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TECHNO-ECONOMIC INVESTMENT PROFILE

ON

LIGHT ALUMINIUM EXTRUSIONS

JUNE 1991

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TECHNO-ECONOMIC INVESTMENT PROFILE

ON

LIGHT ALUMINIUM EXTRUSIONS

1.0 EXECUTIVE SUMMARY

Super light aluminium extrusions are extensively used for picture frames, curtain rails, radio chassis components, electrical heat sinks, all types of domestic appliance fittings, also for tooling and lightweight structural sections. The extrusions are formed by pressing a hot ingot of aluminium through a steel die to produce lengths of finished aluminium section in a conventional extruding press.

An annual production level of 2,000 tonnes per annum is initially recommended, representing an annual turnover of \$ 7,660,000. The projected annual gross return would be \$ 1,664,000 gross profit.

The investment in conventional new machines, installation, commissioning and training is estimated at \$9,789,500 excluding site, building and local costs. However a 33% overall reduction in costs could be achieved if second hand machinery is employed (i.e. US\$ 6,524,000).

Alternatively, there is a recent development known as a wheel type extruder which although only capable of producing a limited range of product shapes can reduce the overall capital cost to a total of \$ 4,594,500.

Finally, note should be taken that various high density plastics are taking an increasing share of the market for aluminium extrusions.

2.0 PRODUCT DEFINITION

Aluminium is mainly marketed as sheet and foil but of equal importance is the extrusion process which produces lengths of metal of constant solid or hollow cross-section. Very high pressures are used to force heated and thereby plasticised aluminium (see Figure 1) in the form of short but large diameter ingots through a steel die of the required profile shape. This process produces, in a single operation, the required sections.

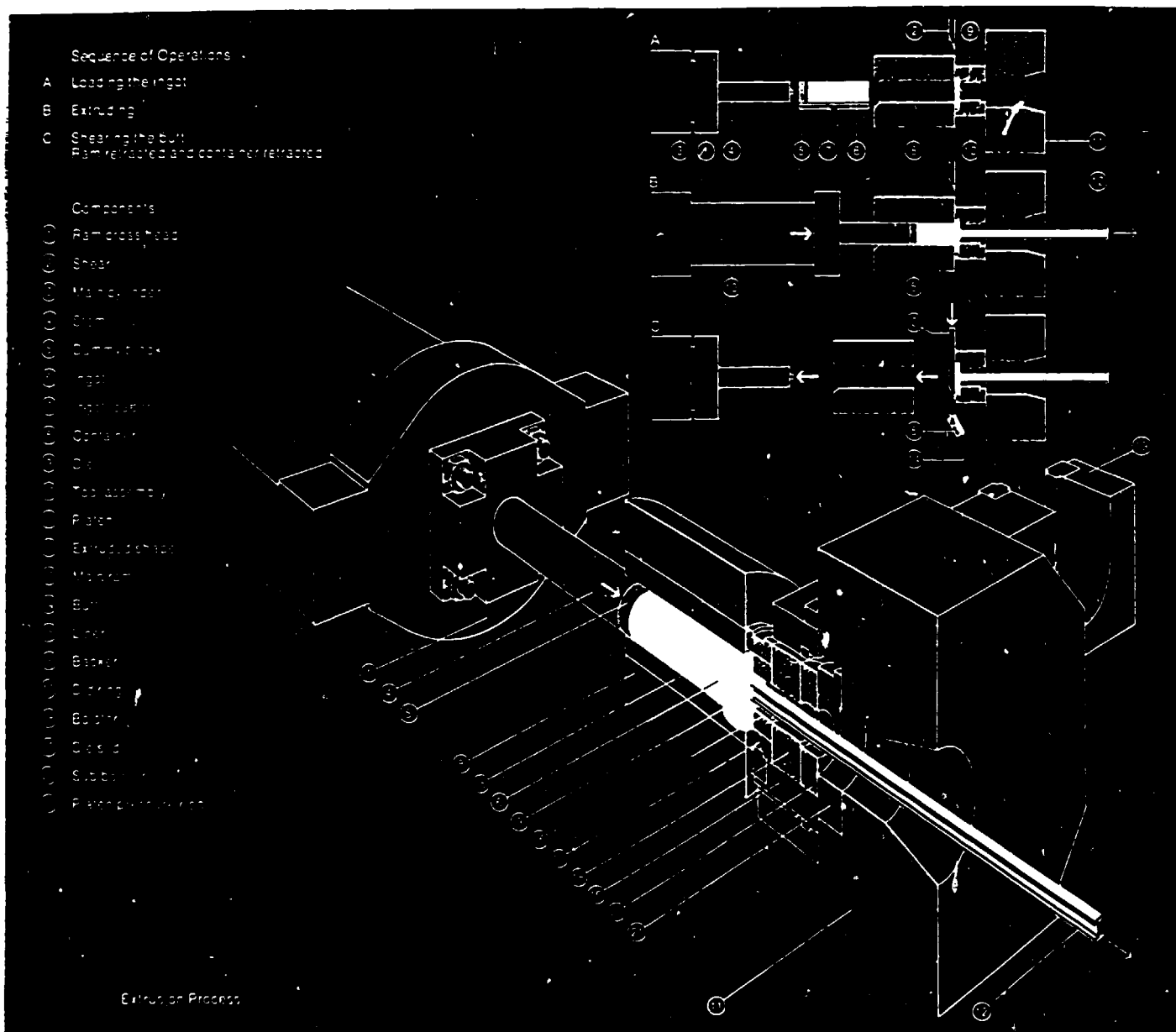
Aluminium is one of the few structural metals that can be extruded and the variety of intricate sections possible encourages ingenious design in many products. (See Figure 2).

