, cutter arm and nozzle.

6.2.1 Valve Block

The valve block is made out of die. casting of brass. This part can also be fabricated easily.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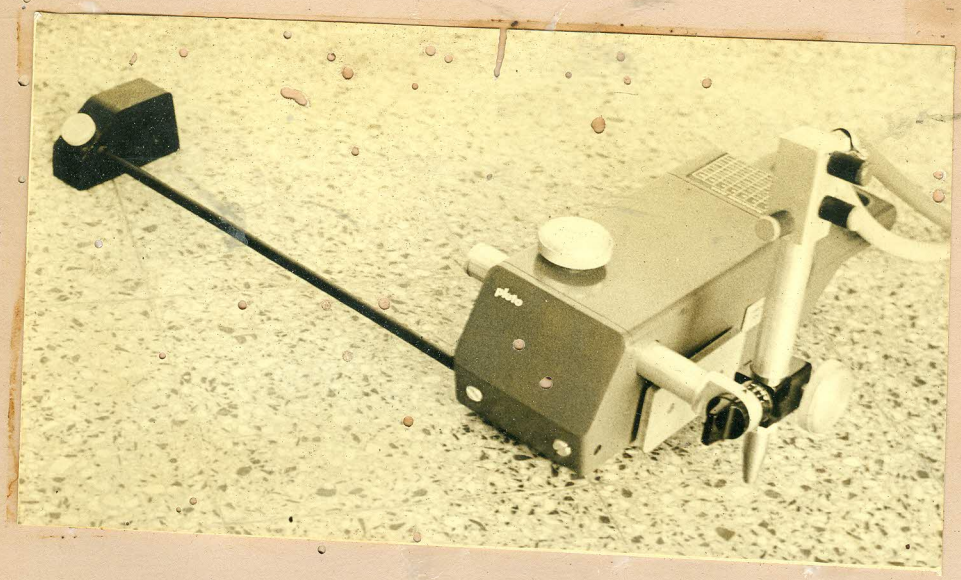
Valve block is mounted on the cutter arm and therefore close to the operator, making it ergonomically appropriate . Three pressure control valves , e ach for th ,control of burning oxygen (red), cutting oxygen (blue) and acetylene (green) are fixed on the wa valve block. The mixing of acetylene with burning oxygen is done inside the block on injector suction principle.

6.2.2 Cutter arm

Cutter arm is a brass pipe which encloses fuel pipe and cutting pipes made out of brass, which lead to the nozzle fixed at the bottom.

6.3 Cutter Holder

The cutter holder holds the cutter and helps it to move up and down for nozzle gap adjustment with the help of rack and pinion. The holder is such designed that it can also be easily fabricated. The holder is mounted on horizontal adjustment arm. Vertical adjustment knob which works the pinion is fixed on to the holders. This knob is made out of brass which is later electroplated with cadminium. The holder can be swivelled and fixed in an angle for bevel cutting and with the help of a small knob which can also be fabricated easily.

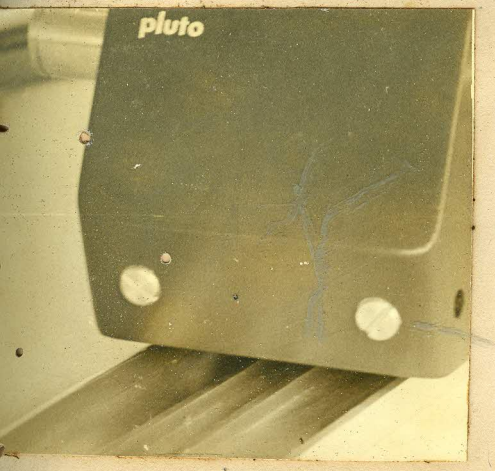


6.4 Front Wheel and Castor Wheel

Front wheels are fabricated out of Mild steel rod. Castor wheel can easily be purchased readymade from the market.

6.5 Heat Shield

Heat shield consists of a 4 mm. thick asbestos sheet which is sandwiched between two 18 gauge steel plates. The heat shield is then mounted on the body with the help of 2 screws.



