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United Nations Industrial Development Organization

SUMMARY

PRODUCTION OF PROTOTYPES BY CENTRES AND THEIR ROLE IN CERTAIN DEVELOPING COUNTRIES OF INDUSTRY IN DEVELOPED COUNTRIES [1]

by

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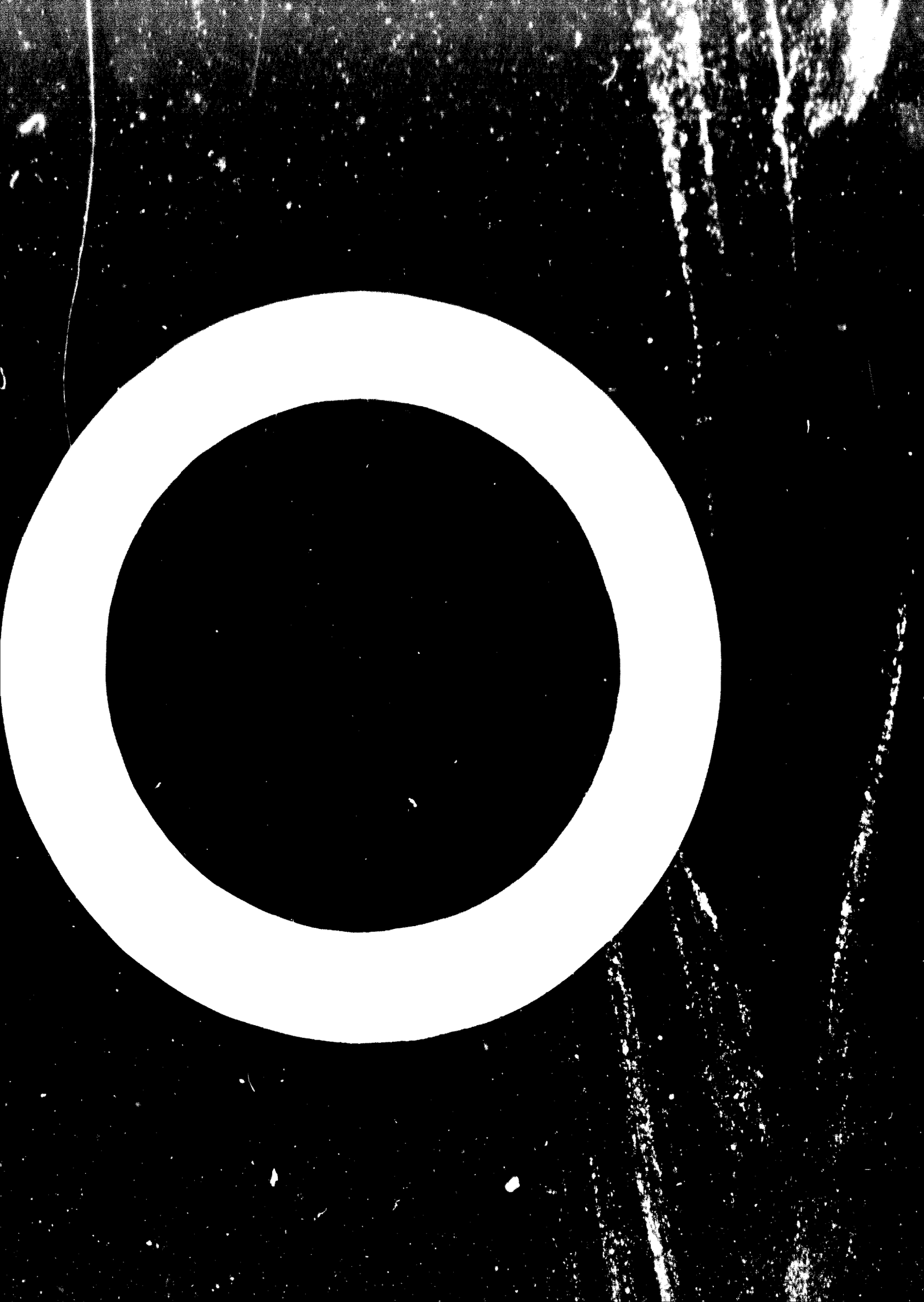

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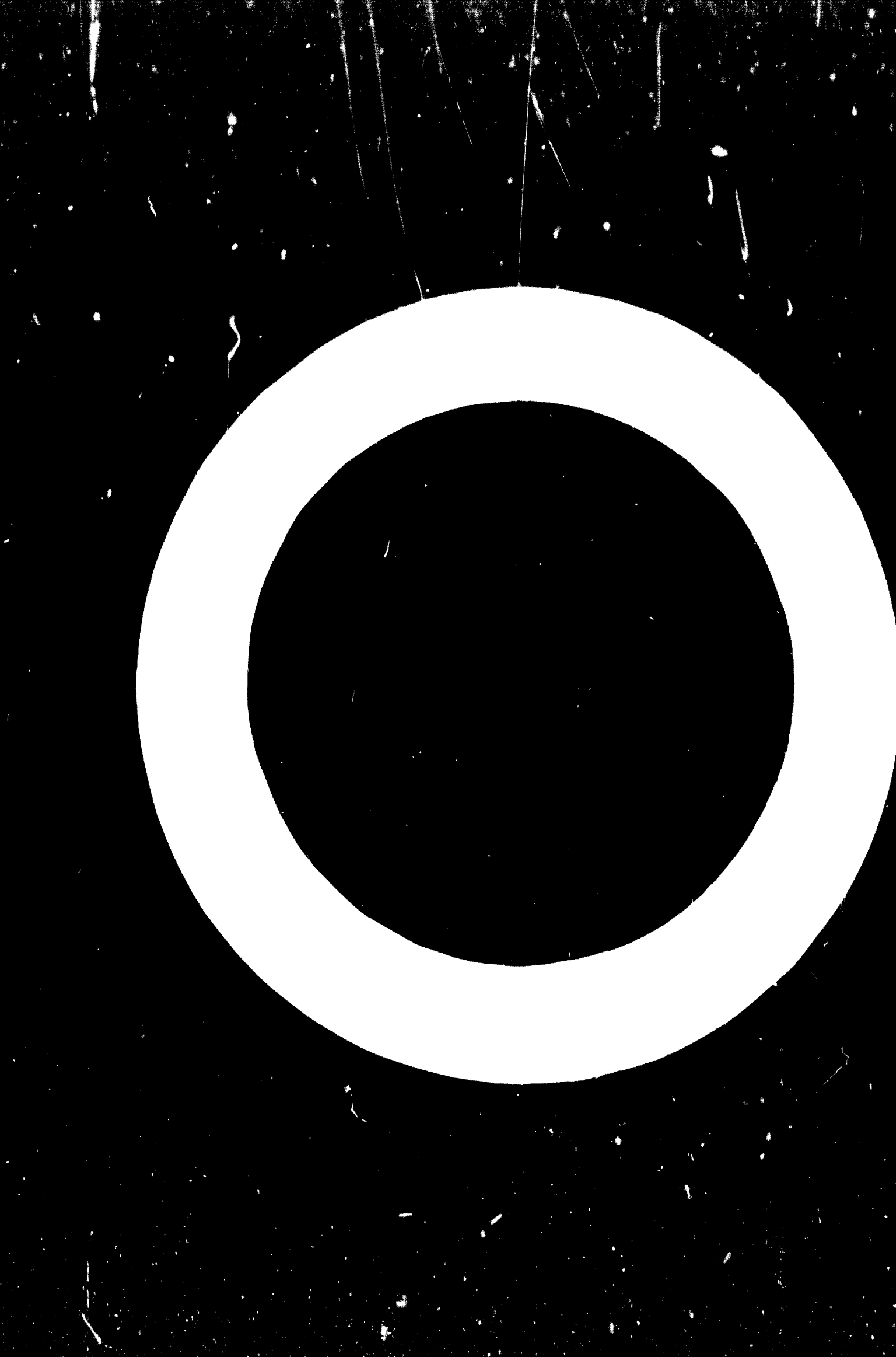

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1. Introduction

This paper is based on [illegible] years of practical experience in developing country settings with the use of [illegible] tools. The author has spent [illegible] years of [illegible] and about [illegible] years in [illegible] level of [illegible], two industrialized countries, Switzerland and Germany, and various developing countries, i.e. he worked in Ceylon, Pakistan, Afghanistan, Tanzania, Iran, Burma and Kenya.

1.1 Scope

This study deals with [illegible] financial and organizational [illegible] with the necessary [illegible] cover, the most suitable [illegible] of future demand, etc. [illegible] all problems arising out of [illegible] in the country and to introduce it for production by [illegible] factories.

As a sample - based on the experience of the author - [illegible] tools have been selected; materials not of the most modern types, but with reliable [illegible] and adaptable to the conditions of the countries concerned.

In most cases, money for investment in developing countries is scarce, hence expensive and complicated equipment like hydraulics and electronics have to be avoided. Spare parts for service facilities, and other supplies must be guaranteed.

Service teams are a basic requirement for further technical production, but only in connection with [illegible] at the very moment, where it is not a question of producing [illegible] production of reliable quality in small quantity, but the transition has to start towards [illegible] industrial [illegible].

Moreover, this paper covers the subjective [illegible] requirements, adaptation to local conditions, manufacturing devices, prototype production, training, [illegible] and recommendations - as outlined in the first [illegible] - which are given to all difficulties and [illegible] which may arise when a [illegible] country [illegible].