Super light aluminium extrusions can be used in a wide range of ways by making use of all the properties and benefits of the material and Figure 3 illustrates the range of typical standard sections which are generally in the size range 15mm x 15mm maximum down to 4mm x 4mm minimum.

The most common extruded products are manufactured in standard 45m lengths to internationally recognised standards defining dimensional tolerances/shapes/finishes and material specifications, for example, BS1474. However it must be stated that, in the area of super light products, when safety, corrosion, dimensional tolerances etc. are of no consequence, the above standards are often waived and alternatives used dependent upon customer requirements.

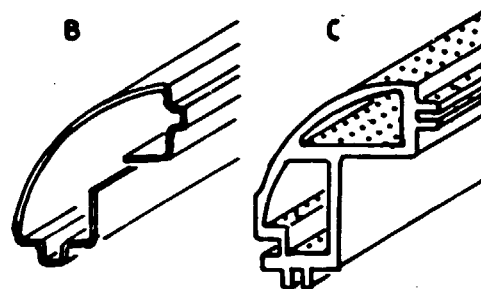
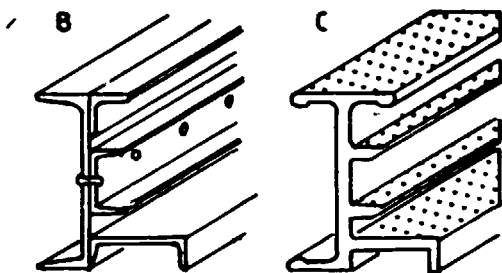
EXTRUSION PROCESS

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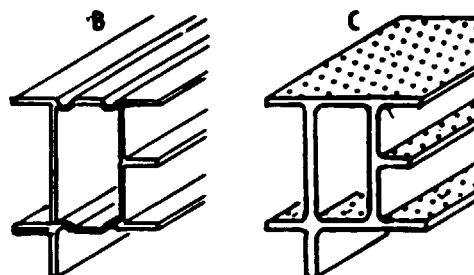
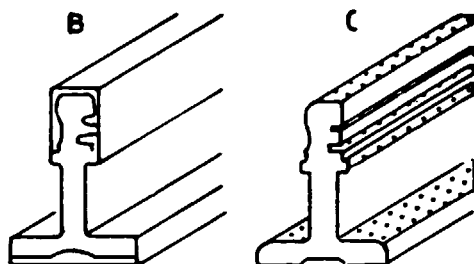
Reduces Costs

Strengthens Sections



Joining costs are eliminated when part B consisting of 4 rolled structural sections is replaced by C, a single aluminium extrusion.

Extruded shape C would have greater strength and would require less tooling to produce than rolled-formed Section B.

















Machining a part in quantity from a cast or rolled sections B is more expensive than extruding C.

Extruded shape C will have greater stiffness and strength than the crimped tubular Section B.



Fig. 2 The variety of profiles that can be extruded in aluminium is practically unlimited. The advantages of this characteristic include lower costs through the elimination of machining and joining operations, and stronger sections through better distribution of the metal and the elimination of weak joints.

TYPICAL STANDARD SECTIONS



CHANNELS

	TYPE 1
	TYPE 2
	TYPE 3 (Section 1)
	TYPE 3 (Section 2)
	TYPE 4 (Section 1)
	TYPE 4 (Section 2)
	TYPE 4 (Section 3)
	TYPE 5 (Section 1)
	TYPE 5 (Section 2)
	TYPE 5 (Section 3)
	TYPE 6 (Section 1)
	TYPE 6 (Section 2)
	TYPE 6 (Section 1 - with Radii)
	TYPE 6 (Section 2 - with Radii)


TEES

	TYPE 1
	TYPE 2

'I' BEAM

	TYPE 1
	TYPE 2

ANGLES

	TYPE 1
	TYPE 2
	TYPE 3
	TYPE 4
	TYPE 5
	TYPE 6

Typical products together with the range of materials are:-

<u>PRODUCT</u>	<u>MATERIAL SPECIFICATION</u>
Tube	1060, 1100, 2014, 2024, 3003, 5083, 7075, 5086, 5154, 5454, 6061, 6063, 6351.
Architectural shapes	6063. Windows and light frames.
Aircraft shapes	2014, 2024, 7075, 7178
Structural shapes	5083, 5086, 6061, 6351, X7004
Super light domestic sections	6063.

The above material specifications are defined in BS1474 and refer to additional alloying metals included to enhance the properties of pure aluminium. The inclusion of magnesium and silicon in the 'Magsil' range of the 6000 and 1200 specifications are the most popular giving good extrusion properties with suitable tensile strength used.

Typical products are:- Sections for picture frames, mirror frames, curtain rails, vanity sets, bathroom fittings, domestic appliance fittings, radio and television fittings, bezels of all kinds, radio chassis components, electronic and small electrical heat sinks, components for the clock and watch industry, instrument components. However, in real terms, the quantities are likely to be small (in tonnage) and varied in design.

3.0 TECHNOLOGICAL REVIEW

3.1 Review of Technological Options

The basic process (see Figure 1) requires a single extruding machine, however, for super light aluminium sections there is now available, an alternative process which should be considered. This is the Wheel type extruder, using solid round aluminium rod or section (see figs. 4 and 5).

In the case of the conventional extrusion press, the machine is a horizontal hydraulic press and although representing a physically large and financially expensive machine, is of simple and well proven design with robust construction. There is also usually a reasonable market in which to purchase used machines at cost savings of approximately 40%.