6.6 Track

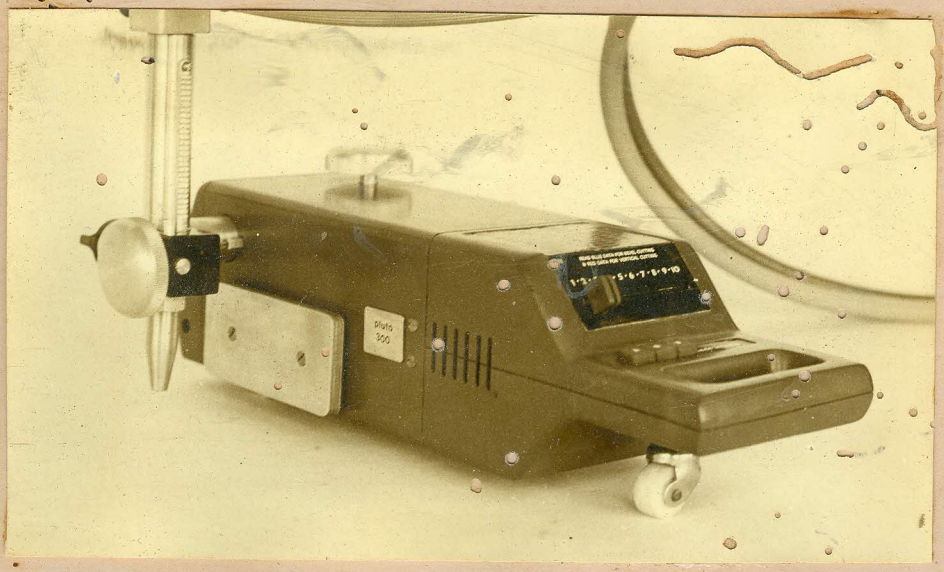
Track can easily be fabricated out of two extruded aluminium channels, which are joined with each other with the help of screws. Another alternative is using rolled steel sections which can then be welded together.

6.7 Trammel Block and Trammel Bar

Trammel block is fabricated out of mild steel. Trammel bar which is also made out of steel can be slided in the block, as per the radius required for circular cut. The overall form of the block also goes with the machine, and thus giving it, a family look.

6.8 Data Panel

Data panel is an anodised aluminium plate, on which operation instruction is printed. The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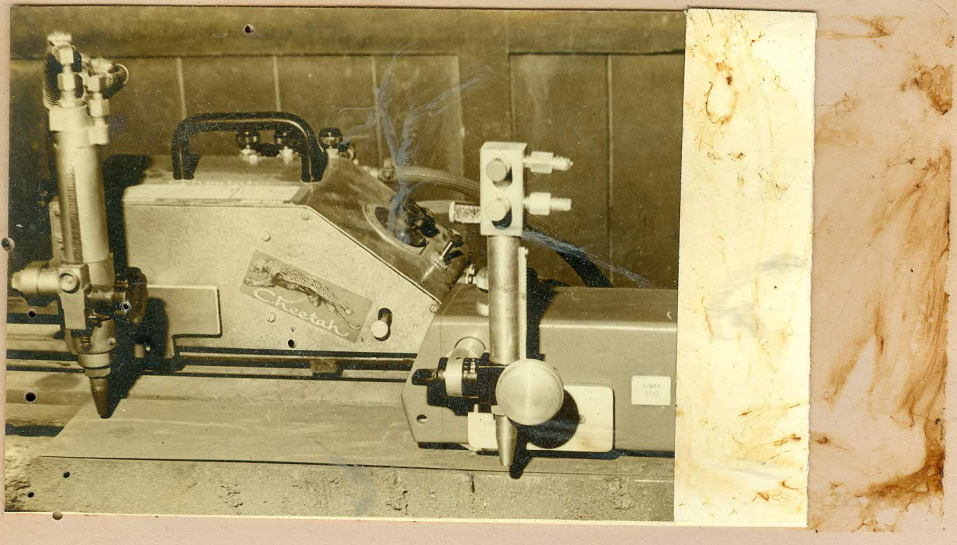
Cheetah

panel is ergonomically placed at an appropriate position to make it convenient for the operator to read the data while setting the gas pressure and the motor speed. The colours used augment readbility as well as aesthetics.

6.9 Push Buttons

Push buttons used for reverse, forward and on switches are injection moulded, have easily to follow graphics and render the machine an electronic look.

6.10 Finish

Bright colour is chosen to make the machine stand out in the dull background of the work area.