1.2 Limitations

The following statements do not contain experience with and in Latin-American states or others than the mentioned parts of the third world. However, one may assume that conditions there are at least similar to those experienced. Variations are unavoidable due to different mentality and other religions in the various parts of the world.

It may be mentioned in this connection that some people consider already parts of Western Europe as overpopulated countries. This would be too much to say, but it is not a subject of this paper. I merely like to point out that in the Federal Republic of Germany there is neither overpopulation nor underpopulation and well established rules of behaviour, as found in this part of the world, have proved their practicability. It is also true that the consumer [illegible].

A further limitation is given by the goods to be produced. A large number of items, e.g. [illegible], machine tools, building hardware, household [illegible], [illegible], and other [illegible], toys, [illegible], machines, tools and devices, [illegible] and scientific knowledge concerning this product are available [illegible], do not justify the [illegible] of prototype [illegible].

The sale of the articles must exist at [illegible] on a large variety of [illegible] in the country, programs of building, [illegible], traditions of [illegible] and eating habits, literacy and education, [illegible] upon the social ability of monetary [illegible] in the [illegible], additional factors are [illegible] and advertising [illegible]. Again, both exquisite money, [illegible] are not considered seriously enough, it will be hard to avoid a failure.

hence, in most cases, to overcome initial difficulties, a certain government participation should be sought, either by means of [illegible] by mainly [illegible] to the available [illegible] [illegible] necessary foreign cooperation, at least [illegible].

[illegible] are not the most subject [illegible] most important [illegible] and consumer [illegible] exist, the more [illegible] the more they cannot be covered by the mass media newspaper, radio and television.

1.1 Financing of a Prototype Centre

This point may be mentioned only without being fully outlined, too many variations are possible. When starting the centre, a clear conception must be available about the purpose and the advantages of it. If there is a 'sponsoring foreign government', the tasks of the centre should be negotiated between the two governments to their full extent. It must be made clear from the very beginning who is responsible for which expenses - in investment as well as recurring costs.

The initial investment costs can be calculated comparatively easily, the main expenditures being:

-- land and buildings
-- machinery and factory equipment
-- initial outfit with tools of all kind
-- office equipment
-- training equipment
-- motor vehicles, means of transportation
-- power, water, sewerage, telephone
-- road and/or rail connections.

When starting the centre, the recurring expenses can be estimated only. They must be thoroughly adjusted from year to year when getting more experience, or the necessary money must be budgeted. There will be frequent problems about payment, if the initial treaty is not outlined clearly enough. The important recurring expenses are:

-- materials (incl. office and auxiliary materials)
-- salaries and wages
-- repairs, spare parts, maintenance
-- power and water consumption
-- motor vehicles' operation
-- technical and general administration
-- foreign experts (mostly to be split between sponsoring and receiving government)
-- depreciation.

All these and - depending on the particular case - many other points should be discussed and estimated as thoroughly as possible when having the intention to start a prototype centre on the basis of foreign cooperation.

1.4 Organization of a Prototype Centre

A prototype centre is somewhat a mixture between a factory of general layout, a cooperative purchase society and a technical training institution, influencing a sometimes wide range of other enterprises in a developing country. Accordingly, the organization of the centre should not be too narrow. The main lines will always be:

-- design department
-- production department
-- training department
-- general administration.

A sales organization will not be dealt with here, there are too many possibilities in developing countries.

The most important subdivisions may be mentioned as follows:

-- standardization
-- tool design, toolroom, tool maintenance
-- production planning
-- material testing
-- stores
-- packing and despatch
-- auxiliary units.

The organization of the centre (and partly also of the participating firms) is an important question when a prototype centre is decided upon. It should be carefully discussed and planned. Obscurities and mistakes in the planning stage are the main reasons of endless discussions later after the centre

is established.

2. Market Research

It is a basic principle - before introducing a new product - that the first money should be spent on market research. For large projects, this can sometimes be arranged by public tenders. But to have market research carried out by a foreign company will often be very expensive for a developing country. A further handicap will frequently be the inexperience of the foreign researchers with local conditions, the country, the people, climate etc.

It is more advisable for the developing country wishing to improve its industry to have a few foreign experts of various specializations, staying for a longer period in the country, thus gaining a better knowledge of industrialization possibilities and related fields like import of materials, sales market, labour conditions, transport facilities, etc.

These few experts can and should give a valuable training to their counterparts and staff. Most of the field as well as desk work can doubtlessly be executed by resident personnel, but guidance and supervision by the foreign experts is highly recommended. It may be possible to replace them by local staff after some years.

One of the most serious obstacles hindering often a reliable market research is the non- or scarce-availability of statistical data. Many countries, being independent only since a few years, do not have any data, or have started collecting data

about import figures, consumption, registration of existing factories, etc. only recently. Import figures may be available only at the ports of entry of goods, figures about existing factories may be manipulated for tax reasons, and mostly those and other figures are not complete at all.

Two other difficulties have to be mentioned:

-- a correct classification of goods, valid on an international basis, is either not available or has been introduced only recently, and figures of previous years are based on other classifications, hence both cannot be compared
-- handling and registration of im- and exported goods is done by personnel without any practical knowledge of the goods; imports are coming from a variety of foreign countries, bills of lading and all other shipping documents are mostly not written in the mother language of the issueing country - all together adding to the confusion instead of giving proper classifications.

Hence, if ever possible, all available data should be cross-checked before taking them for granted.

2.1 Which Machines and Types Are Required

Many countries with problems as how to improve the economy and industrialization try to have a somewhat "planned economy". No doubt that all plans, whether for 4, 5 or even 7 years ahead, contain considerable errors. Adjustments and corrections

from year to year can only be emphasized.

But in spite of these plans being mostly incorrect, containing sometimes even mer wishdreams than reliable facts, they show at least th trend of industrialization and give an outline for the years to come. It is quite a difference whether the plan urges one or more of the following fields for improvement:

-- education
-- transport facilities like roads, railways, harbours, etc.
-- agriculture
-- textile industry
-- electricity production and distribution
-- mining
-- heavy industry
-- national defence
-- medium or small-scale industries.

Only if promotion of medium or small-scale industries is to be emphasized in the current or next plan period, a further upgrading of machine tool production can be looked upon, because it is quite a difference whether a bulk share of the national income will be spent on upgrading of education, agriculture, transport facilities, defence or metal industries.

When trying to upgrade metal industries, only a relatively small number of developing countries will be in the position to promote both, heavy and medium or small-scale industries. In this connection, heavy industry may be understood as the steel and pig iron producing industry, starting with mining of iron ore, coal, etc. and processing of same, especially

mining of iron ore or coal can be a foreign exchange earning industry without giving consideration to the own processing industries.

If this is already done, the following machine tools are basically needed in all developing countries:

-- power hacksaws
-- drilling machines
-- lathes
-- shaping machines
-- milling machines
-- maintenance machines (bench and pedestral grinders, tool and cutter grinders, etc.)

Surface and circular grinding machines are also necessary, but mostly already highgrade machine tools, required in smaller numbers and requiring for their production higher skills, better measuring instruments and - at least some - high-grade materials. Broaching machines and others may be left out also in this connection from local production for reasons of difficult tool maintenance and being only suitable for real mass production. In the first instance, they are not recommended for production in prototype centres, but are well suited to be manufactured after a couple of years of successful experience.

One more critical point for selecting machines to be produced in a prototype centre is the stage of development in the concerned country. As far as, for example, power hacksaws or

drilling machines are already produced by one or more firms, they should be omitted from the programme. It does not pay to create unnecessary competition; but carefully selected advice for improvement of quality and performance can highly be recommended to the local entrepreneurs - assuming that the prototype centre will be staffed with really good technicians and experts.

Components of small or medium size can generally be manufactured more easily than very large ones. An exception are miniature parts for electronics, etc. which do not arise in the proposed type of machine tools.

For this reason it is advisable to start a production with the small types of selected machines as long as several sizes of the same kind shall be produced gradually. It will be easier for pattern making, transport and handling of components and assembly.

After having gained experience, the next bigger size should be started.

Out of the foregoing the main criteria emerge:

-- for prototype production only machines should be selected which are at present not manufactured in the country
-- only machines should be selected which can be sold in sufficient quantities during a number of years
-- a start should be made in general with the smaller or smallest type of selected machines.

2.2 Quantities per Year and Future Demand

When having clarified the question which machine types are required for a particular country, the future demand of these machines is of similar importance. On the one hand, production will for a long time be limited due to lack of sufficient supply of quality materials and lack of skilled labour, on the other hand, a fairly large number of machine tools and production machines in developing countries is going idle for a comparatively long time of the year. The latter point is simply explained but not always appreciated:

-- a number of machines is put up in technical centres, universities etc. for training purposes only, hence being unproductive practically the year round
-- most factories for products of general requirement were - in the planning stage - laid out for the possible maximum demand. This theoretical output is hampered by lack of purchasing power of the population, delayed supply of required qualified raw materials, non-availability of sufficient skilled labour, inefficient sales organization
-- further inefficiency of many machine tools is enforced by missing spare parts, irregular supply of electricity, unreliable maintenance and non-availability of additional tools for other products.

All this shows clearly that the planned capacity should hardly be on the highest side. Medium production figures are always closer to the truth than trying to cover the possible maximum demand.

A minimum of 5 machines per production order should be made sure, better is a quantity of 10, how often such orders are repeated during the year, depends on the overall production capacity, the variety of the manufacturing programme, the sales market and the price of the products.

