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PROMOTION AND DEVELOPMENT OF SMALL
AND MEDIUM INDUSTRIES

DP/BAH/85/002

BAHRAIN

Technical report: Identification of aluminium products*

Prepared for the Government of Bahrain
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of Rolf D. Weber, consultant, non-ferrous metals

Backstopping officer: V. Gregor, Institutional Infrastructure Branch

United Nations Industrial Development Organization
Vienna

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SUMMARY

0. UNITS

Currency: The Bahraini Dinar was at the time of the mission quoted as BD1 = US$2.65.

1. INTRODUCTION

1.1. Purpose of the Mission

To provide direct support to existing small and medium scale industries, as well as promote new industries.

2.1 Requirements of the Mission

Analysis of the present production range of Bahrain Aluminium Extrusion Company (BALEXCO) and Midal Cables in view of their existing machinery and equipment.

Recommendations on the additional products which can be manufactured with small capital investment.

Assessment of domestic and export marketing potential for such additional products and preparation of their marketing.

2. BALEXCO

The possibility to manufacture accessories hitherto imported has been investigated and a number of products have been identified. In this context an extension of the manufacturing resources such as pressure die casting has been found necessary. A number of new products has been suggested.

3. MIDAL CABLES

The possibility to produce aluminium alloy rod for mechanical purposes has been investigated and established as there exists an international market. A further application of the manufacturing resources could be the production of continuously cast and rolled narrow strip for impact extrusions.

The availability of molten metal could in the future be the base for rapid cooled narrow strip production, a technology transforming molten metal into narrow foil strip for electronic purposes.

4. CONCLUSIONS AND RECOMMENDATIONS

The duration of the mission was too short to conduct any reliable market assessment. A lively upswing of the market situation in the Gulf is expected as soon as the war will be terminated.

Recommendations

Balexco: see 2.3.
Midal Cables: see 3.4.

Material Supply

It is of vital importance that the local aluminium processing industry be given preference regarding supply of raw material, even at the cost of the export of ingots.

Research and Development

At present Bahrain's aluminium industry buys the technology they need to catch up. In future, however, as competition will get fierce, it will be advisable to develop materials and/or processing technology as well as new products independently together. At first, independent consultants may be recruited through the services of UNIDO. Later on a collective R&D organisation will be of great advantage.

Power Transmission

The line of products manufactured/assembled by Balexco, Midal Cables and Al Khajah Factories could be the base of a Power Transmission operation, Balexco producing pylons, busbars, etc. Midal Cables the overhead conductor and Al Khajah the switchgears. Knowhow and competent personnel can be provided from Europe, e.g. Sweden.

5. GENERAL OBSERVATIONS : TECHNICAL EDUCATION

The obvious lack of Bahrain technicians could be overcome by a special training programme. The prerequisits of a competent technician are:

1. At least 3 years shop floor practice.
2. A thorough theoretical education (2 years' course) based on the needs of industry.
3. A high social status ("industrial engineer") implemented by a good salary.

Recommendations in this direction are presented and an informal discussion between industrialists and educators is suggested.

CONTENTS

0. Units: Currency: The Bahraini Dinar was at the time of the mission quoted as 1 BD = 2.65 USD.

1. Introduction

1.1 Purpose of the Project

To provide direct support to existing small and medium scale industries, as well as promote new industries.

1.2 Requirements of the Mission

1.2.1 Analysis of the present production range of Bahrain Aluminium Extrusion Company (BALEXCO) and Midal Cables in view of their existing machinery and equipment.

1.2.2 Recommendations on the additional products which can be manufactured with small capital investment.

1.2.3 Assessment of domestic and export marketing potential for such additional products and preparation of their marketing.

1.3 Procedure

The mission has been carried out in two stages:

Stage 1: BALEXCO

Stage 2: Midal Cables.

1.3.1 BALEXCO

A first analysis of the Company's production range and potential called for two main lines of procedure agreed between the Management and myself.

1.3.1.1 Investigation of the possibility to manufacture accessories hitherto imported, based on records on purchasing and sales quantities and prices for the last two years.

...../2

1.3.1.2 Investigation of possibilties to manufacture and market a number of new products, such as:

Air freight containers
Tubing for air conditioners and refrigerators
Furniture frames
Pylons for high tension power lines
Hospital beds, crutches
Fencing
Safety bars for motor highways
Staircases
Telephone booths and bus shelters
Structural systems;
Lamp posts

The increased number of products will call for an increased number of extrusion dies. The installation of a tool making and servicing department has therefore, to be taken into consideration.

1.3.2 MIDAL CABLES

The company's production range and potential can be applied tc the following products not connected with cable manufacture.

These are:

Deoxidizing rod

Rivet wire

Wire for chain-link fencing,

Zipper wire

Welding wire for MIG welding,

Nail wire, metallizing wire

Strip for the manufacture of slugs used in impact extrusion of cans.

Further have "odd" enquiries been examined during my stay with the company in order to find new markets not thought of before.

Regarding the manufacture of cans and collapsable tubes, the market for canned beverages and for creams, foodpaste and toothpaste in the area will have to be penetrated as well as the market for slugs in Europe and other countries. However, a reliable market survey could not be carried out during the time at my disposal. My efforts have, therefore, been limited to investigate what else except cable can be done on the available equipment as well as how and at what cost.

2. THE BAHRAIN ALUMINIUM EXTRUSION COMPANY

2.1. Manufacture of Accessories Hitherto Imported

2.1.1. General

The majority of accessories are imported from France under an agreement with Technal France, Toulouse.

Considering the manufacturing facilities available at Balexco, and the skill and time necessary for training personnel, a number of Technal accessories have been chosen for manufacture to be recommended to Balexco.

2.1.2. Accessories Based on Extruded Sections

The choice of extrusion based accessories has been made according to the following criteria:

a) Ease in fabrication.
b) Quantity sold during 1986.
c) Suitability regarding the training of labour and supervisory personnel.

The following accessories, identified by their catalogue number, have been chosen (for illustrations see Appendix 1).

1442, 1443, 1444, 1482, 1483, 1486, 1503, 1581, 1632, 1635, 1946 and 1953.

During 1986 Balexco sold the above accessories at a total of BD 86750, varying per item from BD 31 (item 1503) to BD 29057 (item 1635).

On condition of good quality and competitive price there should be a possibility of supplying respectable quantities to Technal.

An analysis of metal prices, manufacturing processes, overhead and production margins as well as transport costs showed that Balexco will be competitive if the gross production cost (exclusive profit margins) does not exceed 45% of the purchasing price for Technal products (exclusive packing and tansport). Examples are given in Table 1.

A certain investment will be necessary, such as jigs and fixtures, tools and welding equipment to seal the plastic bags holding the accessories.

The maximum recommended investment for the fabrication of the above accessories at 1986 sales level would be BD 28400. This has been calculated according to the method explained in Appendix 2. The parameters for the calculation are given in Example 1.

The fabricating costs at Technal's present suppliers have been calculated at 55% of Balexco's purchasing price, leaving a margin of 45% and 25% for present suppliers and Technal respectively, according to inside information from Balexco.

The 45% recommended maximum fabrication cost for Balexco will leave a margin of 10% units for competition and /or contingencies.

2.1.2.1. Manufacturing Resources

The operation needed to fabricate extrusion based accessories are, as necessary:

Cutting
Punching
Milling
Drilling
Thread Cutting
Assembly
Control

The Company has all the necessary plant at its disposal. Any investment will, as already pointed out, be limited to tools, jigs and fixtures.

The main resource however, is the personnel which will need training and efficient supervision.

To make this operation successful it will be necessary to delegate a person responsible for all production of accessories. A starting up period of at least one year will be needed for the whole operation.

2.1.3. Cast Accessories

Accessories manufactured by casting represented 26% of the accessories investigated which have been sold most during 1986.

These items were 1280 (270g, 1572 units), 1484 (480g, 5633 units) and 1493 (547g, 1917 units) as illustrated in Appendix 1A. The way to produce these accessories is by pressure die casting. This quantity (totally 2774 kgs during 1986) does not warrant the installation of a die casting plant. On the other hand, if these accessories could be supplied to Technal on a subcontracting basis, there will be considerable quantities to be produced.

As these accessories are required to stand up to considerable mechanical stresses (Fig. 5), pressure die casting is the only method of production to ensure the required material strength. Even regarding surface smoothness, pressure die casting produces the best results. However, as the economical minimum of work pieces per item is about 10,000 and the minimum productivity per equipment unit lies at 75 pieces/hour a minimum production of 150000 pieces p.a will be required.

In order to reach a possible subcontracting agreement with Technal their total annual requirements of die cast accessories must be known, as well as the annual requirements per item before the size of die casting equipment can be decided on.

Potential over capacity is to be used by filling up with collars (2500 units, 7500 kgs in 1986), covers and foundation plates for lamp posts. These products will be dealt with in the chapter covering new products.

Assuming an average weight of 450g per piece and the minimum production quantity of 150000 pieces p.a produced at average weight the total tonnage would amount to 67.5 tonnes p.a. As a general rule the investment costs per ton of pressure die castings are calculated UD$ 4440 (BD 1675) which would mean BD 113062 for a production of 150000 pieces p.a. To this will have to be added scrap re-melting capacity of US$ 200 (BD 75.5) per ton. i.e. BD 5057 for an annual production of 67.5 tons, totalling approximately BD 120000 for the whole plant.

This figure is usually insufficient since it only includes the cost of equipment, but no packing, transport and installation cost, which as a rule amounts to 60% of the cost of equipment. Thus the gross investment would amount to BD 192000 for re-melting and casting equipment only. Painting equipment should be added, since the herementioned accessories are to be painted. A number of other cast accessories are anodised.

A calculation of the maximum recommended investment and total capital cost finishes according to Appendix 2, equation 16, at BD 160000 for the investment and BD 189610 for the total capital cost for the whole operation. In all die casting operations the mould represents the major outlay per cast piece. In the above calculation the cost of the mould has not been included, the reasons being that the customer usually owns the mould as a subcontractor's insurance against potential sudden obsolescence of the design.

The parameters in the above calculation have thus been given the values shown in Table 2.

As supplier of die casting equipment, Weingantan is recommended. This Company supplies all equipment, moulds and know-how.

The availability of molten metal at Midal might at first sight appear attractive for the installation of die casting equipment at that plant. This would, however, impede competitive handling and sales administration.

2.2. New Products

The following new products are already manufactured:

Telephone booths
Bus shelters
Lamp posts

As too short a time for this mission has been allocated a proper investigation of all products mentioned in the introduction cannot be carried out. Time permitting, a few products will be dealt with in extenso. For the remaining products some guide lines will be given for completion on a later occasion. All new products are of the assembly type based on extra staff. The question of die manufacture at Balexco was for the above reasons to be left to a later investigation.

2.2.1. Lamp Posts

The conical collars between the two diameters of the lamp posts are at present gravity die cast. In this context it should be mentioned that the surface of gravity die castings provides a better anodizability than in the case of pressure die castings, which as a whole is satisfactory. It has also been noticed that the present way of fixation in the ground renders any replacement difficult. An alternative way of fixation is suggested guaranteeing quick and simple replacement. (Fig. 6) The cost of this alternative will be approx. BD 7 but is a once and for all investment. Its economy depends on how many times a lamp post gets run down by inattentive drivers.

There is also a market for covers for the power connections and fuse box in the lower part of the lamp post. These covers may be extruded or die cast. One cover weighs 1.06 kg and about BD 0.8 when extruded. Compare:

Extruded:	Material :	1.06 kg	=	BD 0.7/pce
	Extrusion :			
	Fabrication :			
	45 pcs/hr :	$\frac{3.6}{45}$ =	=	BD 0.8/pce
	Total :			0.79/pce
Die Cast:	Material :	1.06 kg	=	BD 0.53/pce
	Casting case:		=	BD 0.51/pce
Mould:	BD 2000 for 30000 pcs		=	BD 0.07/pce
	Total :		=	BD 1.11/pce

2.2.2. Structural Systems

Structural systems (Fig. 7) for displays, shop fittings, exhibition stands, etc, are a product which could be produced successfully at Balexco. Input, material and equipment as well as welding skill exist within the Company. Further training of the welders would have to be effectuated as one goes along. From corespondence passed on it emanates that there is a market for this type of product. There should be no great difficulty to enter this line if the quality is good and the price is right. It is suggested to obtain all necessary engineering drawings from the UK based company marketing these systems and to execute trial orders. No investment is needed.

2.2.3. Fencing

Wire net fencing is a product which can be produced jointly by Balexco and Midal Ltd. Balexco producing poles and gates and Midal the wire for the wire netting. In co-operation with fencing specialists such as BRC Weldmech there should be a possibility to get into this market. There is a great demand for fences in Saudi Arabia to keep the camels from crossing the highways in an uncontrolled manner. Suggested contact: The authorities in charge of roads and traffic. No investment is needed.

2.2.4 Safety Bars for Motor Highways

Safety bars are up to now made of steel and when they do their service in stopping cars from going off the road are often instrumental in hurting drivers and/or passengers due to their superior machanical strength. Aluminium safety bars can be made in high strength extrudable alloys. Their higher plasticity as compared with steel will lessen damage done to people and cars. A slightly different design will be needed to combine higher plasticity with high resistance to bending. The limited time of this mission does unfortunately not allow time to work out detailed suggestions and will have to be left to a later mission. The market envisaged for this product is limited in Bahrain but should be quite attractive in S. Arabia and the other Gulf countries. Besides, there will certainly be a regular market for replacements. No investment is needed.

2.2.5. Pylons for High Tension Power Lines

In co-operation with Midal a power line construction operation can be served with all essentials, cables, pylons, busbars and power transmission accessories in aluminium. This market will be exportoriented in S. Arabia and other GCC countries. In this respect the ties Midal has with Saudi Cable Co. could help.

Know-how on transmission line and pylon construction could be otained through the Swedish Electricity Authority (Vattenfallstyrelsen). No investment is needed.