7. Cost Analysis

No.	Parts	Material and Labour Cost Rs.
1.	Motor Housing	35
2.	Front Cover	15
3.	End Covers	20
4.	Horizontal Adjustment Knob	10
5.	Vertical Adjustment Knob	10
6.	Gears	20
7.	Fuses	4
8.	Motor	150
9.	Potentiometer	15
10.	S.C.R. and Attachments	30
11.	Resistors and Wire Attachments	30
12.	Push Buttons	10
13.	Valve Block	23
14.	Valves	10
15.	Cutter Arm	10
16.	Brass Pipes	5
17.	Nozzle	20
18.	Nuts	5
19.	Ring	5
20.	Cutter Holder	10
21.	Bevel Knob	2
22.	Horizontal Adjustment Bar	2
23.	Front Wheels	5
24.	Castor Wheel	4
25.	Heat Shield	8

No.	Parts	Material and Labour Cost Rs.
26.	Racks	20
27.	Track	120
28.	Trammel Block	10
29.	Trammel Arm	3
30.	Hoses	10
31.	Data Panel	6
32.	Nuts and Screws	10

Total	Rs.	736
Assembly and Labour	Rs.	100
Painting and Finish	Rs.	100
Ex-Factory manufacturing cost	Rs.	936
Over heads	Rs.	280

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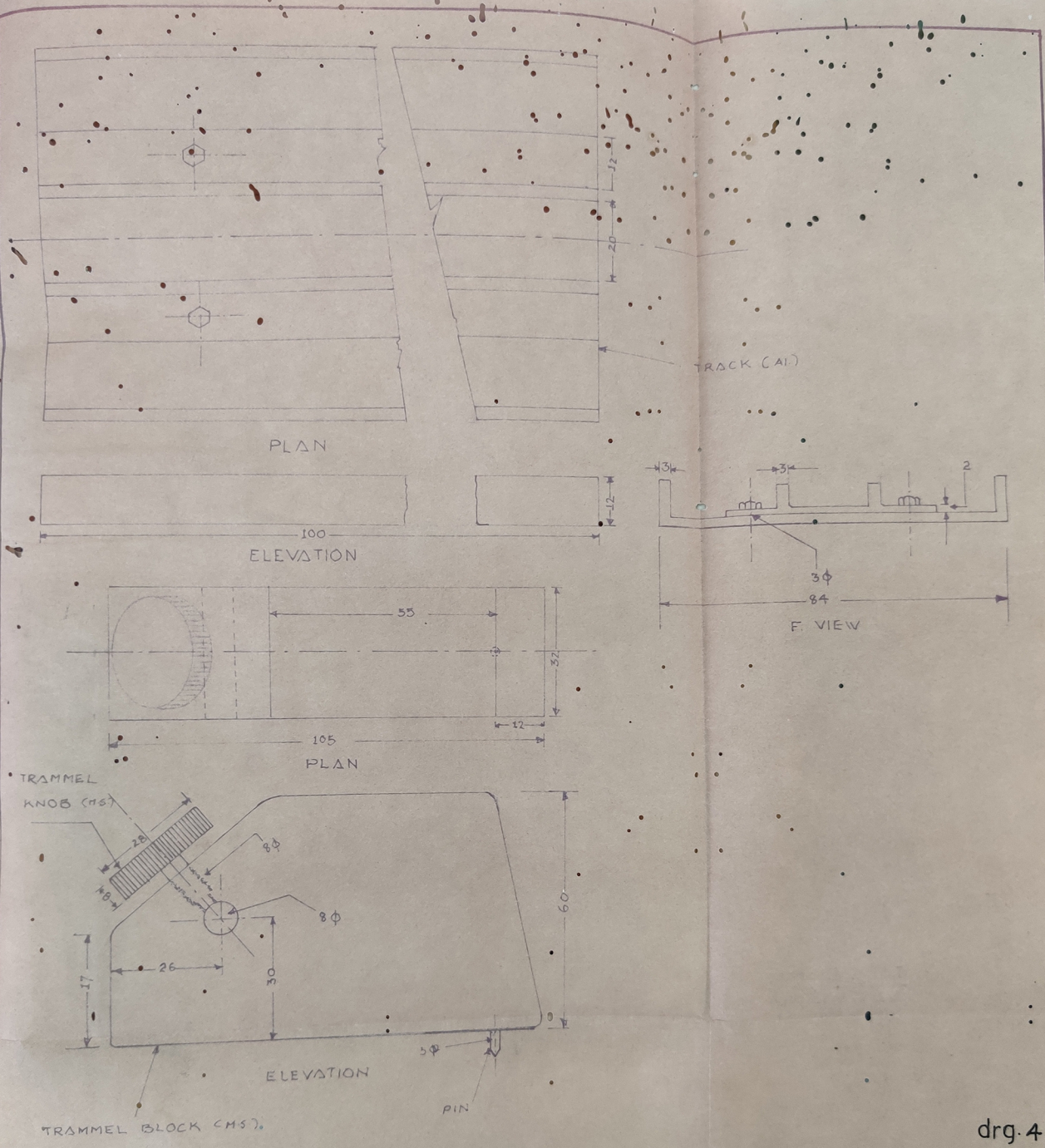
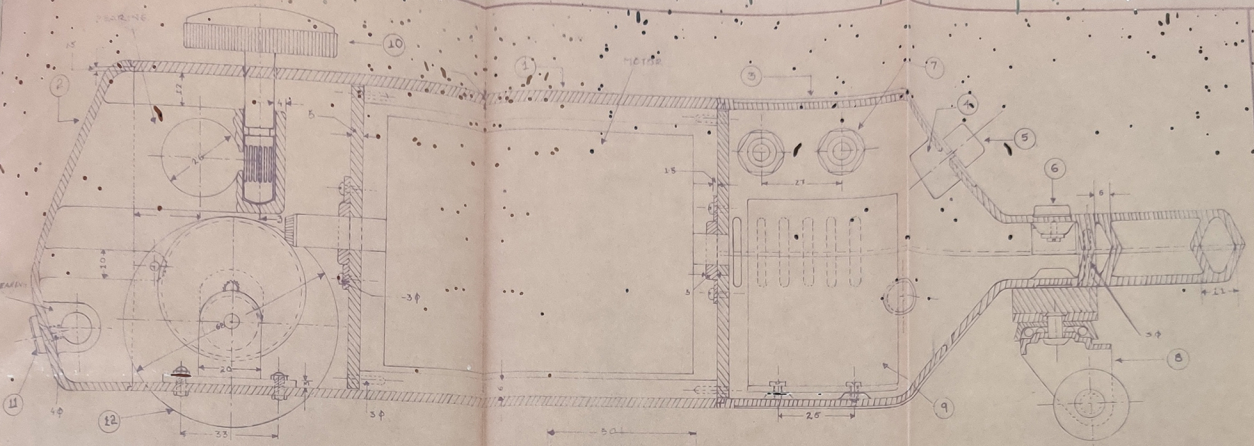
By D. Glizmanenko,