It has sometimes shown that, when a developing country has passed a certain stage of industrialization, it has received an unexpected impetus, and all planning figures were overthrown. If that happens and need arises, there is always the possibility to work overtime or to import some urgently needed material by air, to fulfill an unexpectedly high demand.

The future demand can be influenced considerably by gradual improvement of quality and performance of the machines, by broadening the supply of accessories and by keeping a ready stock of spare parts and wear and tear parts. Even after 10 years, spare parts should be available easily. This should not be overlooked when organizing the production. To reduce the costs of spare parts in stock, alterations of the produced machines should be done only when really necessary or when giving a true improvement of the performance or quality of these machines.

As long as it is not sure that a minimum of 10 to 30 machines per year can be sold, they should not be considered for a transfer from the prototype centre to participating firms, but it may pay to the centre to manufacture only 10 machines per year of a certain type of high precision and performance, are needed in the country and which can only available against valuable foreign exchange.

2.3 Participating firms

No production at present can exist without a close cooperation, in developed countries between the various industries, their material- and subsuppliers, and in developing countries between the local factories and either their foreign licence firms or importers of know-how, materials, tools and equipment. A completely self-contained factory is nowadays practically unthinkable and can never be recommended.

A rough break-down of machine tool production shows the following trades and auxiliary lines:

Main lines

-- pattern making
-- foundry and fettling
-- machining and finishing
-- heat treatment
-- electro-plating
-- assembly
-- assembly and mounting of electrical components
-- inspection
-- painting

-- packing and despatch

Auxiliary lines:

-- design and standardization

-- tool design - toolroom - tool maintenance

-- material testing

-- production planning

-- purchase of materials and components

-- store rooms for raw materials - components - tools - spare parts

-- sales organization

-- general administration.

There are so many possibilities of cooperation that it is impossible to mention them all. The cooperation depends widely on the state of development in the country. A country where no or only one cast iron foundry exists, is barely in the position to develop a machine tool industry. In a number of countries, enough foundries are working, but the performance of pattern making, forming and casting is poor. Other obstacles are electro-plating, heat treatment and material testing.

Thus, also in these lines expert advice should be available with the prototype centre. The following outline gives a sample of a possible cooperation:

2.3.1 Permanent department of the prototype centre should be:

-- design and standardization

-- pattern making and pattern repair

-- tool design - toolroom - tool maintenance

-- material testing - heat treatment

-- purchase of materials, components and tools

-- spare parts store.

2.3.2 The following jobs and departments - as a rule - can be transferred to the participating firms without serious problems:

-- machining and finishing

-- assembly

-- assembly and mounting of electrical components

-- painting

-- packing

-- general administration.

For machining, finishing as well as assembly it is naturally assumed that the necessary facilities are available with the participating firm or that, at least, this firm will be ready to purchase the missing items. The same holds good for painting and spray painting, and packing equipments.

The general administration should in all cases be independent, for the centre as well as for the partner firm. Each has its own structure. Administrative outlines are valid for all of them, but the administrative work for a number of firms cannot be done by a centre.

2.3.3 A decision for other departments must be found for each particular case. These departments are:

-- foundry and fettling

-- electro-plating

-- production planning,

-- storing of raw materials and components

-- sales and service organization.

The subjects foundry and electro-plating are mentioned in chapter 2.3. The production power - as far as work plans and related documents are concerned - should be prepared by the centre. After the transfer of production to the participating firms, some adjustments must be made in work time pre-calculation, but the price orientation of the whole machine will not be influenced seriously by these adjustments. Generally, the overheads of small firms are lower than those of the centre, hence longer working times can be compensated.

The time scheduling after the transfer must be negotiated between the centre and the participating firms.

Storing of raw materials and components depends on the general availability of materials in the country. Foreign exchange sources are often limited, and the danger of black or gray market exists. In case the participating firms are not too far away from the centre and transport conditions are fair, a central store at the centre - also for tool steel and tools - is always recommended.

Most important for the industry of a developing country are well functioning sales organizations. Whether the sale will be promoted by a private or a government company depends on the already existing possibilities. A government organization is mostly somewhat slow and clumsy in action, some members are uninterested and do not have the necessary know-how, but

it can operate on a non-profit base. A private company is generally more vivid and more interested in sale than in service, they want to make profit.

2.4 Locality

The selection of a suitable place for the prototype centre is generally done years before it starts operating, hence, in this instance, only the location of the firms participating, later on in the production of the wanted machines can be discussed.

Normally, the centre should provide a number of services to other industries in the neighbourhood. Therefore, the centre should be somewhat centrally located with regard to other factories, e.g. on the compound of an industrial estate or (as called in other countries) industrial area.

In most developing countries, railway connections are poor. The amount of transported goods cannot be compared with the huge transportation tasks in developed places. Hence, care should be taken when selecting participating firms that road connections and telephone links are already available and serviceable. Some transportation work is necessary at least once a week, and check-backs by telephone almost daily. If road connections are unserviceable for some months of the year due to heavy rains or other reasons, alternatives should be considered in due time.

2.5 Possible Subcontractors and Auxiliary Workshops

One main group of the subcontractors will be considered here, the foundries. Cast iron foundries should exist in a country when starting a machine tool production. It is a question of their equipment and the quality of their castings, whether they can become counterparts of the prototype centre and its production.

Sometimes it pays to have a foundry of its own in the prototype centre with modern sand conditioning equipment, overhead crane, scale for thorough weighing of pig iron, scrap, coke and additions, core drying oven, rattling bowl, hardness tester, etc. For training purposes, this well equipped foundry may be valuable also. But this foundry at the centre would also be a serious competition to other existing ones.

For the improvement of local foundries it would be better to have them as subcontractors and - if and when necessary - to give them expert advice in the fields needed. As mentioned already, pattern making and maintenance should be carried out centrally at the centre. Advice is especially valuable if a local firm wants to buy new equipment, but in nearly all other cases, help will be appreciated also: in forming, drying of cores, sand conditioning, composition of the charge for the cupola, economical melting, etc.

To a small extent, producers of non-ferrous castings can become also subsuppliers to the centre and the participating firms. However, machine tools are produced in relatively

small numbers, there will hardly be a business for aluminium die castings. Permanent dies are too expensive for the small quantities required for machine tool production in developing countries. One exception may be some standard components like handles, hand wheels, name plates etc.

Electro-plating is another sub-line of industrial production, often done by subcontractors. No doubt that a number of large firms, e.g. Bicycle factories, producers of mass quality switches, car accessories and so on, operate on their own, sometimes fully automatic, electro-plating plants, getting the best performance at reasonable prices. But these plants are expensive, subject to difficulties due to lack of thorough maintenance, and are normally not suited for machine tool components.

As a job, electro-plating can practically be started in a small washhouse with one or two workers. But to get a good job done, 3 things are always absolutely necessary:

-- thorough selection of chemicals
-- cleanliness
-- adjustment of electrical data to the job performed.

For some electro-plating work, e.g. chromium plating, a correct neutralization of waste water is an additional necessity to avoid poisoning of drinking water in the vicinity. However, in any case electro-plating of machine tool components is a typical job to be performed by a subcontractor.

Other subcontracted units could eventually be gear boxes and toothed wheels. But their production is a fairly sophisticated job, requiring modern and expensive machines, high skills and thoroughly maintained tools. Often, heat treatment and grinding are necessary. Probably only a few already advanced developing countries have such central factories. The other 2 chances are either to import the gear boxes or to produce them (and others) permanently at the centre.

Electric motors, switches, components or wires are another group to be produced by subcontractors. A further group could be standard components like handles, pins, taper pins, screws, nuts, etc. But it always depends on the state of development of the concerned country, whether these and other items like paints, lubricants, V-belts, show glasses, etc. are directly purchased from the manufacturers through their sales organizations or through importers.

3. Licence Documents

It cannot be recommended to start the production of any type of machine tools in a developing country from the very beginning, i.e. with an own, new design. Even if it will be possible to hire an experienced machine tool designer as head of the design department of the prototype centre, too much time would be wasted and too many chances for mistakes would be incorporated in the drafts of a new machine and its prototypes. Hence, a start of a prototype centre should only be made with machines known for years for their reliable performance and serviceability.

3.1 Source of Licence Documents

A number of prototype centres are known to be sponsored by an industrial country as a technical assistance project to the developing country. In such case, the source of licence documents may be already fixed: the sponsoring country. This can easily be understood and appreciated.

The main problem which may arise is that the industry of the sponsoring country works according to the inch-system, and the receiving country has adapted the metric measuring system or vice versa. Inch or metric systems have naturally nothing to do with the quality of a product, but they are quite different to handle. As a matter of fact, the inch system is much more complicated than the metric measuring system, and the general trend is towards the metric one.

The most important reason that the two main countries conversant with the inch system - Great Britain and the U.S.A. - have not yet changed their measuring system, are the exorbitant costs involved with a switch-over. But this "not-having-changed-up-to-now" should not be a reason for a developing country not to adapt the metric system as early as possible. Already at the initial stage, only some drawings and measuring instruments must be exchanged. The more industrialization has taken place, the more expensive an exchange will become.

If there is no sponsoring foreign government, there will always be the chance to find a licencer either by private investors abroad or through cooperation with the economic

section of the embassy of an industrialized country.