2.2.6. Air Freight Containers

A thorough study of the material available (Alüsingen's Maintenance Manual) and several inspections of the container stationed at Balexco, led to the conclusions that it will be necessary to obtain all international regulations on this type of product, which appear to be stringent. Further reliable market research will be needed. According to information received Gulf Air have promised to supply a market survey which has to date not yet been received. No investment is needed.

2.2.7. Furniture Frames, Hospital Beds and Crutches

In co-operation with Bahrain Light Industries Company some designs could be developed. However, the services of an inventive designer will be needed.

Regarding hospital beds and crutches, designs and regulations will have to be obtained from the health authorities. Further dealers in this equipment will have to be found and contacted. Even this product could be included in a joint operation together with Blico. No investment is needed.

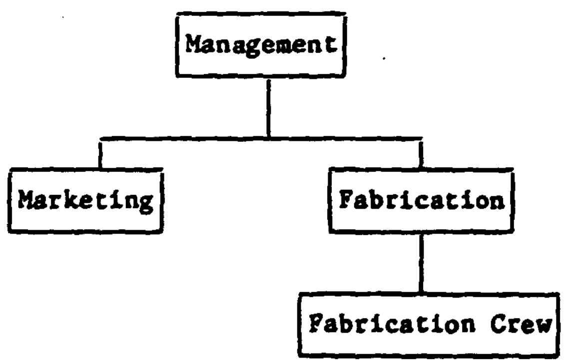
2.2.8. Staircases

Depending on the building activity in the area, staircases can be manufactured with the support of the Technal system. No investment is needed.

2.2.9. Organisation of Operations

If the company decides to embark on fabricated products a suitably working and very flexible organisation will be needed, growing and shrinking with the market requirements.

2.2.9.1 Suggested Organisation Of Responsibilities For Fabricated Products.



It is suggested to start these operations on a small scale as a one man operation with a flexible fabricating crew as needed. In the beginning marketing and fabrication could and should be managed by one person with an absolute minimum of administration in order to assume later an efficient control of the whole operation.

2.2.10. Tubing For Air Conditioners and Refrigerators

A visit to the Al Khajah Factory showed very interesting possibilities for aluminium tube. At the hour of writing the quantities and sizes are not known. There is, however, a very large and interesting market to be served. At present, Al Khajah use copper tube for the cooling units. The copper tube is imported from Japan. Very big orders were being processed at the time of the visit. (300,000 units for Saudi Arabia.)

It is, therefore, suggested that a joint development programme together with Al Khajah and Daikin (the japanese supplier of equipment and know-how) be initiated in order to replace copper tube by aluminium tube. There are some obstacles to overcome in the manufacturing technique, which are not unsurmountable. The development programme will have to include:

Tube manufacture at Balexco
Assembly and welding technique at Al Khajah
Endurance and reliability tests at Al Khajah
Portable repair unit for aluminium welding in situ.

Balexco should even engage themselves in the development stages at AL Khajah as their result will influence Balexco's chances to sell aluminium tube.

A successful change to aluminium tubing in a.c. equipment might even increase Al Khajah's export possibilities because of a more attractive price. The price of copper and aluminium is approximately the same per weight unit. (The price of raw copper amounts to about 90% of the aluminium price). As aluminium has 3.3 times the volume of copper per weight unit the price of aluminium per volume unit is accordingly lower. A further advantage of aluminium tube is the fact that aluminium tube comes from next door with a minimum transport cost, while the copper tube has to be imported.

Some investment will be necessary. At the hour of writing its size cannot be assessed until all necessary information has been received.

2.3. Conclusion and Recommendations

Considering the amount of possibilities to be investigated the duration of the mission was insufficient to provide the company with little more than suggestions which is unsatisfactory from the point of view of both the company and the expert. There exist good potential applications for the company's products.

In order to obtain applicable results the following steps will have to be taken:

2.3.1. A reliable market survey and international regulations on air freight containers must be obtained.

2.3.2. Blico will have to suggest some attractive designs. The market for hospital beds and crutches will have to be assessed with the assistance of the Ministry of Health and a company trading in these utilities will have to be found.

2.3.3. The demand for high tension power lines throughout the Gulf countries will have to be assessed with the help of the Ministry of Work, Power and Water.

2.3.4 The ministries responsible for roads in the GCC countries will have to be approached through the official channels to obtain some indications on future highway building and/or road improvement in order to assess the market for safety bars. If the market so requires the existing design of the safety bars will have to be changed to provide adequate protection and to take account of the mechanical properties of aluminium as compared with those of steel.

2.3.5. Fencing traders will have to be approached to asses the market for wire fencing.

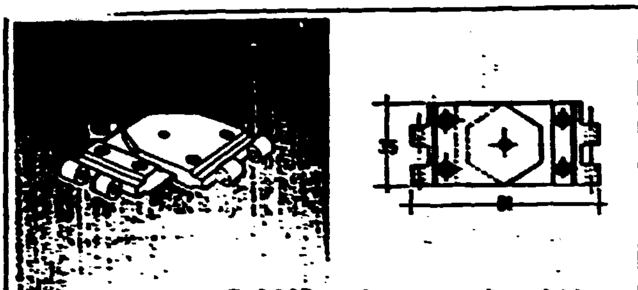
2.3.6. The UK traders in structural systems to be asked to submit all drawings necessary for a trial order.

2.3.7. A joint group for the development of a.c. units based on aluminium tubing together with Al Khajah Factories and Daikin is suggested.

All necessary know-how on manufacture, welding and properties of aluminium tube under cooling conditions is to be gathered and may be obtained with the help of UNIDO.

In order to complete this work the undersigned will be prepared to undertake a second mission UNIDO permitting.

APPENDIX 1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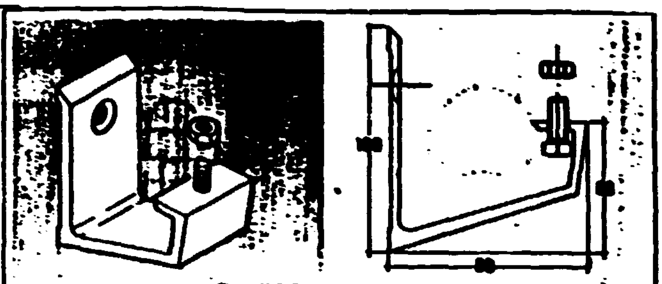
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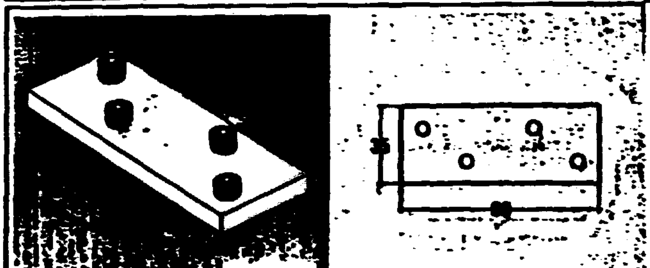
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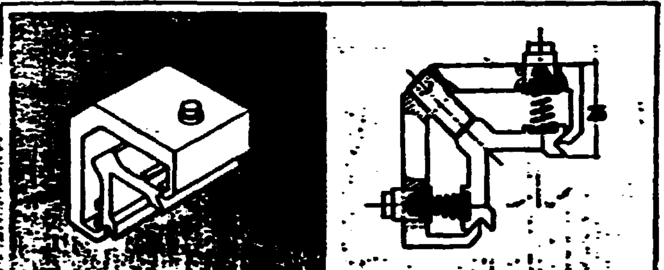
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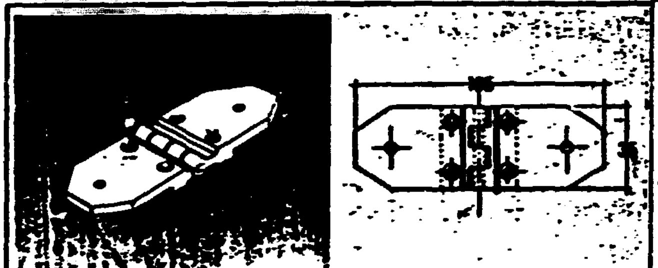
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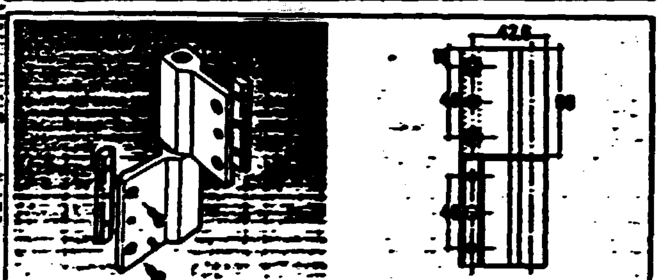
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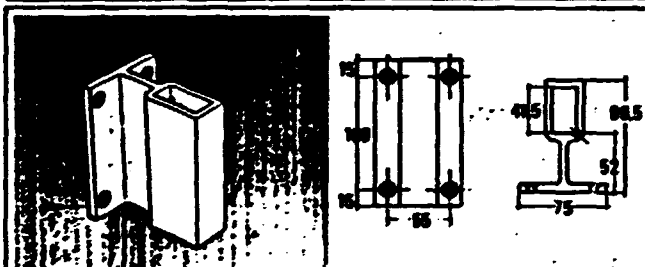
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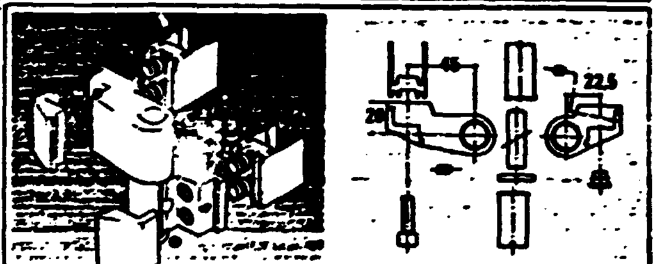
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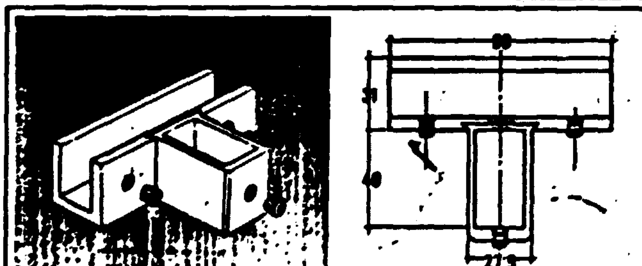
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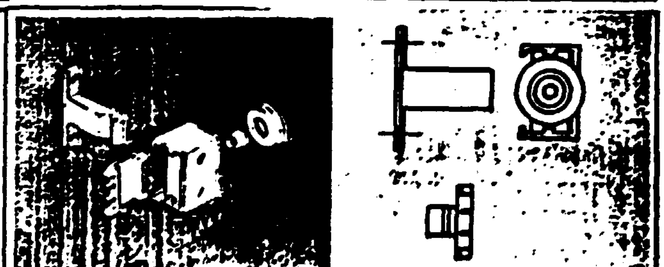
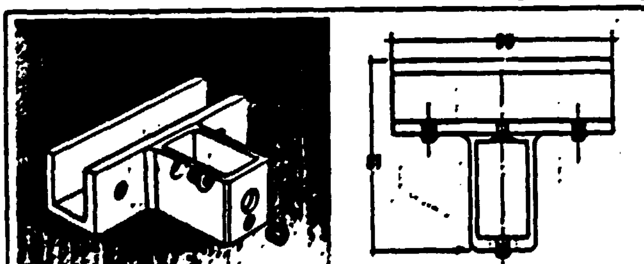

GK 1946 fermeture à poussoir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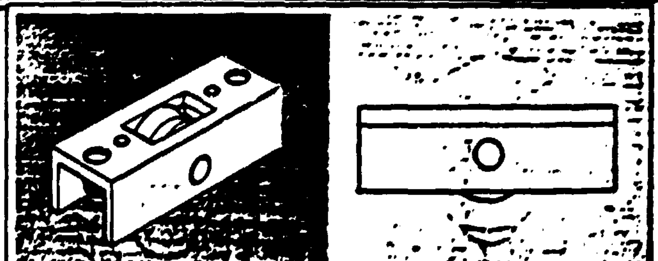
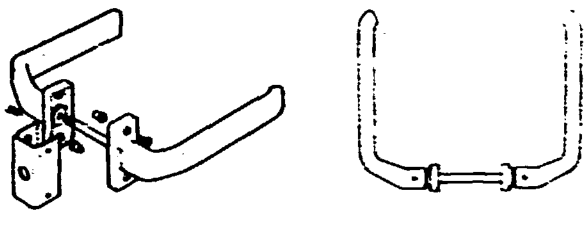
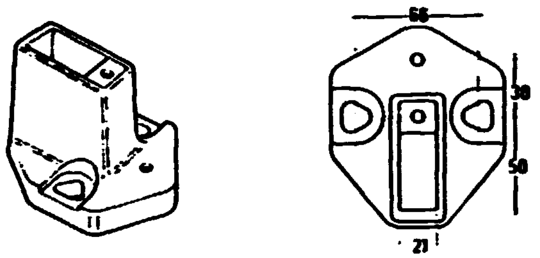

GK 1963 roulette simple

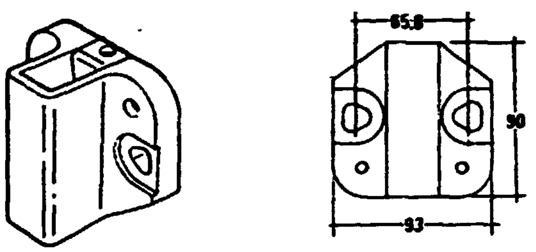
APPENDIX 1A



T 1280 béquille double



S 1484 platine raidisseur 40 x 20



S 1493 platine dalle Acroblock®

APPENDIX 2

Maximum recommended investment

*R D Weber,
Senior Lecturer

The method of calculating the maximum permissible investment, or in short the MPI-method, was developed as a result of assignments in South America and Africa with the United Nations Industrial Development Organisation (UNIDO).