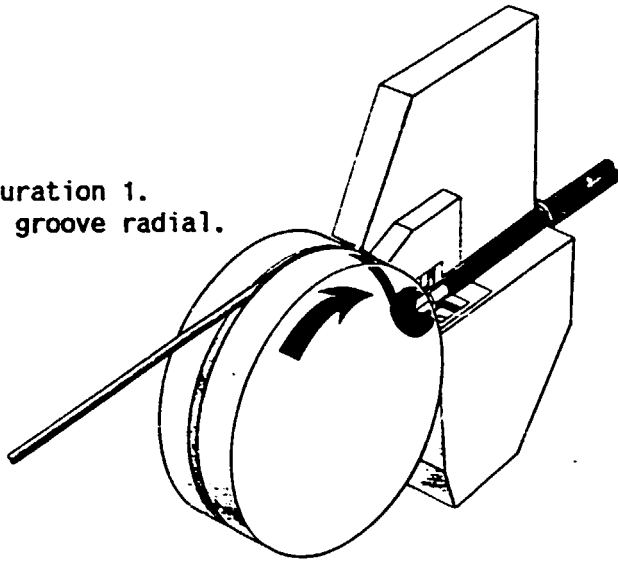
In the case of the Wheel type extruder machines, it must be first stated that the methods are novel and so are the existing designs, however a market is developing for this type of extrusion because the initial capital outlay and running costs are lower and large cast billets are eliminated prior to the extrusion process.

The standard horizontal extrusion press is capable of extruding a number of sections in a single stroke.

The Wheel type extruder using solid rod produces single strands but from a single standard aluminium rod diameter thus reducing stock costs.

It must be emphasised that the expertise in all extrusion processes lies in the size, range and design of dies through which the aluminium

Configuration 1.
Single groove radial.



Configuration 2.
Twin groove radial.

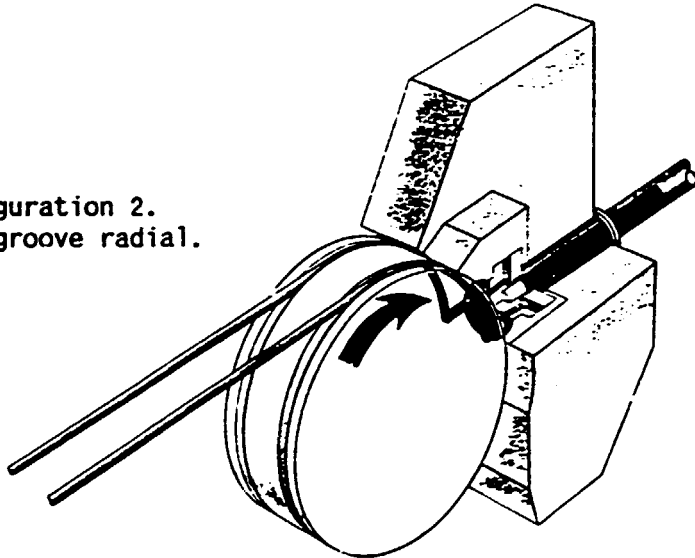
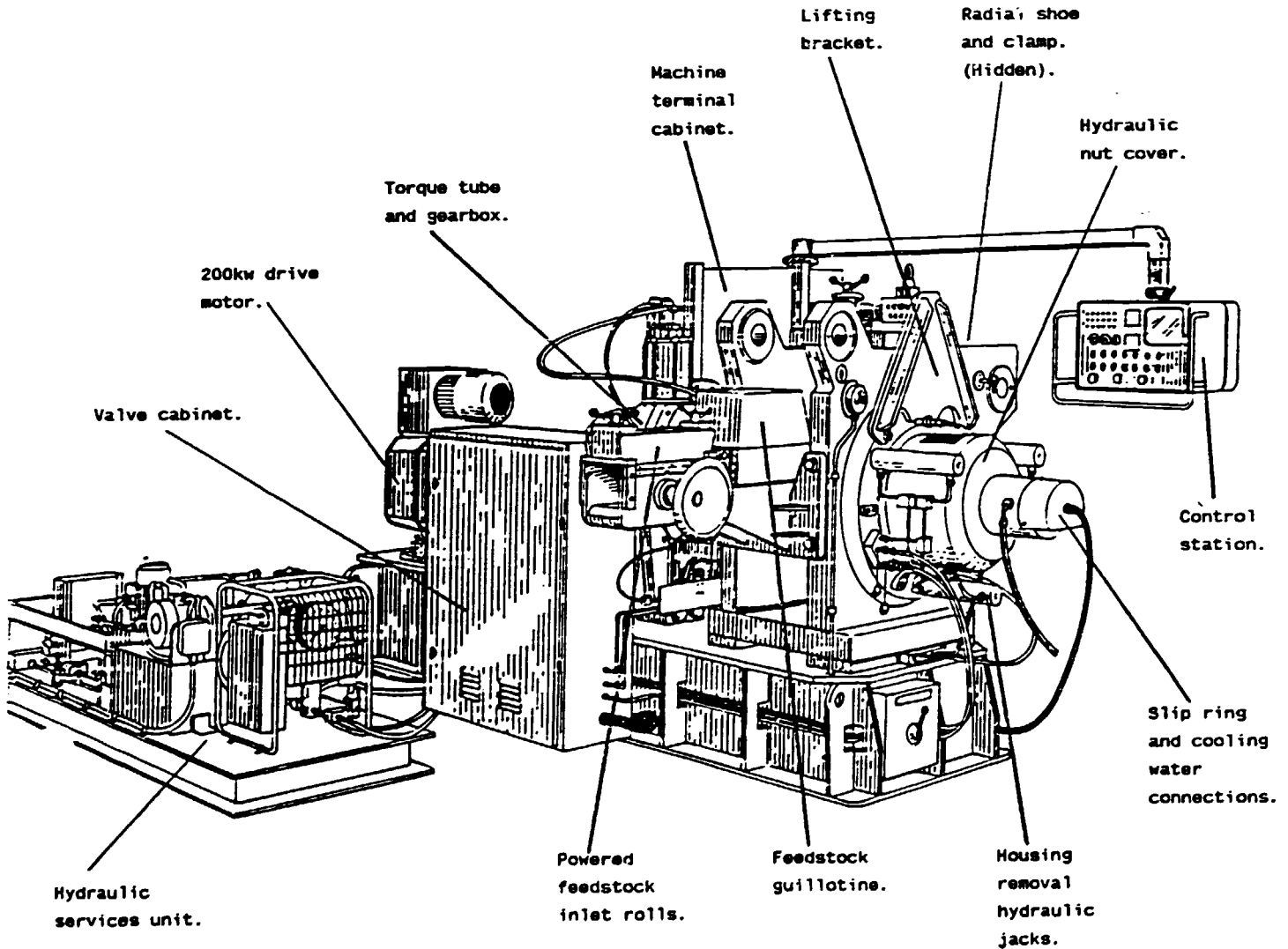


