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United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.462/4
1 August 1986

ENGLISH

Third Consultation on the
Agricultural Machinery Industry

Belgrade, Yugoslavia,
29 September - 3 October 1986

REFERENCE GUIDELINES FOR ESTABLISHING MULTI-PURPOSE AGRICULTURAL MACHINERY PLANTS *

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INTRODUCTION

Background

The multi-purpose approach to agricultural machinery plants has been recognized as a key issue for developing agricultural machinery industry in most developing countries. The Second Consultation on the Agricultural Machinery Industry, held in Vienna, Austria, from 17 to 21 October 1983, discussed the issue of the integrated manufacture of agricultural machinery and capital goods. 1/

The Consultation concluded that production of agricultural machinery should be considered as an integral part of national industrialization, including the promotion of engineering and capital goods manufacturing programmes. The Consultation recommended the establishment, under the auspices of UNIDO, of a group of experts to study the issue in depth, to work out the details of the application of the multi-purpose approach and to demonstrate practical ways of implementing the approach.

As a follow-up activity, UNIDO organized the first meeting of experts from different countries on the development of multi-purpose agricultural machinery plants, which was convened at Guangzhou, China, 13-18 November 1984. 2/ The experts exchanged views and discussed the experience with multi-purpose agricultural machinery plants in their own countries. After thorough discussions, as well as visits to some agricultural machinery plants in Guangdong Province, the meeting recommended implementing the multi-purpose approach, both for common application and for specific regions. One very important proposal was that guidelines on establishing or upgrading existing agricultural machinery plants should be formulated for the use of industrial planners, engineering firms, manufacturers, project engineers and others.

Objectives of the paper

The objectives of the paper are the following:

(a) To serve as a reference for those involved in setting up agricultural machinery plants or revamping existing units. It is clear that there is no standard modality for establishing an agricultural machinery plant. There will be a great variety of types determined by local natural and economic environments. However, some experience relating to multi-purpose plants in general can be presented for reference and for exchange of information.

1/ See: the second issue paper for the Second Consultation "The integrated manufacture of agricultural machinery and capital goods" (ID/WG.400/5) and the related background paper (ID/WG.400/6).

2/ Expert Group Meeting on the Development of Multi-purpose Agricultural Machinery Plants, organized by UNIDO in co-operation with the Government of China, Guangzhou, China, 13-18 November 1984.

(b) To make the personnel concerned aware of the role of Governments at different levels, to formulate appropriate strategy and policies advantageous for promoting indigenous industry, to enable the plants to handle vertical and horizontal integration. A survey has shown that without positive governmental support, plants of this kind could hardly survive, let alone expand and contribute to national industrialization.

(c) To promote national, regional and international co-operation. Technical and economic co-operation among different countries, not only in the starting phase of setting up of this kind of plants, but also in the advanced phase, is indispensable, especially co-operation among developing countries.

1. JUSTIFICATION AND CLARIFICATION OF THE MULTI-PURPOSE APPROACH

1.1 Justification of the multi-purpose approach

It is necessary to ascertain the necessity and validity of the multi-purpose approach, so as to tackle the issue more effectively, for the following reasons:

(a) To meet the diversified needs of farmers and rural development. Farming operations, from soil preparation to post harvest processing, are many in number and seasonal in timing. In some countries, agricultural machinery plants are the only machine building enterprises at the grass roots. It is the inevitable responsibility of the plant to provide the farmers with different tools and implements, as many as possible, and in due time.

(b) In countries with dense populations and scarce cultivated land per capita, an effective way to enrich the peasants is to develop a diversified economy. Peasants, besides farming, can utilize local resources, engage in agricultural product processing and also in rural construction, transportation, storage, merchandising, service trades, etc. Activities of this kind will not only create more wealth, but will also absorb surplus labour force from farming, and prevent the rural population from migrating to big cities. Furthermore, better incomes from rural industries and diversified economy will subsidize agriculture, and the integration of fragmentated plots of cultivated land, due to the transfer of farming labour, will help to achieve economies of scale and to advance agricultural mechanization. Experience has shown that this has created a better environment and better market for the agricultural machinery plant to manufacture different implements and equipment to support farmers and rural industries.

(c) There is an urgent need to repair the large number of non-functioning tractors (amounting to 50 per cent in certain countries) so as to ensure normal farming operations. 1/ Repair services are not only necessary for the present, but also indispensable for the future when the fleet of machinery in the rural areas increases. It is apparent that the repair service offered by the agricultural machinery plant is as important as, or even more important than the manufacturing activities. The machine building

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1/ A.K. Mitra, "Some Aspects of the Promotion of Multi-purpose Production Units Manufacturing Engineering Products in the African Developing Countries".

industry in some countries began with the repair of machines, including imported sophisticated machines. The repairing practice has really trained versatile skilled mechanics and given them practical knowledge of various kinds of machinery.

(d) To reform or upgrade the existing agricultural machinery plants towards multi-purpose is a way out of present difficulties. According to surveys by experts, most of the agricultural machinery plants in developing countries are operating at under 50 per cent of capacity, owing to, inter alia, the limited market. 1/ There are, however, many engineering and capital goods urgently needed that the existing plants are not willing or equipped to manufacture.

(e) A nucleus should be formed for part of a country where there is no machine manufacturing industry, for starting and strengthening the industrialization process. Developing countries only account for about 10 per cent of the world production of machinery while representing more than 80 per cent of the world farming population. 2/ Developing countries will not be able to achieve agricultural mechanization by importing agricultural machinery. Furthermore, without developing an indigenous industry, developing countries will not achieve the target set by Lima Declaration, i.e. 25 per cent of the total world industrial production by the year 2000. Establishing agricultural machinery plants with an integrated manufacturing capability for capital goods will certainly contribute to the process of indigenous industrialization, through the utilization of local resources, utilization and training of local manpower, and the acquisition and mastering of adapted technology.

1.2. Clarification of the multi-purpose concept

The establishment of multi-purpose plants and upgrading of existing units needs concerted long-term efforts. A clear view and sound philosophy of the multi-purpose concept should be the basis for steady and progressive development.

A multi-purpose agricultural machinery plant should diversify its production and services by applying appropriate technology and utilizing available local manpower and material resources to meet the variety of local rural needs.

The basic reason for stressing multi-purpose is that the goal of the plant, to get a foothold in the rural area and grow prosperous, can only be achieved by providing the rural people with the means to enable them to intensify and diversify production.

1/ UNIDO/IS.607, The Multi-purpose Approach to Agricultural Machinery Manufacturing in Latin America.

2/ Most of the production of machinery is concentrated in the more advanced developing countries.

1.2.1 Multi-purpose vs. specialization

It is well known that mass production using specialization is the most advanced and economic mode of production achieved in industrialized countries during the last century. In developing countries, the environment for such production does not exist. At the initial stage, small plants have to manufacture a large variety of tools and implements to meet local demand, even though it is hard to manage the plant and to organize production. The drawbacks and disadvantages of such small plants are well known, but inevitable at the initial stage of development. Specialization, co-operation and integration (Fig. 1) are achieved gradually, as industrialization proceeds. However, "multi-purpose" still remains a basic characteristic of plant production due to the fact that the variety of social demands increases as time goes on.

A new trend can be observed in some advanced machine manufacturing plants in the indusrialized countries, where with the aid of new technologies batch-type and small-volume production is forging ahead vigorously. The multi-purpose approach is a long-term programme, and different technologies and ways of production must be adopted at different stages to suit the environment.

1.2.2. Technical and economic rationale for the multi-purpose approach

The categories and range of products and services should be well grouped and co-ordinated with respect to complexity and technology so as to utilize the available facilities fully and balance the production programme. It is essential that technologies be adapted to suit local conditions.

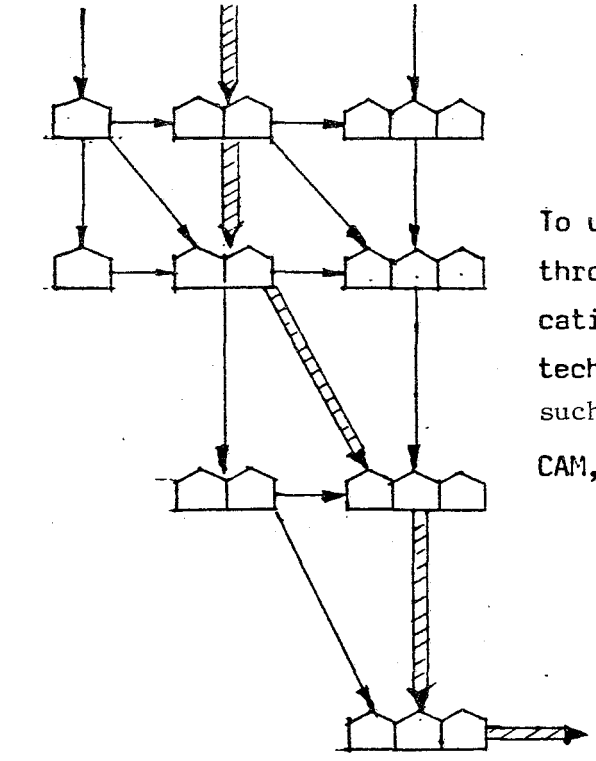
As the multi-purpose plant serves the national long-term interest, at the initial phase profit should not be a major criterion in judging the merits of the plant.

1.2.3. The multi-purpose approach should be characterized by flexibility and dynamism

A multi-purpose plant should be flexible in production and service so as to be able to meet diverse needs. Flexibility is achieved by equipping the plant with general-purpose machine tools and production facilities, and, more important, by staffing it with personnel capable of handling different technical and managerial problems.

The implications of machinery plants and ways to tackle multi-purpose will change as industrialisation progresses. The plant, also serving as a nucleus, is committed to the task of developing an indigenous industry, and will need great efforts in upgrading its capabilities. This will depend to a large extent on the managing personnel.

Level of capability	Category of products	Scale and technology of production: Artisan / Small-scale / Medium-scale / More advanced
I	Hand tools & repair	
II	Animal drawn implements & repair	
III	Power-operated, tractor-drawn implements, & repair	
IV	Engines, tractors, combine harvestors, etc.	



To upgrade through application of new technologies such as CAD, CAM, FMS, etc.

Development of specialization, cooperation, integration to achieve "multi-purpose"

Figure 1. Development of multi-purpose agricultural machinery plant 1/

:e: (a) This figure is intended to show the "dynamic" characteristics or the "nucleus" function of the multi-purpose plants; it does not imply that every plant should follow the same pattern.

(b) New plants could be established at any level as needed.

(c) As industrialization proceeds, specialized production plants will be developed to provide agricultural machinery plants with parts and components through co-operation and integration.

(d) ▨▶ shows the development course of the Beijing Internal Combustion Engine Plant which started with less than 200 people, making animal-drawn single-bottom plows, sugar cane knives, etc. It now has 10,000 people producing medium power internal combustion engines amounting to 600,000 units of different categories and specifications annually.

1/ Source: UNIDO ID/WG.365/6, Profiles for upgrading the production ɔabilities in the agricultural machinery industry in Africa.

2. PRODUCT DEVELOPMENT AT MULTI-PURPOSE AGRICULTURAL MACHINERY PLANTS

2.1. Agricultural mechanization strategy and programme

As pointed out in UNIDO sectoral studies, one of the most serious obstacles faced by the agricultural machinery industry in developing countries is the lack of a definite and consistent farming and livestock policy 1/ and an agricultural mechanization strategy. The lack of such a strategy and policy often resulted in a token and fragmentated rather than a systematic or scientific approach to mechanization as an element in development planning.

World Bank and FAO estimates show that the volume of investment in mechanization will have to increase in order to maintain food production even at its present unsatisfactory level. One FAO estimate, for example, gives the annual gross investment in developing countries for mechanization and irrigation equipment for the year 2000 as in excess of US$ 80,000 million. 2/ The alarming prospect of the continued ineffective use of such a huge investment has prompted national and international organizations to encourage and support the formulation of a rational national agricultural mechanization strategy and programme for developing countries.

2.1.1. Input identification, mobilization and allocation

Agricultural machinery, including both simple tools and sophisticated machines, is the main input of agricultural mechanization and sometimes the main input of agricultural production. Therefore, the machines and equipment to be produced should be identified carefully based on local conditions. For a large country with widely divergent agricultural and economic conditions, identification of machines should be made according to region and level of agricultural mechanization.

Decisions regarding agricultural mechanization operations and the machines to be used should take into consideration biological, chemical and other engineering aspects. As shown in Figure 2, almost all agricultural inputs are closely related to agricultural machines and the mechanization process because almost all input operations are performed through the aid of various appropriate tools or implements.

1/ UNIDO/IS.607, op.cit.

2/ Food and Agriculture Organization of the United Nations (FAO), "Agricultural Mechanization Strategy Formulation Implementation", Report of the 7th session of the Panel of Experts on Agricultural Mechanization.

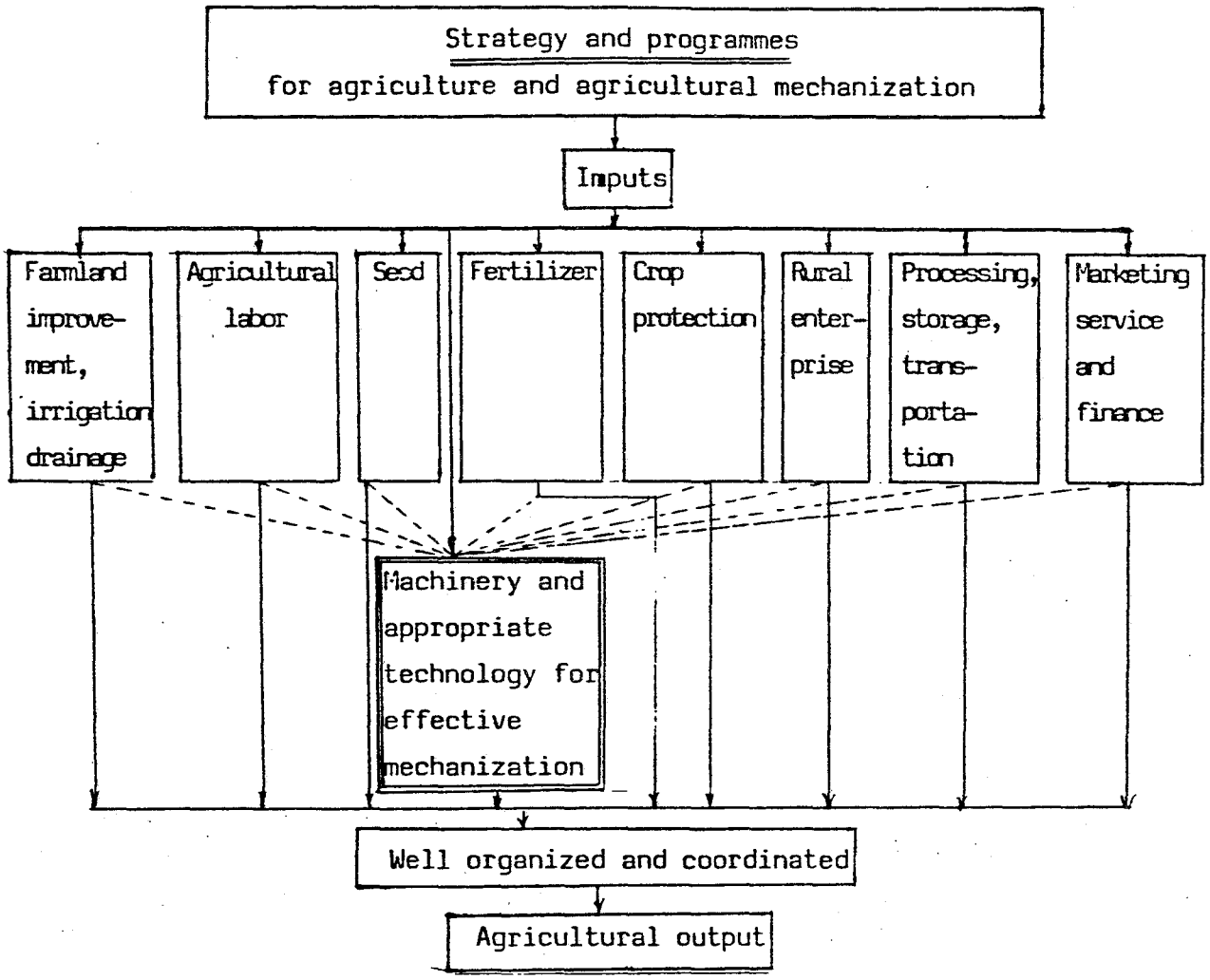


Fig. 2. Agricultural machinery and other related inputs

There are basically two alternatives to ensure the availability of agricultural machines: importation and/or local manufacture and assembly. From the point of view of self-reliance and national industrial development, local manufacture should be of prime importance in the national strategy. Consequently, appropriate policies should be formulated to facilitate the mobilization of all relevant institutions and the allocation of resources and necessary funds to promote local manufacturing projects.