There are plenty of 'investment carcasses' to be found in the Third World, and not only there. Even in the industrialised part of the world there are a good many 'investment follies' in existence. A project may be classified as an 'investment carcass' when there is no chance of paying-off the investment by means of the operational activities created by the project. Evaluation of industrial projects is time consuming and has to be carried out from different angles depending on the purpose of the project in question. Before embarking on a comprehensive evaluation of a project the person charged with this task should have access to a quick and simple method allowing him/her to undertake a preliminary feasibility estimate of the project.

The MPI-method does not claim to be accurate — which method dealing with future activities is? — but should provide a simple and effective instrument for this purpose. The method has been successfully employed even in cases of some European industrial projects and has saved millions for investors, dissuading them convincingly from investing in further carcasses.

The method in this article is illustrated by two examples, a copper tube mill and an aluminium extrusion plant. In order to minimise guesswork and to keep as close as possible to the reality to be expected in the future, using present-day knowledge, certain basic ideas and assumptions have been employed.

1. Basic stipulations and assumptions

1.1. Basic stipulations

The basic idea stipulates that the break-even point, ie the stage where total cost and turnover are equal, should be reached as quickly as possible. The calculating method will also show the time when break-even must be reached for a certain investment volume.

A further basic stipulation foresees a profit of 15 per cent at full production. Full production is here defined as 80 per cent utilisation of theoretical capacity of the plant in question. From the above stipulations it is evident that break-even should be reached at 68 per cent utilisation of the theoretical capacity, ie U = 0.8 × 0.85C.

It will also be shown that the rate of utilisation at break-even point is a function of the maximum permissible investment (MPI).

1.2. Basic assumptions

In order to avoid any over-optimistic assessment, the whole chain of costs and investment outlays will have to be considered. For this purpose the whole sequence of activities from the date of decision to start a project to the date of break-even is broken down into its component parts. Thus the following cost-consuming steps have been considered:

1. Project planning
2. Purchase of site
3. Building, construction and engineering
4. Purchase and installation of equipment
5. Start-up
6. Break-even

1.2.1. Planning and building stage

For the sake of simplicity it is assumed that the accumulating investment burden increases as a linear function, as shown in Figure 1. At the time when the equipment is ready to start up, the total investment is regarded as completed.

It is also assumed that funds for the total investment will have to yield interest at 'x' per cent (%). As the plant does not produce any income during the planning and erecting period, it is further assumed that no interest will have to be paid until the plant is started, when amortisation and accumulated interest are due.

In order to avoid complicated and time-consuming calculations, it is assumed that the total investment and interest accumulated during the planning and erecting period will be paid off within 'n' years by equal annuities, whereby the rate of amortisation increases as the interest decreases with decreasing debt. By this method the annual cost may easily be calculated.

The interest accumulated up to the point of starting up the plant is calculated as follows:

$$X_i = I \frac{x}{100} \frac{n_g}{2} \qquad \ldots (1)$$

Where I = Total investment.
n_g = Time up to starting up (years), including planning and erection.
x = Rate of interest.

Equation (1) is based on the steady increase of the investment as shown in Figure 1.

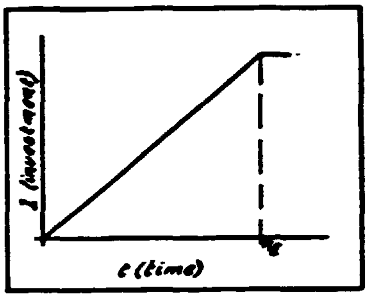


Fig 1 Increase in investment during the planning and erection period n_g = period of planning and erection up to the date of starting-up

The total debt accumulated at the date of starting up will thus be:

$$D_i = I + X_i \qquad \ldots (2)$$

The annuity factor is determined as:

$$f_a = \frac{\frac{x}{100}\left(1 + \frac{x}{100}\right)^n}{\left(1 + \frac{x}{100}\right)^n - 1} \qquad \ldots (3)$$

where x = Rate of interest (%).
n = Number of years for amortisation,

and the annuity as:

$$a_{Di} = f_a \cdot D_i \qquad \ldots (3a)$$

Table 1 shows annuity factors for different rates of interest from one to 50 years amortisation.

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Table 1: Annuity factor up to 50 years amortisation at different rates of interest

$$\text{Annuity factor } f_a = \frac{\frac{x}{100}\left(1+\frac{x}{100}\right)^n}{\left(1+\frac{x}{100}\right)^n - 1}$$

Years (n)	Rate of interest (x)								
	4%	5%	6%	8%	10%	12%	15%	18%	20%
1	1.04000	1.05000	1.06000	1.08000	1.10000	1.12000	1.15000	1.18000	1.20000
2	0.53020	0.53780	0.54544	0.56077	0.57619	0.59170	0.61512	0.63872	0.65455
3	0.36035	0.36721	0.37411	0.38803	0.40211	0.41635	0.43798	0.45992	0.47473
4	0.27549	0.28201	0.28859	0.30192	0.31547	0.32923	0.35027	0.37174	0.38629
5	0.22463	0.23097	0.23740	0.25046	0.26380	0.27741	0.29832	0.31978	0.33438
6	0.19076	0.19702	0.20336	0.21632	0.22961	0.24323	0.26424	0.28591	0.30071
7	0.16661	0.17282	0.17914	0.19207	0.20541	0.21912	0.24036	0.26236	0.27742
8	0.14853	0.15472	0.16104	0.17401	0.18744	0.20130	0.22285	0.24524	0.26061
9	0.13449	0.14069	0.14702	0.16008	0.17364	0.18768	0.20957	0.23239	0.24808
10	0.12329	0.12950	0.13587	0.14903	0.16275	0.17698	0.19925	0.22251	0.23852
11	0.11415	0.12039	0.12679	0.14008	0.15396	0.16842	0.19107	0.21478	0.23110
12	0.10655	0.11283	0.11928	0.13270	0.14676	0.16144	0.18448	0.20863	0.22526
13	0.10014	0.10646	0.11296	0.12652	0.14078	0.15568	0.17911	0.20369	0.22062
14	0.09467	0.10102	0.10758	0.12130	0.13575	0.15087	0.17469	0.19968	0.21689
15	0.08994	0.09634	0.10296	0.11683	0.13147	0.14682	0.17102	0.19640	0.21388
16	0.08582	0.09227	0.09895	0.11298	0.12782	0.14339	0.16795	0.19371	0.21144
17	0.08220	0.08870	0.09544	0.10963	0.12466	0.14046	0.16537	0.19149	0.20944
18	0.07899	0.08555	0.09236	0.10670	0.12193	0.13794	0.16319	0.18964	0.20781
19	0.07614	0.08275	0.08962	0.10413	0.11955	0.13576	0.16134	0.18810	0.20646
20	0.07358	0.08024	0.08718	0.10185	0.11746	0.13388	0.15976	0.18682	0.20536
25	0.06401	0.07095	0.07823	0.09368	0.11017	0.12750	0.15470	0.18292	0.20212
30	0.05783	0.06505	0.07265	0.08883	0.10608	0.12414	0.15230	0.18126	0.20085
40	0.05052	0.05828	0.06646	0.08386	0.10226	0.12130	0.15056	0.18024	0.20014
50	0.04655	0.05478	0.06344	0.08174	0.10086	0.12042	0.15014	0.18005	0.20002

1.2.2. Start-up period

When starting up a plant the rate of utilisation follows as a rule a logarithmic function, Figure 2. This also applies to the turnover (T).

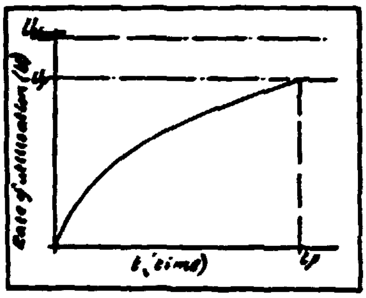


Fig 2 Increase in utilisation during starting-up period. U_{max} = theoretical capacity (100 per cent utilisation), U_p = utilisation at full production, t_p = time to attain full production

$$U = k_U \ln(t+1) \quad \ldots (4)$$

$$T = k_T \ln(t+1) \quad \ldots (5)$$

where U = Rate of utilisation.
t = Time (years).
k_U = Utilisation related constant.
k_T = Turnover related constant.

At the break-even point turnover (T_o) and total cost (C_{tot}) are equal, Figure 3. As shown in Figure 3, the total cost up to the break-even point will have to be met by (borrowed) working capital which has to yield an interest, to be included in the total cost.

1.2.2.1. Initial working capital

The above reasoning enables us to assess the magnitude of the initial working capital needed up to the point of break-even. The accumulated total cost during the start-up period up to the break-even point is represented in Figure 3 by the area ABCD, the initial working capital (C_{IWmax}) being represented by the area ABC.

Mathematically the initial working capital may be determined as:

$$C_{IWmax} = t_o (C_f + a_{IN}) + \int_1^{t_o+1} k_{cv} \ln t \, dt - \int_1^{t_o+1} k_T \ln t \, dt$$
$$= t_o (C_f + a_{IN}) + [(t+1)\ln(t_o+1) - t_o][k_{cv} - k_T] \quad \ldots (6)$$

where t_o = Start-up period (years).
k_{cv} = A constant related to the variable cost.
k_T = A turnover related constant.

The initial working capital will be subject to interest and is assumed to be paid off over a number of years. This cost will have to be included in the total cost (C_{tot}). The annuity is determined as:

$$a_{IW} = fa_{IW} \cdot C_{IWmax} \quad \ldots (7)$$

where a_{IW} = Annuity.
fa_{IW} = Annuity factor (equation 3).
C_{IWmax} = Total initial working capital debt accumulated during the start-up period.

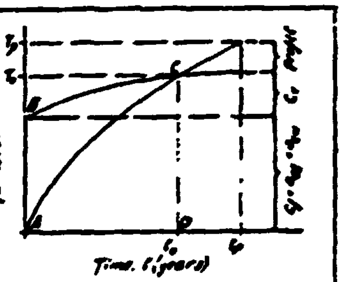


Fig 3 Starting-up function showing annuity and operation costs as well as initial working capital (area ABCD). T_p = Turnover at full production. T_o = Turnover at breakeven. t_o = Time to attain break-even. t_p = Time to attain full production. a_{IN} = Investment related annuity. a_{IW} = Annuity related to initial working capital. C_v = Variable operation cost. C_f = Fixed operation cost

1.2.3. Total cost (C_{tot})

The total cost defined as the sum of all annuities and running costs (C_r) is:

$$C_{tot} = a_{tI} + a_{wc} + C_r \qquad \ldots (8)$$

where a_{tI} = Annuity related to total investment debt.
a_{wc} = Annuity related to initial working capital debt.
C_r = Running cost.

1.2.3.1. Running cost

The running cost is divided into a fixed portion (C_f) and a variable portion (C_v). The fixed portion includes general costs such as wages, salaries, social contributions, insurance, research and development, infrastructural charges, etc. The variable portion includes costs dependent on the level of activity such as power and water consumption, maintenance, wear, raw materials, bonus on wages, etc.

As a reasonable approximation the variable cost (C_v) may be assumed to represent approximately 30 per cent of the total running cost at the break-even point. Wages, salaries and social contributions (C_s) may be assumed at 50 per cent of the total running cost, thus:

$$C_v = 0.3\, C_r$$
$$C_s = 0.5\, C_r$$

These assumptions may have to be modified to reflect local reality in each specific case.

1.2.4. Rate of utilisation (U)

From Figure 2 it will be noticed that the rate of utilisation at full production is less than 100 per cent, which would correspond to the theoretical capacity of the plant. In a well-run industry full production is reached at approximately 80 per cent or more of the theoretical capacity. Modification of this assumption may be necessary for particular local circumstances and for different types of industry.

1.2.5. Break-even point

In order to determine the point of break-even ($T = C_{tot}$) extensive experience in the respective branch of industry is necessary when assessing the length of the starting-up period.

Furthermore, the rate of utilisation at the break-even point will have to be given thorough consideration. In times of recession and generally low activity it is advisable to plan the rate of utilisation at break-even at a level corresponding to the level of activity prevailing in the respective branch of industry throughout the world at the time. This in turn will influence the size of the total investment.

2. Maximum permissible investment (MPI)

Based on the stipulations and assumptions enumerated in Chapter 1, the maximum permissible investment may now be determined as a function of the turnover at break-even:

$$MPI = f(T_e)$$

According to the definition given under "basic stipulations," turnover equals total cost at break-even:

$$T_e = C_{tot} \qquad \ldots (9)$$

Expressed in terms of equation (5) and (8) as illustrated in Figures 2 and 3:

$$k_T \ln(t_s+1) = a_{tI} + a_{wc} + C_r \qquad \ldots (10)$$

The annuity for the total debt at break-even will thus be:

$$a_{tI} + a_{wc} = k_T \ln(t_s+1) - C_r \qquad \ldots (11)$$

Assuming that the annuity factor f_a is the same for the total investment and the initial working capital debt, paying off both debts over the same number of years 'n' the total debt will be:

$$D_t + C_{wcin} = \frac{T_e - C_r}{f_a} \qquad \ldots (12)$$

which equals the total financing requirements.

According to equations 1 and 2:

$$D_t = I\left(1 + \frac{x\, n_E}{100 \cdot 2}\right)$$

where I = The investment in all facilities such as estate, buildings, machinery and other installations, is the maximum permissible investment (MPI).
n_E = The length of erection period in years.
x = Rate of interest (%).