The receiving country should not expect to get the licence documents free of charge. No doubt, the actual costs of the documents should be paid for and probably also some royalty will be due when production is to start. This must be negotiated and should be the lower, the older the type of machine(s) to be produced in the centre will be.

3.2 Volume of Licence Documents

The complete production documents should be given by the licencer to the following extent:

- -- one set of transparency copies of all component, group and assembly drawings
- -- two sets of blue prints of same drawings
- -- one set of blue prints of all required special tools, jigs and fixtures, measuring devices, etc.
- -- for items of before mentioned group of which drawings are not available, one black and white photo of postcard size; for bulky fixtures some more views of various aspects should be supplied
- -- one set of prints of all production papers like lists of materials, working plans, time calculations and list of required tools, jigs and fixtures and copies of all particular production instructions
- -- one set of copies of all standards mentioned in the production papers
- -- short description of all required machine tools with

main dimensions and data about required power, rpm, floor space, etc.

4. Adaptation to Local Conditions

Before starting a prototype production in the centre, the preparatory work is of great importance. It would hardly be possible to give blue prints of the recently obtained transparency drawings into the workstone, to add a production order of - will say - 5 prototype machines and to wait for a reasonable result. Beforehand, nearly all documents must be adapted to the local conditions, to the possibilities of the centre as well as to the production facilities of the participating firms.

4.1 Materials

Generally, the lists of materials for products of European firms show a variety of material qualities and dimensions as required for the most economical production of fairly large series. For rounds e.g. dias of 40-42-45-48-50-55-60-63 etc. are shown, mostly all for one and the same quality of material, and all diameters are easily available from the sales organizations of the steel rolling mills in Europe, or other places. The same is true for the various steel qualities: St34 - St37 - St42 - St50 - St52 - St60 - St70, their deviations and the low alloy steels or high quality tool steels. In exceptional case , material of a particular size and quality is required only in a quantity of a few 100 grammes per machine or even less.

It is impossible to keep such a stock of various materials in the store of a prototype centre in a developing country. If steel producers and rolling mills are already available in the country, these will have - according to the demand - their clearly defined production programme, sometimes normally for months ahead. Then the required sizes of rolled steel material must be adjusted, as far as possible, to the material available in the country.

Materials to be imported additionally must even be more carefully selected. It will often take 6 months or sometimes more from clarifying an order until the material is available in the own store. Often it pays to choose a slightly better quality which may only be a few cents/kg more expensive than the cheaper one. The advantages may be better weldability or easier heat treatment or minor distortion when being hardened or a generally better performance. Conditions for non-ferrous metals and other materials are similar and can be valued at a corresponding level.

Thus the trend in adapting the materials to local conditions should be:

-- not more qualities or material than absolutely necessary
-- reduction of raw material sizes of various qualities as far as possible
-- order quantities should not be too small

keeping these points in mind, ordering and stock keeping of materials will be made easier considerably. The disadvantages - mostly slightly higher costs and sometimes more machining work - will have to be taken into account, but are in most cases less important.

4.3 Standards

Chapter 4.2 already noted that one set of copies of all standards mentioned in the production papers should be supplied as part of the licence documents. However, together with the production instructions, these papers can be a guideline only. Standards are available in abundance in all industrialized countries, and the main task of the standard section of a prototype centre will be a careful selection and shortening of the available standards.

Valuable time all over the world is to get more and more internationally valid standards in the industrialized countries, which can only be appreciated by the developing nations. As these standards are available in a number of languages, there are normally no translation difficulties. It is of minor importance from which country the model of standards will be taken over, often a start is already made with a standardization organization in a developing country, and the prototype centre should be eager to become a member of the organization.

The main purpose of a standard section within the centre is - in close cooperation with the design department - to select

out of the innumerable possibilities e.g. of machine screws the few of which the centre and affiliated factories should make use of. Such a selection is a must as long as there are for screws somewhat

- 12 or more material classifications
- 10 or more diameters (only from ... to ...)
- more than 12 different lengths (in above dia-range)
- 20 or more different forms of heads, points, etc.
- various surface treatment possibilities,

giving for screws only, more than several 10.000 different items if all possibilities are made use of. Only a fraction of 1% in number of all standardized screws will serve the centre and the connected firms.

The suitable selection of the only really necessary screws (and naturally also of other standardized items like washers, nuts, pins, circlips, etc.) is one purpose of a standard section within the prototype centre. One other was already mentioned: material classification and selection of stock sizes.

A further broad field of the standard section are tools, for the centre as well as for participating firms. This requires a close cooperation with the production department, because even a good tool specialist can hardly cover all fields, as there are: drilling and boring, reaming, tapping, turning, planing, grinding, broaching, gearing, filing, fine finishing etc.

3000 and more different tools are probably wanted by the production department for their work; the standard section attempts to reduce this exorbitant number by means of negotiations with the concerned departments production, tool design and toolroom and production planning. It must be calculated whether a most economical production with always appropriate tools or a reduced stock of tools with sometimes slightly longer working times is finally more economical. Probably the latter, because purchase, storage and maintenance of tools is more expensive compared with wages in most developing countries. An exemption could be tools for a valuable, highly loaded machine, the work of which cannot be replaced by other operations.

Other tasks of the standardization section could be: production regulations, inspection rules, supply conditions and manuals. But it will be a matter of the organization of the concerned centre and the availability of qualified personnel to clarify the question, who will be in charge and responsible for one of the particular tasks.

4.3 Accuracy, Dimensions and Tolerances

These are problems which will never be settled to the satisfaction of everyone in the concerned departments. The designers always want the closest tolerances, the production department the contrary, the inspection has to check according to the drawings, but all of them want a machine with good and reliable performance. That is a base for compromises.

When a prototype centre starts its work, there are always some experts of various fields who should be able to negotiate and to compromise. As sure as 30 taper cuts in a 25 years old machine tool design can be replaced by roll pins, but the last 5 ones must remain taper pins, so sure will be that not all close toleranced are necessary. In most cases, not the individual tolerances are decisive but the combination of a number of tolerances. Here again the standard section has to play a vital role because each toleranced dimension shown in a production drawing requires either a special gauge or another - more expensive and more complicated - measuring device.

At this stage it cannot be decided upon whether the system unit-shaft or unit-bore is more advantageous. A number of products is based on the frequent use of closely toleranced bright-drawn rounds (for example, electric switches and devices) hence, the system unit-shaft will be used. Other manufacturers want to reduce the number of reamers and limit plug gauges and make use of the system unit-bore because their shafts are machined and ground in any case. Measuring while grinding with modern cylindrical grinding machines is mostly done automatically.

However, in any case should one try to reduce the number of gauges suitable only for one dimension and one tolerance. A clear decision - according to the requirement of the part and its cooperative function - should always be given by the design department. It must be exactly defined whether a hole in a component can be drilled only (normal tolerance H11) or should be reamed also (tolerance H8 or closer).

It may be clearly stated here that coarsening and simplifying of some tolerances does not necessarily mean a reduction of accuracy as a whole [illegible]. The use [illegible] depends on the cooperation of a number of [illegible] so that a new accuracy can generally be [illegible] only by the machine tool. [illegible] to [illegible] this: the production possibilities of the centre and of the participating firms later on, and the [illegible] of the available machines.

4.4 Production possibilities

There will be no discussion that the production possibilities of a prototype centre must be in line with the intended production programme. A further thing must be [illegible] with the general manufacturing possibilities in the country. If there are poor facilities for horizontal boring, for [illegible] or gear hobbing, for example, necessary machines and equipment have to be provided at the centre.

On the other hand, there may be the possibility that one of the participating firms has got enough capital and also already skilled labour to invest in one of the mentioned lines and - perhaps - to specialize in it, aiming to the efficiency by carrying out job orders for third parties. This is generally only possible when a fairly large number of industrial firms are located comparatively closely together.

The centre cannot always have [illegible] of all of the very economical machines, for [illegible] the [illegible] because the [illegible]

quantities of a machine are often much smaller in a developing country. A sample may show that:

Of a particular type of [illegible] parts are produced annually in the factories of the [illegible] area, but the centre and the participating firms will [illegible] only one type of said quantity. The [illegible] to [illegible] a [illegible] grinding machine will [illegible] the ways and guideways of the bed in one [illegible]. [illegible] machine, costing above [illegible] 30,000.-, cannot be [illegible] to be necessary for the centre. To finish the guideways of some 30 machine beds per year, the old-fashioned but still reliable process of scraping by hand will not only serve the purpose but will be cheaper also.

Doubtlessly, the basic facilities of machining - turning, shaping and planing, horizontal and vertical milling, surface and cylindrical grinding, drilling, [illegible] and tapping - should be available in the centre as well as in the participating firms. Special, partly expensive, facilities like horizontal or vertical [illegible], gear hobbing and shaping, bevel gear production, slotting, [illegible] and heat treatment, electro-plating and others are necessary only in one place, either at the centre or in one of the participating factories or as subsuppliers.

The production planning has to take care of the various possibilities and - if necessary - to change the working plans accordingly and adapt them to the facilities of the centre and/or the participating firms. Cylindrical grinding

can be replaced by fine-finishing on the lathe, surface grinding by scraping, broaching by repeated slotting, etc. Often it is not so much a matter of adapting the design to the production possibilities, but to change the work processes which are necessary to gain the required results.

4.) Inspection and testing

Much more time has to be spent on these subjects in developing countries than in industrialized places. As inspection may be understood the checking of components during and after production, and testing may be valid for the whole machine after assembly, showing the performance, accuracy and efficiency of the same.

