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Promotion of the Multi-purpose Approach to the Manufacture of Agricultural Machinery and Other Related Capital Goods

Contribution to the elaboration of General Guidelines for the Strengthening/Implementation of Multi-purpose Agricultural Machinery Plants in Developing Countries

by

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UNIDO consultant

31,88

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1. Introduction

Discussing the promotion of multi-purpose plants to develop the manufacturing of agricultural machinery and other capital goods in developing countries shows the difficulty and maybe the impossibility of having similar solutions in all these countries. Indeed, the very different size, resources, climate, socio-economic systems, degree of development, etc. make it irrealistic to propose the same solution for Cyprus and Indonesia in Asia or Togo and Algeria in Africa, for example. However, common factors for the development of agriculture and industry exist as the majority of these countries have serious problems to feed their population, to produce basic equipment and machinery in sufficient quantity, reasonable quality, at competitive cost and to manage efficiently their economy. The concept of multi-purpose industrial plants to produce diversified equipment in order to provide as much as possible of the needed equipment and capital goods at competitive cost will be discussed in this report.

The multi-purpose plants should take different forms according to the specific local conditions. They will vary by their size, means of production, category of products, production technology, degree of co-operation with other local industrial facilities, ownership system, management system, dependency on local or imported technology etc.

The following discussion will try to analyse different situations and to propose general guidelines. However, it should be stated very clearly that the realistic and feasible approach is to analyse the sectorial situation in each country and then to define short/medium-term practical arrangements and measures with institutions and specific industrial plants which enable the strengthening of existing facilities already active in the design, production, distribution and utilization of agricultural machinery and capital goods. Following such activities, thorough case-by-case studies should be carried out for each plant to resolve the managerial, administrative, technical, commercial and financial problems and/or to propose the strengthening of the existing plants or the creation of new units. UNIDO has prepared and published a relatively large number of studies which could be utilized for the general discussion and the formulation of preliminary proposals which should be followed by in-depth studies related to each case.

One of the main objectives of all developing countries is to develop the agriculture in order to feed their population. The realization of this objective requires the development of the utiization of agricultural machinery. However, this raises a series of questions of which the following are the most important:

- degree of mechanization;
- type of machinery;
- source of machinery: local/imported;
- type and location of manufacturing plants: specialized/multi-purpose plants, rural/urban location;
- way of developing the local market of agricultural machinery: protection, holiday taxes, subsidies, financing schemes for purchase of equipment, fertilizers and pesticides by farmers, extension services, pricing policy of agricultural products, etc;
- promotion of design, R&D and testing engineering centres.

The right answers to such questions should vary largely from country to country according to the different conditions of soil, climate, crops, farming system, energy situation, volume of the market, available infrastructures and facilities, human resources, industrial situation, political and economical system and situation. Any proposed guidelines to develop the utilization and the local manufacturing of agricultural machinery will be only indicative and should be adapted to the specific situation of each country. The following discussion may represent the salient points to be taken into consideration when planning the development of agricultural machinery utilization.

2. Degree of mechanization and type of machiney

In all developing countries, tractors over 30 HP are utilized to some extent. However, this utilization is often characterized by a very low capacity utilization factor, mainly due to a non-efficient management resulting in a lack of spare parts, poor repair and maintenance situation and which could not be explained only by a lack of repair and maintenance facilities and adequate training personnel. Very often reasonable repair and maintenance facilities, spares inventory, technicians and skilled workers are available but this "wealth" is wrongly utilized. This phenomenon should be tackled case by case to make the system working.

Utilizing large tractors is adequate for large farms of cereals, cotton, potato and soya but it is not adequate for small farms for the same crops if a suitable system of co-operatives or renting organisms is not available. Also large tractors are not suitable for a certain type of soil and crops.

The economical utilization of large tractors requires a minimum number of working hours per year and this could be partly resolved by a multi-purpose utilization of the tractor: transport, powering irrigation pumps, mills, harvesters, threshers, etc. However, utilizing a large engine of 60 HP for example to power a machine of 5 or 10 HP results in a bad economical utilization of the tractor: high specific consumption of fuel (g/horse power-hour) and wearing. In addition to a high investment which the financing capabiity of the potential users could not often meet.