2.2. Identification of products

Identification and survey of potential demand of agricultural machinery and other capital goods is one of the key steps for the proper choice of the size of the plant and the technology of manufacturing to be adopted.

2.2.1. Regional analysis

Agricultural mechanization is a complex issue affected by agricultural and socio-economic conditions, and these conditions vary widely from country to country, and within a country. It is clear that the machines used in arid regions are entirely different from those used on the paddy field, and it is therefore necessary to divide the country into regions according to differences in mechanization needs in order to facilitate the mechanization process.

The main factors to be considered for mapping out the agricultural mechanization regions are:

(a) Agricultural and ecological conditions;

(b) Socio-economic and cultural conditions;

(c) National and regional economic development strategy and programme;

(d) National and regional agricultural production strategy and programme;

(e) Technical environment and infrastructure for developing agricultural mechanization.

Division into sub-regions may be necessary for large countries for more precise assessment of feasibility and justification for the input of mechanization.

2.2.2. Mechanization level analysis

There are many different ways of defining levels of agricultural mechanization. One of the most commonly used is to differentiate levels in terms of the prime power for driving the implements used on the farms.

(a) Hand tools

(b) Animal-drawn implements

(c) Motor-powered and tractor-drawn implements

(d) Self-propelled combine harvesters and more sophisticated specialized agricultural machinery.

From the point of view of agricultural mechanization, there are many factors that determine the choice of tools for different levels of mechanization (see Fig. 3).

From the point of view of manufacturing, the demarcation line between levels differentiated by prime power is not sharp and absolute. If the degree of complexity of implements is considered as a criterion, some simple animal-drawn implements may be grouped at the level of hand tools and some motor-powered implements and even some simple single-axle tractors may be grouped at the level of animal-drawn implements.

Engineering and capital goods with similar complexities could be grouped at the same level, as could the repair of machines.

In this paper, which deals primarily with machinery production in developing countries, emphasis is placed on levels (a), (b) and (c).

2.2.3. Equipment for promoting a diversified economy and rural industries

The production of grain is essential for feeding the growing populations of certain developing countries, and accordingly the task of agricultural mechanization should aim at grain production. However, to neglect other sectors would not only be detrimental to grain output itself, but also bring about stagnation of the rural economy as a whole. Promoting a diversified rural economy (developing cash crops, forestry, animal husbandry, fishery, rural industries, service trades, etc.) will result not only in a flourishing rural economy, but also in increased grain production.

In respect to the socio-economic and food crisis in Africa, the Director-General of UNIDO stressed that "the people concerned are recognizing that emergency measures need to be accompanied by greater support for Africa's own development efforts if a lasting solution to the crisis is to be achieved". "Agricultural production must be accompanied and supported by industrial development", and that "as long as even the simplest industrial inputs required for agricultural production continue to be imported and as long as the lack of local food processing and inadequacy of storage and transport facilities continue to dominate, much of the efforts to save millions of people in Africa from starvation will be rendered ineffectual". 1/

1/ UNIDO Newsletter Number 214/February 1986.

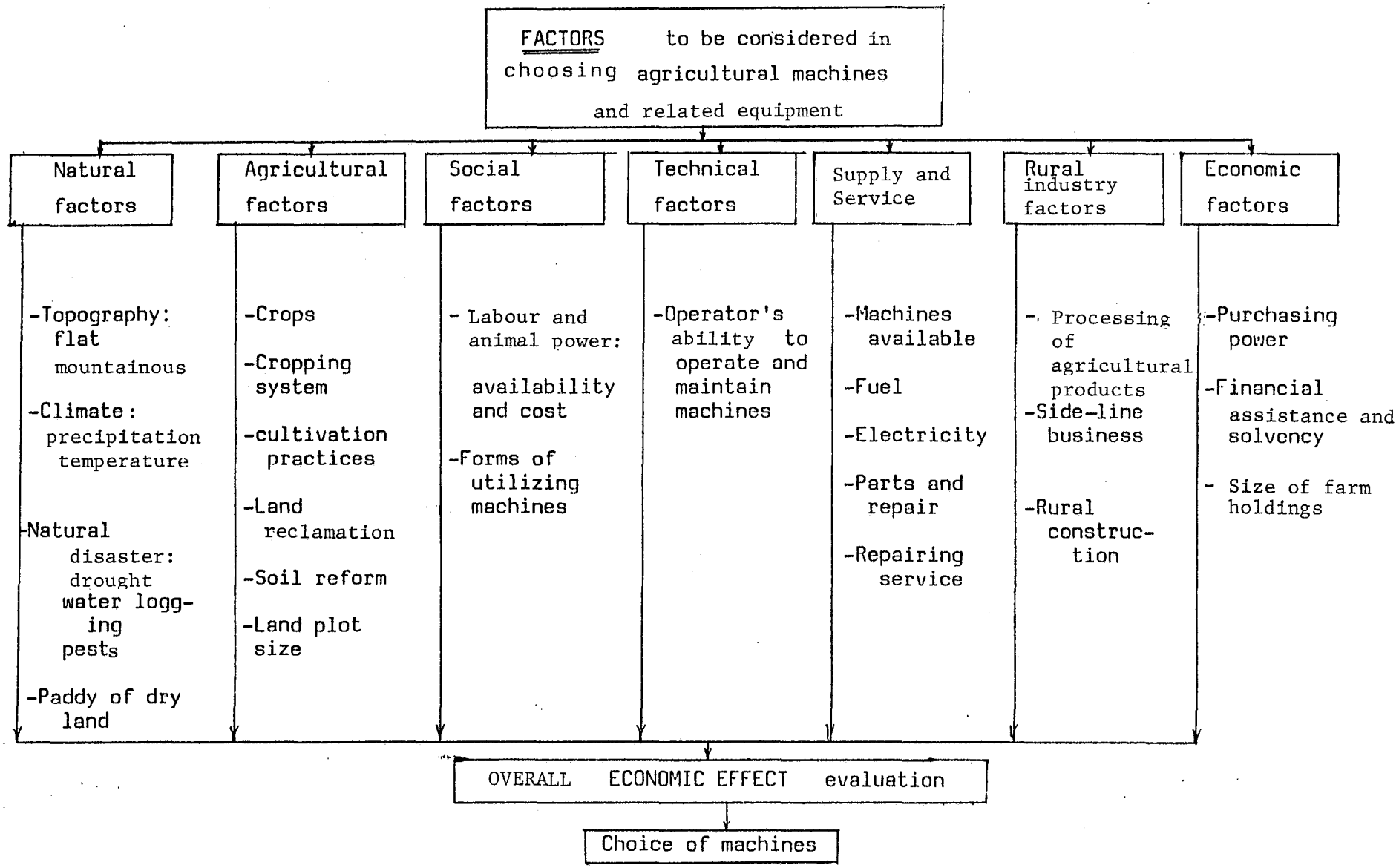


Figure 3 Factors to be considered in choosing agricultural and related equipment

In China, after implementation of the policy for promoting diversified economy, the production value of rural industries increased to 20 per cent of agricultural production as well as 20 per cent of total industrial production of the country, and absorbed more than 60 million peasants in rural industries. In spite of this, the grain output reached record levels the last few years. It is imperative for agricultural machinery plants at the grass roots level to take the challenge to identify and manufacture not only farming machinery for crop production but also the engineering and capital goods to meet the needs of diversified economy and rural industries.

2.3. Procedures for developing new products

Product development could be much more effective if carried out in the light of the strategy and programme of agricultural mechanization.

Generally speaking there are four major stages in the development of new products: 1. survey; 2. design and making prototypes; 3. trial production; and 4. production, as shown in Figure 4.

For developing new farms machines, repeated field tests and appraisals should be undertaken because of the varying soil conditions, farming practices and different regional economic conditions.

In the second stage, the procedure of "selection, adaptation and invention" is recommended as an economical and effective approach for procuring a suitable machine for local production. To start with, an attempt should be made to get the appropriate model through selection, either from a domestic or foreign source. After testing and evaluation, if the model suits local conditions, then it can be used directly for production under license, or, if not, the necessary modifications can be made to adapt it to local conditions. New inventions of machines are only necessary when no appropriate model is available, as this otherwise results in wasting time and money.

The four stages for developing new products are essential for obtaining a suitable agricultural machine both for farmers and for the smooth operation of the plant. For small plants and small batch production, the procedures may be simplified. Experience has shown that the ignorance of the necessary steps, especially the steps of testing and evaluation, often leads to failure and economic loss. It is recommended that experienced farmers or their representatives participate in the field tests and evaluation.

3. PRODUCTION AND SERVICE

3.1. Types of production

The type of production is one of the major factors which determines the kind of organization and technology of a plant. In the agricultural machinery industry, there are mass production plants, batch production plants and some job production plants. The multi-purpose plants described in this paper are

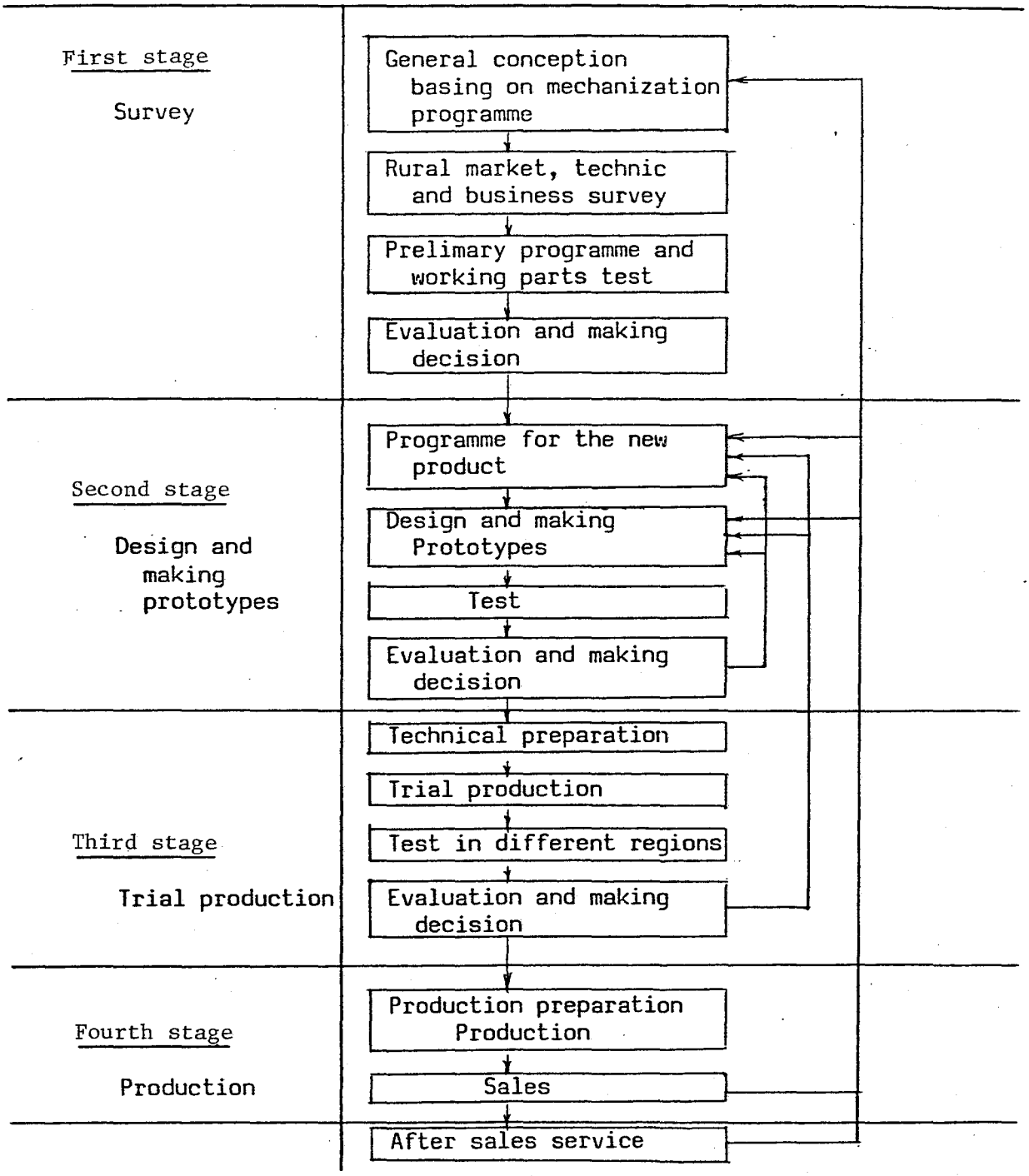


Figure 4 Procedures for developing new products

in the category of small and medium batch production types. Some aspects relating to the types of production, listed in Table 1, deserve attention when comparing the features of different types of production. 1/

3.2. Production organization and management

Production organization and management is a very important and complicated issue for a plant regardless of size. For a plant oriented towards multi-purpose production it is even more complicated to organize the production.

Primary elements and their relationship with management and organization are shown in Figure 5 below.