There are always two inspections necessary: before starting the production of a component, it must be checked if the material serves the purpose (it could be wrongly supplied or mixed up during transport or storing) and after the manufacturing process it must be checked whether the part is dimensionally in order, hardening data are maintained, surface finish is good enough, etc.

Good results in this field can only be obtained by specialists who know how to work with their measuring equipment. It is not necessary that they have a thorough knowledge of the machine and its performance. If some or one of the tolerances are not properly maintained, a decision if the part will be used or not is not with the inspection department, but should be left to the design office or the technical manager.

It may be possible in countries with a generally hot climate to have a number of very close tolerances slightly modified. Often it may be even necessary to have airconditioning in those rooms where gauges are used or a jig boring machine is to be installed. Special care must be taken when measuring components out of aluminium with steel gauges for reason of different dilatation of the materials.

Correct dimensioning and toleration by the design office will always be helpful to the production department as well as for the inspection group. Great care must be given in all countries which recently changed from inch to metric system, to the zeros behind the decimal point: frequently tolerances for inch and millimetre can be mixed up.

5. Necessary Tools, Jigs and Fixtures

Without this group of production auxiliaries an economical serial production of any type of machine is impossible, but these production facilities can hardly be taken over by the centre just as they have been used by the licencer. The production machines in developing countries are often different, the commercial tools used also, not to mention the smaller quantities to be produced and the scarce availability of materials and accessories for the production of jigs and fixtures.

Naturally it is possible - but costly - to manufacture all production auxiliaries in the licencing country and to send

them to the centre, but experience shows that this is an uneconomical way. It takes a lot of time and skill to bring all fixtures etc. in working condition required to the machines provided for the centre or available with the participating firms. The time may be better used for training of draftsmen in the developing country to design appropriate production means, and the skill of workers should be used to manufacture them out of materials available in the country.

5.1 Design of tools, jigs and fixtures

Basic skills of preparing technical drawings are generally at hand in the prototype centre, and it will be a good start to begin with a basic course of draftsmanship to unify the skills and to give general guidelines. Within the frame work of this draftsmen course, simple jigs and fixtures can already be designed in the very moment, when the component drawings are clarified. It is always advisable to outline all operations necessary for the production of a part, as exactly as possible, to discuss design problems with the production department, the expert and the foreman concerned, and to find a decision which special devices are absolutely necessary from the very beginning of production and which can wait until the number of machines per product on order will increase.

This is necessary because neither the designers of jigs and fixtures nor the toolroom can cope with the upRush of the starting period. Often, the drawings and photos supplied along with the literature documents are a valuable help.

To see how others have solved problems frequently inspires own ideas, and sometimes it happens that a newcomer has a better or less expensive conception to tackle a particular task.

A main requirement, valid for all special tools, jigs and fixtures, measuring devices, etc. is that they should be foolproof. This is even more important in developing countries, where most of the workers are not familiar with machine tools and have little or no experience in workshop practice. It should never be possible to locate a part in a jig in the wrong way or to place the jig improperly beneath the drilling spindle or to mix up between a slip-bush for drilling with one for a reaming operation.

3.2 Production of tools, jigs and fixtures

The toolroom should be the first unit in the workshops of the centre to be installed and connected with electricity. After some trial runs of the toolroom machines, the training of the machine operators, the fitters, etc. should start immediately. One may assume that the labourers have worked already for some time with the centre, unpacking the machines, cleaning them, looking for thorough lubrication and finally helping to mount them in their proper place. As soon as the concrete of the foundations is hardened, the training can begin. If there has been a good tuning between the design department, the factory planning and the setting up of the toolroom, it can be a training in production.

This is most desirable because in this case the material machined serves a useful purpose. Often there will be bottlenecks in the supply of materials, in particular tool steel and standard components like dowel pins or Allen head screws, but a start of operating the toolroom machines usefully can be made very early. It is of minor importance if the first fixtures can be assembled and checked only at a later date when all components are at hand.

In the beginning, there will be only a slow progress in the toolroom because it takes quite some time until the workers can operate their machines efficiently, and even more time will pass up to the moment that some jigs and fixtures are in working condition. A lot of improvisation will be necessary, and it will barely happen that the work process is according to schedule. Often jobs have to be performed for the construction site, sets of foundation bolts must be made, weldings are necessary, repairs have to be made, and so on.

One main problem is the fact that the most urgently needed fixtures and devices are mostly of the complicated type, requiring engineering experience when being designed, and considerable skills in manufacturing. A further handicap will often be the non-availability of some materials and components. But when starting the production, only a small series of a prototype will be produced, and it often serves the purpose to have a temporary part in a fixture out of mild steel instead of heat treatable steel, or to fasten the various members of the fixture by means of self-produced slotted

head screws instead of using allen head screws, which must be imported.

Whether production facilities for tools other than necessary for the centre and the participating units should be provided or not, depends on the degree of industrialization in the country. Mostly toolroom facilities are poor in developing countries, and specially tool steel of reliable quality is a scarcity. Hence, it can generally be said that the toolroom should not be poorly equipped and should keep a good stock of quality materials and standard components to serve other parties also, naturally against payment.

For the own machine tool production, for example, only a few punching and drawing dies will be necessary, but for the production of sheet metal items in other factories, there can be a heavy demand of the said tools. These factories have often a lot of trouble to get dies with reliable performance and may be eager to make use of the toolroom facilities at the centre.

5.3 Maintenance, Repair and Re-grinding of Tools

Only medium and large-scale factories are, in general, able to maintain a careful service for their tools and devices. Small factories often import along with a new machine also a set of tools for a particular production but do not have maintenance facilities. I remember a shop with only one machine, a special press making press buttons out of imported

brass strips, about a dozen per minute, the tool was more complicated than the press tool mentioned previously only for a few days. A further disadvantage was that the brass strips were not exactly true to specified sizes, so the [illegible] not skilled were over-stressed [illegible] tool failed at more than [illegible].-

For the small manufacturer and many others like him it would be a valuable help to have a good tool maintenance manual at hand. Quite obviously, this particular shop owner made a mistake. A press with 70 - 80 rpm has worn out a tool of this kind in less than 3 days of continuous operation, hence he should have ordered at least 3 sets, possibly for various sizes of press buttons. However, this may also be a matter of foreign exchange granted for imports. In any case, he should have been on the lookout where to get the tool (or tools) repaired. This would be a typical job order for the toolroom of a prototype centre.

The minimum requirement for investment to run an independent small toolroom with about 25 employees and workers are US$ 180.000 to 200.000.- Such a sum is quite unbearable for small-scale factories, but they need facilities for tool regrinding and repairs, too. Therefore, the toolroom and tool maintenance section of the centre should never be too small. Special importance should be laid on the availability of: regrinding facilities required not for every-day-use, e.g. for circular saws up to about 1000 mm dia, for planing knives of timber dressers, for high speed steel milling cutters of various

types, for carbide tipped turning tools, etc. If only one gear hobbing machine is working in the vicinity, it should be made sure that a regrinding machine for such tools is available. If gear hobs are not thoroughly re-ground, the quality of gears produced will go considerably and soon be sub-standard, giving, on automobile gears, noise.

The machine and tools facilities for devices, jigs and fixtures should not be used for repairs, as this type of work is mostly done with the machinery used for the production of new devices, hence repairs will reduce the capacity of the toolroom. The horizontal and heat treatment section was already mentioned. It does not pay to have a separate one attached to the toolroom, but within the centre a furnace for hardening of high speed steel (up to 1.300° centigrade) should be installed as well as equipment for brazing of carbide tips to carbon steel shafts.

A broad and thorough first outfit with measuring and testing facilities should never be overlooked, what does it help to know that the cutting angle of a turning tool should be 12 degrees if an indigenous worker is unable to measure it. Even if a complicated multipurpose measuring device is supplied - the local operator of the tool grinding machine must get his accessories with which he can work and measure reliably.

In spite of those wanted simple measuring devices, the local workers must be controlled and re-controlled, again and again, because really unexpected mistakes and errors may occur even after years of unobjectionable performance.

in developing countries, tools are often [illegible] the supply is often irregular, tools may rarely be used at the highest possible cutting speed. A reduction of the cutting speed by 40 % to 50 % will give a quadruple service life of a turning tool, before regrinding is necessary.

As regrinding is repeated again and again, a number of special machines have been developed, e.g. for circular and band saws, for turning and profile tools, for twist drills, and some others. As far as possible, these machines should be used because they reduce the costs of regrinding considerably and simplify the work.

6. Prototype Production

The production of prototypes will be the main task of the centre, but there will also be a number of by-products. Some were already mentioned: support to shops, foundry, toolroom and tool maintenance, heat treatment, sheet-plating, purchase, material- and other stores. Whether these departments belong to the centre or are served by subsuppliers, they all should gain profit from the cooperation with the foreign experts of the centre and its facilities.

6.1 General

There should at least be a small permanent staff in the centre, able to speak one foreign language with which the experts are also conversant. This will not often be a serious problem

as in most developing countries higher education is done in a language additional to the native one. This permanent staff will often be assisted later on, after having progressed, to give further advice in their respective fields to workers of the participating firms in the mother tongue.

It may be called a very early start of prototype production when pattern making begins. For the production of machine tools in developing countries, normally wooden patterns will serve the purpose. For mass production, patterns of aluminium or (for small components) of brass will be more advisable.