The two-wheel tractor, also called hand tractor, walking tractor or power tiller, is largely utilized in several Asian countries: India, Thailand, Philippines and Indonesia. This power tiller is equipped with a Diesel engine 4-12 HP but generally with 6-8 HP at 2200 RPM. Sometimes it is equipped with a gasoline engine. It could represent a very good solution to small farms of 3-10 Hectares; it could be adapted for different types of soil and for different utlizations such as: working the soil, planting, seeding, distributing fertilizer and manure, harvesting, threshing, shelling, milling, irrigating and transporting. The equipment/implement could be attached directly to the tiller, or powered through a belt and pulley. The engine may also be disassembled and used as a stationary prime mover. This multi-purpose utilization makes the power tiller often feasible, even for small farms in the range of 3 hectares. However, the feasibility of the power tillers is conditioned to a large extent by a reasonable selling price, availability of repair and maintenance facilities in the area, high capacity utilzation factor, reasonable cost of energy and financial arrangements enabling its purchase with other relevant implements and machinery by the farmers.

Thailand, for example, has produced about 60,000 power tillers in 1984 against only some thousands in Indonesia where the country is larger and the local needs are at least equal to those of Thailand. This may be explained by higher cost of equipment, slightly lower purchasing power, lower financial arrangements and less extension services.

In Africa, power tiller utilization is rather inexistent due to non-local manufacturing, high prices and not enough interest of the local authorities and the testing centres.

The heart of a small mechanization is an engine in the range of 4-12 HP and the question is what type of engine is the most adequate for developing countries: Diesel or gasoline, 2 or 4 stroke. Without going in a detailed comparison between a Diesel and a gasoline engine, it could be stated that a Diesel engine is more robuste, it has a longer life time and it consumes less fuel. However, it is much more expensive than a gasoline engine having the same power (3-4 times more). For example, a 5 HP gasoline engine is sold in Austria in the range of US$ 120 tax-free.

Regarding the two-stroke engine compared with the conventional four stroke engine, its main advantages are a smaller weight for same horse-power and speed and more simplicity of constructin and repair. However, its specific consumption is higher and lube oil should be mixed with the fuel in a certain proportion.

When the working hours per year are not high and gasoline could be procured and stored in safe conditions, the utilization of power tillers equipped with gasoline engines could be envisaged economically for the following reasons:

- smaller weight;
- smaller investment: a limiting utilization factor for small farmers;
- more popularity (mechanics in rural areas who have been linked in general with car repair know better how to repair a gasoline engine than a Diesel engine).

However, an in-depth study should be undertaken by the local authorities (extension services, testing centres, etc.) in order to advise the farmers on the conditions of such utilization.

Implements and agricultural machinery could be classified in several ways; for our discussion the following will be adopted:

(simple) Hand tools: hoe, machete, spade, weeder, knife, sickle, axe, pick-axe, shovel etc.

Manually-operated equipment: pedal thresher, hand sprayer, corn sheller, cassava puller and chopper, hand pump, chaff cutter, storage bins etc.

Animal-drawn implements: plough, cultivator, leveller, ridger, seeder and fertilizer drill, pump, sugar-cane crusher, reaper, cart etc.

(intermediate) Tractor-drawn basic implements: plough, cultivator, harrow, leveller, seed drill, reaper, trailer etc.

Simple, low-cost low-power equipment: power thresher, pump, chaff cutter, corn sheller, peanut decorticator, rice mill, hammer mill, power tiller, low-power engine etc.

(standard) Power-operated equipment: tractor, pump, harvest and post-harvest equipment.

The feasibility of utilizing each type of the above-mentioned equipment varies from a developing country to another; however, the following comments may be made:

- It is desirable to promote the local manufacturing of simple and intermediate equipment which meets to a large extent the needs of local agriculture.
- Animal-drawn implements should not be rejected automatically as a backward means of developing agriculture. In countries or parts of countries, where the availability of energy constitutes a problem, a reasonable share of the needed energy may be substituted economically by animals.
- Manually or pedally operated equipment: The manufacturing of this type of equipment should be promoted in the short and medium term. It is of low cost, but also of low capacity, and may resolve the problems of very small farmers in their seasonal activities (threshers, shellers, decorticators, sprayers etc.). It constitutes a good solution in a large number of African countries.
- Low-power equipment: Manufacturing and utilization of this type of equipment should be largely encouraged. It is generally adequate for small farms (the major part of the farming system in developing countries); it could be utilized economically, particularly when connected to a power tiller. A well-established technology exists already for different applications: soil working, fertilizing, seeding, planting, pre- and post-harvesting. This technology has been originally developed in India and the Philippines and is now popular in other countries, such as Thailand, Indonesia and Malaysia. Its adaptation to African conditions does not represent a serious difficulty and its utilization constitutes to a large extent a right solution for the major African needs.
- Large tractors and tractor-drawn basic implements: The feasibility of manufacturing tractors over 30 HP in developing countries should be studied very carefully. However, except in very large countries with adequate existing industrial infrastructure, such projects could not be feasible in the short and medium terms. Manufacturing tractor-drawn implements should be encouraged, since the degree of complexity is not very high and the production costs may be competitive.

