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SOME CONSIDERATIONS ON THE DEVELOPMENT OF ALUMINIUM SEMI-PRODUCTS MANUFACTURING INDUSTRIES

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1. Introduction

To promote the establishment and expansion of the aluminium industry in developing countries is one of UNIDO's concerns, looking back to a past of more than 10 years. At the outset, UNIDO focused most of its efforts on boosting the development of alumina and aluminium metal production in the developing world (1, 2).

Table 1 shows some figures relevant to these efforts

TABLE 1
Share of different economic areas in world aluminium production (8)

Per cent

Group of countries	1980 actual	1990 forecast	1995-2000 forecast
Developed countries	68	63-56	61-53
Centrally planned economies incl. Yugoslavia and People's Rep. of China	22	21-23	20-22
Latin America	5	10-11	13-14
Other developing countries	5	6-10	6 -11
TOTAL	100	100	100

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In more recent years, however, the desirability and possibility of local processing of aluminium metal through the establishment of aluminium downstream industries has more and more come into sharp focus. This trend has been substantially supported by various case studies on this subject prepared under the auspices of UNIDO (3,4,5,6,7,8,9).

2. Different models of technical development in the semi-manufacturing field

It may be emphasized that the promotion of an industry for production and/or processing of aluminium semi-fabricated products represents a special case in each country, whether large or small. This paper deals with the most important semi-fabricated products, such as hot and cold rolled sheet and strip, extrusions, foils, etc., usually called "semis".

To develop an industry for aluminium semi-fabricated products is a complex matter governed by a combination of geographical, political and technical circumstances. A few of these are enumerated below:

i. general standard of economic development in a given country; its population, infrastructure and energy supply;

ii. availability of local manpower; average level of education of the workforce and its working morale; the conditions of stationing foreign specialists for some months or years;

iii. raw material situation on site;

iv. present status of local raw material manufacture, if any, and its future potentialities;

v. ownership of available aluminium raw material-producing facilities (whether a subsidiary of a multinational or run by local or regional capital);

vi. magnitude and potential of the domestic market; how an envisaged project may fit into the general pattern of the country's economy etc.

vii. foreign trade prospects; possibilities of regional long-term agreements; outlook of exports to industrially developed countries;

Although an efficient industry for fabricating semis calls for complex and up-to-date equipment, envisaged projects are not only governed by marketing considerations, but also whether or not adequate utilization of equipment can be ensured and funds are available for their implementation (e.g. in the case of installation of modern strip heat-treating lines, a high duty hot strip mill, etc.).The purchase of less costly equipment only (e.g. that of a continuous strip-casting machine) however, frequently tends to reduce the range and to impair the standard of available products, imposing limitations on their marketing (e.g. mass items of lesser quality to be disposed of at the domestic or regional markets only). In each of these cases the economic feasibility is a consideration of paramount importance.

In view of the above, three main alternative models of technical development may be considered on the understanding that there are numerous sub-variants which permit an almost unlimited number of combinations. The three basic technical development models hereafter dealt with have been chosen in such a way that the different technological variants may closely fit into the framework of any of the three basic alternatives, irrespective of what conclusions may in each case be reached after considering the overall effect of favourable or unfavourable factors involved.

2.1 The traditional model

In dealing with this alternative, first of all the already existing finished product fabricating facilities have to be taken into account assuming that these enterprises of mostly moderate capacity have exclusively been using imported semis. As a first step, consideration has to be given to how to replace at least part of such imports by the input of locally manufactured semi-fabricated products. Limited capital available, the general standard of manpower, inadequate industrial infrastructure and limited domestic market may be negative factors limiting the size of a planned new semi-fabrication plant. In developing countries, therefore, at this stage preference is given to installing

various moderately-priced small-capacity target equipment easy to handle for the manufacturing of a relatively small range of well-marketable items. Such equipment, as a rule, is capable of performing the final operations of semi-manufacturing only with a raw material stock (e.g. coils of hot-rolled strip, rod wire, etc.) being imported from abroad.

Advantages of such plants:

- Manufacture on a modest scale; the unit capacities available are easily adaptable to actual market demand;
- Relatively small amount of skilled labour required;
- Small capital investment involved, especially if efficiently operating second-hand equipment may be installed;

Disadvantages of such plants:

- Limited product mix, usually of poorer quality;
- Relatively low productivity of labour, coupled with poor specific energy efficiency.