The patterns should be manufactured - if at all possible - out of indigenous wood. In a number of tropical countries teak wood will be very good, but it should be well seasoned to avoid unwanted warping. If such seasoned wood cannot be purchased within an acceptable distance of the centre, a wood seasoning plant should be planned for in the centre.

Other necessary equipment for pattern making are rules, vernier callipers and gauges for pattern makers with shrinkage allowance. Most of these are naturally foreseen for grey iron castings, but a basic outfit should also be available for aluminium castings (larger shrinkage). If need arises, or for patterns to be manufactured for outside parties, some measuring devices for patterns of bronze or brass castings would be an additional advantage.

To make the centre a success, good will of cooperation and understanding must be maintained on both sides. The foreign experts should never forget that they are guests in a country

where the population has a different attitude towards labour, efficiency, social status and money, compared to their home country. Arrogance, narrow-mindedness and too much ambition are great handicaps for a fruitful cooperation. The same is true for indigenous personnel and workers. It gives a somewhat wrong impression if, for example, a worker requires a sweeper to clean his lathe because he thinks that such work is beneath his dignity.

6.2 Production of Components

After having the licence documents altered suitably to the conditions of the country, and after at least some machines in the centre are installed, first trials can be made to produce components.

6.2.1 Cast Iron Components

Whether a foundry will be attached to the centre or the grey iron castings will be ordered from subsuppliers, depends on the local conditions and the possibilities of the country in general. This was mentioned already in chapter 5.3. Especially for engaging contractors expert advice will be necessary, serving not only the castings produced for the centre, but also the general production of the foundry (or foundries) and other customers. In the beginning, the ordered quantities for the centre will be quite small, and it will take some time to satisfy all conditions for the castings such as:

-- proper hardness
-- good machinability
-- no blow holes and gas bubbles
-- dimensions within required tolerances
-- clean surfaces
-- thoroughly fettled runner gates and risers.

Insisting on meeting all these conditions means an improvement of all castings of the concerned foundry which practically serves also other industries in the country.

If at all possible, the castings should be seasoned at least for some months. This will hardly be possible when starting production in a prototype centre, as far as it has its own foundry. The first castings, specially if they do not fully meet requirements, may be used as trial pieces for machining operations and trial runs with tools.

Artificial seasoning cannot always replace the natural aging of cast iron and thus can hardly be recommended for a developing country. In some places it may be suitable for mass production, if storing costs are high and storing space is limited.

For most cast iron components of machine tools, the hardness is very important. Especially the various hardness grades of matching parts like bed, saddle, cross slide rest, tailstock and others, sliding one upon the other, must be maintained correctly. The abrasion should be always with parts not influencing the accuracy of the machine, e.g. the vees of the bed of a lathe should be harder than the matching bearings of the saddle.

The composition of the charge for the cupola is decisive for the result of the wanted castings. Additional factors are the quality of coke, [illegible] pressure of air-blow, final temperature of the melt and the cooling rate of the castings in the moulds. For all these operations as well as forming, core making, and sand conditioning expert advice will be very helpful.

When machining of the first castings begins, special care should be taken that some time should pass between the rough and the finish machining, and the fine-finishing (scraping of guideways, vees etc.) should be done even later. Between these operations, inspections have to be performed to check that no shrinkage or warping has occurred. There is some difference between machining of cast iron and steel parts with regard to the tools as well as cutting speed and cooling. To demonstrate all the various operations and to control them are the main tasks of the experts attached to the centre.

6.2.2 Steel Components

A fairly large group of components in a machine tool are the parts manufactured of steel of various material qualities like shafts, spindles, wheels and gears, levers, handles and similar items. These are mostly machined out of hot rolled or bright drawn rounds; other components are made of sections. Only a few parts will be based on drop forgings. If, in a particular case, drop forgings as semifinished materials are unavoidable, the unmachined parts should be imported because

it generally does not pay to have an own drop forging equipment in the centre, the quantities to be produced are too small. Nevertheless, there may be the possibility of long-termed job orders, but that must be reliably explored before planning a drop forging shop, and also the manufacture of required dies should be made sure of, adding to the costs of such a project.

In the beginning, the components to be machined will give the necessary practice to the workers to learn how to operate the new machine tools in the centre. Naturally, they should be conversant already with the various handles, levers, wheels and switches of their machines, but it will take quite some time to operate a machine efficiently. In addition, the workers (as well as the foreman) have to learn now to work with modern measuring devices like micrometers, vernier calipers, limit snap and plug gauges, thread gauges and so on.

Another field of learning for the workers in the centre are the new tools imported along with the machinery of the prototype centre. It is quite a difference whether to work with water-hardened or high-speed steel or a carbide tipped turning tool, whether to make use of a high-grade single cut machine tap or of a set of 3 hand taps out of carbon steel. Most of the workers in developing countries are not aware of the good performance of high-quality tools. They are often handicapped by the old and underpowered machines they used to work with and the anxiety not to spoil tools.

On the other hand, one moment of inattention or a wrong motion

can crack a valuable tool completely. Therefore, when the workers of the centre are operating their machines, 2 aims should be observed:

-- to utilize the high performance of modern tools and machine tools at least to a certain extent
-- to be always attentive and watchful when the machine is in operation.

Quite a number of modern devices, tools and means of production are fairly unknown in developing industries. This is a broad field for teaching and information through the foreign experts. Whether a self-opening die head for threading is used in the production or copy turning is employed or vertical slotting, horizontal boring or fine-finishing, gear nobbing or bevel gear shaping, all these operations need their time to be demonstrated repeatedly and then to be learned by the indigenous foremen and workers. Often there are only a few foreign technicians to train their local counterparts, and progress will be slow because they cannot be present with all machines at the same time.

Not all machining operations and necessary production facilities can be mentioned here, this would be possible only if production drawings were attached. That is not the purpose of this paper. When starting the production of components for prototypes with inexperienced personnel, situations will change quite frequently, and close supervision will always be advisable. This is naturally also valid for the processing of other than steel components.

6.2.3 Parts of Non-Ferrous Metals

Compared by weight with the afore mentioned cast iron and steel components, the share of non-ferrous metal parts in a machine tool will be small, being some bearings and bushes, guideway ledges and perhaps some gears out of brass or bronze and some aluminium parts. Lead is rarely used. Operation sign-plates of aluminium sheet and similar parts or symbols will be mentioned under the heading "Subcontracted Parts". Bronze and brass castings in developing countries are often better performed than grey iron castings, but material composition must be checked for each charge.

For each machining of non-ferrous metal components different rules have to be applied than for steel parts. Carbide tipped tools are normally not used, high-speed steel and sometimes even carbon steel tools will serve the purpose. Cutting angles are others than those to be maintained for machining of steel or cast iron. For fine-finishing of aluminium (e.g. pistons for combustion engines) diamond tools may be applied but do hardly arise for machine tool components of the type to be manufactured.

For high-quality bearings mostly a special bronze and/or bearing metal are necessary, probably to be imported for a long time. As such materials are fairly expensive (US$ 1.- to 2,50 per kg approx.), great care must be taken when machining it, and specially when fine-finishing is done. These difficult components also require high accuracy on assembly.

For reason of the high material costs it often pays to import thick walled tubes as raw material for the bearings. Chips can be sold to bronze foundries. Guideway ledges of bronze are generally finished by scraping. A thorough execution of lubricating grooves should always be observed.

The few aluminium parts in a machine tool are seldom a "must" in developing countries. They can often be replaced by galvanized or chromium plated steel parts. Only when the weight is limited, light metal has to be applied. The machining generally provides no obstacles, surface quality and resistance to climatic conditions are good.

Little use will be made of gravity or pressure die cast components in developing countries, because the high costs of the permanent dies are normally not justified for the small quantities produced, not to mention the high operating expenses of a pressure die casting machine. These will generally not be made good by low machining costs compared with the machining costs of sand castings.

Components of lead and similar materials may be omitted here, they are quite unusual in machine tools. If one or the other part should turn up, the main production process would be casting or soldering; machining provides no difficulties, it can be cut by a knife.

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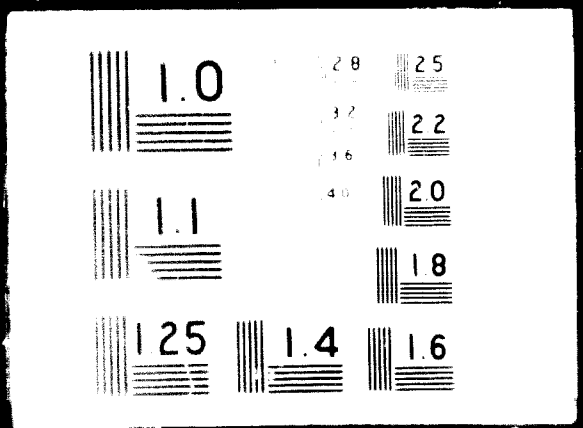

6.3 Subcontracted Parts

Castings were already mentioned in chapter 6.2.1. As raw material, they would be subcontracted parts too if the centre has no foundry of its own. Further wide fields for subcontracted parts are: electric components like motors, switches, contactors, wires, etc.; clutches, standard components, licence plates and operation symbols, possibly compression and injection mouldings, electroplated parts and auxiliary materials.

A close contact to possible subcontractors should be maintained from the very beginning. They often have a lot of good will but poor knowledge, ready workers but poor facilities. The raw material supply is generally as insufficient as the performance of tools. Hence, before starting the production, the centre should always try to stand on two legs:

-- negotiations with and advice to possible subcontractors
-- 4 to 6 months stock of vital parts, imported in the beginning from the licencer.