3. Source of machinery, type and location of manufacturing plants

The limited market in the majority of small and medium-size developing countries does not make it possible to envisage the implementation of very specialized plants in the area of agricultural machinery. The diversification of the production seems as the unique opportunity to starting and/or surviving of plants active in this field of production. The findings of the mission of the consultant in Cyprus and Kenya (refer to Chapter on Findings) show that the plants which are diversifying their production are generally achieving good results. Diversifying the production requires the establishment of multi-purpose plants capable of producing by batches different types of equipment. UNIDO has prepared and published several studies in this field which discuss th problems in detail. Among them are the following:

- Appropriate industrial technology for agricultural machinery and implements, ID/232/4, December 1979, 159 pages.
- Appropriate industrial technology for light industries and rural workshops, ID/232/11, May 1980, 155 pages.
- Metal production development units (MPDU), ID/271, July 1982, 69 pages.

The concept of multi-purpose plants is very wide and depends mainly on the products to be manufactured at competitive cost. It could go from a simple plant with some conventional machine tools, metal forming machines, welding equipment, preliminary forge and heat treatment facilities and a small foundry with an investment in the range of US$ 200,000, for example to a large plant with sophisticated and heavy duty machine tools, modern pressing and forging units, mechanized foundry for pieces of several tons and different kinds of casted metals, well-equipped quality control unit, etc. with an investment of several millions of US$. A well-prepared feasibility study will identify the products and the adequate technology in the light of the local situation. However, a workable approach may be schematized as follows: After identifying the tentative local needs quantitatively and qualitatively in the short and medium terms (such studies exist already in a large number of developing countries), feasibility studies will be prepared taking into consideration the following factors:

- Minimizing the investments by maximum utilization of existing infrastructure, other industrial facilities and in particular making optimal use of sub-contracting services;
- Starting and/or increasing the production of small-powered agricultural machinery;
- Utilization of already developed machinery by international/regional institutions, such as IRRI and eventually co-operation with similar institutions and industrial plants in other developing countries;
- Maximizing the locally manufactured equipment, parts and components; however, this should apply only if the locally produced equipment, parts and components are of competitive production cost or going to be competitive in the short term. The selling price should be comparable or only slightly higher than in the other countries. The argument of establishing agricultural machinery industry to create jobs regardless of the interest of the farmers should be avoided;
- Cast iron foundries should be included in the multi-purpose plants only if the volume of production justifies such arrangement or if no adequate casting facilities are available in the country (examples: Guinea, Togo). However, non-ferrous casting facilities may be eventually included in the project as the investment may very low. In countries such as Cyprus and Kenya, equipment for such facilities is in-house built and used lube oil is often utilized as fuel;
- In case of including a cast iron foundry in the project, the moulds and the cupolas may be locally built. For example, a 60 cm internal diameter cupola (about 2 tons/hour theoretical capacity) costs about US$ 2,000 in Kenya. Rudimentary low-cost small cupolas may be built with used fuel barrils (such cupolas have been built in a UNIDO-assisted project in Nigeria) and they can serve in the rural areas for small annual productin of pieces not requiring special mechanical characteristics;
- Electrical energy is a "noble" energy and its production is generally expensive (the global efficiency of converting thermal energy into electrical energy and the transport and distribution of electricity is generally in the range of 15-20 %). The utilization of electric furnaces should not be encouraged if cupolas or oil furnaces could meet the required characteristics. Also drying ovens heated by electrical energy should be avoided as much as possible;

- Metal cuttings could be utilized to manufacture some products, for example, in a Kenyan firm the cuttings of the sheets serving to produce shovels are utilized to manufacture pad-bolts and hinges;
- Scrap should be utilized as much as possible in preparing the feed for cupolas and furnaces. Also certain scraps could be utilized economically and in some cases systematically in manufacturing low-cost agricultural machinery and rural transport equipment;
- Repair activities may be considered as a part of the multi-purpose plants when this is needed in the area and/or when this improves the feasibility of the project;
- Manufacturing spare parts should be positivly considered as a part of the multi-purpose plant;
- Manufacturing and repair by the industrial multi-purpose plants of their needed jigs, fixtures and dies for the production operations should be one of the main objectives. This should be done independently or in co-operation with other local plants.
- When planning a multi-purpose plant, utilization of preliminary non-expensive NC machines should not be excluded before thorough studies, if a large number of similar pieces are to be produced;
- Also, the utilization of multispindles machines and/or semi-automatic machines should be analylsed when considering the manufacturing of a large number of similar pieces;
- Extendible and flexible lay-out should always be considered when planning multi-purpose plants;
- The production of foreign patented equipment may be considered only for complicated equipment if simplified equipment having reasonable efficiency and robustness could not be achieved locally. In any case, robustness, life-time and efficiency should not be sacrificed under the pretext of encouragement of locally made machinery. Stopping a machine for some days during the planting or harvesting operations for example may result in damage to the farmer much more expensive than buying an expensive machine. Also, the efficiency of powered equipment should be given high consideration as this influences largely the energy bill. For example, an axial flow pump similar to the type developed by IRRI and produced now by