In view of the pros and cons outlined above, it may be recommended in such cases to start with t' · manufacture of extruded products (8). If justified by domestic demand, conductors, as well as sheet and discs of medium thickness and commercial quality may be produced. Items of somewhat higher finish may also be considered, such as corrugated aluminium sheet manufactured by roller lines, or claddings and components of buildings made by mechanical folding or by using roller lines. An important equipment in producing such products is also a slitter for slitting and edging of the imported wide strip coils.

The manufacture of more sophisticated rolled products (foils and thin strip) usually calls for a great deal of experience even if not the latest equipment is used.

In discussing this model, a brief reference has also to be made to the recycling of scrap. When designing and installing an aluminium semi-fabricating plant even if of modest capacity (say about 1000 tpy) it is expedient to make provisions for the effective remelting of scrap on site. If melting of the metal or remelting of the scrap is not done in effective way, this may

involve losses varying from 5 to 30 %. On the other hand, the sales price of poor quality remelted metal may be smaller than one-third of that of the primary metal. Fig. 1 demonstrates a simplified lay-out of a small capacity scrap refining plant which is fit for processing scrap of the following composition (in tons per year):

Sheet and extrusion scrap	400-500 tons
Castings' scrap	200-300 tons
Foil and thin strip scrap	150-250 tons
Turnings and chips	50-100 tons
	800-1150 tons

Depending on local conditions, investment costs are of the order of one million US dollars.

In Fig. 2 the model of a traditional plant based on an old-fashioned sheet rolling mill is demonstrated. In many cases this would be expanded later by a shop for manufacturing rolled products of higher finish, nothwithstanding the multiplicity, design, size, capacity and range of items to be produced. A general lay-out scheme of such a plant is given in Fig. 3 as an example. Let us provide a rough estimate as to investment costs involved in such ventures in the following.

The prices of equipment may vary a great deal on the source of manufacture or supply, on how up-to-date the facility is and how extensively it is automated. The prices below refer only to the equipment proper, without buildings and extra costs.

- tube welding line for the manufacture of small-diameter 12-50 mm) tubes	800 000 - 1,000,000 US$
- Narrow strip coil-coating line (max. width 180 mm)	500,000 - 600,000 US$
- Profiling line for profiles of max. 100 mm circular dia.	300,000 - 400,000 US$
- Wide-strip coil-coating line max. width: 1,800 mm	6 - 9 million US$

2.2. Smelters as semi-product manufacturers

In a second model, aluminium smelters are acting as also manufacturers of certain semi-fabricated products. This development is due to the worldwide introduction of continuous casting techniques in producing rod wire and wide strips. Smelters may thereby become an integral part of the semi-product manufacturing industry, especially as far as initial operations in producing various feed-stock items are concerned.

The minimum feasible annual capacity both of a continuous rod-wire and strip casting unit is 10,000 tons. Several such relatively small capacity lines may be installed in sequence next to each other to be directly and continuously fed by molten metal from the smelter. For this end only pure metal is usually used, treated with special care, to eliminate impurities. Nothwithstanding the obvious attractions of this technology, on the debit side there is the fact that only a limited range of semis may be produced.

An example of how a semi-fabricating facility dependent on continuously-cast products of a smelter may be operating is given in Fig. 4

As a rule, further processing of the semi-fabricated feed stock furnished by the smelter is done in entirely separated premises. The major aluminium companies operating aluminium smelters may have a vested interest in promoting the installation of such latter type of downstream manufacturing capacities as well.

Apart from developing countries with a large population and strong domestic market, in other developing areas the demand for aluminium metal by the aluminium semi-manufacturers could and would be regionally supplied virtually along the same lines (e.g. meeting the local semi-manufacturer's demand of Middle East countries and Pakistan by processing products shipped from the smelters of Bahrain and Dubai; smelter operations in Argentina acting as an indirect incentive for developing semi-product fabricating facilities in other Latin American countries).