According to equation 6:

$$C_{wcin} = t_s(C_f + a_{tI}) + [(t_s+1)\ln(t_s+1) - t_s]\,[k_{cv} - k_T]$$

but as $k_{cv}\ln(t_s+1) = C_{ve}$ the variable cost at break-even and $k_T \ln(t_s+1) = T_e$ the turnover at break-even, then

$$k_{cv} = \frac{C_{ve}}{\ln(t_s+1)} \quad \text{and} \quad k_T = \frac{T_e}{\ln(t_s+1)}$$

As mentioned above, the variable cost at break-even could safely be assumed to be approximately 30 per cent of the running cost, thus:

$$C_{ve} = 0.3\, C_r \quad \text{and} \quad C_f = 0.7\, C_r$$

Generally speaking, we can put:

$C_{ve} = mC_r$, where $m<1$
and therefore $C_{fe} = (1-m)\, C_r$

As mentioned under section 1.2.2. and shown in Figure 2, both the rate of utilisation and turnover follow a logarithmic function during the start-up period, which leads to equation (16). The calculation may be simplified by assuming that the increase in rate of utilisation and turnover follows a linear function, Figure 4. The initial working capital (C_{wcin}) is in this case determined as follows:

$$C_{wcin} = t_s(C_f + a_{tI}) + c_{ve}\frac{t_s}{2}$$
$$= t_s\left(C_f + a_{tI} + \frac{C_{ve}}{2}\right) \qquad \ldots (17)$$

where C_f = Fixed portion of running cost (C_r).
C_{ve} = Variable portion of running cost at break-even.
a_{tI} = Annuity related to the total debt accumulated at the date of starting-up (see equations 1, 2 and 3).

The value of the variable cost factor 'm' depends on the type of industry and on local conditions.

The object of this exercise is to express the maximum permissible investment MPI as a function of the turnover at break-even (T_e) and the different cost and time related factors. In this context the relation between running cost and turnover is important:

$$p = \frac{C_{re}}{T_e} \qquad \ldots (13)$$

$$\text{thus } C_{re} = p \cdot T_e \qquad \ldots (13a)$$

where p = Running cost/turnover ratio.
C_{re} = Running cost at break-even.
T_e = Turnover at break-even.

Equation (6) may thus be written in a simplified manner:

$$C_{wcin} = T_e(mp-1)\left(t_s + 1 - \frac{t_s}{\ln(t_s+1)}\right) + t_s(C_f + a_{tI}) \qquad \ldots (14)$$

From equations 1, 2 and 12 the maximum permissible investment may thus be expressed as follows:

$$I = MPI = \frac{\frac{T_e - C_{re}}{f_a} - C_{wcin}}{1 + \frac{x \cdot n_E}{200}} \qquad \ldots (15)$$

Note: $C_r = (1-m)\, pT_e$ and $a_{tI} = f_a D_t$

By inserting equation (14), equation (15) may be written as below (equation 16):

$$MPI = \frac{T_e\left[\frac{(1-p)}{f_a} - (mp-1)\left(t_s + 1 - \frac{t_s}{\ln(t_s+1)}\right) - t_s p(1-m)\right]}{\left(1 + \frac{x \cdot n_E}{200}\right)(1 + t_s f_a)} \qquad \ldots (16)$$

If, according to equations (13) and (13a)

$$p = \frac{C_{ve}}{T_e} \quad \text{and thus } C_{ve} = p \cdot T_e$$

and further

$$C_{ve} = mpT_e \text{ and } C_f = (1-m)\,pT_e$$

the maximum permissible investment based on a linear starting-up function will be:

$$MPI = \frac{T_e\left\{\frac{1-p}{f_e} - t_e\left[(1-m)p + \frac{mp}{2}\right]\right\}}{\left(1+\frac{xn_t}{200}\right)(1+t_e f_e)}$$

$$= \frac{T_e\left[\frac{1-p}{f_e} + t_e p\left(\frac{m}{2}-1\right)\right]}{\left(1+\frac{xn_t}{200}\right)(1+t_e f_e)} \quad \ldots (18)$$

This way of looking at the starting-up period results in a less favourable level of permissible investment because of the need for higher initial working capital. This leaves a less accurate picture of the real circumstances which could be decisive when the magnitude of investment just touches the permissible level. The examples presented in the Appendix will illustrate this point.

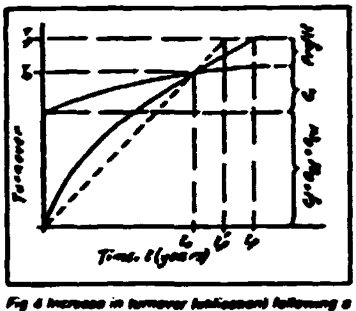


Fig 4 Increase in turnover (utilisation) following a logarithmic and a linear function (dashed lines). T_p = Turnover at full production. T_e = Turnover at breakeven. t_e = Time to attain break-even. t_p = Time to attain full production. a_{ID} = Investment related annuity. a_{CW} = Annuity related to initial working capital. C_v = Variable operation cost. C_f = Fixed operation cost

2.1 Technical reliability

If the investment concerns well-known and well-tried manufacturing processes the technical reliability will be high, ie the chances of interruptions in production due to unforeseen mishaps will be very small. Thus the utilisation at full production is known and may be taken into consideration at its known value.

Should, however, the investors in a developing country be brave (or more likely foolhardy) enough to embark on a new production technique, possibly still in its infancy, they should be discouraged by the expert and/or the suppliers of equipment and know-how.

If all persuasion should prove to be fruitless, a factor of technical reliability will have to be introduced into the calculations, $0<R_t<1$, by which T_e will have to be multiplied. This factor will lower the level of break-even and thus the maximum permissible investment. The reasons for low technical reliability vary with the production process from reoccurring cobbles in an automatic wire rod rolling mill to unreliable electronically controlled dosage in a chemical processing plant where electronics are exposed to large variations in temperature and/or humidity caused by the process.

The factor of technical reliability will have to be determined on the basis of earlier experience. Where such experience is not available the reliability factor should be given a safely low value, say 0.5. In this context it is vital not to be influenced by wishful thinking which could have devastating economic consequences.

2.2 Investment components

The maximum permissible investment must even include planning and engineering cost, site and buildings. A breakdown of the total investment into its component parts enables the expert to suggest cuts if the MPI should result in too low a value to accommodate all components. To start an industry on a small scale, as often should be the case in developing countries, does not necessitate company-owned estate. On the contrary, it might be wise to rent an existing building, thus avoiding blocking capital. Such reasoning applies only if there exists the necessary infrastructure which is mostly not the case in many developing countries.

The following investment components will have to be considered: project planning, building site, buildings, engineering, purchase, transport and installation of equipment.

In order to arrive at a realistic assessment of the different components an analysis of their relative proportion will be necessary. Even here an approximation will be the only possibility for arriving at a reasonable proportion of the different components to the total investment, which differs with each industrial branch. The following values may be considered as an average for the mechanical industry:

Project planning: Approximately 15 per cent of total investment.

Engineering: Approximately 15 per cent of total investment, including foundations for machinery, installation of electric power, communications, water supply, drainage and — where necessary — provisions for environmental protection. The engineering cost does not, however, include infrastructural provisions.

Equipment: Total cost, including transport and installation, will have to be calculated as 180 per cent of the purchase price of the equipment.

Site and buildings: To be assessed according to local costs for estate and building.

3. Procedure for determining MPI

The procedure for determining the maximum permissible investment requires determination of the parameters T_p, C_f, t_e, m, p, f_e and n_t as per equations (16) and (18) respectively.

3.1. Determination of likely turnover at full production (T_p) based on knowledge of the market to be satisfied. According to the basic stipulations a profit of 15 per cent is anticipated at full production, which means that: $T_p = 1.15\,C_{tot}$ where C_{tot} = total cost.

Since the variable portion of the running cost (C_v) is a function of the level of activity it increases with turnover. In order to determine the total cost, C_v will have to be added to the total fixed costs ($C|_{fixed}$):

$C_{fixed} = a_{ID} + a_{cw} + C_f$ (see equation 8) and the total cost

$C|_{tot} = a_{ID} + a_{cw} + C_f + C_v$

Note: $C_f + C_v = C_r$ (running cost).

In order to be able to determine T_p it is necessary to acquire a fairly realistic idea about the magnitude of the market and the share in that market which is realistically attainable.

3.2. Determination of turnover at break-even. For the sake of simplification the turnover at break-even is assumed at $T_e = 0.85\,T_p$

3.3. Determination of running cost/turnover ratio 'p':

$$p = \frac{C_{re}}{T_e}$$

where C_{re} = running cost at break-even

$$C_{ve} = m \cdot C_{re}$$

$$C_{fe} = (1-m)\,C_{re}$$

$$C_{we} = q \cdot C_{re}$$

ie, the cost for wages and salaries at break-even. C_{we} may be determined by the estimates concerning number of employees needed to run the plant based on local conditions regarding wages, salaries and social contributions. The factors 'm' and 'q' are both less than 1 and will be typical for each type of industry and local conditions.

3.4. Determination of annuity factor (f_e) based on local conditions regarding credit lines and rates of interest. In order to simplify the calculating procedure it is advisable to employ the same annuity factor for the basic investment D_i as well as for the initial working capital (C_{wcin}).

According to equation (12):

$$D_i + C_{wcin} = \frac{T_e - C_r}{f_e} \text{ and } D_i = MPI + X_i$$

where X_t is the accumulated interest on the capital needed during the planning and construction stage up to the date of start-up, as calculated according to equation (1).

3.5. Determination of t_s (length of starting-up period). This is a matter of experience and sound judgment. An expert knowing the respective branch of industry should be in a position to assess the likely length of time needed for starting up the production facilities.

Note: Do not be too optimistic in assessing the starting-up time. Conditions in developing countries are not the same as in Europe or North America or any other industrialised area.

3.6. Determination of MPI as per equation (16) or (18), depending on whether one chooses to regard the starting-up period as a logarithmic or linear function.

4. Total capital requirements

The total capital requirements are defined as the sum of maximum permissible investment and initial working capital:

$$K_{tot} = MPI + C_{win} \qquad \ldots (19)$$

It will be noticed that the initial working capital is not considered to be an integral part of the maximum permissible investment. The maximum permissible investment represents the sum of all production facilities on which the turnover is 'earned.' The initial working capital represents the means by which the production facilities are brought to work in order to create the necessary returns and depends on local conditions and the level of skill of the labour employed. It should, therefore, be considered separately from the investment proper.

5. Minimum turnover required based on available capital

If the available capital is given, the minimum turnover required to break even after 'T' years is calculated from equation (12), then the term $D_t + C_{win}$ represents the total capital available, including the initial working capital. If we know the running cost/turnover ratio 'p' for the type of manufacture in question the running cost at break-even C_{ro} may be expressed as $C_{ro} = p \cdot T_{ro}$ and the minimum turnover as:

$$T_{min} = T_o = \frac{f_a(D_t + C_{win})}{1-p} \qquad \ldots (20)$$

The annuity factor f_a is taken from Table 1 as applicable. By computing T_o as obtained by equation (20) into equations (16) or (18) the MPI will be obtained, and with the help of equation (14) or (17) the sufficiency of the remaining capital as initial working capital may be tested.

Whether or not a project can be realised depends on whether the virtual total cost of the required production facilities up to the point of starting-up can be accommodated within the available MPI.

6. Minimum capacity required based on available capital

The minimum turnover required depends amongst other things on the unit price. The next step is to determine the minimum capacity of the plant envisaged as being necessary for guaranteeing a profitable operation.

If P_{min} be the minimum unit price to be charged with regard to the most pessimistic business forecast available, the minimum number of units to be produced in order to break-even will be:

$$N_{min} = \frac{T_o}{P_{min}} \qquad \ldots (21)$$

According to experience it will be safe to assume that full production providing approximately a 15 per cent profit will be reached at approximately 80 per cent of theoretical capacity. The minimum theoretical capacity required will thus be:

$$N_{Cmin} = \frac{T_o}{0.85 \cdot 0.8 \cdot P_{min}} = 1.4\, N_{min} \qquad \ldots (21)$$

7. Elements of influence

7.1. Infrastructure

The method of determining the maximum permissible investment, elaborated in this article, pre-supposes a working infrastructure. The establishment of the necessary infrastructure is one of the major problems in developing countries and the most costly part of all development work. The large debts of the 'third world' are largely due to the tremendous cost of infrastructural development. The infrastructural investments will have to be paid off partly by the state through financing by taxation and partly by the consumers of infrastructural services (electricity, water, etc).

An alternative solution would be the establishment of infrastructural facilities financed by syndicates of user-enterprises and partly paid for by private consumers (electricity, water) whereby the syndicates would be granted exemption from taxes to the amount corresponding to amortisation plus interest during a period of time when this type of investment would normally be amortised, since financing the infrastructure is, in fact, an advance payment of taxes independent of income.

7.2. Inflation

Many developing countries suffer from extremely high inflation, exceeding 50 per cent per year. The rate of inflation and the rate of interest are to be taken into account when splitting up the total capital requirements into foreign and indigenous capital. Most of the equipment will probably be imported and will have to be paid in foreign currency. It is, however, advisable to build as much as possible of the equipment locally, whenever adequate workshop capacity and engineering skill is available. The cost should always be calculated in a steady currency as inflation always means continuous devaluation of the local currency.

7.3. Economic trends

Economic trends, such as an unexpected recession, often spoil the best of feasibility studies. Since 1945 and into the mid-1970s nobody believed in a recession over a long period of time. Short recessions came and went, nearly always offset by shorter, more or less strong booms providing sufficient profits to bridge-over the next recession. Much too optimistic planning has in many cases been responsible for the collapse of big enterprises such as the steel and shipbuilding industry the world over.

Many 'third world' industrial enterprises, results of development projects, have suffered heavily during the recession which started with the so-called oil crisis in 1973. No one had taken into account a possible recession of several years' duration when planning these development projects. The general euphoric idea of a forever growing economy in all parts of the world infected even the establishment within the developing countries.

Seeing the result of overoptimistic planning, one should expect a more careful and sober approach to industrial investments in developing countries.

As a safeguard against future unpleasant surprises it would be advisable to provide for break-even at 60 per cent of full production (ie, 50 per cent of theoretical capacity). When calculating MPI it is important to assess a reasonable market price for the products to be manufactured at the planned industrial plant. For products subject to large price variations the profit margin at full production will have to be fixed at a level permitting a substantial fall in price. This will, of course, influence the level of MPI as the level of break-even will have to be lower than for products which are not much affected by price variations.