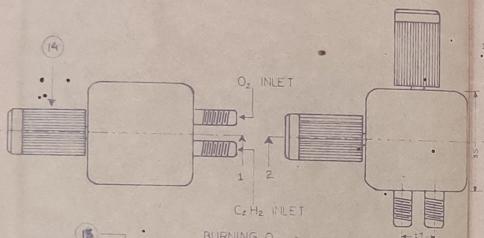
G. Yevceyev

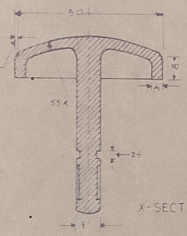


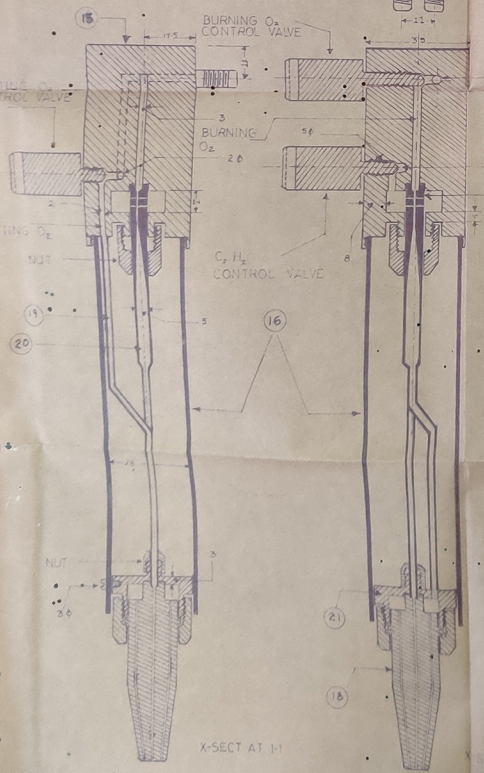
drg. 4

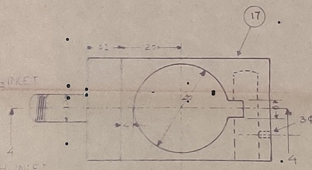
ALL DIMENSIONS IN MM	SCALE 1:1	DATE NOV 77
GAS CUTTING MACHINE		
[illegible] DESIGN CENTRE	G. S. BHIMRA	