2.3 Erecting of independent, integrated complexes for manufacturing of aluminium semi-products

The third model envisages the establishment of a complex for fabricating semis fully independent of an adjacent smelter, with a slab and billet-casting shop of its own, engaged in the manufacture of a full or limited but extensive range of items and operating in an area where potentials for a diversified aluminium downstream industry exist locally and/or in the geographical neighbourhood, and where sufficient volume of metal is available or may be obtained to feed the facility. A case in point is a semi-fabricating plant built in the 1970ies in Brazil for the manufacture of rolled and extruded items, as well as of foil (10) (see as an example Fig. 5). Such a project may be implemented in several successive stages. In our example a first stage of 12,000 tpy of rolled products was introduced; of these 5,700 tons are strip, sheet, welded tubes, plied profiles and painted strips; of the 6,300 tons of manufactured foil 2,000 tons are further processed. Material to be rolled is furnished by two 1,600 millimetre wide continuous casting machines. There is also a 16 MN extrusion press which was installed prior to the rolling mill, and a billet-casting shop to feed it. After completing the last stage of the project, the rolling capacity would achieve 50,000 tons per year. By that time, raw material will be furnished partly by continuous casting units and partly in the form of slabs produced in conventional casting shops. To deal with high-strength alloys, which are difficult to process, a separate hot-rolling stand is to be installed. At the same time, all auxiliary equipment and the extrusion plant may also be expanded.

The erection of a complex like this calls for a developed infrastructure, skilled manpower or labour that may be suitably trained, and, or course, for a significant amount of capital. Hence such a project is in most cases implemented with the participation of a financially sound syndicate co-operating with one of the major aluminium companies, or by local state authorities.

No doubt, the standard and product mix of such a large plant are superior to those turned out under the first, traditional model discussed earlier, and specific production costs, too, are bound to be lower. On the other hand, the traditional model may certainly be more elastic in faster following and adapting itself to local conditions and developments on site, despite difficulties in infrastructure, skilled labour and limitations in capital.

Therefore, the installation of such equipment may only be recommended in regions where sufficient engineering experience is available.

2.4. Foil rolling and processing

By definition the aluminium foil is a continuous web in the thickness range between 6 and 20 microns (0.00025" - 0.0006") depending on local standards.

Before deciding whether to establish a foil producing and processing industry or only a foil processing one which uses purchased plain foil, it is indispensable to prepare a detailed marketing research in all the possible market fields. The demand of the home market has to be considered in the first place. The most important fields in the use of aluminium foil for packaging are the different branches of the food industry, including the packaging of consumer goods like soft drinks, ice-cream, etc. In case of countries with tobacco industry the availability of foil may again be very important. Every country has to take into account its own industry of special products which need aluminium foil for wrapping, such as does the pharmaceutical production in substantial quantities, or for the "dressing-up" of foreign products. Based on the data of this detailed marketing research the expected quantity and its sortiment can be determined.

Up-to-date packaging materials, of which the majority are complex today, contain, apart from aluminium also other components like paper, plastic films, etc.,. Therefore, a study is always to be made on the possibilities of their procurement.

Besides those materials, the different lacquers, glues and waxes must also be purchased and stored under special conditions.

In most cases, the printing of aluminium foil is practically indispensable. If the marketing research in the given country shows that it seems to be necessary to establish printing capacity as a first step the kind of printing method to be used has to be decided by marketing research. Afterwards it is necessary to pay attention to two main factors. On one hand it has to be decided how to procure and store the printing inks and lacquers and also how to manage the mixing of the inks and the preparation of required shades. On the other hand the availability of printing cylinders has to be clarified. The purchasing of ready made cylinders is one possibility, their production on the spot, is the other. The latter is a highly sophisticated technology which needs well-qualified operators with a relatively long experience, but ensures a more flexible product mix.

Both steps - the foil rolling and the foil processing - need workers with higher qualifications than in the industry in general and in any case, longer training and practical experience. Therefore, it is necessary to study how to secure workforce to fulfil the above mentioned requirements.

The procurement of production machinery is basically done in the usual way. We would like to draw attention to the special care to be taken on the references and reputation of the potential supplier. The manufacturers of foil producing or foil processing equipment should possess the special knowledge for and practice in manufacturing such equipment. This has to be proved by references of operation of their equipment in other foil plants for a sufficient longer period of time and with good results and reputation.

Aluminium foil processing has some special requirements in connexion with environment pollution. The evaporated fume of the used solvents - if not specially handled, is a source of direct pollution, The left over lacquers, inks, glues and unclean, used solvents must be disposed of as wastes without posing environmental hazards.