Figure 5

TYPE 350/200 CONFORM MACHINE.



Product requirements dictate the extent to which ancillary equipment is needed to operate in-line with the Conform extrusion machine. The machine is shown in radial mode suitable for the production of solid and hollow sections this being the product range that requires least ancillary items. Minor alterations to the geometry of the extrusion machine would transform it into tangential mode and the addition of necessary ancillary equipment would provide for the sheathing of cable cores or for the cladding of wires.

is extruded. The quality and costs of the products is nearly entirely dependent on the quality of the dies and their ability to repeatedly maintain the desired dimensional tolerances throughout a production run. The expertise of die design and production is well proven but relies upon highly trained craftsmen with attention to detail.

3.2 Production Scale Ranges & Governing Factors

The production of super light extrusions in aluminium can be roughly separated into three types of sections:

- a) Standard sections - square; round; oblong and angle sections
- b) Multi-sided sections - 'H'; 'I'; 'J'
- c) Hollow sections - round and oval tubes; box sections

Standard sections can be produced in reasonably large quantities (see figure 3) which will depend upon catalogue range and market demand. It is assumed that stocks would be held of the most popular sections. There is very little commercial risk due to lack of deterioration through shelf life.

In the case of multi-sided and hollow sections, die design and manufacture should be balanced against individual customer requirements. Tooling should be amortised over specific contracts. Stocks should only be carried at the customer's own risk. In any event, no less than 0.5 tonne per section would be viable in an enterprise of this nature.

Competitive market pressures for standard sections and medium quality sections of very light aluminium sections necessitates the production of 0.5 to 2 tonnes per section per programme to ensure good profitability, whereas 250 kg to 2 tonne lots of special sections can be tolerated to attain similar profit levels.

It is important to understand that the competitiveness of the market for super light extruded sections is great and the emphasis must be placed on presenting a product which has minimal surface blemishes, is well packed and quickly supplied.

It is initially recommended that a plant capacity of 2,000 tonnes per annum is installed (i.e. 500Kg/hr x 3 shifts x 8hrs/shift x 220 days/yr at 75% efficiency).

3.3 Recommended Production Technology

It is strongly recommended that a detailed market analysis is carried out for the particular local conditions in order to determine whether the limited range of sizes and shapes obtainable from the wheel type extruder is acceptable in view of the significantly less capital cost of the equipment.

For a start up project it is essential that aluminium sections should be reasonably easy to produce yet be in good demand in a general market.

Product range could include profiles for bezels, heat sinks, radio chassis parts, curtain rails etc. as well as 'standard' sections including square tube for general applications. window or ladder manufacture as well as 'standard' sections such as angle, channel, tee and round and square tube for general applications.

It is recommended that one conventional extrusion press would be required of 800tonne pressure with 4" to 6" diameter container. Thus giving the opportunity to produce a range of sections (solid and hollow) as well as larger sections.

Comparable European plants would expect to achieve 500kg per working hour (typically 6m/min).

This is an estimated average and will depend to a great degree on actual product and alloy mix as well as surface finish requirements.

This plant would be compatible for future product expansion within the range of aluminium analyses already given and enabling flutes and multi-sided sections to be produced. These sections are not initially recommended due to the higher level of in-house expertise required.

3.4 Sources of Technology

The main sources of technology are the existing manufacturers of super light extruded sections. However, most manufacturers will not impart their 'in-house' knowledge unless License agreements or similar inter-trading contracts are arranged.

Alternatively, additional limited access to technology can be obtained from reputable consultancy services specialising in aluminium extrusion and also from the suppliers of the various items

of capital equipment. The production of good quality finished product is as much an art as a science, 'in-house' expertise is vital and for a start-up project of this nature, it will be necessary to import personnel with good experience of this type of production. The three essential areas are a) die design, b) metallurgical knowledge, and c) production 'know-how'.

Suitable suppliers of equipment are:

Extrusion Presses

FIELDING & PLATT LTD

PO Box 10, Atlas Works, Gloucestershire, England, GL1 5RF

Tel: 0452 28611 Fax: 0452 27175

SCHLOEMANN-SIEMAG AG

Edward Schloemann Strasse 4, Postfach 23 02 29, D1000,

Dusseldorf 1, West Germany

Tel: 010 49 211 8810 Fax: 010 49 211 1902

Ingot Heater/Saw

WELLMAN FURNACES LIMITED

Cornwall Road, Smethwick, Warley, West Midlands,

England, B66 2LB

Tel: 021 558 3151 Fax: 021 558 1703

METATHERM GMBH

1200 Wien, Alliertenstr 2-4, A1020, Vienna, Austria

Tel: 010 431 214 5561 Fax: 010 431 214 556121

Handling Equipment - Wheel Type Extrusion - General Consultancy

EDWARDS OF ENFIELD

Aden Road, Enfield, Middlesex, England, EN3 7SX

Tel: 081 804 5025 Fax: 081 805 1291

Wheel Type Extrusion Lines

BWE Ltd

Beaver Road Industrial Estate

Ashford, Kent TN23 1SH, England

Tel: 0233 627736 Fax: 0233 630670 Tlx: 965782

4.0 THE PRODUCTION PROCESS

4.1 Description and Flow Sheet for Conventional Extrusion Process

The manufacturing process flow is shown in Figure 6 and a typical layout is shown in Appendix A. The basic concept of the process holds for either a conventional press or a wheel type extruder (see description under 4.2).