7.4. Taxation

When assessing attainable profit levels it will be necessary to gain a fairly good knowledge of the taxation system of the country where the investment is to be placed. Special attention will have to be paid to 'hidden' taxes, such as dues for social security calculated on profit, profit-sharing systems and other profit-based costs. All these payments should be taken into consideration and the required break-even level should be adjusted accordingly.

$$MPI = \frac{T_e\left[\frac{(1-p)}{f_e} - (mp-1)\left(t_a+1-\frac{t_a}{\ln(t_a+1)}\right) - t_a p(1-m)\right]}{\left(1+\frac{x \cdot n_E}{200}\right)(1+t_a f_a)} \quad (Eq\ldots 16)$$

7.5. Conclusions

Every assessment of the maximum permissible investment should take into consideration the above-mentioned elements of influence, if not always by figures, at least as a reservation and a reminder of the limitations imposed by local conditions.

Summary

Calculation of maximum permissible investment (MPI) (see above):

If it is assumed that the increase in turnover and utilisation during the starting-up period follows a linear function, then:

$$MPI = \frac{T_e\left[\frac{1-p}{f_e} + t_a p\left(\frac{m}{2}-1\right)\right]}{\left(1+\frac{x n_E}{200}\right)(1+t_a f_a)}$$

T_e = Turnover at break-even (68% of theoretical capacity)
C_r = Total running cost
$p = \frac{C_r}{T_e}$ (running cost/turnover ratio)
f_e = Annuity factor (see Table 1)
t_a = Starting-up period (years)
x = Rate of interest (%)
n_E = Planning and erection period (years)
$m = \frac{C_{ve}}{C_r}$, ratio between variable cost and total running cost at break-even

Total permissible capital requirements

$$K_{tot} = MPI + C_{wm} = \frac{T_e - C_{re}}{f_e} - X_t$$

X_t = The interest accumulated up to the date of starting-up
C_{wm} = Initial working capital

Appendix

Examples

1. Copper tube mill

This project was to be started in a developing country with rich mineral resources, amongst others, rich copper ore. There already exists smelting and refining capacity within the country.

The market for copper tubing within the country itself and the neighbouring countries was estimated at approximately 3200 metric tons per annum (further on referred to as mtpa). There exists a small facility manufacturing non-ferrous semi-finished products including approximately 500 mtpa of copper tubes. The remainder (2700 mtpa) is manufactured abroad from the country's own copper and re-imported as copper tube. The existing non-ferrous metal manufacturer could be convinced to take on the production of 3200 mtpa of copper tube in a new plant, thus freeing capacity for other products for which there is a market in neighbouring countries.

Out of several quotations received one was found to get as near to reality as could be expected under existing circumstances.

Contents of the quotation

Capacity: 4000 mtpa of finished tube.
Turnkey price (fixed capital): US$11,200,000.
Working capital: US$1,670,000.
Annual operating cost at 4000 mtpa: US$1,530,000, of which:
Variable cost: US$800,000 pa ($C_v$).
Fixed cost: US$1,100,000 pa ($C_f$).
Estimated time of erection (n_E): Two years.
Estimated starting-up period (t_a): One year.
Operation time: 12 years.

Calculation of MPI and total capital requirements (K_{tot})

The conversion charge is (considering the prevailing international price level) set at US$1.40 per kilogramme, ie US$1400 per mt. As the market is estimated at approximately 3200 mtpa, it is advisable to stipulate break-even at 60 per cent of full production, even considering other elements of influence. Thus:

Turnover at break even:
$T_e = 0.8 \cdot 0.6 \cdot 4000 = 2.69 \cdot 10^6$ US$ where full production has been defined as 80 per cent of the quoted capacity.

Operating cost at break-even:
$C_{re} = 0.6 \cdot 0.64 \cdot 10^6 + 1.1 \cdot 10^6 = 1.48 \cdot 10^6$ US$

$$p = \frac{C_{re}}{T_e} = \frac{1.48 \cdot 10^6}{2.69 \cdot 10^6} = 0.55$$

$$m = \frac{C_{ve}}{C_{re}} = \frac{0.6 \cdot 0.64 \cdot 10^6}{1.48 \cdot 10^6} = 0.26$$

The rate of interest has been estimated at the current level in the United States, which at that time was 12 per cent. According to Table 1, the annuity factor for 12 years' amortisation at 12 per cent interest will thus be: $f_e = 0.16144$.

The maximum permissible investment (MPI) will be according to equation (16) (see below) and the total permissible capital requirements, according to equations (12) and (19):

$$K_{tot} = \frac{T_e - C_{re}}{f_e} - X_t$$

$$= \frac{2.69 \cdot 10^6 - 1.48 \cdot 10^6}{0.16144} - \frac{12 \cdot 2}{200} 5.9 \cdot 10^6$$

$$= 6.79 \cdot 10^6 \text{ US\$}$$

and from equation (19):

$$C_{wm} = K_{tot} - MPI = (6.79 - 5.9)\, 10^6 = 0.89 \cdot 10^6 \text{ US\$ (initial working capital)}$$

The values for MPI, K_{tot} and C_{wm} as calculated above are the maximum permissible values if the project shall have a chance to pay for itself considering the local circumstances.

Comments

The determination of MPI shows that the project as quoted will not satisfy the demands on profitability if adequate security against receding trade and price variations is included.

Whether or not the project should be further pursued can only be decided after having considered the different elements of influence, which should facilitate a more thorough appraisal.

Before penetrating the different elements of influence appertaining to this project, it is advisable to check the minimum turnover required at the total investment quoted, ie US$11.2 million applying the quoted operating time of 12

$$MPI = \frac{2.69 \cdot 10^6 \frac{1-0.56}{0.16144} - (0.26 \cdot 0.55 - 1)\left(1 + 1 - \frac{1}{0.693}\right) - 1 \cdot 0.55(1-0.26)}{\left(1+\frac{12 \cdot 2}{200}\right)(1+1 \cdot 0.16144)} = 5.9 \cdot 10^6 \text{ US\$} \quad (from\ Eq\ldots 16)$$

years, a 12 per cent rate of interest and the other parameters as quoted. This may be done with the help of equations (20) and (14):

$$T_{min} = T_o - \frac{f_a(D_i + C_{wm})}{1-p}$$

$$D_i = I\left(1 + \frac{x \cdot n_g}{200}\right)$$

$$= 11.2 \cdot 10^6\left(1 + \frac{12 \cdot 2}{200}\right)$$

$$= 12.54 \cdot 10^6 \text{ US\$}$$

$C_{wm} = 1.67 \cdot 10^6$ US$ as quoted.

Assume 'p' at break-even according to the basic stipulations (85 per cent of full production):

$$p = \frac{C_{vo}}{T_o} = \frac{0.85 \cdot C_{vo} + C_f}{T_o}$$

$$= \frac{(0.85 \cdot 0.8 + 1.1) \cdot 10^6}{0.85 \cdot 4.48 \cdot 10^6} = 0.47$$

Thus:

$$T_{min} = \frac{0.16144(12.54 + 1.67)10^6}{1-0.47}$$

$$= 4.33 \cdot 10^6 \text{ US\$},$$

which represents 97 per cent of the turnover at full production. The slightest recession in trade and/or increase in labour cost will create an operational loss. Since the minimum turnover to break-even at the level of the capital requirements as quoted lies too near the turnover at full production, the project is not to be recommended.

Other elements of influence

Infrastructure
The turn-key plant as quoted implies a well-established infrastructure.

Inflation
As inflation in most developing countries also means continuous devaluation against other stable currencies, its influence on the profitability of a project is limited to debts in foreign currency and variations in the rate of interest.

Economic trends
The general price of refined copper will not affect the profitability of this project since the calculation is based on the conversion charge from cathode copper to tube and the raw material consists of indigenous copper.

The choice of break-even at 50 per cent of full production should provide adequate protection against unbalancing economic trends. The level of break-even calculated from the capital requirements as quoted does not allow any variations in cost or conversion charge exceeding 3 per cent, which means that even from the point of view of economic trends, the project should not be pursued any further.

Taxation
As shown above, the profit margin is insufficient to cope with any unexpected social or other additional contributions imposed on the company by the state at a later stage, if these contributions are related to labour cost and not levied as a profits tax.

Conclusions and recommendations

The calculation of MPI and total capital requirements as well as the considerations of other elements of influence show that the project as quoted is not to be recommended since the investment exceeds the maximum permissible level for a successful operation.

It is recommended to investigate the possibility of limiting the total investment either by making use of existing buildings (if available) and/or by employing a different technology better suited for small-scale operation.

2. *Aluminium extrusion plant*

As a step in planning development, the government of an African country asked for an investigation on the feasibility of installing an aluminium extrusion plant. Rolled products such as sheet and strip had been manufactured locally for over 20 years. An analysis of average annual imports (1982 to 1984) of semi-finished aluminium products shows the following product mix:

	Metric tons (mt)
Bars and sections	570
Tubes	35
High tension cable	436
Bolts and nuts	16
Total	1,057

of products which could be manufactured from extruded stock.

Annual consumption of this magnitude could not justify the installation of an extrusion plant. However, taking into account the development plans presented by the government, one could assume three alternative hypotheses for the period 1985 to 2000.

Applying the minimum hypothesis, the annual consumption of extruded products would increase from 1057 mt in 1984 to 1800 mt in the year 2000, following the expected annual growth in population (3.38 per cent) during the same period and assuming a constant consumption per inhabitant. The price of imported extruded products and aluminium cables for 1984 averaged US$3.88 per kilogramme inclusive of freight, a 63 per cent import duty on CIF price and metal cost (US$1.3/kg at the time). This would leave US$0.95/kg for manufacture and freight. The production cost of locally manufactured sheet and strip (exclusive of material cost) amounted to US$0.575/kg at the time.

Approach
Assuming a period of three years for planning and erection and two years for starting-up the plant, the break-even level would be reached in 1991 at the earliest, if a decision to install the plant is taken in 1986. According to the minimum hypothesis, the annual consumption in 1991 would be 1335 mt.

Basic manufacturing unit
Table A1 shows the approximate investment costs for a basic manufacturing unit (price level of 1984). This extrusion plant is not envisaged for the production of heat treatable alloys and anodised products, but represents the essential basic unit to manufacture bars, sections, tubes and high-tension cables.

Table A1: Basic unit for manufacture of extruded bars, sections, tubes and high-tension cables in aluminium

Equipment	Direct investment (millions of US$)
Extrusion press (20 MN extrusion force) Preheating furnace for dies Straightening machine Induction preheating furnace for billets Maintenance shop for dies	2.8
Wire drawing machine Stranding machine	0.5
General maintenance shop	0.1
Material handling and stock	0.2
Power supply, compressed air, water supply, drains	0.5
Buildings (10,000 sq m)	2.0
Internal transport	0.6
Cost of transport and erection of equipment	2.82
Contingencies (15%)	1.43
Project planning (15%)	1.64
Total	12.59

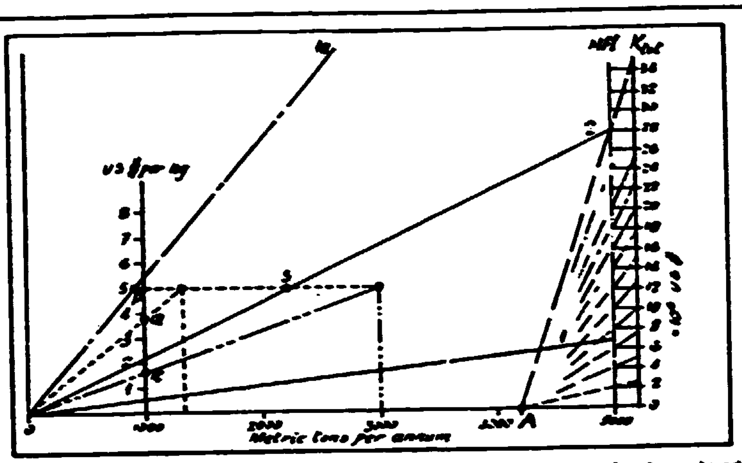


Fig A1 Alignment chart for determining MPI and K_{tot} as a function of production cost per unit and annual production

Parameters for the determination of MPI

An analysis of the distribution of manufacturing costs at the local rolling plant provided the basic values for the calculation of the essential parameters according to equation (13):

$P = 0.62$ and

$$m = \frac{C_{vo}}{C_v} = 0.31$$

It is further assumed that the period of planning and erection be:–

$n_E = 3$ years

and the period of running-in to break-even level:–

$t_b = 2$ years.

The rate of interest on borrowed capital is assumed to be:–

$x = 10$ per cent

during an amortisation period of 20 years. According to Table I the annuity factor will thus be:–

$f_a = 0.11746$.

Maximum permissible investment (MPI)

The MPI is calculated by inserting the above parameters in equation (16). Thus $MPI = 2.346 \cdot T_e$ and the total capital requirements according to equations (12) and (19) where $K_{tot} = 2.88 \cdot T_e$ of which the initial working capital will be $C_{wm} = K_{tot} - MPI = 0.534 \cdot T_e$ where T_e = turnover at break-even.

The given parameters and the approximate total investment for a basic extrusion unit, Table A1, enable the drawing up of an alignment chart for determining the MPI, the total capital requirements and the range within which the conversion costs may be allowed to vary. The chart includes an annual production of up to 5000 mt. Lines 1 and 2 represent the MPI for conversion costs of 0.575 and 2.38 US$/kg respectively at break-even. The chart is shown in Figure A1.

By connecting point A on the abscissa with any point on the MPI scale and proceeding in the same direction to the K_{tot} scale, the total capital requirements for the corresponding MPI may be read directly. By multiplying the scale on the abscissa by ten and following line 1a one arrives at the MPI and K_{tot} for tonnages exceeding 5000 mtpa.