In result of producing plain aluminium foil and its processing a relatively high quantity of solid scrap develops requiring special and diversified attention. The plain foil scrap and the paper laminated foil scrap can be recycled by remelting or using special technologies, other kinds of scrap has to be disposed of.

In summary in all cases when thinking of starting foil production it is advisable to engage a special consultant who should be responsible for all issues concerning the installation of such a unit up to the selection and purchasing of the main equipment and participation in the warranty tests. Establishment of production of the thinnest variants of aluminium foil may require additional special knowledge and experience to be possessed by such a consultant.

3. General considerations as to the establishment and operation of the facilities (energy, maintenance, workforce, laboratories, etc.)

As in many other cases, an important requisite for the establishment of an aluminium semi-fabricating plant is the availability of a complete infrastructure covering:

- energy supply
- water supply
- a sewage disposal system and/or equipment for treating or destroying sewage or wastes
- a suitable road network
- the availability of auxiliary utilities and services essential in operating the facility
- housing, including such providing health and medical services and catering for the cultural and religious needs of the workforce, together with schools and an adequate network of shops, etc.

It should be remembered that it is of paramount importance for the plant to have a permanent and experienced workforce on whose services it may always rely.

If no infrastructure is available right at the doorstep of the plant, it is up to the investor or the state to provide for what may be missing. Of course, the smaller a plant, the more difficult it is for it to defray such extra costs. In selecting a suitable location for such a project, the problem of infrastructure, existing or one to be provided for, is always a crucial point. Another important consideration is the plant's distance to the end-using industries; transport costs of semi-fabricates to end-users greatly influence the viability of a project.

To sum up, before a project may take concrete shape, a multiplicity of problems in the field of know-how, technology and engineering has to be resolved. Evidently, it is advisable to entrust such complex matters to a renown firm of special knowledge and experience and to buy know-how from a semi-fabricator of proven good reputation.

4. Development and Marketing of Aluminium Products in Developing Countries

The establishment of an aluminium industry in developing countries - whether in centrally planned or market economies - is always a matter in which the governments take a keen interest. When envisaging such projects, the first step is to set up - with state-sponsorship or without - a body sufficiently familiar with all commercial and technological implications of the matter, capable of promoting the realization of such schemes, and to help later on the newly established industry to organize the marketing of its products. Even in this starting phase of technical development, there has to be a nucleus of a future marketing and technical advisory organization to render the venture technologically effective and financially sound services. In going ahead with such projects, the services of foreign firms experienced in technical development, designing and engineering, combined with the purchase of know-how, the engaging of specialists and the concluding of joint venture arrangements, may

greatly expedite preparatory work and reduce the time necessary for the implementation of projects. Subsequently, operators of a sizable aluminium semi-products fabricating industry have to set up gradually research, development and engineering facilities of their own. Experience being obtained has to be permanently upgraded by following in the shortest possible time latest developments in world technology, and by exchanging information with other producers or specialized institutions.

Such centralized or de-centalized consulting and marketing units should operate in close co-operation with all local industrial producers, consumers, as well as technical development and advisory bodies, so as to ensure optimum efficiency of continuous development and sales efforts.

4.1 Economic benefits of specialized marketing organizations for semi-product manufacturers

Every country or firm operating an aluminium industry in a developing country has to develop a business strategy of its own, which has to be flexible enough to cope with market fluctuations. Even the installation of a new equipment may affect and alter such a business strategy. In defining this, the range of products to be put on the market is an important consideration.

New products have to be marketed in the folllowing three steps:

- Introduction of the products on the domestic market;
- Exports to regional markets; and
- Exports to world markets

The situation is different when the plant is installed with the aid of foreign capital or know-how furnished by one of the major aluminium companies. Here there is a growing trend by these companies to accept large shipments of commercial-quality semi-manufactures in compensation for their capital investment. This practice, usually governed by long-term agreements, may be very advantageous to the semi-product fabricating plant of a

developing country; it may not only permit a better utilization of available capacities, but also to derive extra benefits in the pricing of products wherein higher finish and more labour are involved. Related to aluminium ingot, such phase-differences in pricing are tabulated below:

Aluminium ingot	100 %
Continuous-cast rod wire coils	115%
Continuous-cast strip coils	120-125%
Unalloyed and weakly alloyed strip coils of 1.5-0.7 mm thickn.	130%
Thin strip of commercial quality	140%
Thin strip of special quality (minimum)	150%
Foil of commercial quality	180%
Converted foil	210-250%
Low-alloyed extruded sections	180-220%
Low alloyed extruded sections of anodized surface	220-250%

4.2 Some suggestions for the possible organization of a specialized marketing organization

In organizing and stimulating the domestic and export markets effectively, it is necessary for the sales organization to keep close contacts with the various end-using industries and the agencies responsible for technical development. This applies equally to countries of centrally planned and market economies. Another important task for the sales organization is to adopt a certain pattern of pricing system. There are two alternatives for the latter:

- Buyer and seller agree - for a definite length of time (usually long-term) - to carry out business on the basis of prices tied to the so-called official aluminium ingot market price. This is the usual pricing model practised by the international metal trade, based on co-operation and mutual understanding between the two parties.

- Under the second model, prices of semi-manufactures are determined by the market quotations of the Metal Exchange of London or COMEX of New York. In this case, semi-fabricated products become typical market commodities exposed to ups and downs of fast fluctuations, with small chances of contacts between buyer and seller.

Adopting an effective pricing system calls for a great deal of experience and foresight on the part of the trading organization. As to how such grading organization may best operate in a developing country, several alternatives and combinations thereof exist:

- An independent producer of semis is running a combined sales and technical development division of its own (This applies in the first place to enterprises operating under the model discussed in sub-chapter 2.3., i.e. an independent integrated complex).
- The semi-fabricating plant is directly or indirectly integrated into the framework of a national or major aluminium smelting company, in this event the manner in which marketing and sales are to be organized largely rests with the multinational or national company whose part or subsidiary the plant is (This applies in the first place to semi-fabricators operating under the model discussed in sub-chapter 2.2. "Smelters as semi-product manufacturers").
- The sale of aluminium semi-product manufactures is a high priority of the government's domestic and foreign trade policy; in this case it is advisable to combine marketing and technical development into the frame of a single, centrally controlled organization.
- And finally, when several smaller finished product manufacturers are operating in the country it is expedient to persuade them to enter into voluntary partnership in a joint technical development and marketing agency (see sub-chapter 2.1 "The traditional model"). How such organizations may work is explained in more detail in a separate UNIDO study entitled "The economic use of aluminium".

5. Recommendations:

The development of an industry for aluminium semi-fabricated products - especially in developing countries - is a typical field of significance for the case of transfer of technology.

In order to further pursue this case with the involvement and assistance of UNIDO it may be recommended that developing countries in the Arab region wishing to acquire the necessary know-how to operate aluminium semi-fabricating industries of their own with an optimum of techno-economic effectivity may first of all wish to

(a) familiarize themselves with the contents of "Guidelines for Processing Aluminium Semi-Fabricated Products", a UNIDO study published in 1985, discussing in detail the relevant aspects of how a semis fabricating industry may be established or developed with special regard to different branches of technology;

(b) initiate the organization - it may be under UNIDO auspices - of an international symposium or seminar, where specialists from developing countries may meet together with experts from prominent aluminium companies and bodies as well as representatives of firms engaged in the manufacture of equipment to be used in fabricating semis or processing aluminium, to exchange experiences and discuss technological alternatives.

(c) join efforts aimed at the establishment of an Arab Aluminium Development Centre possibly including a testing laboratory for semi-fabricated aluminium products and acting as a training and commercial centre for the Arab Region, as was pointed out in the paper by Mr. Balazs, Head of Metalllurgical Industries Section of UNIDO.