Stage 1A - Die Supply

Dies should be purchased initially from a specialised tool manufacturer. The dies have to be pre-heated in an oven prior to use.

Stage 1B - Aluminium Ingot Supply

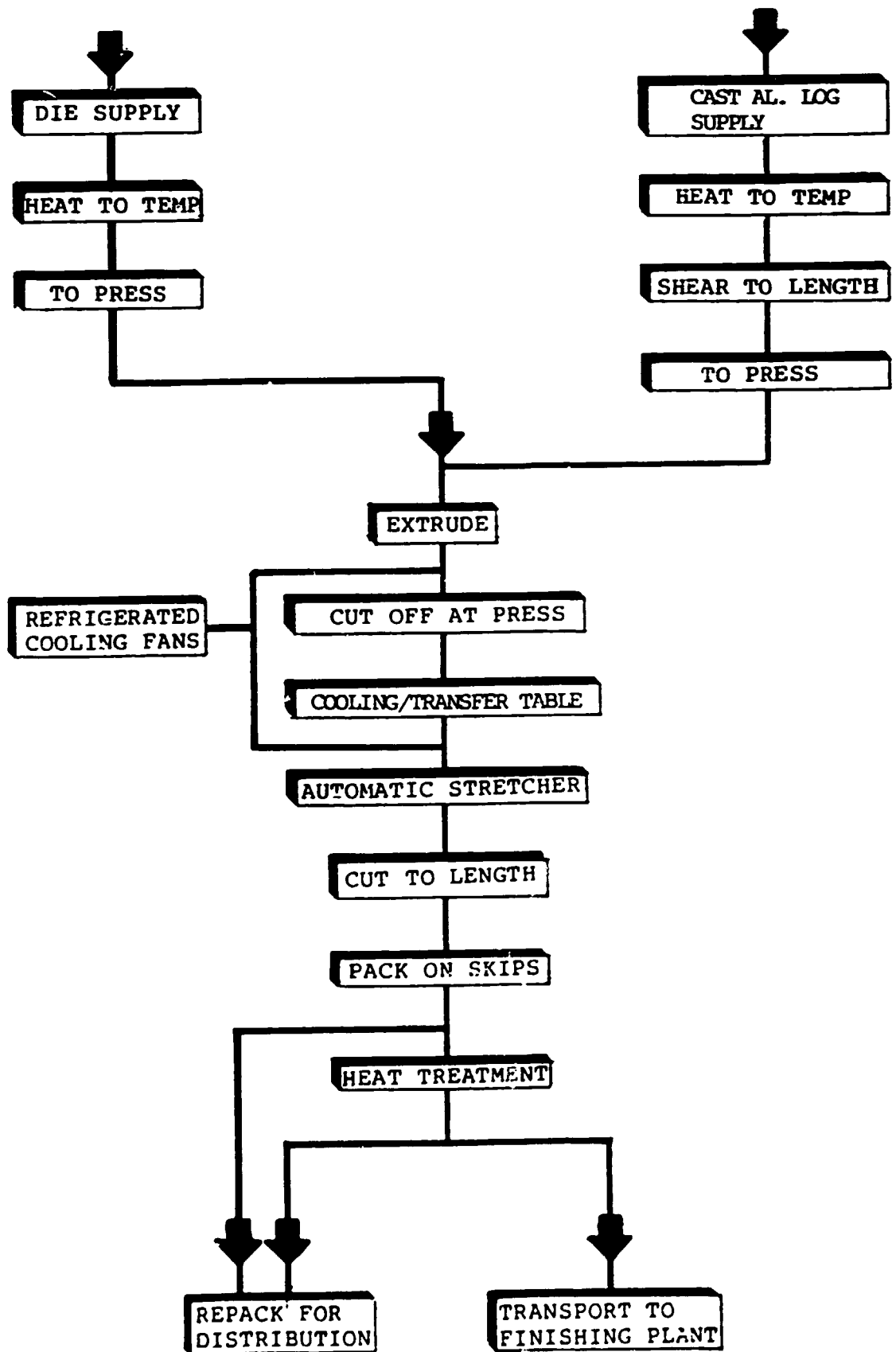
Aluminium ingots should be purchased as cast logs (4" or 6" diameter). The length of the logs should be in the region of 3 metres long thus keeping the purchase costs to a minimum and to maximise the use of aluminium when cutting the logs into billets. The billets are then pre-heated in gasfired or electrically heated ovens prior to extrusion. The sawing of the logs into billets and thence onwards to the heating oven can be undertaken on one special purchase machine to minimise handling.

Stage 2 - Extrusion Production Line

The pre-heated cylindrical billet is placed into a holder within the extrusion press and thence pushed into the extrusion chamber by a hydraulic ram. The ram then squeezes the aluminium billet at high pressure horizontally through a steel die so that it emerges from the exit side of the die complex in the desired cross section.

The extrusion press is essentially a special purpose horizontal press hydraulically activated often with integrated auxiliary equipment

Figure 6



such as loading and unloading tables, billet and die pre-heat and log shearing equipment, straightening rolls and cut-to-length saws. The complete manufacturing unit is now normally under automatic control using dedicated programmable logic controllers (PLC's) such that the billet-to-finished product is achieved in one operation.