Sometimes it will be a help when the centre supplies a particular tool to the subcontractor or takes care that the required raw material will be available in time, either imported or supplied by an indigenous factory.

All these negotiations and consultations take a lot of patience and time, and sometimes there seems to be no result for years. But frequently, no other way is possible in developing countries than to take the burden. National pride, the necessity to

create more workplaces, scarcity of foreign exchange may be a few reasons to manufacture components in the country, even if it will be more expensive. It is always impressive to say "when we started production, 50% of material and components had to be imported, now after 5 years of local production, imports were reduced to merely 20%". Such a remark will support the national prestige.

The manufacture of electric motors, switches and so on in the concerned country is often based on foreign cooperation. For this reason, serious dimensional difficulties can be expected only if for example the centre has adopted the metric system and the electric factory - being established a number of years ago - still works according to the inch system because it is (or was) a British cooperation. But the international standardization, especially in the electric field, is well progressing, and difficulties will be diminishing. Basic electric components produced at an early date in developing countries are mostly electric wires, hardly ever giving trouble when purchased from local sources. For highly loaded wires possibly the electric conductivity must be checked, to be on the safe side that there will be no overheating when permanently in full load.

Clutches used in machine tools are frequently of such special types and designs that a replacement by others or local products will be impossible. Also, they are often produced from a number of special materials, and their manufacture requires high skills. Thus, it will be advisable in most cases to import the necessary clutches for quite some time.

The most productive group of subcontracted parts are standard components. To mention only a few: antifriction bearings, screws, nuts and bolts, washers, pins, feather keys, valves, belts and veebelts, greaseheads and oil nipples, tools and tool fasteners. They will be generally purchased by the centre, partly from dealers and partly from local producers. Fasteners are mostly manufactured early within the country, because they are used all over. Antifriction bearings, particularly those for machine tools, must be of a quality which is not always easily available in a developing country. However, being standardized to close tolerances all over the world, the procurement should not provide difficulties. As a quality test of antifriction bearings can be made only after assembling the whole machine, if no special devices are provided, care should be taken that only products known for their reliability have been chosen.

Tools and tool fasteners will generally be subcontracted parts, also veebelts, grease heads and other components necessary for the complete outfit of a machine tool. It needs always negotiations and compromises to find parts of local production suited for the purpose and the required quality conditions.

Licence plates, operation sign plates and similar instruction plates are generally of aluminium sheet with a thickness of 0,4 to 1 mm. Whether they are produced by engraving, etching, a photo-chemical process or other means, depends on the size of the plates, the quantities required and their exposure to

climatic conditions. Machine tools are normally designed for indoor use, and the sign plates should be as long lasting as the lifetime of the machine. Engraving is mostly not economical even for small quantities, but sometimes the only possibility to get a few plates in time. Since a couple of years plastic transfer labels are in use too. Which types of plates and labels are used depends widely on the production facilities in the vicinity of the centre.

If at all possible, operating symbols without any inscriptions should be used. They should be impressive and clear so that no writing is necessary. This will be particularly helpful in countries where a number of languages are spoken and not all workers are literate. These symbols are already internationally standardized to a wide extent.

Compression and injection mouldings of special design are sometimes used in machine tool production when large series can be sold. Generally, the small numbers of machines produced in developing countries do not justify the manufacture of particular moulds or dies for special components. However, standard parts like ball grips, handles, plugs or others will surely be made use of, because they are required also for other products.

Electro-plating is frequently done on a job order base. The parts are completely machined in the ordering factory, and only the surface finish is done by the outside party (see chapter 2.5).

The procurement of auxiliary materials like welding rods, brazing and soldering materials, lubricants, coolants and such like is generally a matter of the purchase section of the centre. But the production and design departments should render thorough advice, because the commercial staff of the purchase section has no expert knowledge of such types of material.

In an exceptional case there may also be the possibility to subcontract high-quality parts to an already well established firm with free production capacity, e.g. for the thorough turning of lead screws or horizontal boring of headstock castings. But in general - if such a factory already exists - it will be too late for the establishment of a prototype centre. Its value may be reduced to nearly zero, because other firms are more advanced than the centre.

6.4 Assembly

When starting a prototype production, not all parts will be machined up to the closest tolerances. But a lot of components can be saved by thorough reworking and careful assembly. The quality of a machine tool can be improved considerably if the guideways and vees of e.g. bed, saddle, cross slide rest, tailstock etc. are scraped.
It is sure that scraping takes a lot of time, and good scraping can be done by skilled workers only, but wages in developing countries are mostly not as high as those of industrialized ones, and training is always a must in the beginning of all

production work. Thus the time for scraping exercises is not wasted.

Of course, all parts have to be inspected before starting the assembly. Subgroups which can be assembled independently, should be completed at an early date and should be checked before further mounting. So subsequently more and more groups and parts will work together properly.

As a matter of fact, the correct functioning of e.g. a lathe will not be influenced when the height of centres is 180,3 mm instead of the nominal height of 180 mm. The proper functioning and a good performance depend on the reliable tuning of the various components, which can mostly be guaranteed by a thorough assembly.

Main problems are the right angles and the parallelity between the various moving parts of a machine tool. A lathe on which no straight facing is possible, or a milling machine without the perpendicular movement between spindle and knee are nearly useless. These and other facts like exact pitch of the lead screw or balancing of vee-belt pulleys and gears in a headstock should be carefully observed.

Some special tasks have to be mentioned: thorough cleaning of cast iron components, inside painting of gear boxes and similar parts before assembly, careful heating (or cooling) of parts, if pressfits are to be made, use of the right lubricants, clean handling of antifriction bearings, non-scratching of all sliding faces, use of correct tools for assembly work.

Spanners, screw drivers and special tools must be available in correct sizes and proper conditions for the work performed. Only if these and other rules are observed, finally a machine in working condition will result which has to be subjected to trial runs for a long time and must be tested again and again.

Only after completion of all tests, the last finish of the early prototype machines can be given: final cleaning and painting. Degreasing is more important for a good painting than anything else, and the painting must be absolutely wear and tear resisting. Probably the first machines assembled in the centre will never be sold but are show pieces. This is a further reason to give them the best possible finish in painting.

7. Training of Personnel

The training of the centre's staff was repeatedly mentioned in para 6 "Prototype Production". It must be coupled closely with the begin of utilizing the machines installed in the centre. Later on, the permanent staff will be the backbone for economical production of further prototypes. The training of the permanent crew cannot be profound enough, they should be carefully selected, and after probation time their pay should be above average. In the following, mainly the training of personnel of the participating firms may be considered.

The counterparts of the foreign experts should be engaged as soon as the date of arrival of the concerned expert is fixed. If possible, both should start their work at the centre at the same time and should work closely together.

In most cases this will be better than a training course of 6 or 12 months of the local counterpart in a foreign country. Experience shows that such a course of counterpart engineers or foremen is not only expensive but has generally poor results. The problems which arise during a training abroad are:

-- often language difficulties
-- separation from family and customary environments
-- completely different climatic and food conditions
-- machine types and production facilities abroad are usually not used in the home country or the centre.

A training course in a foreign country for a foreman or engineer will be successful only if young people, if possible unmarried, can be instructed exactly in the line of their future employment and with the same means of production, e.g. licence assembly of television sets or manufacture of razor blades and so on.

7.1 Personnel of Technical Offices and Foremen

This group is a very important one for the centre as well as for participating firms, being responsible for progress and success of the production of various machines. It starts with the training of designers and draftsmen, mostly only one or two from each participating firm, and this should be done by means of a training course in the centre. For this purpose, at least one class room with the necessary facilities should be provided.

The duration of the course of 2 to 3 months should be sufficient and should be similar to the one mentioned in chapter 5.1. The main purpose is the introduction of valid rules for preparing technical drawings, to make sure that all personnel concerned in the group of firms will "speak the same technical language". As long as national standards, dealing with drawing practice, are already available in the country concerned, they should be used.

The training of foremen of attached firms is already more difficult, to decide upon. It is certain that it will be appreciated to make them conversant with modern machines, tools and measuring equipment, when they are trained at the centre in courses of 4 to 6 months duration. However, often when they return to their shops, they can make only poor use of the acquired knowledge due to the fact that the new machines, tools and instruments they have learned to work with are not available with their parent firms. In spite of being a burden for a small factory to delegate a foreman to the training course, it would be very useful now if the small firm could add some of the modern equipment, which the foreman has learned to operate, to its own facilities.

This is naturally not meant for expensive and scarcely loaded machines at the centre, it is meant more for good tools and reliable measuring devices. In exceptional cases only, after thorough consultations with everyone concerned, an expensive additional machine should be ordered, after having assured that work will be at hand for a long time to keep this machine running. Too often overcapacity in installing of expensive

machinery is observed in developing countries.

7.2 Training of Administrative Personnel

Not much training will be necessary in this line as in most developing countries desk work is more appreciated than practical work with dirty hands in the workshops. However, all administrative people of the technical and the commercial sections must be made conversant with the various forms jointly used in the centre and the participating firms. These forms should be worked out by the centre and introduced to all concerned. It should be a task of the standard section. A special training course is not necessary.

Often the desk work in a small participating firm is carried out by the owner himself or a member of his family. In such case it will suffice that he spends a couple of days with the administration of the centre and takes a set of forms home for further information and reference. The cooperation between the centre and the firms will hardly be influenced by other commercial or financial activities as there are general administration, payment of wages, or income tax.