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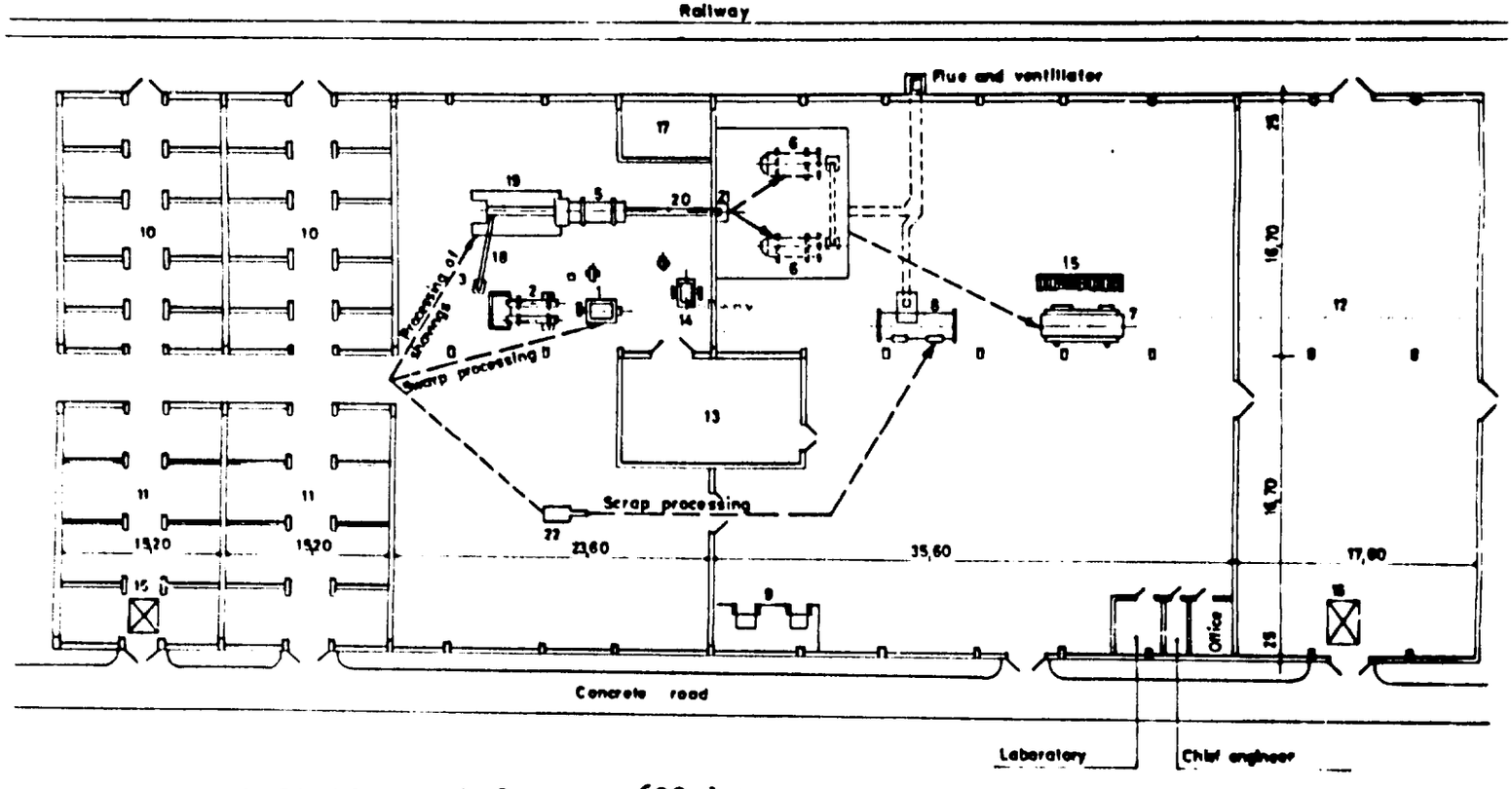
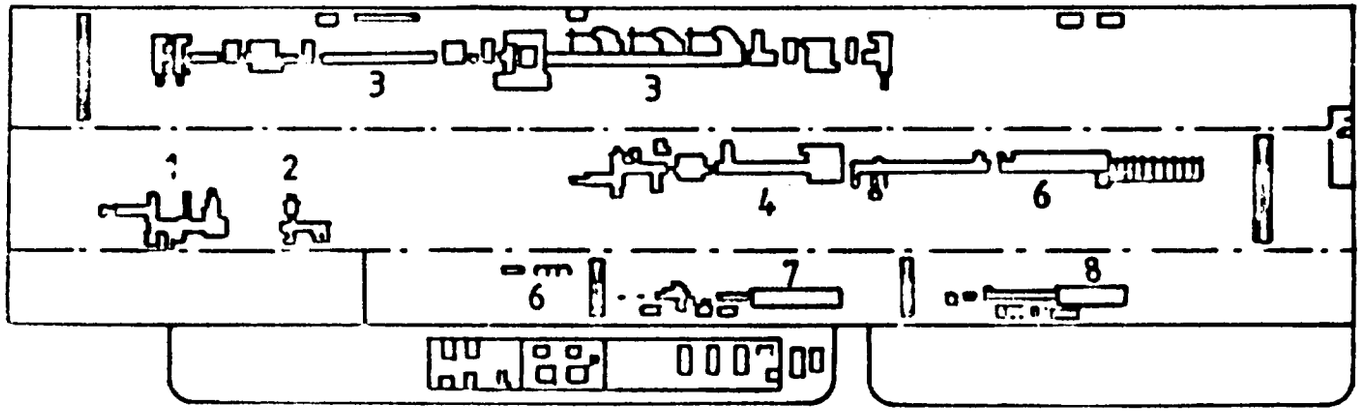
Fig. 1 Small capacity scrap processing plant (approx. 1000 tpy) - simplified outlay