thousands per year in the Philippines, Thailand and Indonesia, needs about 4 HP. Assuming that this pump will run about 2000 hours/year, this means a gas oil consumption in the range of 2000 kg/year. Improving the efficiency by, e.g. 10 per cent, will result in saving 200 kg of gas oil per year or about US$ 100 (this depends on the local cost of energy). If the life time of this pump is 10 years, this means a saving of US$ 1000 which is much more than its purchasing price;

- Standardization of equipment should be encouraged and the locally manufactured products should be conform with the standards. Countries not yet having local standards for agricultural machinery (this is the case of the majority of African countries) may adapt temporarily standards of other developing countries which are generally less difficult than those of developed countries. However, ISO standards should be utilized to the maximum extent. Available testing facilities in technical ministries and engineering colleges should be utilized. This will improve the capacity utilization of these facilities and economise on new investments.
- The Regional Network of Agricultural Machinery (RNAM), Economic and Social Commission for Asia and the Pacific (ESCAP), has started the publication of a series of test codes and procedures for farm machinery. These codes may be adopted in other developing countries. Test codes and procedures for ploughs are given in the annex as example;
- The size of multi-purpose plants depends mainly on the volume and specificatins of the products. In large countries, such as China for example, the optimum size of the plant (which should not exceed a certain level) leads to have a large number of plants and this will influence the geographical location. In small countries, where only one plant could be envisaged in th short/medium term, the location will be selected according to the availability of industrial infrastructure, manpower and supporting facilities/institutions.

  The transport of end products may not constitute a decisive factor;
- The equipment of a multi-purpose plant should be selected according to the products to be manufactured and to the production technology. This has been discussed in the above-mentioned UNIDO publications and an in-depth study should be carried out in relation with each specific project;

- Successful diversification of production in a multi-purpose plant depends mainly on the local market, the production facilities and the final production costs. The production operations may be roughly grouped into: metal forming, forging, heat treatment, welding, casting, machining and finishing. The specifications of the products (degree of complexity, dimensions, tolerances, materials etc.) enable the identification of agricultural machinery, capital goods and spare parts which may be produced by a plant. Indeed, only the market conditions and the resulting production costs are the decisive factors. The concerned firms are finding through their local experience the new equipment and products which could be added to their current products. The institutions concerned by the design, testing and promotion of agricultural machinery and capital goods should assist them by providing preliminary or final designs of prototypes with enough information and the adequate technology to produce such prototypes.

When diversifying the production, the local plants should study carefully the local possibilities of subcontracting the components which they cannot produce or of which the in-house production cost is high. The avaiability of other tooling and machining facilities in the area is favourable to the enlargement of the range of machinery which could be produced economically.

A main concern when manufacturing agricultural machinery is the production costs in which the purchasing price of raw and semi-finished materials and components constitutes often a major part. Unfortunately, in African countries, the cost of such materials is often very high which results in a high production cost of locally manufactured products and this, along with the very low purchasing power of the farmers, hinders to a large extent the development of utilization of agricultural machinery. Several approaches may be made to correct this situation. Among the possible solutions is the establishment of a common body (inter-professional or governmental) on a commercial (and not bureaucratical) basis to make the procurement of the main materials/components. UNIDO may play a very positive role in providing practical information on the sources and prices of raw materials and components utilized in the production of different types and sizes of agricultural machinery. This type of information may include also the machinery and equipment utilized in the multi-purpose plants.

Engines are the main components of the agricultural mechanization, they are produced in various large size developing countries, such as Brazil, Argentina, India, Thailand, Indonesia. Other developing countries are planning also the manufacturing of gasoline and Diesel engines.

Manufacturing small gasoline engines of a fraction to 12 HP in small and medium-size developing countries seems too difficult to be feasible. These engines are produced in very large series in developed countries with a relatively small production cost. For example, a 5 HP gasoline engine is sold in Vienna for about US$ 150 (sales tax not included). It is very difficult to imagine that in the present situation an African, Middle East or small Asian country could produce such engines in this price range.