Run-out from the extrusion press would be assisted by a single head linear motor puller and slat conveyor with an automatic press saw. Cooling of extrusions is achieved by refrigerated air fans on a cooling/transfer table with automatic stretcher facilities.

Liquid nitrogen die cooling may be considered. A combination of good die design and die cooling technology can significantly increase productivity.

Final cut would be at the opposite end of the run-out table from the press. Packing, at this stage, would be on to aluminium skips with cardboard or Kelvar spacers to permit air flow during ageing.

Stage 3 - Post Extrusion Heat Treatment

For material specifications requiring heat treatment to achieve the correct mechanical properties there follows transfer to an ageing furnace with floor loading.

Stage 4 - Finishing/Packing

Items requiring a surface finishing process would be transferred to an adjacent plant without packing. A repacking station would be needed for mill finished items to be despatched to customers. This could be placed on skips with cardboard protection, alternatively

bundles where surface finish is not important, or smaller cartons - as required.

Finishing plant for anodising or painting of sections is not initially recommended.

Mechanical Handling

Mechanical handling equipment will be required both for the loading of hot dies and moving skips around the plant and vehicle loading. Consideration should be given to the need for plant maintenance and a lifting capacity of 10 tonnes may be required for lifting parts of the extrusion press during annual maintenance.

4.2 Description and Flow Sheet - Wheel Type Extruder

A wheel type extruder or 'Conform' as it is known by its commercial name requires the same basic layout as a conventional press and in summary the main differences are as follows:-

Stage 1a - Die Supply

The dies are different in design but similar in construction. They do not require pre-heating as this is integral with the extrusion machine. In all probability the dies will only be available from a single source because of the proprietary nature of the design.

Stage 1b - Aluminium Supply

Raw material is supplied in standard rod form.

Stage 2 - Extrusion Production Line (see figs. 4 and 5)

The 'Conform' extrusion process is a unique concept for the production primarily of aluminium and copper sections. The process is extremely energy conservative when compared to conventional extrusion methods and has demonstrable advantages in several other areas of production.

A Conform extrusion process line consists of the extrusion machine with ancillary processing equipment both before and after the extruder. The extent and complexity of the ancillary equipment depends upon requirements which are generally dictated by the product and in its most basic form a line would be extruding simple solid or hollow sections. The Conform extruder takes feedstock which is usually, but not always, in rod form. The feedstock is passed into the rotating extrusion wheel and fed into the extrusion zone where pressure and temperature encourage the material to plasticise and thus be available for extrusion.

At this point the material is introduced into a die chamber and is allowed to extrude through a die suitably designed for the section required. The extrusion wheel has either one or two peripheral grooves to accept the feedstock. The pressure and temperature referred to is process generated by design. There is not any input of power other than that being expended by the drive motor which turns the extruder wheel.

Prior to arriving at the extruder the feedstock requires pay-off, cleaning, guidance and control equipment and, subsequent to the product being extruded, quenching, control and take-up facilities. For more sophisticated products such as clad steel wired or sheathed

cables additional items of ancillaries are needed both before and after the extruder.

Step 3 - Post Extrusion Heat Treatment

All as a conventional extrusion process.

Step 4 - Finishing/Packing

All as a conventional extrusion process.

4.3 Outline List of Machinery & Equipment

	<u>US \$ Dollars</u>
ITEM	
1. Log heater/shear	350,000
2. Extrusion presses - 1 off 800 tonnes capacity	1,200,000
3. Automatic control equipment to suit the above	595,000
4. Puller unit (including cut-off saw)	1,500,000
5. Transfer tables and stretcher	1,500,000
6. Cut to length and packing equipment	210,000
7. Heat treatment ageing furnace	580,000
8. General ancillaries for handling including mobile lift trucks	437,000
9. Refrigeration, cooling, water pumps, transformers	1,200,000
10. Spare part dies, etc.	340,000
11. Racking for storage of extrusions, dies, etc.	250,000
TOTAL	<u>8,162,000</u>

- NB: 1) The above costs can be reduced by 40% if second-hand equipment is purchased instead of new (i.e. \$4,897,000).
- 2) Items 1 to 5 plus 9 would be included in a wheel type extruding line which would cost \$ 1,700,000 inclusive. Therefore total equivalent of a wheel type extruding line is \$ 3,517,000.

4.4 Budget Cost for Machinery & Equipment - Ex-Europe

The estimate for the minimum machinery listed in 4.3 based on ex-works Europe cost is:

	<u>Conventional</u>	<u>Wheel Type Extruder</u>
Machinery	\$ 8,162,000	\$ 3,517,000
Carriage	\$ 0,650,000	\$ 0,300,000

4.4 Budget Cost for Erection of Machinery & Equipment

	<u>Conventional</u>	<u>Wheel Type Extruder</u>
Erection	\$ 0,400,000	\$ 0,200,000

4.5 Site Requirements

The proposed site is set out as Appendix B.

Estimated size of site required:

$$200 \text{ m} \times 80 \text{ m} = 16,000 \text{ m}^2$$

Comprising main factory space:

$$190 \text{ m} \times 50 \text{ m} \times = 9,500 \text{ m}^2$$

Office Space:

$$10 \text{ m} \times 50 \text{ m} \times 2 \text{ floors} = 1,000 \text{ m}^2$$

$$\text{Hardstanding} = 6,000 \text{ m}^2$$

4.7 Details of Buildings and Any Special Civil Works

The main building should be weatherproof and appropriate to local climatic conditions. Surface drainage should be adequate to minimise the chance of flooding the factory area. Floor loads will not exceed 5 tonnes/square metre. The side walls should be of a height not less than that required to accommodate overhead cranes having a hook height of 7 metres. The office areas which is integral with the main factory should contain:-

- General Managers office
- Sales and administration offices
- Clerical offices
- Production Managers office
- Reception area
- Latrines

Total office space is likely to be 1000 m², and should be serviced with:

- 3 phase 140V electrical supply;
- Water (general washing/cleaning etc.);
- Sewage (no special effluents).