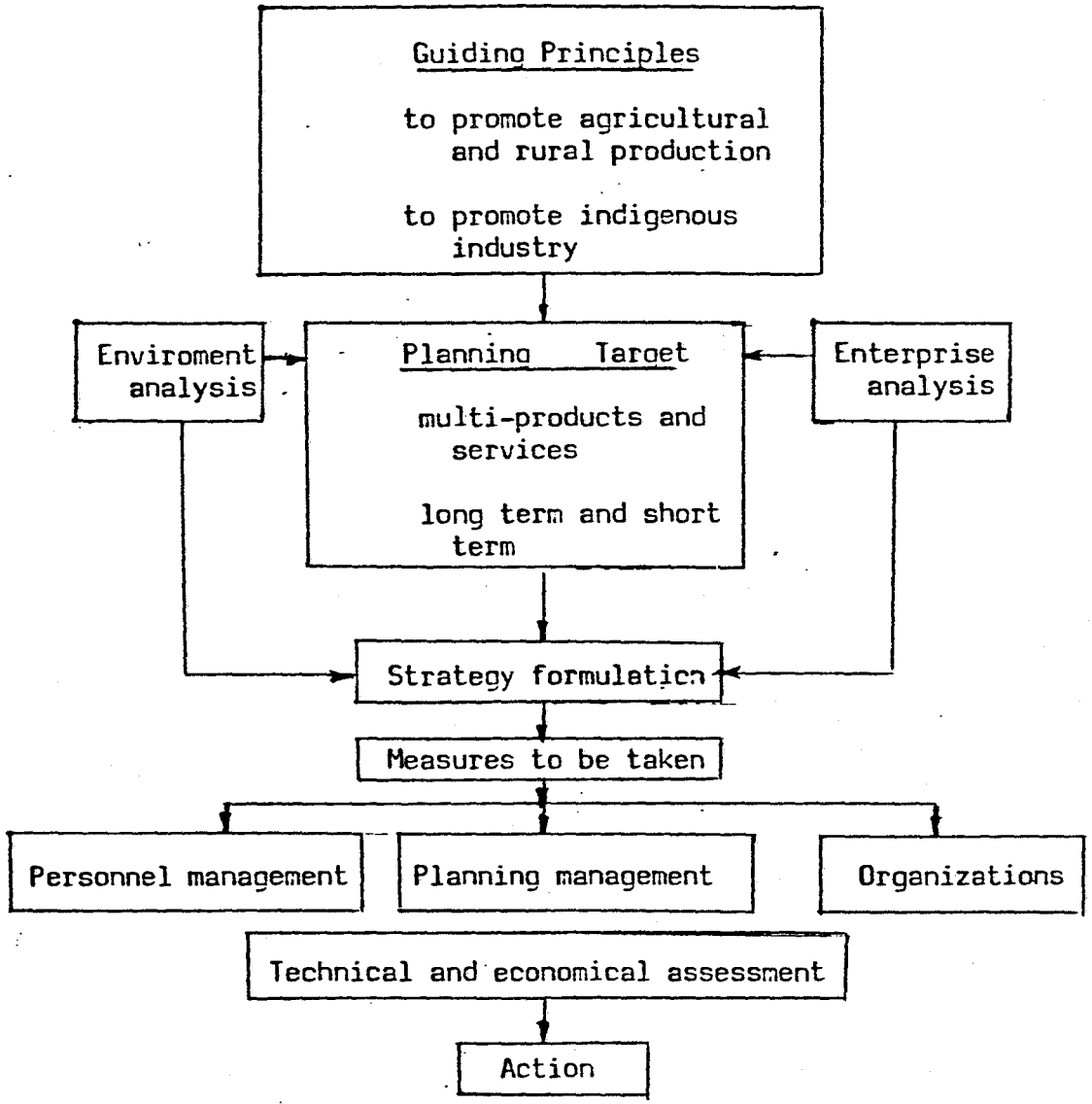


Figure 5 Elements and working stages for enterprise management

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1/ Encyclopedia of Enterprise Management of China, 1984.

Items of importance	Types of Production		
	Large batch production	Medium batch production	Job and small batch production
Number of products	Single or a few	More	Many
Number of operations at one position	A few, usually 1-2 operations	More	Many
Production equipment	Mostly specialized, with high efficiency	Partly with specialized and partly with general purpose type	Mostly of general purpose type
Arrangement of production equipment	Organizing unchageable flow line or automated line	Organizing changeable flow line or production line, basing on products or technology	Basing on technology, impossible to organize production line
Technological work	High level of standardization and interchangeability, drafting technological process according to working procesures	Medium level of standardization and interchangeability, technological process rather sketchy	Medium or low standardization and interchangeability, sketchy technological process
Process tools	Specialized and with high efficiency	Mixture of specialized and general purpose	Mostly general purpose
Coefficient of process tools	High: 2.1 - 5.3 with annual production of 500 - 5000 pieces	Medium: 1.3 - 1.7 with annual production of 150 - 500 pieces	Low: 0.2 - 1.0 with annual production of 1 - 150 pieces
Technical level of workers	High level for fitters lower level for operators	Medium high	High and versatile
Utilization of production facilities	High	Medium high	Low
Production cycle	Short	Medium	Long
Planning work	Simple	Medium	Complicated
Productivity	High	Medium high	Low
Production cost	Low	Medium	High

Table 1 Technical items relating to types of production

Some basic requirements for the organization of production are given below:

(a) Continuity of production - to keep all phases of production, from material input, processing, inspection and transportation, to output of products, in a state of continuous flow, and to keep stoppage at a minimum.

(b) Proportionality and coordination of production - to keep the production capacity of different shops and different processes well proportioned and coordinated.

(c) Rhythmic production - to keep the production in a given period (months, weeks, days) at a steady pace.

In the case of multi-purpose agricultural machinery plants of small batch production, it is very hard, owing to seasonal demand of agricultural machinery, to follow the three basic principles unless appropriate measures are taken.

3.3. Some aspects of production technology

3.3.1. Technological preparation

After the prototype of the product has been approved through testing and evaluation, and the volume of production has been surveyed, technological preparation work will be one of the major procedures for organizing the production plan and the operating schedule.

For a multi-purpose plant, "group technology" is an efficient technique for organizing production based on the similarities of the parts from different products. It is also a technique necessary for upgrading the capabilities and economic effect of plants with small- and medium-scale production.

Processing of a product depends on many factors, such as the type and scale of production, technical level and existing production facilities of the plant. An analysis should be made to ensure convenience and economy both in the course of manufacturing, and the after-sales repair and maintenance. It may be necessary for the designers to make modifications of the drawings to facilitate the production process.

In technological preparations, the principle of "value engineering" should be applied to ensure the lowest possible cost and at the same time a satisfactory output.

3.3.2. An example of technical analysis of a centrifugal pump

Probably the majority of agricultural machinery plants in developing countries produce pumps for fighting drought or waterlogging. The Lomè meeting on irrigation sponsored by FAO in April 1986, revealed that the area of land under irrigation accounts for 6 per cent of total African cultivated land, and is concentrated mainly in a few countries situated in the east and west of the continent. African experts claimed that if water resources in Africa could be fully utilized, the irrigation area could be doubled or tripled, thereby substantially improving food production.

It is therefore worthwhile to draw up a technical analysis of the most commonly used types of centrifugal pump for irrigation, for those who are interested in producing pumps in a multi-purpose plant.

Table 2 shows the main specifications of some models of centrifugal pump. Figure 7 shows all the parts of the pump. Table 3 gives a brief technical description of all parts.

From the technical analysis, one can see that a centrifugal pump of BA type comprises 22 parts, of which 11 are grey iron castings. However, the weight of the grey iron casting parts amounts to about 90 per cent of the total weight of the pump. The remainder are small parts or purchased parts.

The machine tools required to manufacture the pump consist of: (1) engine lathes of small- and medium-size, with some saddle type for turning short but large parts, (2) vertical lathes of medium size, (3) horizontal boring machines (if the batch size is fairly large, some special boring machines, which are very simple and cheap, should be installed), (4) shapers or planers of medium-size, (5) universal milling machines of small- or medium-size. All machine tools used in the machine shop are of medium precision.

To sum up, if the multi-purpose plant is to produce centrifugal pumps of BA type in small or medium batches, it is necessary to: (1) establish a foundry shop of appropriate capacity within the plant or to co-operate with a nearby specialization foundry shop, (2) have available almost all commonly used machine tools of general purpose type, small- or medium-size and medium precision, (3) provide workers for key operations, such as pattern-making, mould-making, and machining operations, with a skill level above grade 4 or 5 in the 8-grade system.

3.3.3. Standardization

Standardization is an essential aspect of industrialization that should be considered at the initial phases of industrialization of a developing country. For machine manufacturing, standardization involves almost all phases of production: design, quality control criteria and performance specifications, production technology, test and inspection norms, sales and after-sales service (supply of spare parts). It also involves the process of purchasing materials, parts and components. In addition, it

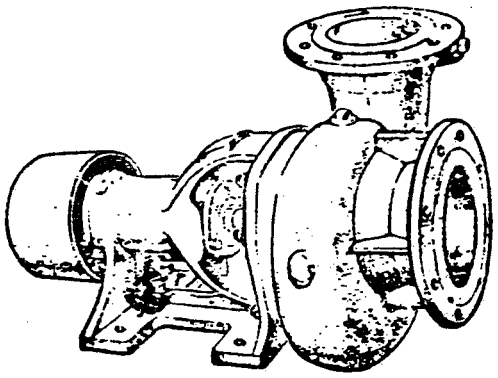


Figure 6 Centrifugal Pump of BA type
(single stage, sigle side suction)

Table 2 Main specifications of some models of centrifugal pumps of type BA

Model	Discharge	Head	Rotor speed	Power of motor	Suction head allowed	Diameter of rotor	Weight of pump
	m^3/h	m	rpm	kw	m	mm	kg
2BA-6A	10 20 30	28.5 25.2 20	2900	3	8.7 7.2 5.7	148	35
3BA-6A	30 40 50	45 41.5 37.5	2900	10	7.5 7.1 6.4	192	116
4BA-6A	65 85 105	82 76 69.5	2900	40	7.1 6.4 5.5	250	138
4BA-8A	70 90 109	48 43 36.8	2900	22	5.0 4.5 3.8	195	116

Explanatory Note of Model:

2BA-6A: "2" diameter of suction pipe = 2 × 25 (mm)

"BA" type of centrifugal pump, single stage single side suction

"6" specific speed divided by 10

"A" a modification, with reduced rotor diameter

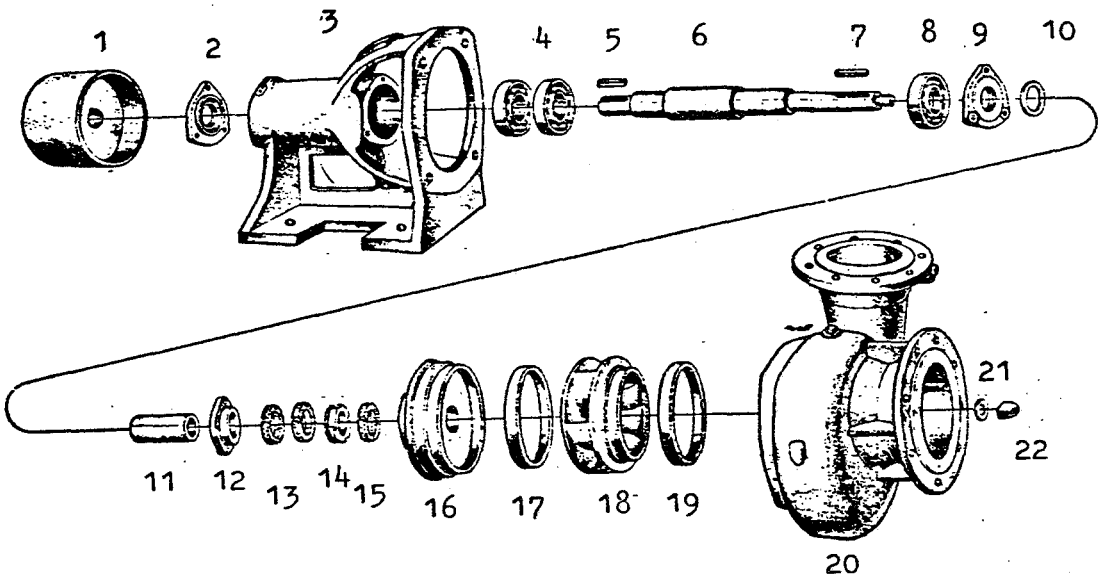


Figure 7 Parts of the centrifugal pump type BA

necessitates co-operation among enterprises, regions and countries. It is incorrect to believe that standardization is not indispensable because the plant is small and the products are not sophisticated.

For the multi-purpose plants, it is of vital importance for reducing production costs and benefiting the end-users, to rationalize the production in series of products of the same family, to use common parts as far as possible among different products of the same and/or different categories, and to be able to interchange parts, especially spare parts.

In drafting standards for agricultural machinery and capital goods the international standards (SI) are highly recommended for direct adoption or as the basis for adaptation.

Table 3 Parts and machining process (centrifugal pump type BA)

No.	Item	Quantity	Material	Activity*	Main machining	Equipment
1	Pulley	1	Grey iron casting	M	Turning surfaces Making keyway	Engine lathe Slotting machine
2, 9	Cover	2	Grey iron casting	M	Turning Drilling	Engine lathe Upright drill
3	Main frame	1	Grey iron casting	M	Planing Boring, rough and finishing	Shaper or planer Boring machine
4, 8	Ball bearing	2		P		
5, 7	Key	2		P or M		
6	Shaft	1	Medium carbon steel	M	Turning, screw cutting Making keyway Grinding	Engine lathe Vertical milling Cylinderical grinder
10	Washer	1		P or M		
11	Sleeve	1	Tube, low carbon steel	M	Turning	Engine lathe
12	Cover	1	Grey iron casting	M	Turning	Engine lathe
13, 15	Packing	2		P		
14	Water seal	1	Grey iron casting	M	Turning	Engine lathe
16	Cover	1	Grey iorn casting	M	Turning	Engine lathe
17, 19	Seal	2	Grey iorn casting	M	Turning	Engine lathe
18	Water wheel	1	Grey iron casting	M	Turning Making keyway	Engine lathe Slotting machine
20	Housing	1	Grey iron casting	M	Turning Drilling Tapping	Engine lathe Upright drill Tapping tools
21	Lock	1		P		
22	Nut	1	Mild steel	M	Turning Screw cutting	Engine lathe

*Activity: M - Made in the plant; P - Purchased outside

3.3.4. Quality control

The quality of products is the lifeblood of an enterprise. For agricultural machinery and allied machines for use in rural areas, the quality of products is of special significance, as the working conditions in the countryside are very tough, technical skills for operating and maintaining machines are poor and repair services are insufficient. The breakdown of agricultural machines in busy seasons often brings farmers irremediable losses.

The quality of a product depends on the whole course of production: design, processing, inspection, sales and after-sales service. It is affected by the influence of men, material, machine, method and environment (4MlE). Therefore, Total Quality Control (TQC) is recommended to ensure quality. TQC is an operation system that, using scientific methods, organizes all relevant sectors and personnel, and carries out comprehensive control measures on all factors which may affect the quality of the product in the whole course of production.

In the formulation of quality standards for agricultural machinery, a representative of the end users, the farmers, should be involved.

3.4. Repair and maintenance

Repair and maintenance has been recognized as an important link between the plant and the farmers, ensuring operation of farm machines at all times.

As has been pointed out, it is estimated that 50 per cent of the existing tractors in some African countries cannot be used due to lack of spare parts and repair services. If repair and maintenance facilities are not established, farmers will not be able to benefit from agricultural mechanization.