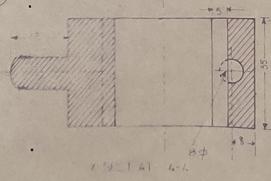












INDEX	DESCRIPTION	MATERIAL	NO. PARTS
21	RING	BRASS	1
20	FUEL GAS PIPE	BRASS	1
19	CUTTING OXYGEN PIPE	BRASS	1
18	NOZZEL	BRASS	1
17	CUTTER HOLDER	AL.	1
16	CUTTER ARM	BRASS	1
15	INJECTOR PIPE	"	1
14	PRESSURE VALVE	"	3
13	VALVE BLOCK	"	1
12	FRONT WHEEL	M.S.	2
11	TRAMMEL BAR FIXING SCREW	AL.	2
10	HORIZONTAL ADJUSTMENT KNOB	BRASS	1
9	SOLID STATE CONTROL UNIT	-	-
8	CASTOR WHEEL	STEEL	1
7	FUSE	-	2
6	REVERSE-ON-FORWARD SWITCHES	POLYSTYRENE	3
5	SPEED REGULATOR BUTTON	"	1
4	POTENTIOMETER	-	1
3	HEAD COVER	AL.	1
2	FRONT COVER	AL.	1
1	MOTOR HOUSING	AL.	1

ALL DIMENSION IN MM
X-SECT DETAILS
SCALE 1:1
DATE NOV 77
G.S. BHUMRA

drg.3


CUTTER ARM (BRASS)
HORIZONTAL ARM (AL)
250
drg.2
ALL DIM IN MM
CUTTER
INDUSTRIAL DESIGN CENTRE
SCALE 1:1
DATE NOV 77
G.S. BHUMRA

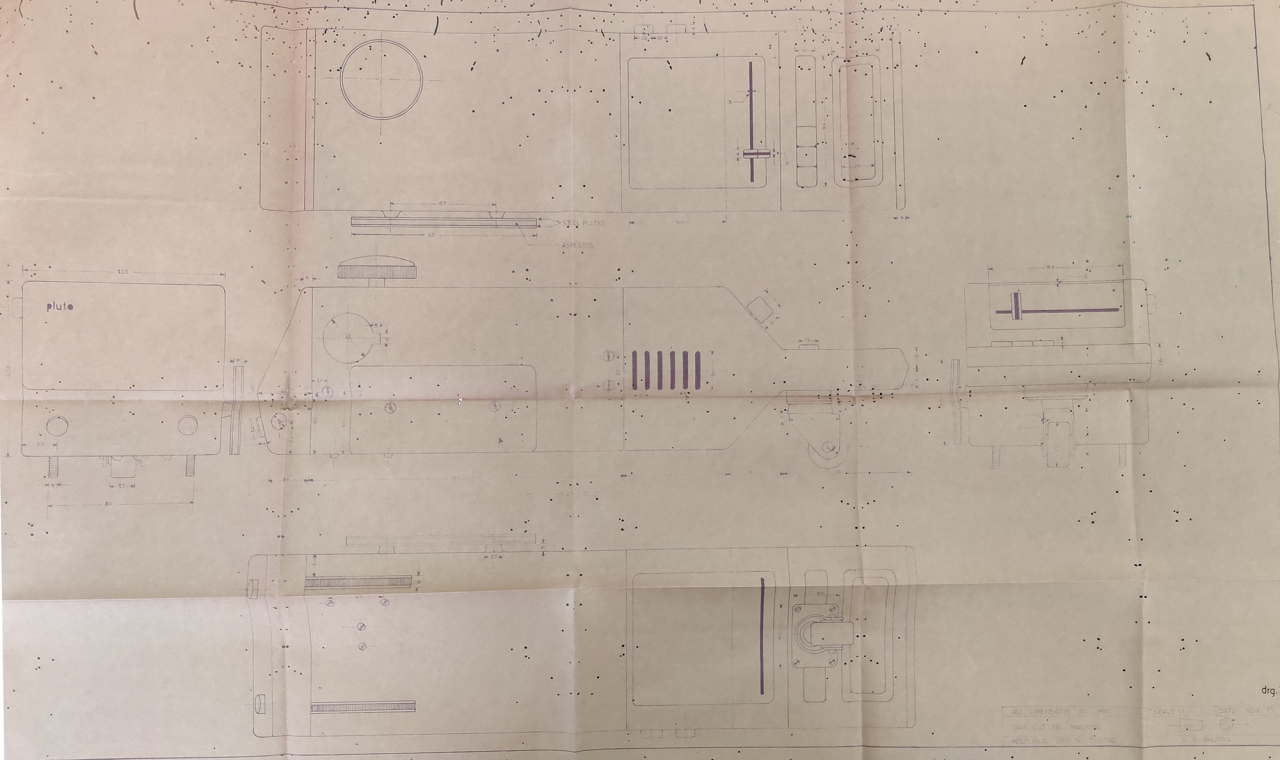


plate
drg.