The ground level floor should be of pre-stressed concrete with smooth granolithic surface all at one level throughout the building.

Allowance should be made for the foundations of the extrusion press to include 'below ground' level pits of approximately 10 x 4 x 2 metres.

The building would be typically steel frame and cladding.

It is imperative that the outer perimeter of the establishment is securely fenced against intruders and that there is a secure bonded area for the aluminium stocks.

4.8 Raw Materials and Consumables

The basic raw materials required to support a nominal 2,000 tonnes per annum output are:-

1. Aluminium ingot in log form. A typical 7% scrap rate indicates 2,140 tonnes total required.
2. Tooling (dies). Approximately 250 die sets at \$3,000 per set. Renewable every 2000 tonnes of extruded product.
3. Aluminium skips. 100 skips at \$78.57 each.
4. Cardboard for spacers in ageing and general packing requirements. \$32,000 pa
5. Billet & container lubrication. \$ 7,000 pa
6. Good natural water supply for press cooling. \$10,000 pa
7. Hydraulic oil for presses and ancillaries. \$14,300 pa

4.9 Raw Materials and Consumable Items Prices

Log price for aluminium	\$	2,040 per ton
Oils approximately:	\$	35 litre
Natural gas	\$	0.72 per therm
Electricity	\$.0.1 per kwh
Water	\$	0.59 per cubic metre

4.10 Utility Requirements

(based on 2,000 tones pa output)

Fuel:	Gas: 38,000 therms pa
	Oil: 5,000 litres pa
Electricity:	1,600,000 kwh pa
Water:	3,000 cubic metre pa

4.11 Normal Annual Maintenance/Spare Parts Required

These costs should be low in Year 1, rising to an ongoing rate in Year 3. Typically, these will be under 13% of the overhead cost, ie, under \$ 0.13 per kilo of aluminium based on a three year potential output of 2,000/2,200 tonnes per annum.

4.12 Manpower

Direct

Production Supervisor	1 per day
Assistant Supervisor	1 per day

Die Corrector	1 per day
Press Driver	1 per shift
Sawyers	1 per shift
Packers/ageing loaders	2 per day
Utilityman	1 per shift
<u>Total</u>	<u>8 Persons</u>

Indirect

Office:	2 executive
	3 clerical
	2 sales
	1 Reception/telephone
Works:	1 test house
	3 security
	4 production planners
	3 mech & hydraulic maintenance
	1 electrical maintenance
<u>Total</u>	<u>20 Persons</u>

TOTAL DIRECT & INDIRECT **28 PERSONS**

This assumes that:

- The two administrators would handle all planning, purchasing issues, etc.
- Sawyers would cut to customers' final ordered lengths and pack onto skips for the furnace (if necessary). One man per press.
- Packers/ageing loaders would be responsible for loading the furnace and final repacking of the ordered sections.
- Utilityman would maintain log and billet supplies in the press area, handle dies, lubricate ingot/ram, etc.

4.13 Pre-Production Costs

Training - 10 men for 6 weeks @ \$3,500: per week	- \$210,000
Commissioning - 3 months	- \$367,500
	<hr/>
TOTAL	- \$577,500
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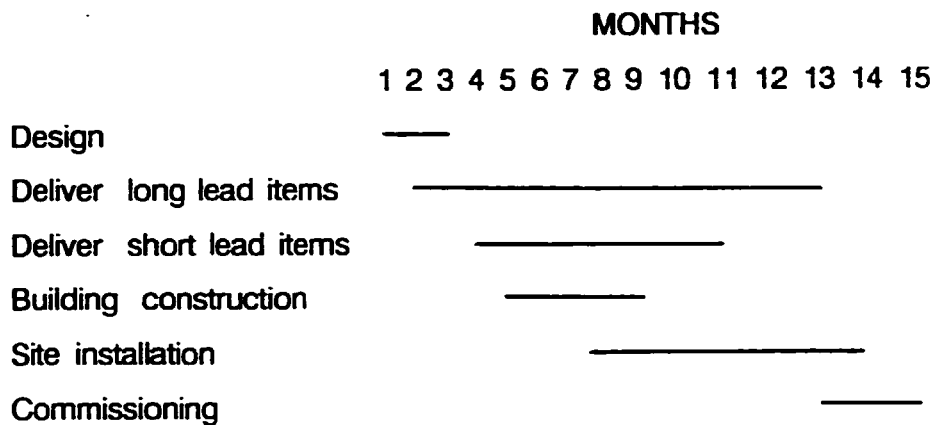
4.14 Early Years Production

Utilising one press :

First 3 months	40 to 160 tonnes
Second 3 months	80 to 200 tonnes
Next 6 months	160 to 800 tonnes
Year 2	800 to 1,800 tonnes
Year 3	1,600 to 2,200 tonnes

It is to be expected that one 800 tonne x 6" diameter press would produce 700 tonnes per annum on a single shift basis of 48 week basis at 90% efficiency.

4.15 Construction Period



4.16 Environmental Aspects

In the event of producing a standard product (without painting or electrolytic finish), no environmental problems should exist.

Waste oils can be stored in barrels and sold off for reclamation.

All scrap metal is non-toxic, has value and would be returned to the smelter.