Consequently, repair services are an important aspect of the multi-purpose oriented agricultural machinery plant. The repair shop of the plant must have the necessary repair facilities, test meters and instruments, and mechanics specialized in repair techniques. The shop may collect tractors or vehicles from the farmers to overhaul them on an annual or seasonal basis. For minor repairs some simple and practical means are recommended, such as gluing (mainly by epoxy resins) for mending metallic and non-metallic fractures, oxygen-acetylene-powder surface welding and brush plating for mending journal or bearing surfaces.

The repair shop should also be equipped with mobile units which could repair machines on-the-field in the busy farming seasons. Besides the multi-purpose plant, it is recommended that a country could establish a central reconditioning plant to handle the major repairing service more efficiently if the environment permits.

Repair and maintainance courses will be offered by the Development Centre (chapter V) in co-operation with the plant, to train the mechanics and also to teach the farm operators to handle and maintain the machines properly.

4. PLANT LAYOUT AND UPGRADING

The production of agricultural machinery and allied capital goods, with different complexities, sophistication and production volumes, requires different types of production and accordingly different levels of equipment and plant layout. The multi-purpose plants at the grass roots level in most developing countries are mostly small or medium in size and produce in small or medium batches. Therefore, these plants have the following requirements:

(a) Labour-intensive type of production, no automation;

(b) Machine tools and facilities of general purpose type and mostly of medium precision;

(c) Workers and staff with versatile capabilities;

(d) Appropriate technology;

(e) Reserve space for future expansion.

4.1. Plant location and site

Since there is a close link between agriculture and the agricultural machinery industry, the location of an agricultural machinery plant should be accessible to both rural and urban populations. The following factors should be considered in deciding on the location of a plant:

(a) The requirements for constructing the plant;

(b) Access to water and electricity;

(c) Access to transportation facilities (waterways, highways, railways);

(d) Access to urban areas as well as to other enterprises working in co-operation with the plant, such as the design and engineering centre and the ancillary plants;

(e) Protection of the environment.

4.2. Plant layout

The plant's production, ancillary and service sectors, as well as its transportation and conveying systems, should be well arranged and organized. Some basic guidelines are given for reference below:

(a) The general layout should conform to the production process, the production line should be short and smooth, avoiding cross-flow or counter-flow of the products.

(b) The arrangement of the equipment should follow the sequence of the technological process, should provide sufficient space for operators, storage of works-in-process and transportation, and should efficiently utilize the floor space of the shop.

(c) The tool-making shop is the backbone of the multi-purpose plant, responsible for tooling up for production, for making equipment and providing expertise to further expand and upgrade the plant. Special attention must therefore be given to the shop in the layout.

(d) Repair and maintenance facilities should be located for easy access by the customers and be large enough to repair big farm machines.

(e) The shops which generate poisonous gases or dust should be located on the downwind side of the plant and away from residential areas;

(f) Ancillary sectors and service sectors should be conveniently located for production and for the welfare of the workers and staff.

(g) Sufficient extra space should be provided around the shops for possible further expansion of the plant.

4.3. Feasibility study

The purpose of a feasibility study is to provide the decision-makers, before investment, with an analysis of the technical and economic aspects of the project. A feasibility study is crucial for the successful establishment and smooth operation of the project. It is indispensable for all projects regardless of size. Before making a feasibility study, it is necessary to make a prefeasibility study and a preinvestment study. The contents of the feasibility study could be simplified according to the practical conditions, as long as the essentials of the study are affected.

The following outline shows the format of a feasibility study as recommended by UNIDO:

I. Executive summary

II. Project background and history

III. Market and plant capacity
- A. Demand and market study
- B. Sales and marketing
- C. Production programme
- D. Plant capacity

IV. Material inputs
- A. Materials and inputs
- B. Supply programme

V. Location and site
- A. Location
- B. Plant site and local conditions
- C. Environmental impact

VI. Project engineering
- A. Layout and physical coverage of project
- B. Technology and equipment
- C. Civil engineering

VII. Plant organization and overhead costs
- A. Plant organization
- B. Overhead costs

VIII. Manpower
- A. Labour
- B. Staff

IX. Project implementation

X. Financial and economic evaluation
- A. Total investment outlay
- B. Project financing
- C. Production cost
- D. Commercial profitability
- E. National economic evaluation

Annexes

4.4. Upgrading of the existing plants

As shown in the reports by UNIDO consultants, most of the existing agricultural machinery plants in South America and Africa are operating far below capacity. There are many reasons for this: financial difficulties; shortage of technical personnel; lack of materials; limited market, etc. The most important of these is lack of material and manpower to meet the diversified needs of the farmers and the rural community and there is an urgent need to find a solution to this problem. In some countries, the upgrading or revamping of the existing plants has priority over establishing new units.

Most of the guidelines elaborated in the previous parts of this paper for establishing multi-purpose agricultural machinery plants should be taken into consideration in upgrading the existing units. In addition, the following suggestions should be considered:

(a) The manager of the plant should be flexible and follow the principle "to make whatever the farmers need".

(b) It is important to identify the actual needs of farmers and the rural community and to widen the spectrum of services provided, to produce not only agricultural machinery but also allied capital goods and engineering goods for rural construction and industries. Experience has shown that improved economic conditions in the rural community will encourage and enable the farmers to buy more capital goods, including agricultural machinery.

(c) The relevant authorities should help research and development centres to procure prototypes of implements and machinery appropriate to local conditions and let the centres test and evaluate them in order to help the plants solve problems such as shortages of materials, machine tools, etc.,

(d) Existing production equipment should be evaluated and, where possible, adjustments should be made so as to acquire the capability of multi-purpose production.

(e) Workers and administrative personnel should be trained to be versatile in knowledge and technique.

(f) Unnecessary expansion of the existing plant should be avoided in the course of upgrading; any expansion must be based on careful consideration of the reliabililty of the potential market.

5. DEVELOPMENT CENTRE PROPOSED FOR PROMOTING THE AGRICULTURAL MACHINERY AND ALLIED ENGINEERING INDUSTRIES

5.1. Background

A development centre is highly recommended as an institution to promote the establishment and development of agricultural machinery and allied engineering goods industries for following reasons:

(a) Agricultural machinery and allied engineering industries in rural areas, unlike those located in urban areas, face many difficulties in management, technical and marketing operations as well as insufficient infrastructure. Failure to solve the problems often results in declining output and eventually closure of the plants, even those well designed and established. This has been the fate of a number of agricultural machinery enterprises in many developing countries.

(b) As has already been pointed out, the multi-purpose agricultural machinery plant at the grass roots level could not develop and serve as the nucleus for industrialization in state of isolation. The plant can become more efficient, productive and profitable only when the supporting enterprises and institutions for horizontal and vertical integration or co-operation are established and the linkages between them strengthened. The speed of setting up this network will in the long run affect the tempo of rural construction and industrialization.

(c) Some institutions, such as the proposed development centre, have already been set up in some developing countries and have been operating successfully for some years. Thus, the proposal of establishing such a centre in a country is not only necessary but also practical and promising.

However, owing to the scope of its activities, such a centre is mainly limited to the design and testing of prototypes of machines. Other bottle-neck problems, such as those in the existing agricultural machinery plants, have hardly been tackled. In this context, the proposed centre will expand its activities and services to cover those aspects which are vital to the successful operation and steady growth of the multi-purpose plants.

The development centre is the brain trust of the network. The centre will render services in three areas: institutional services, technical common services and promotion of engineering ancillary industries (see Figure 8). 1/

1/ The structure and function of the development centre, illustrated in UNIDO Monograph on Appropriate Industrial Technology No 4, are adopted here with modifications.

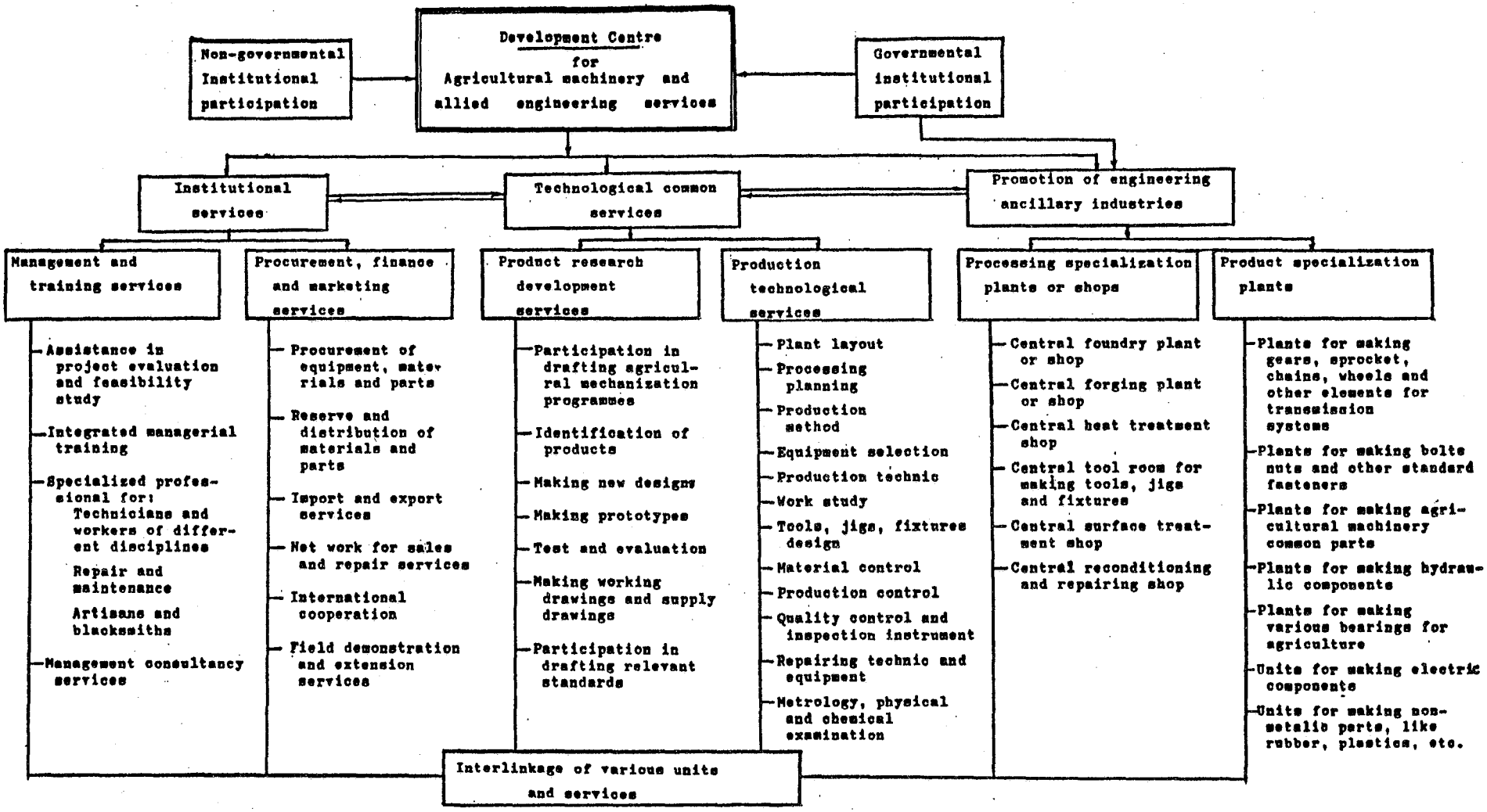


Figure 8 Functions and services of the proposed Development Centre

5.2. Institutional services

5.2.1. Management and training services

Management and training services are organized according to the following criteria:

(a) Services are common to and indispensable to all production units.

(b) A complete and competent set up of the institutions in small plants is impractical and will inevitably increase the overhead cost.

(c) The well-organized and co-ordinated services, supported by government, will benefit all partners.

The main services provided are the following:

(a) To assist the relevant authorities to carry out project evaluation and feasibility studies for the plants;

(b) To offer training courses. As pointed out in all reports the lack of qualified indigenous personnel (managers, technicians, workers and other professionals) is one of the most serious constraints hindering successful operation of the plants. Training is therefore an important service of the development centre. The following training courses could be offered in co-operation with relevant local institutes:

(i) Training courses for managers and owners

(ii) Training courses for professional personnel

(iii) Training courses for workers of different abilities

(iv) Training courses for artisans and blacksmiths

(v) Training courses for repair and maintenance personnel.

5.2.2. Procurement, finance and marketing services

The supporting services in this field rendered by the development centre will certainly facilitate the effective operation and economic viability of rural industries These services include:.

(a) Procurement of equipment and raw materials and parts. A survey of enterprises in developing countries shows that the stoppage of operation and sometimes the closure of the plants are mainly due to the lack of materials, parts and critical production equipment, especially the imported items. It is not unusual for delivery to take 6-12 months from the date of ordering to the date of actual use of the imported materials, which represents about 70 per cent of the cost of many products. The lack of foreign currency inhibits small industries from importing items individually and independently. The development centre will be able to assist the rural enterprises in:

(i) Selection of proper materials, parts and appropriate machine tools and equipment;

(ii) Introducting a bulk purchase system in close co-operation with government agencies, private importers and rural industries.

The availability of a minimum stock of indispensable materials will keep the small and medium scale plants operating continuously. This kind of service is absolutely necessary and also feasible if the Government is actively involved.

(b) Finance and marketing services. Small rural industries need, inter alia, finance and marketing assistance, and the centre can organize the following services:

(i) Loans from commercial, private or state-owned banks for the purchase of production materials, parts and equipment;

(ii) Recommendations for the extension of government subsidies, which are indispensable for supporting rural enterprises, especially the agricultural machinery industries;

(iii) Promoting international co-operation in obtaining finance;

(iv) Promoting subcontracting schemes to enable small plants to obtain materials and parts through mutual co-operation;

(v) Organizing co-operative marketing systems;

(vi) Establishing sales centres and display centres and providing market information;

(vii) Organizing field demonstrations and popularizing new products;

(viii) Providing finance and marketing consultancy.

5.3. Technical common services

This is the central technical part of the centre; it will provide the network with all technological advice and technical documents needed for the development and production of new products. The technical services should be rendered according to the following principles:

(a) Applying appropriate technology to suit local conditions;

(b) Utilizing as much as possible local manpower, materials and domestically-made parts;

(c) The development of indigenous industry should be the objective of all technical services.

5.3.1. Product research and development services

The functions of this part of the Centre are the following:

(a) To participate in the drafting of agricultural mechanization programmes and the identification of products, including agricultural machinery and allied engineering goods;

(b) To conduct tests and evaluate procured or imported implements or machines, and to make technical and economic evaluations in order to accelerate modification and adaptation;

(c) To make new designs if no appropriate machines are available, in which case some research work will be necessary;

(d) To make prototypes and conduct tests and evaluation of them;

(e) To make and supply working drawings and specifications of products, and, in co-operation with the manufacturing plant, to improve the processability of parts and components;

(f) To participate in the formulation of standards relating to product development and manufacture.

5.3.2. Production technological advisory services

This part of the centre is in charge of the following:

(a) Plant layout;

(b) Processing planning;

(c) Production methods;

(d) Machinery and equipment selection;

(e) Production techniques;

(f) Work study;

(g) Tooling techniques, design of tools, jigs and fixtures;

(h) Material control, production control, quality control;

(i) Repair techniques and equipment;

(j) Metrology, physical and chemical examination techniques.