Assuming that lines 1 and 1a represent the level of unit conversion cost acceptable on the international market (0.575 US$/kg) and line 2 the unit cost of imports. (except metal cost) it is possible to determine at a glance the range of permissible conversion costs and MPI as well as K_{tot} for any level of annual consumption.

Reverting to the basic requirements of breaking even at 1335 mtpa on a basic manufacturing plant as presented in Table A1 the unit conversion cost can be determined, (point Q in Figure A1), arriving at 3.8 US$/kg, which is unacceptable, being more expensive than imported goods. This leads to the conclusion that the basic requirement cannot be satisfied by conventional extrusion techniques, unless local production is protected by higher import duties. The minimum annual tonnage at the maximum permissible unit conversion cost will break-even at 2200 mt (point S, Figure A1). In order to produce at the minimum unit cost production will have to be not less than 9400 mtpa (line 1a, Figure A1, point P).

Capacity of basic plant

Under favourable circumstances the basic unit as presented in Table A1 could produce at the most 3000 mtpa on three shifts (5400 hours pa). Figure A1 shows that the maximum permissible conversion cost at break-even at this level would be 1.6 US$/kg, which would price the products at an average of 3.2 US$/kg including metal cost (1.3 US$/kg) and a profit of 15 per cent on the conversion charge. This corresponds to world market prices at the time the investigation was carried out.

Conclusions and recommendations

The foregoing example shows that an extrusion plant of the basic type can pay off at an annual production of 2200 to 3000 mt in the country in question if no export is considered at a level of production below 3000 mtpa. If the local market stays below 2200 mtpa local manufacturers will have to be protected by increased import duties. As the major part of consumption next to bars and sections consists of high tension cable, the total cost covers even this product. The investment for the cable manufacturing part totals (all included) only about 5 per cent of the total cost. The major part of the conversion cost for cables will have to be carried by the extrusion plant because of the higher level of investment as compared with the drawing and stranding units. The planned extension of the high tension cable network does not warrant the installation of a Properzi plant, the minimum type producing approx 12,000 mtpa in three shifts.

As there are no abandoned suitable industrial buildings available in the country a complete factory will have to be erected.

This article is available in booklet form from Magnum Publications Ltd, 110-112 Station Road East, Oxted, Surrey, RH8 0QA, England, price £5 (payment with order).

It will also be available at the Wire Industry Stand No 10E25 at Wire '86, Düsseldorf.

Table 1

Maximum Recommended Fabricating Cost At Balexco For Technal Accessories

Item	PURCHASING PRICE/UNIT(BD)		RECOMMENDED FABRICATING COST/UNITBD)		
	Plain Matt Bronze(BZ)	Mill Finish	Total	Material	Conversation Cost
1442		0.242	0.109	0.024	0.085
1443		0.228	0.103	0.038	0.065
1444		0.254	0.114	0.024	0.090
1482	2.162(BZ)		0.973	0.327	0.646
1483	0.780		0.351	0.113	0.238
1486	0.769		0.346	0.113	0.233
1503	0.621		0.280	0.087	0.193
1581		0.532	0.240	0.070	0.170
1632	1.396		0.628	0.066	0.562
1635	2.488		1.120	0.206	0.914
1946	0.631		0.284	0.037	0.247
1953		0.547	0.246	0.026	0.220

Note:

All costs are based on the purchasing costs computed from FF to BD at the exchange rate of 8.8.87 at BD 0.0619 per FF and a primary metal price of US$ 1318/ton at the same date.

The material cost per item is based on the extruded section cut to length, whereby the scrap resulting from fabrication is considered as non-recoverable.

Table 2 -

Parameters For Calculating Investment For Diecasting Equipment

To = 2.64 . 0.45 - 0.45.050 - 0.3 = BD 0.665/Piece

Comment:

45% of purchasing price less metal cost and cost of mould per piece.

The cost of the mould has been assumed at BD 3000 average and the mould endurance at 10000 pieces.

$$Cvo = \frac{3.3.6}{75} + \left(\frac{50.2000}{15000} + \frac{800.67.5}{15000}\right) . 0.01 = BD\ 0.154/piece$$

Comment:

Variable cost including manpower and energy consumption at BD 0.01/KWh. One man for painting and inspection has been included.

$$Cro = \frac{Cvo}{0.3} = \frac{0.154}{0.3} = BD\ 0.513/piece$$

Which gives $p = \frac{Cro}{To} = 0.77$ and m = 0.3

The investment factor is calculated according to equation 16, Appendix 2

fMPI = 1.609

MPI = fMPI.To = 1.609.=.665 = 3D 1.07/piece

Total investment: 1.07.150000 = BD 160000

Total capital requirements

Ktot = MPI + Cwin

$$Cwin = \frac{(To-Cro)}{fa} - MPI\ \frac{(1+xne)}{200}$$

$$= \frac{0.665-0.513}{0.11746} - 1.07\ (1.025) = BD\ 0.194/piece$$

Comment: initial working capital
Ktot = 1.07 + 0.194 = BD 1.264/piece

Total Capital Cost: 150000.1.264 = BD 189610

Example 1: Item 1442, see figs. a, 2 & 3

Purchasing cost (See Table 1): BD 0.242

Calculated Fabricating Cost at Balexco (F = 0.45. 0.242 = BD 0.109

Material cost calculated from Figs. 2 and 3

Relative weight of extruded section: q = 0.683 kg/m (Fig.2)

Weight of detail, cut to length: G = 0.683.0.035 = 0.024 kg (Fig.3)

Material cost: (BD 0.5/kg) C_M = 2.0.0024.0.5 = BD 0.024

Conversion cost: (C_F - C_H = 0.109-0.024 = BD 0.081

Maximum Recommended Investment (MPI)

In order to manufacture this item some investment in jigs and tools may be necessary. The maximum recommended investment may be calculated quickly and easily:

Equation 16, Appendix 2 can also be written as:

MPI = fMPI .To

Where the investment factor (fMPI) is assumed to have a constant value for each item based on the conditions prevailing at Balexco until conditions change.

The different parameters influencing the investment factor are listed below:

To = turnover at break even
Cro = total running cost at break even

$$p = \frac{Cro}{To}$$

fa = annuity factor (See Table 1, Appendix 2)

to = starting up period (years)

x = rate of interest (%)

nE = variable cost at break even

Cs = salaries, wages, social contributions, staff overheads, etc.

As the fabrication of extrusion based accessories is, apart from extrusion, labour intensive general variable (Cv) and salary (C_s) costs are assumed to have the following proportion to the total running cost (Cr_o):

C_{vo} = 0.9 C_{vo} i.e. m = 0.9

C_s = 0.85 C_{ro}

Example 1: (Cont'd)

For most accessories from extruded stock the fabricating department will not be occupied for a whole year just to fabricate one item. Therefore parameters pertaining to planning and starting up period are neglected.

For accessories from extruded stock the investment factor may thus be expressed as:

$$fMPI = \frac{1 - P}{fa} - mp + 1 \text{ (compare with equation 16, Appendix 2)}$$

or simplified:

$$fMPI = \frac{1 + fa}{fa} - p \left(\frac{1}{fa} + m\right)$$

fa is based on 10% interest, and on average life of investment (tools, fixtures, jigs) of one year (tools wear, fixtures and jigs last longer)

According to Table 1, Appendix 2

$fa = 1.1$

Thus $fMPI = \frac{1 + 1.1}{1.1} - p \left(\frac{1}{1.1} + 0.9\right)$ or:

$$\underline{fMPI = 1.91 - 1.81p}$$

In Table 1 the total recommended fabricating cost per unit represents To per unit and the conversion cost Cro.

As $p = \frac{Cro}{To}$, it's value for certain local conditions and for each accessory may be shown on a diagram. (See Fig. 4)

For the item covered by this example

$$p = \frac{0.085}{0.109} = 0.78 \text{ and from Fig. 6}$$

The investment factor

$fMPI = 0.5$

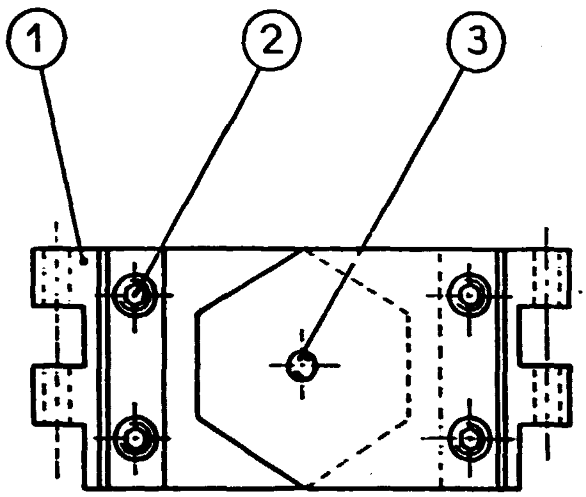
The maximum recommended ivestment will therefore be

$MPI = fMPI.To = 0.5.0.109 = BD\ 0.05$ per unit

Note:

In reality accessories are manufactured repeatedly through several years. The maximum recommended should in this case cover the total amount of units until the item in question is considered to become obsolete. As the investment is given per fabricated unit it remains to assess the total number of units to be produced.

FIG. 1



NOTA

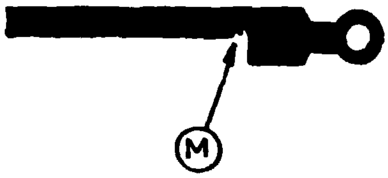
- lors du montage, l'axe (3) sera maté aux deux extré-mités tout en assurant la rotation des deux éléments
- ne pas monter les vis (2) sur les éclisses (1)

- *when assembling, axis (3) will be hammered at both ends, rotation of two parts must be assured*
- *don't mount screws (2) on fish-plates (1)*

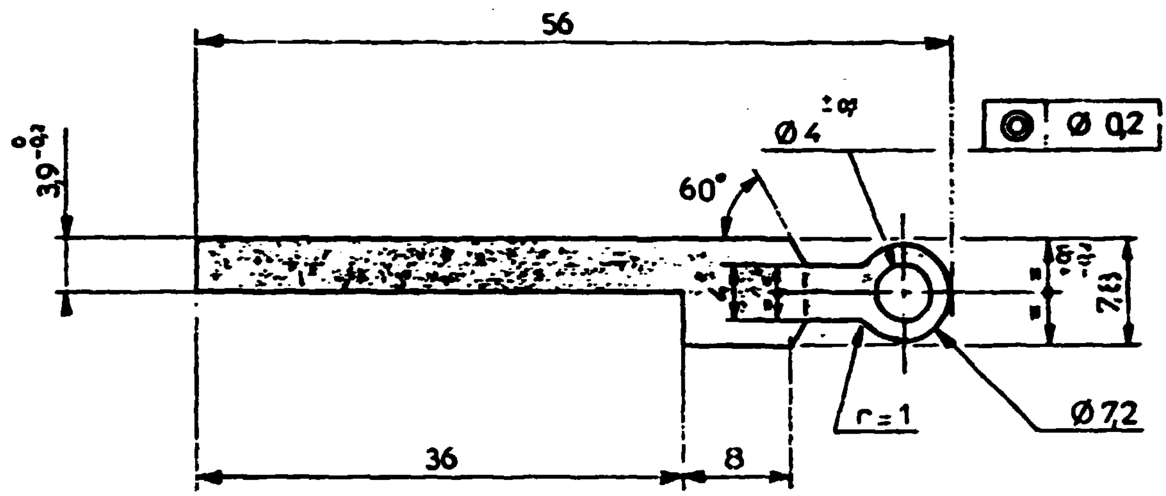
REP	ENS	S/ENS	BASE	DESIGNATION	NB	MATIERE *MATTER*
3		0956 R		AXE Ø4 - 7,8 *AXIS Ø4 - 7,8*	1	Z 12 CN 18-10
2		B 235		VIS STHC M6 x 6 cuvette *SCREW STHC M6 x 6 cup point*	4	Z 2 CN 18.10
1		A950	A949	ECLISSE *FISH - PLATE*	2	6005 A

ECHELLE *SCALE*	1	SAUTERELLE	TECHNAL FRANCE	
MATIERE *MATTER*		*HORIZONTAL COUPLING*	DATE	22.11.82
POIDS *WEIGHT*			DESSINE PAR *DRAWN BY*	S. M.
			ENSEMBLE *SET*	
			INDICE	R 03
A4		SECURAL®	REF.	1442

FIG. 2



TOLERANCES DE FILAGE / *EXTRUSION TOLERANCES*		
EPAISSEURS / *THICKNESS* < mm ≤		TOLERANCES mm ±
1	3	0.15
3	6	0.20
6	10	0.25
10	18	0.30
18	30	0.40
30	50	0.50
DIMENSIONS < D mm ≤		TOLERANCES mm ±
1	12	0.20
12	20	0.25
20	30	0.30
30	50	0.40
50	70	0.50
70	100	0.65
100	130	0.80
130	180	1.00
180	250	1.30
SUIVANT : / *FROM :* APNOR NF A 50710		



NOTA

- toutes les cotes sont en millimètres
- • r = 0,5
- longueur standard : 6,04 ml
- Ⓜ place de la marque du fournisseur (en creux)

- *all dimensions are in millimetres*
- *• r = 0,5*
- *standard length : 6,04 ml*
- *Ⓜ identity marking place of supplier (in space)*

ECHELLE / SCALE	1 - 2 -
MATIERE / MATTER	6005A(R26)
POIDS / WEIGHT	0,683 kg/ml
DEV. MECA / POL. SURF	
DEV. ELEC / RET. TYPE	
	A4