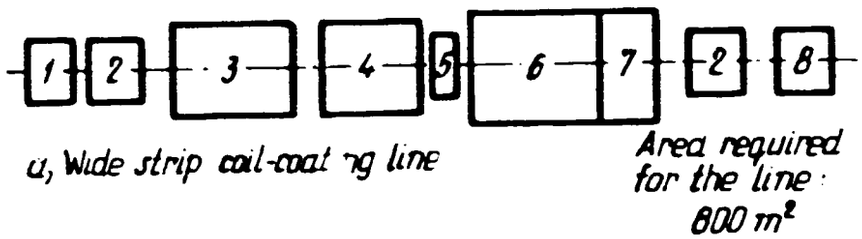
1 Ball-Mill
2 Washer
3 De- oiling Centrifugue
4 Crusher
5 Dryer
6 Rotary furnace
7 Precipitating f nace
8 Reverberatory furnace
9 Tilting pot furnace 600 kg
10 Shavings stacks
11 Swarp stacks
12 Ingot store
13 Flux residues store
14 Flux crusher
15 Cont. chill-mould chain
16 Scales
17 Fresh flux store
18 Conveyor belt
19 Lift
20 Lift
21 Magnetic separator
22 Faggotting press for sheet scraps

Fig. 2 Strip finishing shop (annual capacity 5,000 - 10,000 tons)



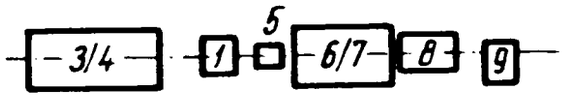
1 Slitter I;
2 Slitter II;
3 Coil coating line;
4 Cutter;
5 Sheet profiling line;
6 Strip-profiling line;
7 Tube-Welding line I;
8 Tube-Welding line II

Fig. 3 Examples of manufacturing and/or finishing some special semi-fabricated products