5.4. Promotion of ancillary engineering enterprises

At the starting stage, the multi-purpose agricultural machinery plant must equip itself with all necessary production facilities, such as a simple foundry, forging and heat treatment sections or shops to enable the plant to start up. However, as the industry develops, specialization and integration will emerge and grow, owing to the technical and economical superiority of the production mode. Government agencies must take the initiative in planning the enterprise and the development centre should promote and provide them with necessary all technical assistance and advisory services.

The following are examples of ancillary enterprises that can be developed:

(a) Process specialization plants:

Central foundry plant (shop);

Central forging plant (shop);

Central heat treatment shop;

Central tool room for making tools, jigs, fixtures, etc.;

Central reconditioning and overhauling plant (shop);

Etc.

(b) Product specialization plants:

Plant for making gears, sprockets, chain, wheels and other elements for transmission systems;

Plants for making bolts, nuts and other standard fasteners;

Plants or shops for making agricultural machinery parts, such as disks, shares, tines, etc.;

Plants or shops for making different sorts of bearings;

Plants or shops for making electric components;

Plants for making hydraulic components;

Plants or shops for making non-metallic parts, such as plastics, rubber, etc.

6. INTERNATIONAL CO-OPERATION

International co-operation has an important role to play in the establishment and development of the multi-purpose plants for agricultural machinery and allied engineering goods in the developing countries. As pointed out by some experts working in this field, it would be better to dispatch tractors and agricultural implements together with food grains to help solve food shortage problems, and it would be still much better to take effective measures to assist the countries in building up their own industries gradually, so as to enable the people there to manufacture agricultural machinery and other capital goods, and thus to produce food, clothing and other necessities of life, working towards increased self-reliance.

International organizations such as UNIDO and FAO and some industrialized countries can provide assistance to countries in starting up their agricultural machinery and allied capital goods industries in the following areas:

(a) Organizing experts of different disciplines to assist the experts of the host country to draft the agricultural mechanization strategy and programmes;

(b) Helping the Government to set up a development centre for agricultural machinery and allied capital goods industries;

(c) Helping the centre to identify the local needs for agricultural machinery and allied capital goods;

(d) Helping set up the R and D department by providing technical and material assistance for developing implements and tools;

(e) Helping the centre by providing facilities for making prototypes, and for testing and evaluating; helping to procure prototypes from foreign countries and bringing them to the host country for testing;

(f) Helping to set up reserve supplies of raw materials, parts and components, and distributing them to the plants that need them at reduced prices;

(g) Helping to organize training courses by providing qualified teaching staff and demonstration machines and instruments;

(h) Helping to set up ancillary plants for manufacturing various standard and common parts and components (mechanical, electrical, hydraulic and non-metallic) needed for manufacturing agricultural machinery and capital goods. These parts and components are usually not specific to individual agro-climatic conditions and the technology for their manufacture is readily available from developed countries.

(i) Helping to promote the transfer of technology in forms that are appropriate to the technical and economic conditions of the recipient country.

Because of the similarities of conditions in respect of technology, economy and ecology, some kinds of co-operation between developing countries might be more practical, acceptable and beneficial to all partners. Some examples of this kind of co-operation are the following:

(a) Setting up joint R and D centres to deal with issues of common interest;

(b) Based on the principles of division of labor and mutual agreement, organizing regional or interregional production and marketing schemes for some implements for which the potential market in a single country is rather limited;

(c) Exchanging information and experience among experts of the region;

(d) Exchanging prototypes of machines for testing and evaluation.

Annex

This paper presents two approaches to the planning of multi-purpose agricultural machinery plants: one medium-scale and one small-scale. The author intends, based on Chinese experience, to provide a rational design, including appropriate technology and equipment, for planning a multi-purpose agricultural machinery plant, and also to advance some important points to be considered concerning the establishment of such a plant. Some data are also given for reference for those who intend to design the layout of a specific multi-purpose agricultural machinery plant. 1/

I AN APPROACH TO THE PLANNING OF A MEDIUM-SIZED MULTI-PURPOSE AGRICULTURAL MACHINERY PLANT

1. Scale and programme of production

1.1. Area served

The medium-sized multi-purpose agricultural machinery plant should be able to serve a district with about 60,000 hectares of cultivated land, producing agricultural machinery and allied capital goods and rendering repair service.

1.2. Representative products

The factory should be able to produce fairly complicated machine-powered implements and allied capital goods, and various manual or animal-drawn implements and tools according to needs.

The following items could be representative products: (see Figure 9)

(1) Tractor-mounted plough

(2) Tractor-mounted harrow

(3) Rotary tiller

(4) Tool bar: planter
drill
cultivator
fertilizer
dresser

(5) Knapsack sprayer

(6) Windrow harvester

(7) Grain thresher

(8) Trailer (for single axle tractor)

(9) Trailer (for medium tractor)

(10) Hay mower

(11) Hammer mill

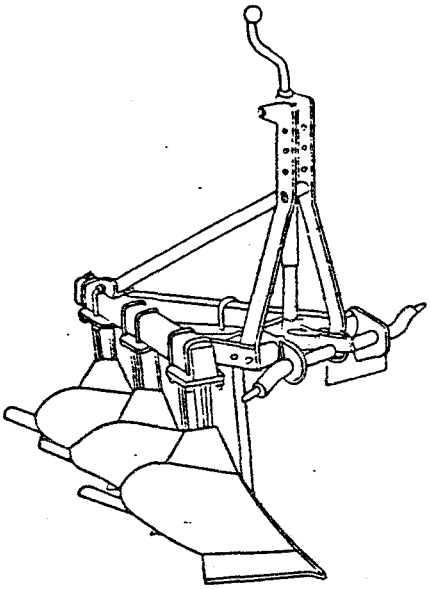
(12) Oil expeller

(13) Water well driller

(14) Centrifugal pump

(15) Bulldozer

1/ Source: "Design and study of multi-purpose agricultural machinery plants" by Wang Wanjun and Liu Hongshu.



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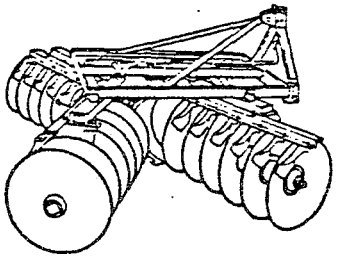

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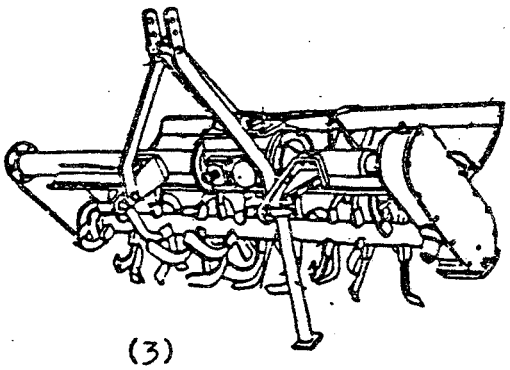

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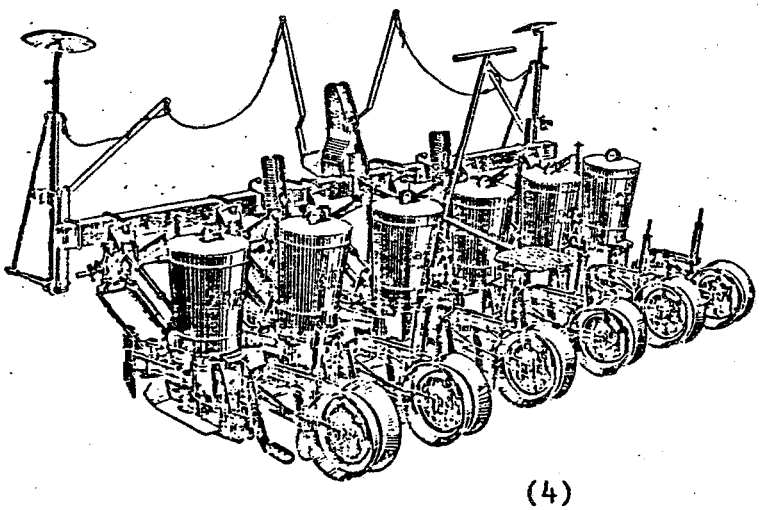

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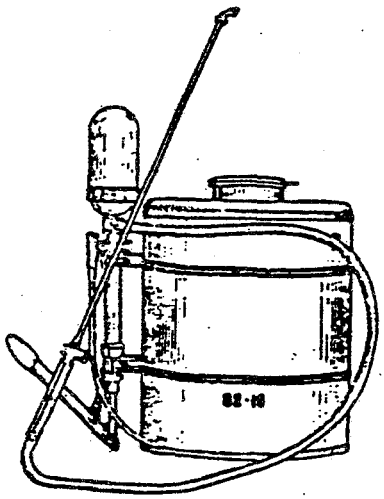

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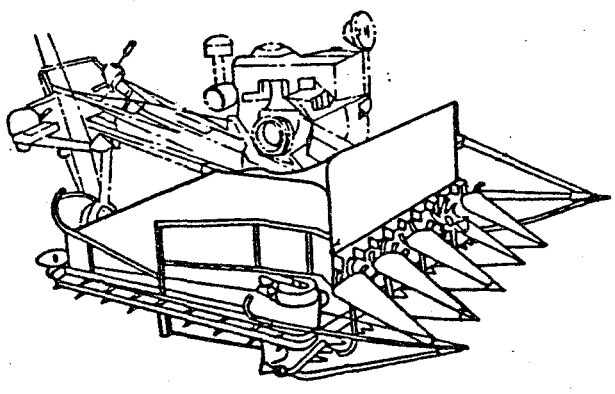

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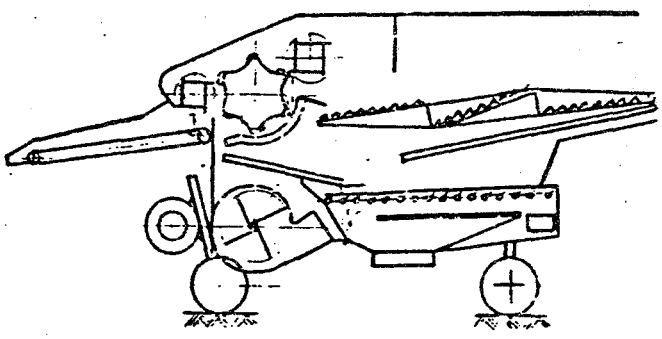

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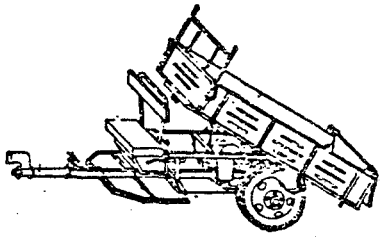
Figure 9. Representative products of medium-sized multi-purpose agricultural machinery plant.



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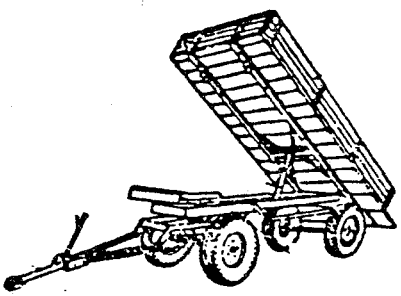

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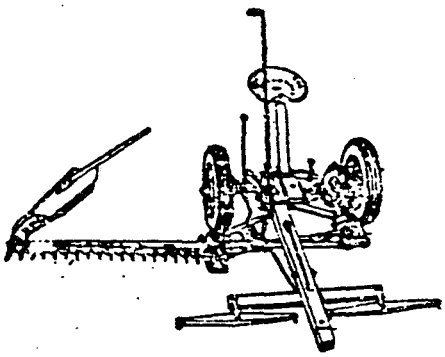

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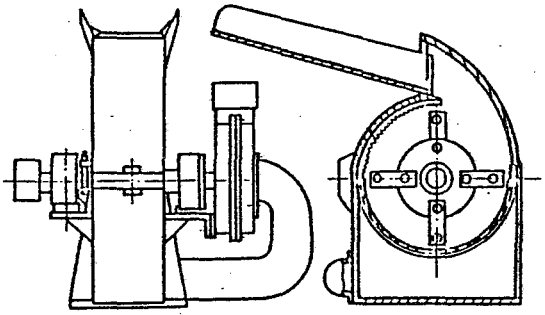

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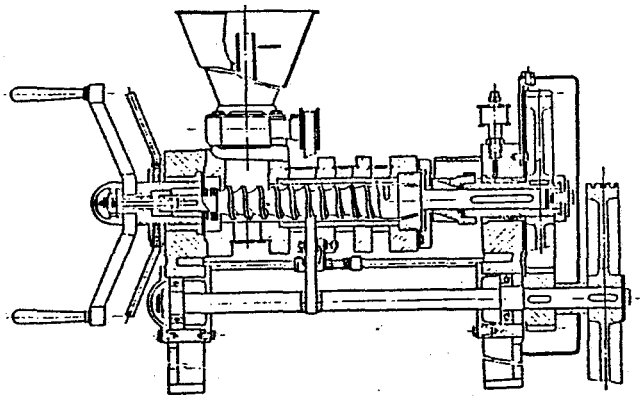

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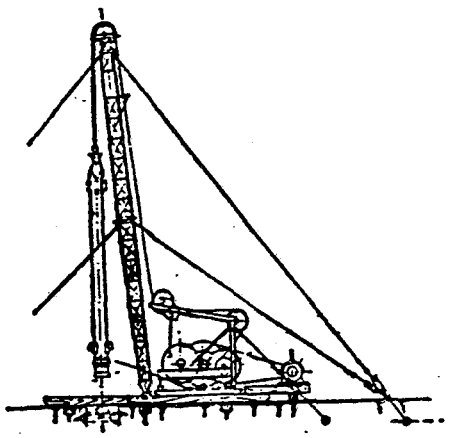

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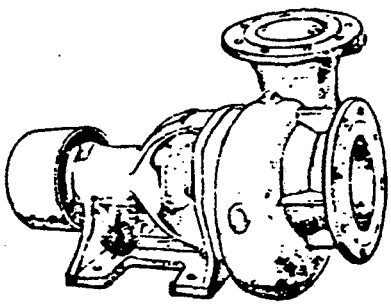

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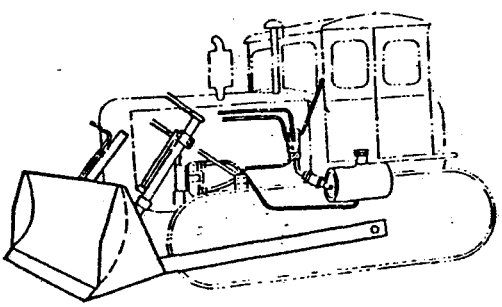

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Figure 9. (continued)

1.3. Repair service

The plant should be capable of repairing 100 units of various medium-sized tractors per year (including engines), and of manufacturing and supplying spare parts for its own products.

1.4. Production programme

The plant is planned to produce about 5,000 mixed units of the representative products. Total weight of annual output is about 500 tons.

1.5. Value of annual output

Under Chinese conditions, the total value of annual output in normally about 5 million yuan, of which the repair service represents about 15 per cent or more.

1.6. Some ancillary components and parts to be purchased

(a) engines required;

(b) electric motors, elctronic measuring instruments, control devices;

(c) bearings, standard fasteners, oil seals, chains, etc.;

(d) non-metallic parts such as rubber, plastics, leather, glass;

(e) steel castings, malleable cast iron, precision castings;

(f) electro-plating;

(g) precision tools;

(h) oxygen for gas cutting and welding.