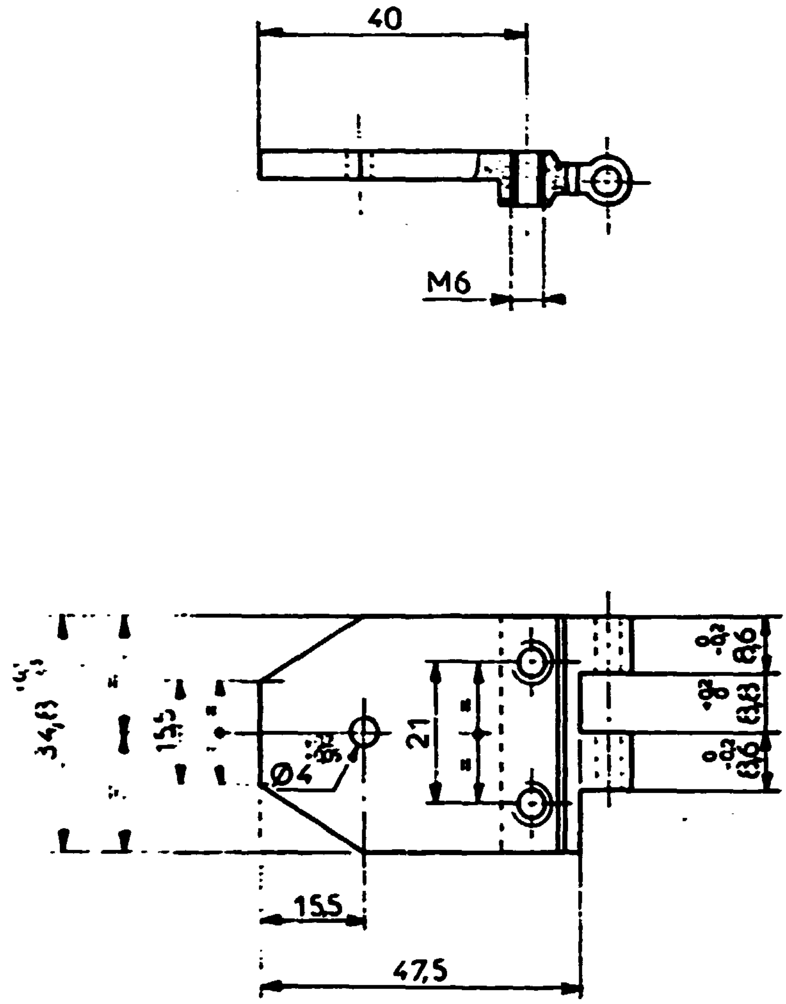
PROFIL ECLISSE

FISH PLATE SECTION

SECURAL®

TECHNAL FRANCE	
DATE	30 - 04 - 81
DESSINE PAR / DRAWN BY	S - M -
ENSEMBLE / SET	1442
INDICE	000
REF.	A949

FIG. 3.



NOTA

_ pièce tirée du profil A949 | _ part taken from A949 section

TOUTES LES COTES SONT EN MILLIMETRES *ALL DIMENSIONS ARE IN MILLIMETRES*	TOLERANCES GENERALES *GENERAL TOLERANCES* ± 0,3

[illegible]	1	ECLISSE *FISH - PLATE*	TECHNAL FRANCE	
[illegible]	6005 A		[illegible]	04_05_81
[illegible]			[illegible]	S_ M_
[illegible]			[illegible]	1442
[illegible]			[illegible]	0 0 0
A4		SECURAL®	REF.	A950

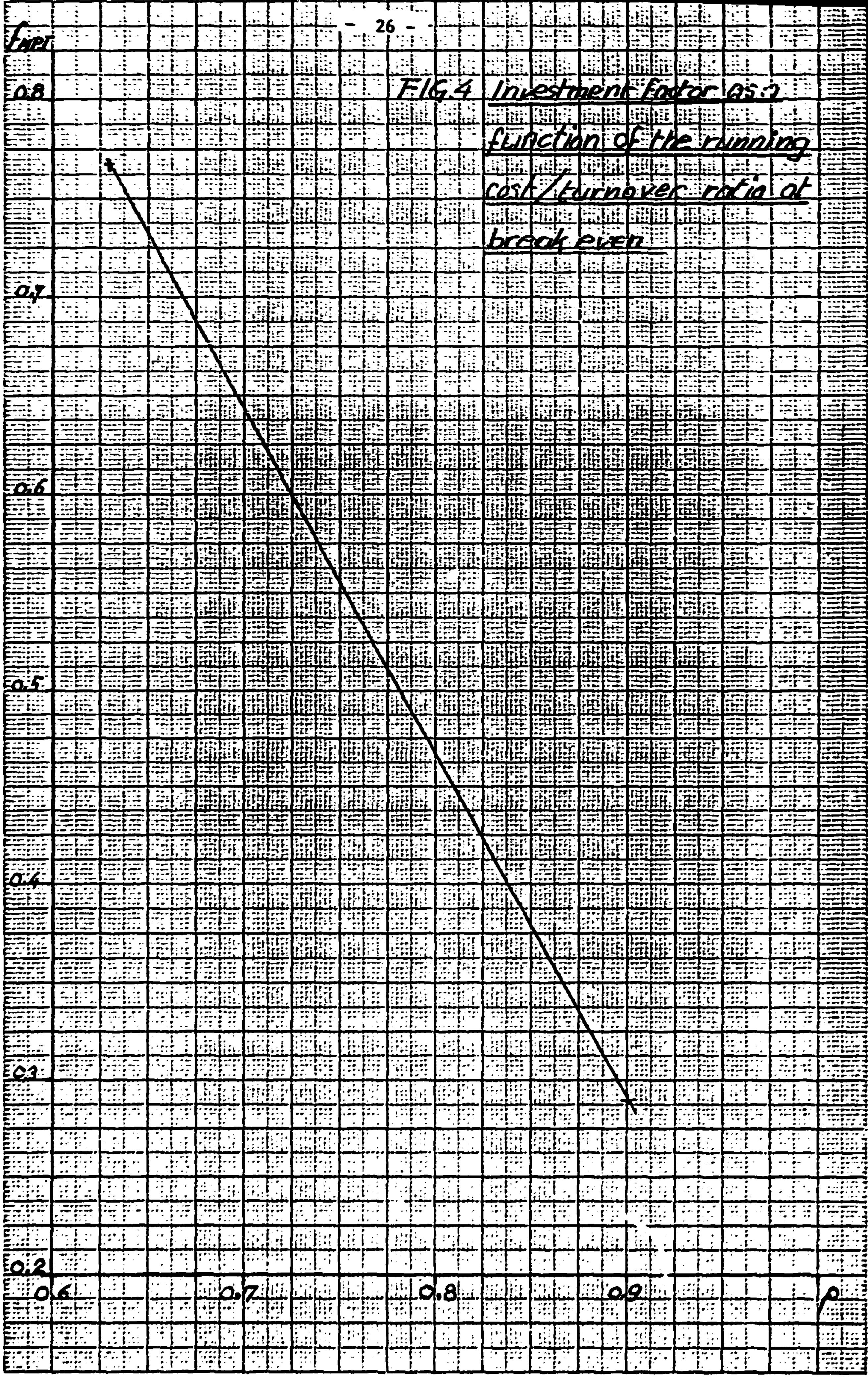


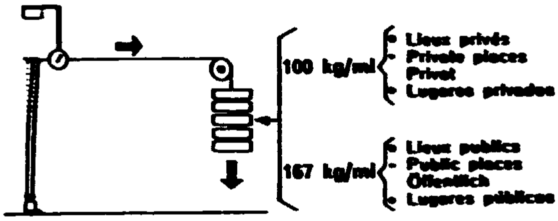
FIG.4 Investment factor as a function of the running cost/turnover ratio at break even

• SAFETY

FIG 5

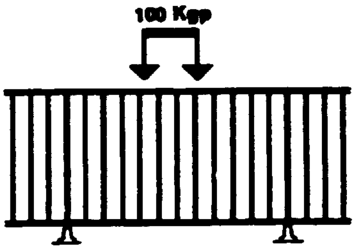
- ESSAIS DE STABILITE ELASTIQUE
- ELASTIC STABILITY TESTS
  BIEGEFESTIGKEITSVERSUCHE
- ENSAYOS DE ELASTICIDAD

TEST: 1

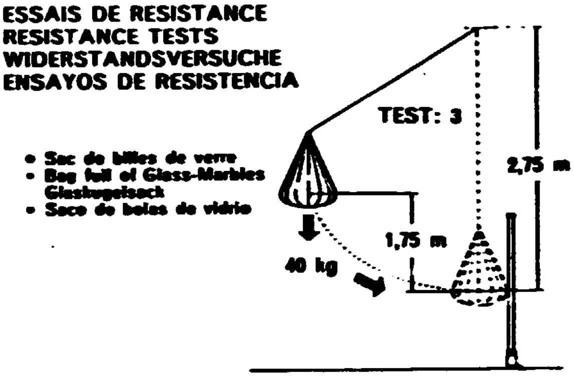


- ESSAIS DE RESISTANCE
- RESISTANCE TESTS
  WIDERSTANDSVERSUCHE
- ENSAYOS DE RESISTENCIA

TEST: 2



TEST: 3



STRUCTURAL SYSTEM

Truss Junctions

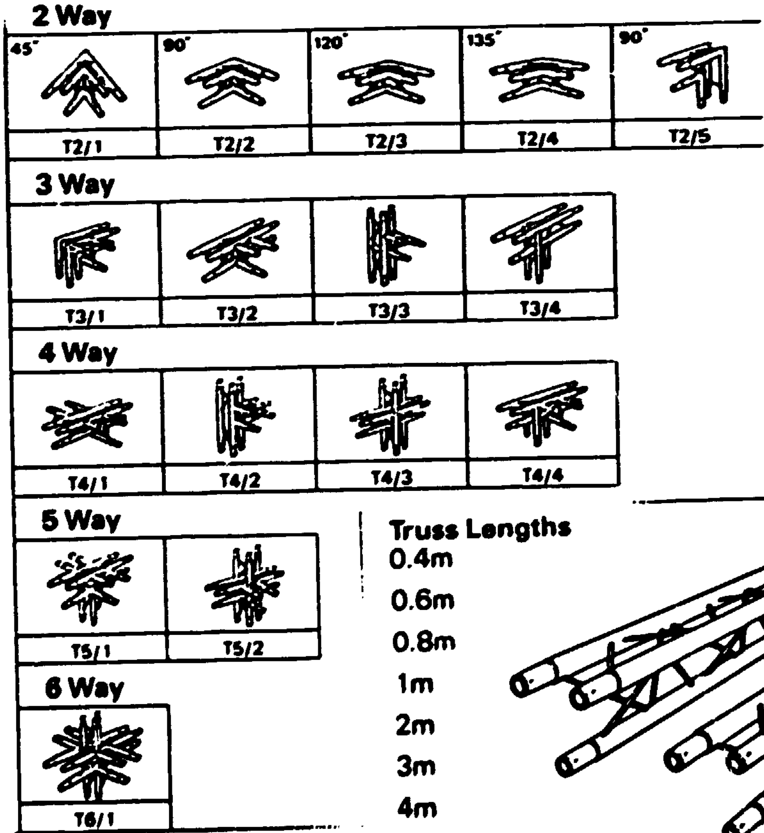
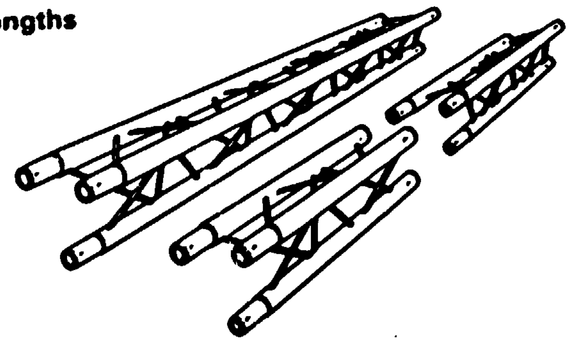


FIG. 7

Truss Lengths

0.4m
0.6m
0.8m
1m
2m
3m
4m
5m



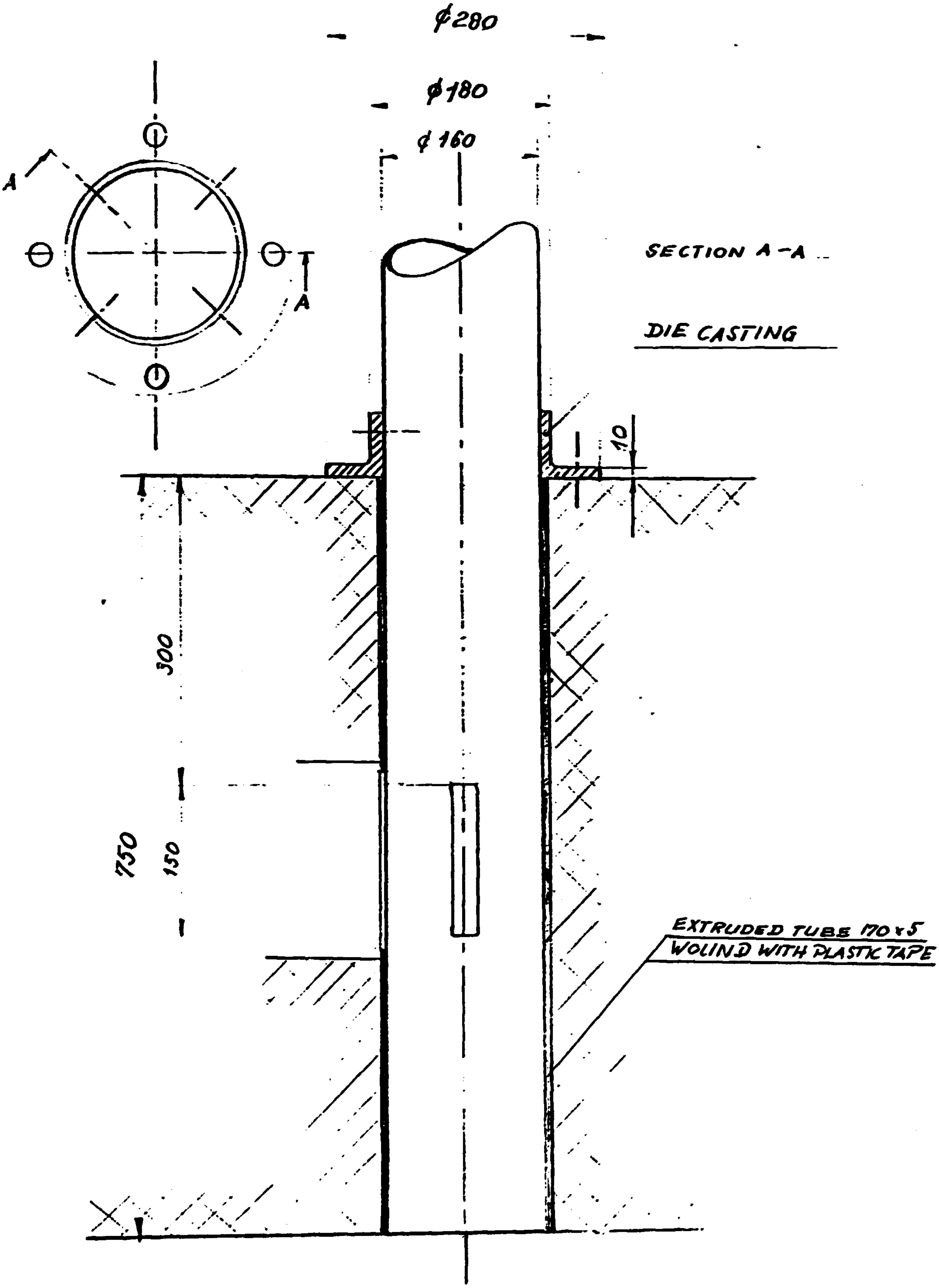


FIG.6 FIXATION OF LAMP POST

3. MIDAL CABLES

3.1 General

The company's production range and potential as well as the equipment at its disposal have been examined. As the company wishes to enlarge their range of products in order to become less dependent on the power cable market, a number of possible products not connected with power cable manufacture have been investigated.