5.0 COMPARATIVE EUROPEAN PRODUCTIONS COSTS

These are indicated as cost per tonne of finished product in US\$ Dollars having an ex-works price of \$ 3,830.00

Material	\$ 2,390.00
	(London Metal Exchange plus 10%)
Labour	\$ 55.65
Overheads	\$ 552.35
Profit	\$ 832.00

Assume a product mix of:40% standard solid sections
40% Multi Sided Sections
20% Hollow Sections.

The material content includes an allowance for production scrap and its sales value.

6.0 INTERNATIONAL PRICES

Typical international retail prices per tonne of standard sections are:

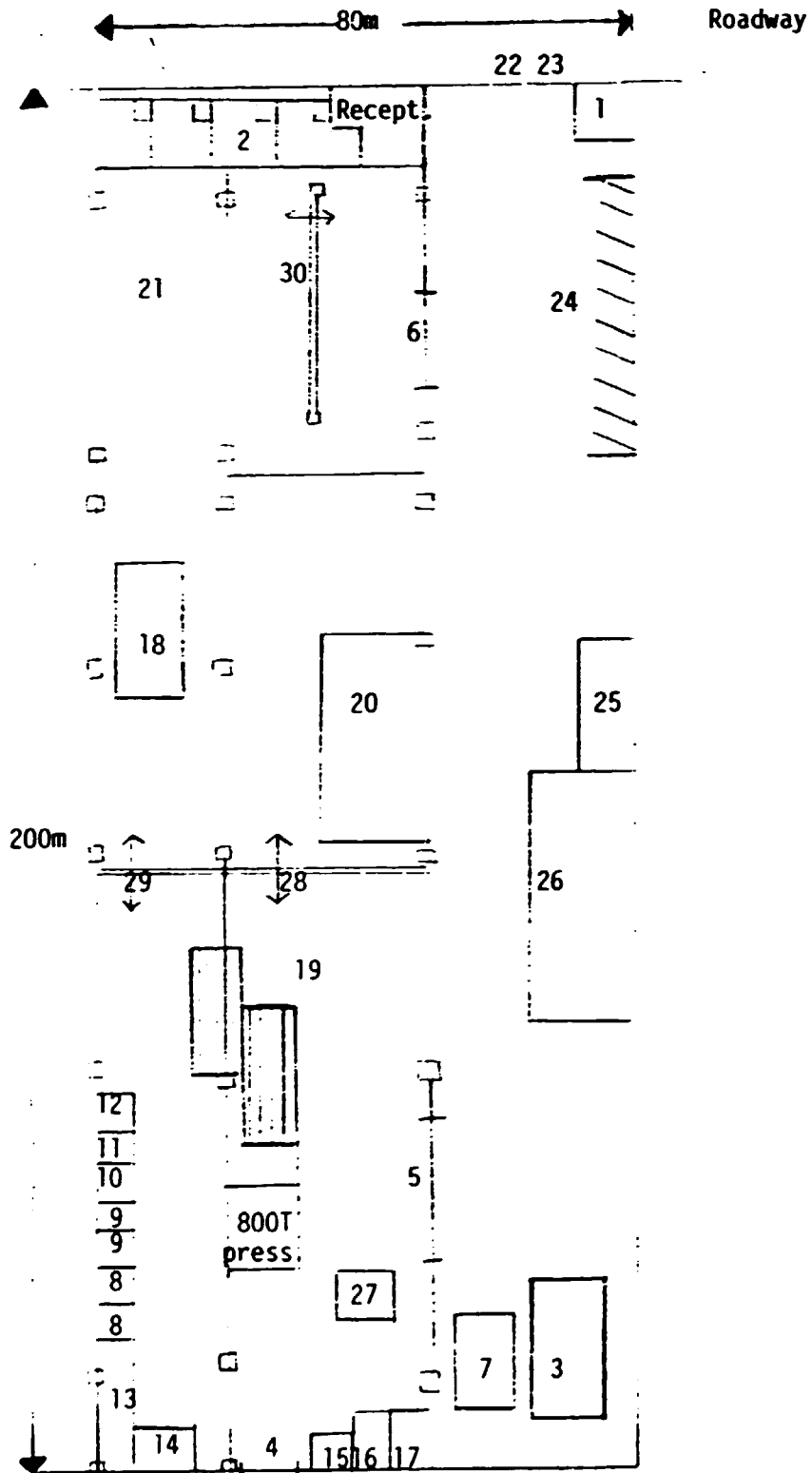
Solid sections	\$3,830 / tonne
Hollow sections	\$3,890 / tonne

It is impossible to calculate the prices of special sections without knowing the details of each profile. However, an example such as general quality radio chassis, 6 finned heat sink section having an overall dimension of 25 mm x 35 mm and sold in 250 Kg lots is selling at \$4,300.00/tonne.

APPENDIX A

MAIN PRODUCTION AREA LAYOUT

BUILDING LAYOUT



Scale: 1cm = 10 metres

KEY:

1. Policed gate house.
2. Two story administrative block.
3. External AI: log storage: totally secured.
4. Entrance to works for raw materials & stores.
5. Entrance/exit to works for all capital equipment.
6. Exit from works for finished products.
7. Area for water cooling towers, filter beds, fuel, etc.
8. Works control offices.
9. Mechanical stores.
10. Electrical stores.
11. Electrical stores office.
12. Furnace control office.
13. Maintenance department (fitting shop).
14. Test house.
15. Die storage.
16. Canteen.
17. Lavatories and showers.
18. Ageing furnace area.
19. Extrusion bay.
20. Extruded section storage area.
21. Finished extrusion sorting packing and despatch.
22. Works entrance from road.
23. Office entrance from road.
24. Office car park.
25. Works garage and maintenance area.
26. Works open car park.
27. Prepared billet storage area.
28. 25/5 ton double hoist crane.
29. 5 ton single hoist crane.
30. 5 ton single hoist crane.