2. Plant planning

The plant requires well-trained workers who are adaptable and able to: produce different types of agricultural machinery and other machines with similar materials and manufacturing technologies; maintain and repair products; make necessary prototypes; and adapt the factory production to fulfill changing requirements.

2.1. Production departments

Production is to be managed at two levels: plant and work-shop. Within the plant, there are the following seven main production workshops:

(a) Foundry shop: Its task is to produce iron castings and non-ferrous metal castings used both for production and equipment maintenance by the plant. Under the workshop there are working groups: melting, moulding, cleaning, non-ferrous metal castings and wood-working. The wood-working group can both make wood patterns and also provide services for packing products and plant building maintenance.

(b) Forging and heat treatment shop: It consists of two parts: forging and heat treatment. The former is reponsible for making forged pieces for products, tool making and equipment repairing. The task of the latter is to carry out heat treatment on forged pieces and the heat treatment for products, tools, dies, and repair parts.

(c) Punching and welding shop: It consists of two parts, punching and welding. The task of the former is to cut and to form parts from sheet metal and section steel; the latter does the welding work for parts, components and assemblies, and also for non-standard equipment and steel structures.

(d) Machine shop: It performs the machining work for castings, forged pieces and other blanks; some large equipment in this shop can also do the machining work for repairs.

(e) Assembly and test shop: It should be able to perform the following operations: part assembly, total assembly, adjustment, testing and painting.

(f) Farm machinery repair shop: It should be able to repair tractors (including engines) and various kinds of farm machines and capital goods.

(g) Tooling and maintenance shop: It is an important auxiliary department of the plant and it should be able to make cutting tools, measuring devices, supplementary holders, jigs, fixtures, metal patterns, moulds and ordinary production equipment; to make accessories for repairing power units; to make non-standard equipment and mechanized transportation devices; to make prototypes of machines; and to do some innovation work.

2.2. Management sections

Generally, the plant has the following eight sections, which can either be merged or separated according to specific conditions.

(a) General office: It executes the director's decisions, deals with daily business and is in charge of administration, general affairs, welfare services, etc.

(b) Production planning section: Responsible for production planning, controlling, statistics, handling semi-finished products and blanks, ensuring that production is well-co-ordinated.

(c) Supply and sales section: Responsible for raw material supplies, fuels, purchased parts, managing warehouses and transportation, product sales and after-sales service and maintenance.

(d) Technical section: Responsible for product design, testing and evaluation, production technology, technological innovation, product development. If necessary and possible, a product research institute can be set up.

(e) Quality control section: Responsible for examining product quality, appraising measuring instruments, chemical and physical testing of materials, managing the metrological laboratory and the physical-chemical lab.

(f) Personnel and security section: Responsible for the payroll, transfer of personnel, checking work attendance, system of rewards and penalties, guards, etc.

(g) Power plant section: Responsible for working out the plant maintenance plan, ensuring safety in production, and managing power units such as transformer and distribution substations, electric power station, pump room, etc.

(h) Finance section: Responsible for all financial affairs of the factory, including receiving and paying out money, cost accounting, and loss and profit analysis.

2.3. Choice of technology and equipment

The following list details the operations to be carried out within the plant as well as the necessary tools and equipment.

(a) **Casting**

A large amount of grey iron castings are often required for farm machinery and other capital goods. The plant should therefore be equipped with a blast furnace with a capacity of 2 tons/hour; however, the chamber size of the furnace can be changed and adjusted according to the amount of molten iron needed. If necessary, a molten iron ladle can be built in front of the furnace for making large castings (2-4 tons/piece). Generally, the materials to be fed to the furnace are broken manually except for large steel scraps, which can only be cut by gas cutting. Weighing and charging can be simply mechanized. Pouring molten iron is done mainly by hand.

The malleable cast iron and steel castings that are required as production inputs will be purchased. It is advisable to try to master the production technology of nodular cast iron, and to use nodular cast iron instead of steel wherever possible.

The white cast iron required for soil working parts can be made using permanent moulds, while for common grey iron castings sand moulds can be used. When a large number of castings are produced, jolt type moulding machines are used. The core is man-made, and drying is done in the oven. Sand shaking out and sand mixing are carried out continuously by a combined unit. Top risers and burrs are generally removed by hand chiseling or grinding. Castings are then put into a tumbling barrel for cleaning and then put in the open air for natural aging. If necessary, the water-tight test can be performed to examine the quality of important castings.

The woodworking group should be equipped with universal machines such as a jigsaw, planer and tenoning machines. The wood for making parts and patterns must be treated by steaming, boiling or natural seasoning so as to prevent cracking and deformation.

A pot furnace with 100 kg capacity must be set up for melting non-ferrous metals in order to meet the requirements for some special parts and repair work.

The annual output of the shop can reach 400 - 500 tons or more.

(b) Forging

The forged parts for farm machinery and repair parts are characterised by great variety, simple process, and small lots. Free forging and hand forging are commonly used.

When the forged parts are made in batches of 30-40 pieces or more, stamp forging technology should be used. If hand tools such as sickles, picks, axes, spades, etc. are produced in mass production, special equipment should be devised for this production.

For a medium-sized plant, it is better to choose electric air hammers of three sizes: 400 kg, 150 kg and 65 kg. A friction press (300 tons) is necessary for making gear blanks with a diameter of more than 100 mm. Various cutter handles and thin bars can be forged on a 150 kg or 65 kg air hammer. Press forming of plate steel can be done on a friction press after the plate is heated, e.g. for small mouldboards, disks, etc.

Coal furnaces are often used for heating forge blanks. According to local conditions, a gas, electric, or oil furnace can also be used.

The annual output of the forging shop can reach 200 tons or more.

(c) Punching and pressing

Most of the sheet metal parts for farm machinery are made of steel sheet, and some of them require only cutting, pressing and punching, without any other machining. A few sheet metal parts require drilling/tapping, for which a table drill is set up beside the stamping machine.

Shears with a capacity of less than 6 mm or with a capacity of less than 10 mm and combined stamping-shearing machines could be used for material blanking. A three-roller mill, for plane-checking or rounding, is necessary, as well as a 60-ton stamping machine for forming. Tubes and section steels can be cut off with some simple tools such as hand tube cutters, hand shears. Tube bending with die blank could be done by manual cold working. The burrs and edges of sheet metal parts are removed by chisel or hand grinder.

(d) Welding

Most welding is done with an A.C. electric welder. For section steels, some equipment, and some repair work, gas welding is preferred. The rectification of welding deformation is done by hand. For batch production, different types of welding jigs must be devised. Welding operation posts must be separated and a smoke and dust hood must be provided.

(e) Heat treatment

Since most of the working parts of farming machines, such as shares, mouldboards, tines, knives, disks, etc., are subjected to severe abrasive or wearing conditions, close attention must be paid to the choice of materials, heat treatment technology and equipment. Parts for quenching and tempering may be heated in a box-type electric furnace, those for carburizing in a well-type gas carburizing furnace, and those for case hardening in a medium size high frequency furnace. A low-temperature tempering oil tank is used not only for tempering but also for cooling. Further equipment needed for a heat treatment shop include: an aqueous alkali tank for cleaning putty, a hand press for rectification, and various hardometers for hardness test. All the installations mentioned above are also good for the heat treatment of common structural steel parts, some dies, and gears. The shop can treat about 300 tons of parts annually.

(f) Machining

To meet the requirements of small batch production, conventional production technology and universal machine tools are used; some different technological devices are attached in order to extend the machining range.

Specialized machine tools must be used to machine special parts in large quantity, for instance, knives, blades, etc. For mass production and for products of high quality, specialized production lines should be set up.

Box-type parts are generally made of grey cast iron, for which the milling machine can do surface roughing and precision boring, and the drilling machine can do drilling and tapping. For large production lots, special boring machines, special planing machines, and special jigs and fixtures are used for ensuring quality. Sometimes a production line consisting of simple and special machine tools may be set up to fulfil the requirements of both quantity and quality.

Dish-type and drum-type parts and small shafts are mainly machined with an engine lathe. As for special major shaft-type parts or large-diameter parts, universal machine tools with some supplementary attachments are required.

Cast iron gears, stamping gears or sprockets for farm machinery are not machined; however, machining is necessary for gears for high speed power transmission. Individual or small numbers of spur gears, bevel gears and spline shafts can be machined on universal milling machines. For steel gears, "gearing in" should be undertaken after heat treatment to improve the meshing engagement. The choice of sizes and specifications of the gear cutting machines used in the machining shop and those used in the repair shop should be well co-ordinated to ensure full utilization.

Milling machines should be equipped with different sizes of working tables. Both vertical and horizontal universal milling machines are necessary. Shapers with a 500 mm stroke and a double housing planer, 800 mm in width, can meet the requirements of surface machining for box-type parts for most types of farm machinery.

For grinding machines, medium- and small-sized internal grinders, external grinders, and face grinders are usually used.

For drilling machines, a few different sizes of upright drills, bench drills and radial drills are sufficient. Boring machines and shaping machines are generally of medium and small size.

It is advisable to try to study and apply "group technology" for machining similar parts from different implements.

The number of machine tools of general-purpose type required in the machine shop is about 30.

(g) Farm machinery repairs

As the repair service is one of the major activities of the multi-purpose plant, the repair shop must be well equipped with necessary facilities. Furthermore, the repair work and manufacturing work must be well co-ordinated by the planning section of the plant so as to permit other shops to support the repair shop in busy farming seasons and the repair shop to support other shops in the slack seasons.

For minor repairs, some simple equipment such as an electric welder, a lathe, an anvil or small hammer, a bench grinder, a bench drill, etc., should be provided for ready use. Some simple amd practical means for repairing are needed, such as gluing (e.g. using epoxy resins) for mending fractures of metallic or non-metallic parts, as well as oxygen-acetylene-powder surface welding and brush plating for mending journal and bearing surfaces.

For reconditioning engines, a complete set of equipment for dismantling, washing, sorting, welding, machining, assembling, etc., must be provided.

Spare parts should be available to replace worn-out or broken parts as far as possible.

A water test stand, a hydraulic dynamometer, and a static balancing unit should be provided, as well as test stands for hydraulic systems, electric systems, fuel systems etc.

In order to serve farmers' needs, mobile units with simple repair equipment and a dynamometer should be provided and sent to farms for fast repairing and checking of the repaired machines.

Tyre mending is always a problem for farmers. A complete set of tyre-mending equipment should be provided in the repair shop if there is no other special maintenance shop near the plant.

(h) Tooling and maintenance

The plant should be provided with all necessary equipment for the tool-making and equipment maintenance required for normal production, as well as for making new products and manufacturing special equipment for further expansion of the plant. The precision of machine tools required in this shop is higher than that required in the machine shop. The specifications of machine tools here, such as vertical lathes, boring machines, gear-hobbing machines, must be co-ordinated with those in the machining shop.

Products and equipment for which higher precision is required should have holes, etc. machined with a precision milling machine.

(i) Assembly and test running

The products made in the plant will generally be assembled by hand. Large products or products produced in large lots should be assembled at fixed tables. Medium and small-sized products can also be assembled on a common assembly line or at fixed tables. Special asssembly benches and test rigs can also be set up, according to the different requirements of products. Before they are assembled, the components or parts should be cleaned, and putty and burrs should be removed.

Painting, both for components and complete machines, could be done by hand spray painting, brush painting or immersion painting, followed by natural drying. The painting room must be separated from the rest of the shop. A paint mixer should be provided.

(j) Metrology, chemical and physical testing

In order to standardize the system of weighing and measuring, standardizing instruments should be provided for checking and adjusting the measuring instruments used so as to ensure that they conform to standard length, weight, temperature, and electric measures. High precision instruments can be sent to the governmental measuring standard organizations to be checked and adjusted.

2.4 Working schedule

As a general practice, a two-shift workday system is adopted. Exceptions are the assembling, testing, forging, welding and farm machinery repair shops, which usually have a one-shift workday; the heat treatment section and power station, which have a three-shift workday; and the casting section or foundry shop, which vary the work schedule according to production requirements.

Personnel assignment

For basic production, workers are assigned to groups; for key equipment, workers are assigned to a specific post. Workers are asked to be an "expert in one thing and good at many" to meet the changing requirements of production. The average technical level of the workers in the multi-purpose agricultural machinery plant should be about grade 4 according to an eight-grade technical level system.

In order to ensure adequate capability in product design and in the improvement of production technology, and to meet the needs of production management, the plant should have a certain proportion of engineers and technicians, approximately 4 to 6 per cent of total staff members.

2.6 Plant building

Generally speaking, hot working shops are built independently of the others, while cold working shops are located in one building, so as to reduce the distances over which materials must be transported. In designing buildings, great attention must be paid to having uniform construction parameters, such as column distance, span, height, etc.

2.7 Utilities

Since the electricity supply is not sufficiently guaranteed all year round in some localities, a spare diesel generator with a capacity of about 30 per cent of the total power required by the plant is necessary in order to ensure continuity and also the safety of production.

According to local fuel resources, coal, oil, natural gas or electricity may be used for heating processes. Steam will not be used for production. As the amount of compressed air required is not large, a movable air compressor is sufficient. In order to obtain the water required for production and other needs, if no utility water is available, a water pump room, a water tower or a high level water pool should be built, . Drainage problems will be solved on the basis of local conditions.

Business offices and facilities for staff within the area of the plant should be subject to unified planning. The living, welfare, cultural and education facilities outside the area of the plant are the responsibility of local authorities, so the items and cost of living quarters, public dining room, nursery, kindergarten are not included in this programme.

2.8 Production route

The production routes for general products and farm machinery repairs are shown in Figure 10.