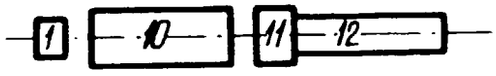
a, Wide strip coil-coating line

Area required for the line: 800 m²



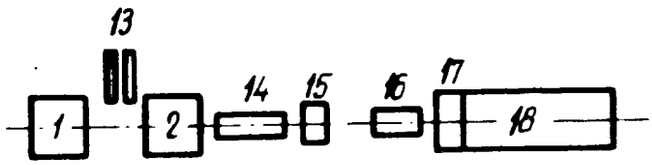
b, Narrow strip coil-coating line

150 m²



c, Narrow strip profiling line

150 m²



d, Tube welding line

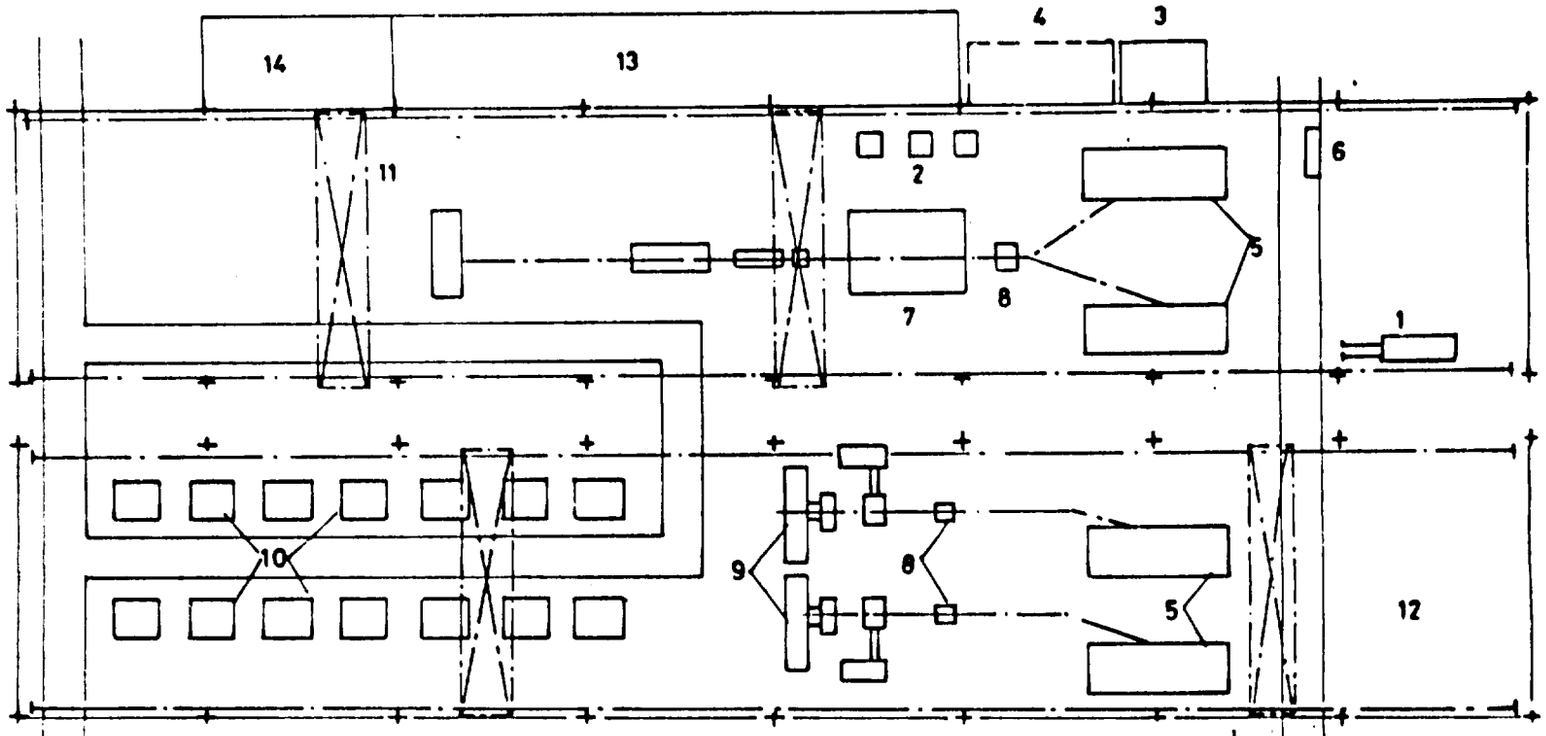
350 m²

Fig. 3

AL-Do 3

1 De-winder
2 Strip accumulator
3 Purifier, degreaser
4 Preliminary surface treatment and anodization
5 Application of lacquer
6 Lacquer fusing
7 Cooler
8 Winder, lifter
10 Profile rolling line
11 Saw
12 Finishing table
13 Manual welding apparatus, splicer
14 Tube rolling stand
15 Welding equipment
16 Tube calibration
17 Cutting

Fig. 4 Casting shop with continuous casters for wide strip and wire rod
(wide strip: 25,000 tpy; wire rod: 20,000 tpy)



1 Tool Preheating Furnace
2 Slag Crucible Preheater
3 Liquid Chlorine Tank and Evaporator
4 Liquid Nitrogen Tank and Evaporator
5 Casting Furnace, 25-t
6 Road Weigh - Bridge
7 Continuous Wire Bar Casting Equipment
8 Continuous Metal Cleaning Unit, e.g. Union Carbide SNIF
9 Continuous Wide Strip Caster, e.g. JUMBO 3c
10 Coil Storage Racks
11 20/5 Mp-Capacity Bridge Crane
12 Scrap Storage Area and Storage for Auxiliary Materials
13 Offices and Social Units
14 Maintenance Work Shop

Fig. 5

Layout of integrated aluminium semi-manufacturing plant