3.2 Rod and Wire Products

Since the equipment is layed out for the production of rod and wire, all possible applications for electrical and mechanical rod and wire should be penetrated. The following products for mechanical applications can be manufactured on the company's equipment:

Welding wire and electrodes

Rivet Wire

Nail Wire

Wire for chain-link fencing

Wire for zip fasteners

Metallizing wire

Table 1 shows the compositions and Table 2 the mechanical properties of the respective alloys.

3.3 Other Products

The existing facilities put a limit to the manufacture of any products other than rod and wire.

The manufacture of narrow strip, cast and hot rolled, represents such a limited possibility. This strip can be used for the manufacture of cans for beverages and for narrow foil. The latter alternative would mean an investment in a cold strip rolling mill with the possibility of producing narrow foil.

As GARMCO has plans to produce foil on a large scale, the above investment is not advisable.

- Continuously cast and rolled narrow strip produced on the SECIM/MRB continuous casting and rolling plant could, on the other hand, represent a viable alternative product. This is the cheapest way of producing imput material for the production of cans for beverages and collapsible tubes.

With no other investment than four sets of rolls, three sets of flat and one set of edging rolls at a total investment of BD1952, this strip can be produced. Its width will, however, be limited to 53- 55 mm.

With an extra investment of approximately BD 2000 for a blanking press and no edging rolls, slugs for the production of cans and collapsible tubes can be produced.

This operation is described and economically assessed in Appendix I.

Since the company has liquid metal at its disposal, rapid cooling technology for the production of narrow foil for the electronic industry, could become interesting at a later date. The main feature of this technology implies production of foil directly from molten metal. Know-how and information on the "state of the art" may be obtained through UNIDO.

3.4 Conclusions and Recommendations

The capacity of the plant allows the company to produce about 24 000 tons p.a. of alloy rod and wire for electrical and mechanical applications. It is therefore suggested to penetrate the market for mechanical alloys. This rod and wire will be a 100% export operation. This applies even to production of slugs for collapsible tubes and cans if no canning plant is set up in Bahrain. The annual import of soft drinks, being about 10 million litres (1985), would justify a moderate size canning operation from the point of view of employment opportunities (approximately 20 persons), availability of input material and for environmental reasons. Aluminium cans can be re-circulated.

However, before embarking on this line of products, all possibilities to market rod and wire for electrical as well as mechanical applications should be exhausted, if not additional investments are to be made.

Chemical Compositions —
in percentage of weight — unless otherwise indicated, percentages are maximum values.

Alloy	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Other Elements (1) Each	Other Elements (1) Total	Aluminum by Diff.
AA-1100(2)	1.0	Si+Fe	0.05 0.20	0.05	—	—	0.10	—	0.05	0.15	99.00 min.
AA-1175(3)	0.15	Si+Fe	0.10	0.02	0.02		0.04	0.02	0.02		99.75 min.
AA-2117	0.8	0.7	2.2 3.0	0.20	0.20 0.50	0.10	0.25	—	0.05	0.15	Remainder
AA-4043(2)	4.5 6.0	0.8	0.30	0.05	0.05	—	0.10	0.20	0.05	0.15	Remainder
AA-4643(2)	3.6 4.6	0.8	0.10	0.05	0.10 0.30		0.10	0.15	0.05	0.15	Remainder
AA-5052	0.25	0.40	0.10	0.10	2.2 2.8	0.15 0.35	0.10	—	0.05	0.15	Remainder
AA-5056(2)	0.30	0.40	0.10	0.05 0.20	4.5 5.6	0.05 0.20	0.10		0.05	0.15	Remainder
AA-5154(2)	0.25	0.40	0.10	0.10	3.1 3.9	0.15 0.35	0.20	0.20	0.05	0.15	Remainder
AA-5356(2)	0.25	0.40	0.10	0.05 0.20	4.5 5.5	0.05 0.20	0.10	0.06 0.20	0.05	0.15	Remainder
AA-5554(2)	0.25	0.40	0.10	0.50 1.0	2.4 3.0	0.05 0.20	0.25	0.05 0.20	0.05	0.15	Remainder
AA-6053	(1)	0.35	0.10	—	1.1 1.4	0.15 0.35	0.10	—	0.05	0.15	Remainder
AA-6061	0.40 0.8	0.7	0.15 0.40	0.15	0.8 1.2	0.04 0.35	0.25	0.15	0.05	0.15	Remainder
AA-6063	0.20 0.6	0.35	0.10	0.10	0.45 0.9	0.10	0.10	0.10	0.05	0.15	Remainder

(1) Silicon 45 to 65 percent of actual magnesium content
(2) For Welding Wire Alloys. The Beryllium Content is 0.0008 Percent maximum.
(3) Gallium 0.03 maximum. Vanadium 0.05 maximum.

TABLE 2

Alloy Designation & Temper

Alloy & Temper designation	Ultimate Tensile Strength Range Ksi	MPa	Kg/mm2	Various End Uses
AA-1100-0	11.0-15.5	76-107	7.7-10.9	Rivet wire
-H14	16.0-21.0	110-145	11.2-14.8	Welding wire & electrodes
AA-1175-F	11.6-17.4	80-120	8.2-12.2	Metallizing wire
AA-2117-0	25.0 max.	172 max.	17.6 max.	Rivet wire
-H15	28.0-35.0	193-241	19.7-24.6	
AA-4043-F	20.3-23.9	140-165	14.3-16.8	Welding wire & electrodes
AA-4643-F	18.9-25.4	130-175	13.3-17.8	Welding wire
AA-5052-0	25.0-32.0	172-221	17.6-22.5	Rivet & screen wire
AA-5056-0	46.0 max.	317 max.	32.3 max.	Rivet wire, zipper wire, nail wire
AA-5154-0	30.0-41.0	207-283	21.1-28.8	Welding wire
AA-5356-F	37.0-44.2	255-305	26.0-31.9	Welding wire
AA 5554-F	31.9-37.0	220-255	22.4-26.0	Welding Wire
AA-6053-0	19.0 max.	131 max.	13.4 max.	Rivet wire
-F	22.0-30.0	152-207	15.5-21.1	
AA-6061-0	22.0 max.	152 max.	15.5 max	Rivet, nail wire & armour
-T1	30.0-36.5	207-252	21.1-25.8	rod stock
AA-6063-T4	22.0-28.0	152-193	15.5-19.7	Rivet & nail wire, extrusion

All the mechanical drawing rod alloys shown in this page are currently being drawn on conventional drawing machines

APPENDIX

MANUFACTURE OF SLUGS FOR IMPACT EXTRUSIONS

This product can be manufactured on the MRB two-high mill line as per Table 3.

An investment in a blanking press will be needed. The approximate total investment will be about:-

Press	BD 2000
3 sets of rolls	BD 1464

	BD 3464

i.e. between 3500 and 4000 BD. The rolls would have to be replaced every 12000 tons.

Cost per Slug ∅ 50 x 3.6 mm: (120 slugs/min)

Material Cost:	10.4	fils/slug	
Rolling Cost:	0.97	"	
Power Cost of the press at 75% utilisation :	0.097	"	(one shift) 12.96 million slugs p.a.
Labour Costs (incl. overheads)	0.66	fils/slug	
Annuity for the press (10% over 10 years)	0.025	fils/slug	
Maintenance (press)	0.06	"	

Total cost per slug : 12.212 fils

Import price per can of 18.5 g : 26.6 fils

Strip required: approx 315 tons p.a.

TABLE 3 : MANUFACTURE OF SLUGS FOR IMPACT EXTRUSIONS (BASED ON 2.5 TONS/HR OF STRIP)

OPERATION	SIZE (MM)	AREA (MM²)	REDUCTION %	SPEED M/S	GRIP ANGLE (DEG)	POWER CONSUMPTION (KW)	EQUIPMENT	REMARKS
CASTING	41 X 31.5 (TRAPEZOID)	1150	-	0.22	-	-	SECIM	EXISTING
ROLLING	42 X 17.6	746	35.1	0.34	19.2	21	MRD-ROD MILL	EXISTING
ROLLING	50 X 9.6	480	35.7	0.53	14.5	20	PASS 1 MRD, PASS 3	FLAT ROLLS
ROLLING	53 X 5.8	308	35.8	0.826	10	16	MRD, PASS 5	FLAT ROLLS Ø250
ROLLING	55 X 3.6	197	36	1.29	7.6	15.4	MRD PASS 7	FLAT ROLLS Ø250
						72.5		
BLANKING	Ø 50 X 3.6	-	-	-	-	50 KW BLANKING FORCE 85 KN (8.5 TONS)	BLANKING PRESS (25 TONS)	NEW

Ø = Diameter

4. CONCLUSIONS AND RECOMMENDATIONS

For conclusions and recommendations regarding each company please turn to 2.3 and 3.4.

4.1 The Present Situation

As mentioned earlier the mission was too short to make a reliable assessment of the markets for the different suggested products.

The equipment of the two companies guarantees a high level quality of very good international standard. Therefore an assessment has been made of new products which could be produced on the existing equipment.

It is expected that the market situation in the Gulf area will undergo great changes once the war in the area is terminated. It is, therefore, advisable to be prepared for a rapidly increasing demand as soon as the situation in the area will stabilize itself.

4.2 Recommendations

4.2.1. Metal Supply

It is vitally important that preference will be given to local enterprises regarding the accessible input material.

The export of ingots from ALBA at the cost of the local industry is in no way justifiable. The additional added value for the products of Balexco, Midal Cables and Garmco above export metal price will exceed US$25 million p.a. during the coming years. It is, therefore, imperative that these companies are being fed with sufficient indigenious raw materials.

4.2.2. Research and Development

The aluminium processing companies in Bahrain have consulting agreements with the world's major aluminium companies, which should safeguard future technical development.

As the consulting companies themselves are producers of finished and semi-finished products and assist even producers of the same products in other parts of the world they will most certainly, in their own interest, withhold information on future developments which could benefit the Bahrain aluminium industry at the cost of the consultants. It is therefore suggested that Bahrain's aluminium processing industry plans its own technical development independently together. This will be particularly interesting in the fields of improved material properties and process technology as well as product development.

Independent consultants can always be recruited through the services of UNIDO at first. In due course a collective research and development organisation to serve the Bahrain aluminium industry will be a great advantage, whereby the existant equipment resources of the different companies could be utilised.

4.2.3. Power Transmission Operation

The line of products manufactured by Balexco, Midal Cables and Al Khajah Factories suggests the possibility of an integrated Power Transmission Operation, whereby Midal Cables would produce the overhead conductors, Balexco the pylons, busbars, etc. and Al Khajah Factories the switchgear. Knowhow and competent personnel to start up the operation can be provided from Europe eg Sweden.

5. GENERAL OBSERVATIONS : TECHNICAL EDUCATION

As an educator of engineers and technicians, I have observed the lack of Bahraini technicians, the "sergeants" of industry.

In order to achieve a Bahrainisation of industry, the education of competent technicians is imperative. The prerequisits of a competent technician are:-

At least 3 years practice on the shop floor.

A thorough theoretical education based on the needs of industry and a high social status ("industrial engineer") implemented by a good salary.

It should be remembered that it is the technicians who make the wheels turn. The competent technician is a practically as well as theroretically highly qualified person. Highly developed European countries like Germany, Sweden, Switzerland, hold this position, mainly thanks to a corps of competent technicians.

Unless there are competent Bahraini technicians, the country will for ever be dependent on expatriates.

To arrive at the education of competent technicians, the following steps are suggested to be taken:-

1. The Bahrain industry reserves every year a certain number of paid employment opportunities for technician apprentices which during their 3 years' apprenticeship, rotate among all the jobs on the shop floor.

2. To be accepted as a technician apprentice, good marks in mathematics, physics and chemistry as well as in English from secondary school should be required.

3. The above requirement will ensure the ability to follow and complete the theoretical courses successfully,

4. Due to a thorough practical training, the theoretical education could be limited to two years.

5. The syllabus of the school should be flexible to an extent as to satisfy the needs of the country's industry.

It is suggested to assemble a number of industrialists and educators for an informal discussion on the possible ways of creating competent Bahraini technicians within the coming 7 years and to draw up a frame-work for an appropriate syllabus.