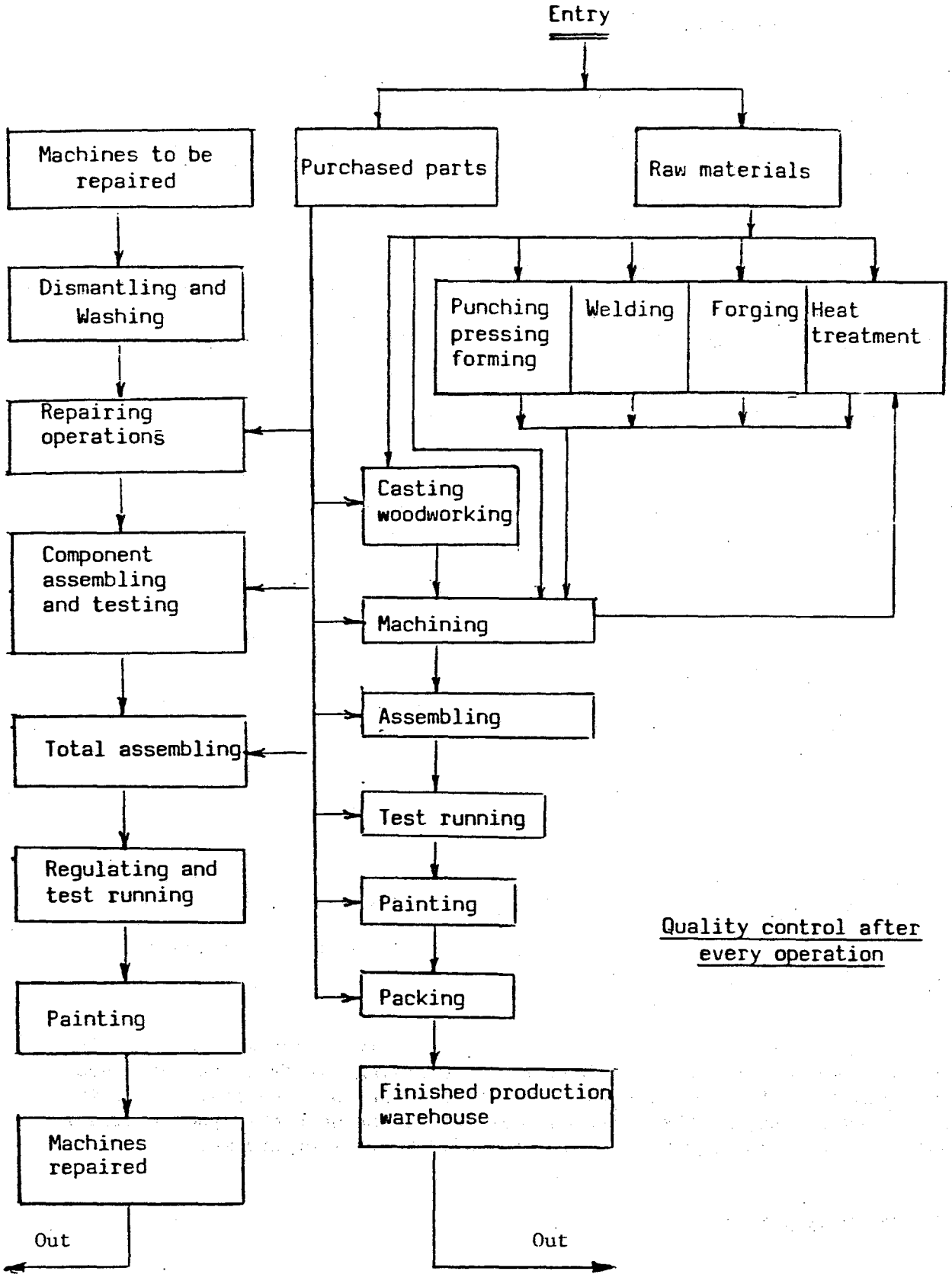


Figure 10. Production route in the multi-purpose agricultural machinery plant

2.9 Plant layout

According to such factors as the organization of production, topography, production procedures, communications and transportation, the possible plans for plant layout are many and varied. Generally, great attention should be paid to choosing the shortest routes for parts and materials transportation and to the possibility of further expansion of the plant.

A sketch drawing of the plant layout is provided on the next page for reference (Figure 11). The reference numbers on the items in the drawing are as follows:

1. Foundry shop
2. Woodworking room
3. Forging and heat treatment shop
4. Punching and welding shop
5. Assembly and testing shop, tooling and maintenance shop, machine shop
6. Agricultural machinery repair shop
7. Power station with power distribution/transformer room
8. Finished products store
9. Supplementary room
10. Office
11. Warehouse
12. Water pump room
13. Stock yard

2.10. Main data for each department of the plant

Because conditions vary widely as to the construction site and plant design, it is impossible to state the figures here precisely. This paper can serve mainly as a study of the interrelations and rough configuration of different units of the plant. The figures given in Table 4 should be taken for reference only.

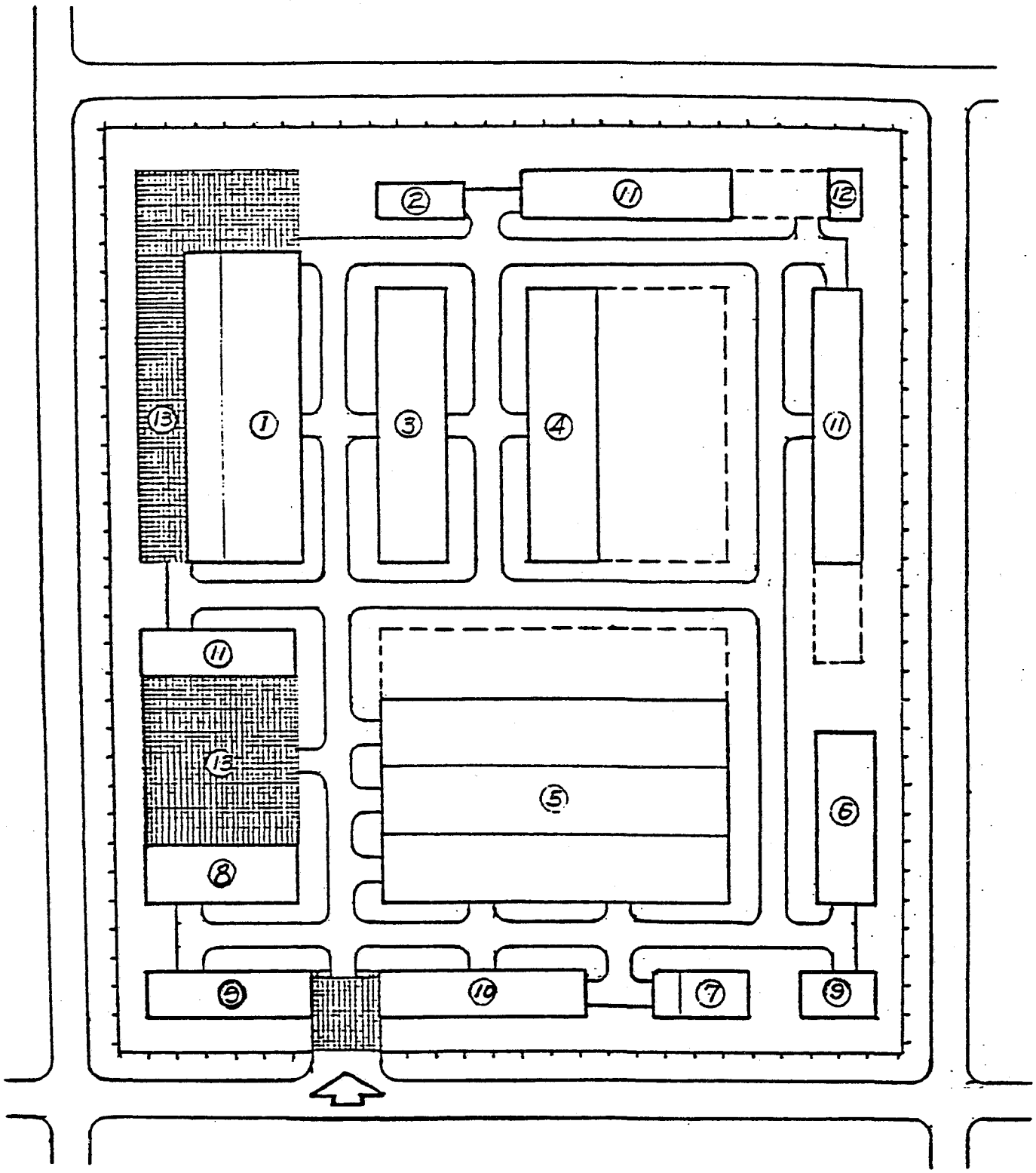


Figure 11. Sketch of plant layout of the medium-sized multi-purpose agricultural machinery plant

No.	Main departments	Main items of equipment	Staff and workers(persons)	Building area (m^2)	Investment (1000 yuan)
1	Foundry shop	13	42	1,000	300
	Woodwork room	5	5	200	80
2	Forging and heat treatment shop	20	35	460	300
3	Punching and welding shop	12	27	500	180
4	Machine shop	32	115	1,000	500
5	Assembling and testing shop	5	35	500	150
6	Agricultural machinery repairing shop	14	30	360	350
7	Tooling and maintenance shop	19	25	360	170
8	Metrological lab.	-	3	60	100
9	Physical and chemical lab.	2	5	60	50
10	Warehouse and transportation	5	20	2,000	320
11	Public facilities	10	13	300	160
12	Management and welfare	-	65	1,500	300
13	Purchased area and factory engineering	-	-	-	240
	Total	137	420	8,300	3,200

Table 4. Main data for each department of the medium-sized multi-purpose agricultural machinery plant

2.11. Main data for the entire plant

Annual output (mixed units of representative products)	5,000	units
Annual production weight (mixed units)	500	tons
Total value of annual production (manufacturing and repairs)	5 million	yuan
Total number of main equipment items	135-140	units
of which: machine tools	40-50	units
forging and punching machines	12-15	units
Total number of staff and workers	400-450	persons
of which: workers	310-340	persons
Total equipment installation capacity	550-600	kw
Site area of the plant	2.0-2.5	hectares
Building area of the plant	8000-8500	m^2
Annual consumption of essential materials	about 1000	tons
of which: steel	about 200	tons
pig iron	about 600	tons
Estimate of capital construction investment (excluding the constructions outside the plant)	3-3.5 million	yuan

II. AN APPROACH TO THE PLANNING OF A SMALL-SIZED MULTI-PURPOSE AGRICULTURAL MACHINERY PLANT

N.B. Some general planning requirements common to multi-purpose agricultural machinery plants elaborated in Annex Part I will not be repeated in Part II

1. Scale and programme of production

1.1. Area served

A small district with a cultivated area of about 30,000 hectares is taken as the area to be served by the small-sized agricultural machinery plant. The plant should be able to produce the main machinery and equipment required in agricultural production and to provide some allied equipment and repair services for rural construction.

1.2. Representative products (Figure 12)

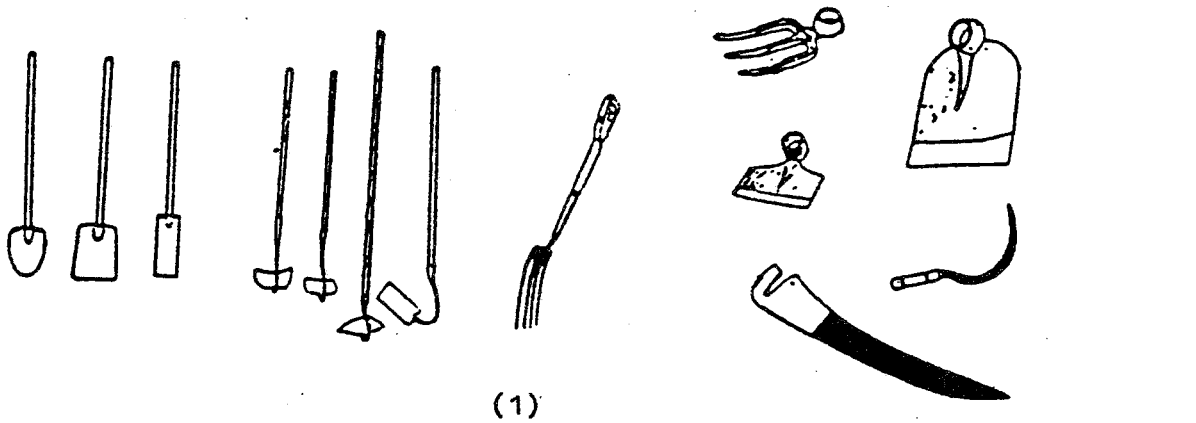
(1) Hand tools
(2) Animal drawn plough
(3) Animal drawn cultivator
(4) Animal drawn planter
(5) Pedal thresher
(6) Small rice mill
(7) Small cotton gin
(8) Corn sheller
(9) Small flour mill
(10) Hand cart (push type)
(11) Hand cart (pull type)
(12) Centrifugal pump
(13) Chain type water lifter by hand
(14) Diaphragm water lifter by hand
(15) Wooden channel water lifter by wind mill

1.3. Repair service

The plant is capable of repairing 60 units of medium and small-sized tractors (including engines) and other kinds of farm implements per year.

1.4. Production programme

The annual production of the plant is approximately 40,000 pieces/units with a total weight of approximately 330 tons.



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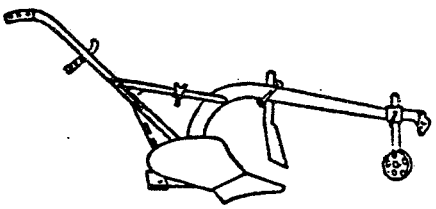

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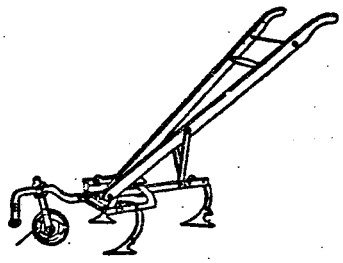

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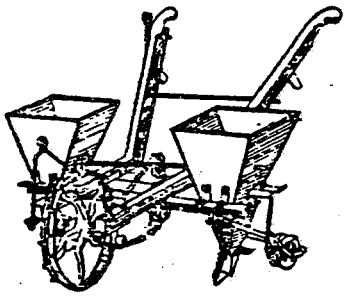

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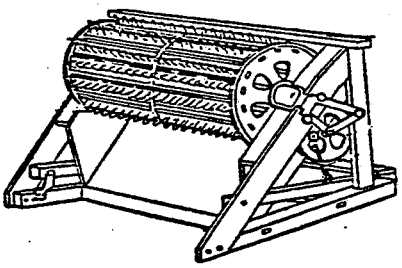

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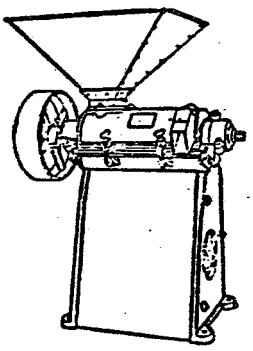

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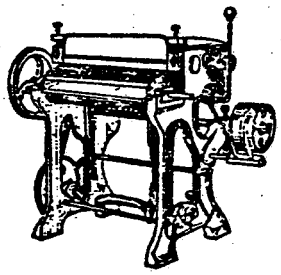

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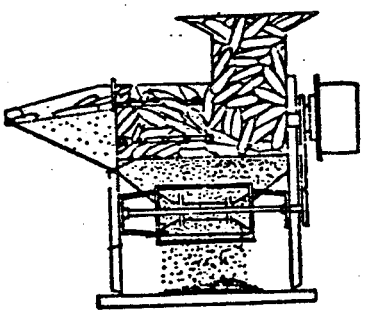

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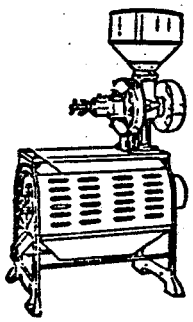

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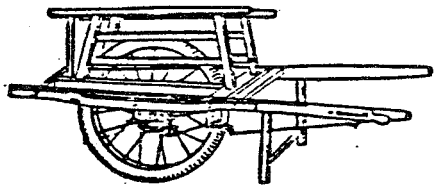
Figure 12. Representative products of the small-sized multi-purpose agricultural machinery plants



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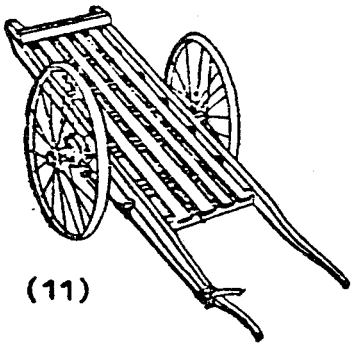