7.3 Training of Production Personnel

The productive personnel of the participating firms as there are machine operators, fitters, welders, painters and so on should be trained as far as possible in their own workshops. There they are familiar with machines and equipment, they

remain in their places and within their families, and it will always be the least expensive way of training with usually good results. Nevertheless, the training of workers should naturally be supervised by the centre and emphasizes the importance of foremen training.

If the training of workers takes place within the own factory, it is obvious that the main work and responsibility will be with the local foreman, trained at an earlier date at the centre. The performance and quality of work of any factory depend to a wide extent on the experience and sense of responsibility of the foremen. They must be able to train and teach their workers so that these are in the position to take over the production of components and the assembly of machines from the centre.

There may be exceptions to the general recommendations of training through the own foremen, being special courses e.g. for scrapers, welders or painters of about two weeks duration which do not require expensive machinery or equipment. These "refresher" courses are meant to upgrade the skills of certain groups of workers and to teach them the basically needed theoretical knowledge of their respective trades. The personnel of the centre must naturally be made conversant with this type of teaching and training before such courses will start.

Particular care should be given to handling and reading of all measuring instruments used in production. Reliable performance of workers depends to a large extent on their ability

of correct measuring. It will not always be possible to make use of single purpose limit snap or plug gauges or similar simple equipment. Adjustable gauges should be set in any case by a particularly trained foreman, and it must be checked frequently that no disadjustment has taken place. Complicated measuring exercises should be done along with the assistance of the inspection department. If frequent disagreements occur in a particular case, the centre should provide a special measuring device as soon as possible.

Basically needed knowledge of nearly all productive workers as well as foremen, inspection personnel etc. is the reading of drawings. Preparing of uniform drawings was mentioned already in chapter 5.1 and 7.1. The practical training and exercises should be done by means of drawings and blueprints prepared by the centre, being close to reality. Frequently, the workers (and also the draftsmen) have difficulties in "translating" of drawings from the drafting plane into the three-dimensional shape or vice versa. Only patient and repeated practice will be a reliable possibility to overcome this problem. If this trouble is a prevailing one in certain countries, it must be tackled with correspondingly in all lines of training.

8. Transfer of Production from Centre to Participating Firms

It will take some time to develop the production of the first prototype in the centre to a point where the performance of the machine is unobjectionable, and serious problems in trans-

ferring the manufacture to the participating firms will not arise any more. All material questions must be clarified beforehand, the drawings must be up-to-date, supply of components must be secured and the bulk of necessary special tools, jigs and fixtures, measuring devices etc. should be available and in reliably good working conditions.

When starting to operate the centre, all employees and workers are newcomers, so that as a rule it will take more time to transfer the production than expected in the beginning. However, one day this is possible: to get components manufactured by an outside party.

8.1 Transfer of Component Production

No doubt that the basic skills of machining metal components to close tolerances must be available with the members of the participating firms. Some simple components can be made by other parties at a relatively early date, but that will often coincide with the demand of the centre's production department for more work and more training objects. Thus, the transfer of component production should not be started too early. First of all, all parts, subgroups and units concerning the correct functioning of the whole machine should be thoroughly evaluated and tested at the centre.

It is a question of the production capacity of the participating firms how far the machining of components should (or must) be split. Further consideration must be given to the costs

of necessary transportation. The best way will be a comparatively straight line, e.g. foundry - fettling - seasoning - machining - inspection - assembly; or: raw material store - machining - (heat treatment) - finishing - inspection - assembly - testing.

If possible, at least some of the mentioned stations should be in the same place: casting, fettling and seasoning might generally be one station, machining, inspection and assembly a second one. That saves transportation costs. The ideal way would be to have finally the production of a particular machine (components and assembly) in one place. In this connection, pattern making, casting and seasoning may be left out, castings will be mostly subsupplied semifinished material.

All splitting of the machining of components will add to the expenses due for the production of a machine, influencing the sales price of the final product always to the high side. This should be kept in mind when trying to have a participation of a large number of small or smallest workshops in the production schedule of the prototype centre.

8.) Assembly of Machines

The assembly of machine tools should be linked closely with the machining of components. In the ideal case, assembly, testing and painting have to go together when machine tools are produced.

Normally it will be expensive to manufacture all components

in a number of different places always correct to required tolerances, and to supply them in conformity with a fixed time schedule to an assembly line where the products are mounted in required quantities and in predetermined time. This will generally be possible only in industrialized countries without material problems, or transport or skilled labour difficulties.

In countries of the Third World this way of production may be recommended only for some items required in quantities of several 10.000 per year or more; things produced for years without serious alterations like alarm clocks, radio receivers, amplifiers or similar goods. Even bicycles or lorries are not very suited for this type of split production and assembly.

It cannot at all be applied to a variety of machine tools in quantities of some hundred per year or even less. Problems like material, time scheduling, transportation, quality control and so on are serious and economical handicaps in developing countries. Hence, if possible the same firm which is machining the bulk of components should also be engaged with the assembly, the basic testing, reworking and final painting of the machine tools.

To maintain a reliable quality for a long time, it may be an additional advantage to have every 10th or 20th machine, produced by a participating firm, thoroughly tested at the centre. This will serve the quality of workmanship and performance.

The general rule will always be: production of components, assembly, testing and painting as closely together as possible to avoid unnecessary transportation costs and delays.

9. Conclusions

The production of prototypes in a centre is not only possible but in a number of cases also desirable, giving improvement and additional services to existing factories to a wide extent.

The centre should be staffed for a couple of years with a number of foreign experts being specialists in various fields; not only necessary for the production of the centre and the attached firms, but the experts should also be able to help and guide all viable factories within a relatively wide distance of the centre.

As soon as possible, the foreign experts should be joined by their local counterparts, the qualifications of which (and their pay) should be above average prevailing in the country. Foreigners and counterparts should be conversant with one identical language. The counterparts have to play a vital role in the further training of foremen and workers of the firms later on participating in the manufacture of machines, doveloped for serial production in the prototype centre.

The main purposes of a prototype centre should be:

-- to develop machines and similar complicated goods for serial production in the attached firms without troubling these through material-, tool-, fixture- and sales problems
-- to render technical advice and services which are otherwise not available, not only to participating but to all firms in the vicinity of the centre

-- to improve the quality of goods produced and performance of workmanship as far as possible in all factories asking for expert help.

10. Recommendations

Out of the aforegoing notes, recommendations can easily be evaluated. A number of special services should be established in the centre, giving advice to all firms in the vicinity, whether they are participating in the project or not. These special services are naturally varying from case to case, but the following departments deserve always serious consideration:

-- standardization
-- material testing
-- heat treatment
-- pattern making
-- foundry (ies)
-- toolroom
-- electro-plating
-- (cooperative) purchase.

Standardization is by far not only a matter of the centre but should be considered always in a national framework; utmost preference should be given to a close linkage to the improving international standards, which should be adopted, if possible.

Very important are testing facilities for material, especially for heat-treatable steel. All developing countries have a heavy demand for dies, tools, jigs and fixtures. They are

machined with a considerable amount of time and skill, but often it is not known how to harden the steel, or the specifications supplied are incorrect. The only reliable way out is checking the composition of the steel before heat-treatment, being a reason to have material testing and heat-treatment facilities close together.

For a number of components it will be necessary to have them absolutely crackfree, to avoid hair cracks caused by machining, as well as hardening cracks after heat-treatment. For this purpose, a magnetic crack detector will be desirable.

Pattern making has been mentioned already, it is a very important trade in countries starting towards industrial development, and needs improvement. Frequently a wood seasoning plant to get qualified wood for patterns will be very useful. Whether a foundry is attached to the centre or not, expert advice for improvement of castings should be available at the centre for quite some time.

Special tools, jigs and fixtures are necessary for serial production all over the world. But the know-how of designing these items and of production processes are equally important. Specialists in these fields must be with the centre for a long time. An expert foreman in the toolroom might probably be replaced earlier than an expert tool designer because years of practical shop floor experience are a presupposition for designing reliable special tools, jigs and fixtures.

A large stock of tool steel should always be kept to be able to serve also other parties. Regrinding of tools requires frequent supervision. The production facilities in the toolroom should not be too narrow to serve also outside parties e.g. with punching and drawing dies and other equipment.

Advice in electro-plating must be available at the centre, for purchasing the necessary chemicals as well as for fixing the technical data for a good performance of the jobs. Important are cleanliness and waste water purification.

The purchase section should work cooperatively for all participating firms. Materials, auxiliary materials, components and tools are more easily purchased by the centre, especially if they have to be imported, than by each individual member firm. In a number of places, a central store will be advisable. Contracts with subsuppliers should also be made by the centre.

A few further recommendations may finally be given:

-- the internationally valid classification of goods of all kind (for import and export statistics) should be used as soon as possible
-- a fairly large group of developing countries is using the English language as teaching medium for technical and higher education, but has adopted the metric measuring system. As technical instruction books from USA and Great Britain are available in plenty, but may mislead due to the inch system still applied in these countries, these books should be translated for the metric system.

-- the prototype centre must be able to develop own machines without obtaining licences after some years of experience and training, but care must be taken that the machines are saleable in the market

-- prototype centres should not be installed for the production of simple goods and not for specialized items. They are not yet recommended in places where only one or no foundry at all exists (processing of metal goods is not sufficiently developed).


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