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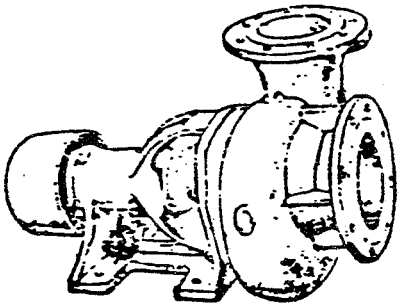

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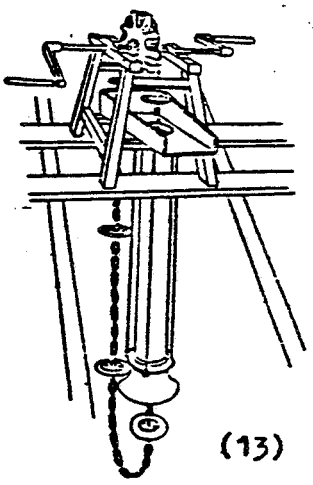

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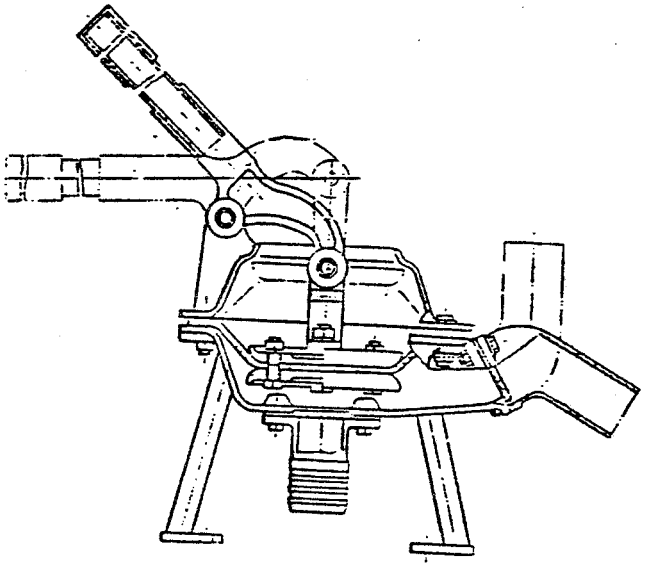

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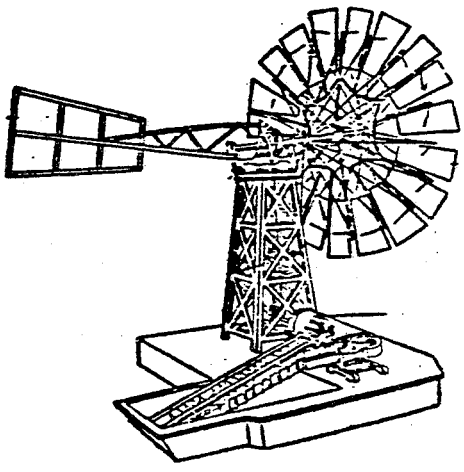

(15)

Figure 12. (continued)

1.5. Value of annual output

The total value of annual output is normally about 2 million yuan, of which the repair service accounts for about 15 per cent.

1.6. Some ancillary components and parts to be purchased

(a) Engines required

(b) Electric motors

(c) Bearings, standard parts such as fasteners, chains, oil seals, etc.

(d) Non-metallic parts made of rubber, leather, plastics, etc.

(e) Nodular cast iron, malleable cast iron

(f) Oxygen for gas cutting.

2. Plant planning

The plant requires well-trained workers who are adaptable and able to: produce hand tools and various animal-drawn implements as well as allied machines with similar materials and manufacturing technologies; maintain and repair products; make necessary prototypes; and adapt the factory production to fulfill changing requirements.

2.1. Production departments

Within the plant, there are 5 main production workshops:

(a) Foundry shop: to produce iron castings and non-ferrous metal castings. There are various working groups in the workshop: for melting, moulding, cleaning, non-ferrous metal casting and woodworking.

(b) Hot working shop: including forging, punching, welding and heat treatment groups for working on products, making tools and repairing machines.

(c) Machine and assembly shop: including various machining operations, assembling, testing and painting.

(d) Farm machinery repair shop: to repair medium and small-sized tractors, various kinds of farm machines and allied capital goods.

(e) Tooling and maintenance shop: to make cutting tools, measuring devices, supplementary holders, jigs, fixtures, patterns, moulds and ordinary equipment; to make accessories for repairing power units, non-standard equipment and transportation devices; to make prototypes; and to do some innovation work.

2.2. Management sections

The plant management consists of the following 6 sections which can either be merged or separated in accordance with specific conditions.

(a) General office

(b) Production planning section

(c) Supply and sales section

(d) Technical section

(e) Personnel and security section

(f) Finance section

2.3. Choice of technology and equipment

(a) Casting: A large amount of grey iron castings are used in making agricultural implements. A small-sized plant should be equipped with a blast furnace with a capacity of 1.5 tons/h; the chamber size of the furnace can be changed according to needs. If necessary, a molten iron ladle can be built in front of the furnace for making large castings.

The common grey iron castings will be made using sand moulds. The white cast iron required in tillers can be made using permanent moulds for chilled casting. The core is man-made and dried in the open air. Sand shake-out and sand mixing are carried out using a combined unit.

A pot furnace with 50 kg capacity must be set up for melting non-ferrous metal to meet the requirements of production and maintenance.

The woodworking group should be equipped with universal machines such as a jigsaw, planer and tenoning machines. Wood must be treated by boiling or natural seasoning.

The annual output of the foundry shop can reach 250 tons or more.

(b) Forging: Free forging and hand forging are used for job or small-batch production. Sometimes stamp forging may be used for batch production. Some large section materials can be formed by press forming after heating. Small-sized plants should be equipped with electric air hammers with capacities of 150 kg and 65 kg, a friction press (160 tons), and a hand-forging anvil.

The annual output can reach 150 tons or more.

(c) Punching: Some sheet metal parts require only cutting, pressing and punching, without any other machining. A combined punching-shearing machine, puching machine (30 tons), three-roller mill and many other shearing and forming tools/die blocks may also be used.

(d) Welding: An A.C. electric welder and gas welding set are required; different types of welding jigs can be used for batch production.

(e) Heat treatment: A box-type electric furnace, and a well-type gas furnace are required for the operations of quenching, tempering, normalizing and carburizing; oil troughs and water troughs for hardening, cooling and low-tempering; and various hardometers for hardness testing.

Approximately 100 tons of parts can be treated per year.

(f) Machining: To be multi-purpose, conventional production technologies and universal machine tools are used; supplementary attachments are used to extend the machining range.

Box-type parts are generally made of grey cast iron, for which a milling machine can perform surface roughing and finishing, a lathe can be used for roughing and precision boring, and a drilling machine can do drilling and tapping. The large box-type parts used for equipment maintenance should be machined on the small size double-housing planer. For special major shaft-type parts or large diameter parts, universal machine tools with some supplementary attachments are used.

Gear hobbing machines may be used for common gear cutting; they should be co-ordinated with the equipment in the tooling and maintenance shop.

The metal-cutting machine tools used in the shop are of small and medium size and of common precision. Large machine tools are provided.

(g) Assembling, testing and painting: Products are generally assembled at fixed tables. Painting parts, components and whole machines could be done by hand spray painting, brush-painting or immersion painting and then dried in the open air.

(h) Farm machinery repairs: A few universal machine tools, an electric welder and gas welders should be provided in the shop for carrying out repairs. Seriously damaged parts of agricultural machines can be repaired in the machine shop or tooling and maintenance shop. Worn out parts should be replaced with new spare parts as far as possible. Stands for testing the hydraulic systems, electric systems and fuel pump systems should also be provided.

Simple, cheap and effective repair techniques such as gluing, brush plating, oxygen-acetylene-powder surface welding, etc., should be used wherever possible.

(i) Tooling and maintenance: The plant should be provided with all necessary equipment for the tool-making and equipment maintenance required for production as well as for making new products and manufacturing special equipment for further expansion of the plant.

(j) Metrology, chemical and physical testing: Common physical and chemical instruments and meters for material checking and for precision measurement checking should be provided.

2.4. Working schedule

Generally, a two-shift workday system is adopted in most machine shops. Exceptions are the assembling, testing, forging, welding, farm machinery repair shops, which usually have a one-shift workday; the heat treatment shop and power station which have a three-shift workday; and the casting and mould-making sections, which vary the work schedule according to production requirements.

2.5. Personnel assignment

Workers are trained to be an "expert in one thing and good at many" to meet the changing requirements of production. The average technical level of workers in the multi-purpose plant should be about grade 4 of the eight-grade system.

2.6. Plant building

Generally speaking, hot workig shops are built independently of the others, while cold working shops are located in one building in order to locate production units close to each other and to reduce the distances over which material must be transported. In designing buildings, great attention must be paid to having uniform construction parameters, such as column distance, span, height, etc. If an existing plant is to be reconstructed, the overall planning should try to make use of the old building as much as possible.

2.7. Utilities

These plants are generally located in rural areas where the power supply is usually difficult. In such cases a stand-by diesel generator with capacity of about 30 per cent of the total power required by the plant should be installed in order to ensure continuity and safety of production.

According to the local fuel resources, coal, oil, natural gas or electricity may be used for heating processes in production. Steam is not to be used. A movable air compressor is sufficient. In order to obtain the water required for production and other needs, a water pump room or a water tower should be built.

2.8. Plant layout

Because of the small production volume, the small-sized multi-purpose agricultural machinery plant should have a greater flexibility in the arrangement of production equipment and facilities. The general principle is to ensure the shortest routes for transportation of materials and parts, and also to consider the possibility of further expansion of the plant (Figure 13).

The reference number on the items in the sketch drawing of the plant provided on the next page is:

1. Foundry shop
2. Hot working shop
3. Machining, assembling, tooling and maintenance shop
4. Agricultural machinery repair shop
5. Finished product warehouse
6. Office and supplementary room
7. General warehouse
8. Power station and distribution/transforming room
9. Woodworking room
10. Pump room
11. Stock yard

2.9 Main data for each department of the plant

The figures in the Table 5 are suggested for reference.

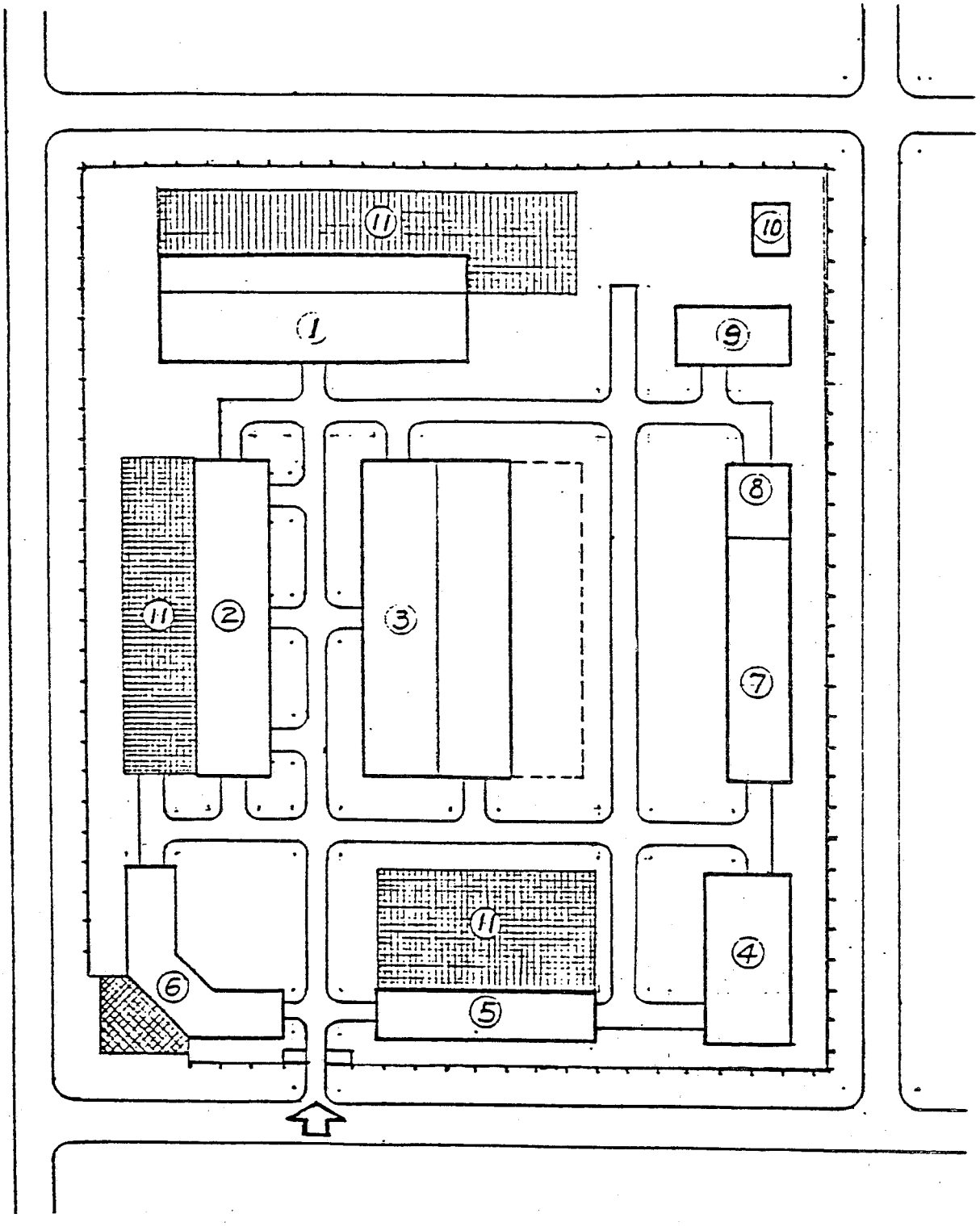

Figure 13. Sketch of plant layout of the small-sized multi-purpose agricultural machinery plant

No.	Main departments	Main items of equipment	Staff and workers (persons)	building area (m^2)	Investment (1000 yuan)
1	Foundry shop	8	20	600	200
	Woodwork room	4	4	120	50
2	Hot working shop	20	25	600	290
3	Machining-assembling shop	25	60	1000	400
4	Agricultural machinery repairing shop	15	18	300	150
5	Tooling repairing shop	10	15	300	240
6	Metrological laboratory	-	1	50	80
7	Physics-chemistry laboratory	2	2	50	40
8	warehouse and transportation	5	8	1200	180
9	Public facilities	5	8	300	100
10	Management and welfare	-	28	1000	160
11	Purchased area & factory engineering	-	-	-	210
	Total	94	189	5520	2100

Table 5. Main data for each department of the small-sized multi-purpose agricultural machinery plant

2.10. Main data for the entire plant

Annual output (mixed units)	40,000 pieces/units
Annual production weight (mixed units)	330 tons
Total value of annual output (manufacturing and repairs)	2 million yuan
Total number of main equipment items	90-100 units
of which: machine tools	30-40 units
forging and punching machines	10-13 units
Total number of staff and workers	180-200 persons
of which: workers	140-160 persons
Total equipment installation capacity	400-450 kw
Site area of the plant	1.2-1.8 hectares
Building area of the plant	5000-5500 m^2
Annual consumption of essential materials	about 400 tons
of which: steel	about 150 tons
pig iron	about 200 tons
Estimated capital construction investment	2 - 2.2 million yuan