Regarding Diesel engines which are produced generally in smaller series, they are already under manufacturing (refer to the Chapter on Findings) in Thailand and Indonesia. The production cost in Thailand in the Japanese joint venture Cubota plant is only slightly higher than the export price of Japan. This can be explained by the relatively large market: 40,000 units per year, the importance of the locally manufactured part of the components (about 70% of the engine), the existing reliable industrial facilities in the country, the low cost of manpower, the availability of reasonable training facilities, the efficient after-sales service, the very modern assembling factory built by the Japanese joint venture and the reasonable level of investment. In Indonesia, the Japanese firm Yanmar has established a joint venture in 1973, the production cost for similar products is about 20% more than in Thailand.

In the light of these two examples it appears that manufacturing Diesel engines in small and medium-size developing countries could not be feasible under the present conditions and in any case such plants should be established as a joint venture with a reputable international firm after preparing a serious feasibility study and negotiating equitable transfer of technology conditions. Pending having, in a near or a medium-future, favourable conditions for local production of Diesel and gasoline engines, developing countries should arrange for the procurement of their needs from one or two international firms with the conditions of establishing a repair and maintenance network through the country and providing spare parts at reasonable prices.

The idea of establishing sub-regional/regional projects to produce items needing a large market is good and desirable, however, their implementation is rather difficult. The difficulty of taking decisions on time, the exaggerated overheads caused by the cost of the representatives of the different countries participating in the project, the higher cost of workers, technicians and managers who are not from the country in which the project is established, etc. will increase the production cost and may lead to the non-functioning of the project.

4. Development of the local market of agricultural machinery

Developing the utilization of agricultural machinery requires:

- Availability of machinery adequate to the climatic, soil and crop conditions;
- Reasonable acquisition prices of agricultural machinery within the purchasing capability of the farmers and availability of financial arrangements to enable the farmers to buy the needed machinery, fertilizers and pesticides;
- Availabiity of spares and repair facilities;
- Equitable prices and immediate cash payment against the delivery of agricultural products to governmental agencies when this applies;
- Adequate extension services to the farmers and to the local manfuacturers.

The government should encourage the production of certain crops which are needed to feed the population rather than the crops destinated for export. This encouragement may be done through an equitable price policy, the promotion of utilization of an adequate technology going from preparing the soil till the post-harvesting activities including financial arrangements to acquire machinery, fertilizers and pesticides.

The Government may also promote the production of agricultural machinery by making available and disseminating adequate technology for producing agricultural machinery at competitive prices and this requires among others:

- Very low taxes on raw materials and components utilized in the manufacturing of agricultural machinery;
- Organizing training programmes in the concerned industrial areas for different categories of personnel.

5. Promotion of engineering centres

The development of manufacturing of agricultural machinery and capital goods in developing countries requires very often external assistance to the existing industrial plants by public, semi-public or inter-professional bodies. The assistance could be done in one or more of the following activities: identification of the problems (managerial, technical, commercial financial, training) faced by the plants and elaboration of adequate solutions, identification of new products which may be added to the present range of products, providing detailed technical data and drawings of the proposed new products, obtaining equitable conditions of supply of equipment, material, know-how and subcontracting services, testing, etc. The assistance on the national level could include identification of new projects, feasibility studies, negotiation of contracts with foreign firms, design supervision and commissioning of industrial projects, linkage between R and D activities and the industry.

The above-mentioned bodies could take various names and forms: Industrial Research Centres, Technological Centres, National Consulting Centres etc. These institutions could be public, semi-public, interprofessional etc. A country could have one or more of these centres, they could be linked directly to the Prime Minister or a Minister. They could also be linked to a Ministry. The activities could be general or specialized; services could be free of charge or against payment. As example of the organization of such institutes, the following extracts give basic information on the Kenya Industrial Research and Development Institute (KIRDI) and on an Engineering Industry Development Institute (EIDI) to be established in Thailand with Japanese assistance.

As a positive example of the type of extension services which such institutions could provide, the following extract from a brochure prepared by the Industrial Service Institute in Bangkok, Thailand, on power tillers gives the kind of practical information which could serve efficiently the potential manufacturers. However, such brochures should give, when possible, the dimensions and tolerances of the different components.

Based on the findings of the mission and on the above examples, it appears that the situation of each country and industrial sector in a country snould be studied case by case and no general solutions could be found. However, in the case of countries where such centres do not exist, it is highly recommendable to start from an existing core and to strengthen this core which may be reorganized (splitted) later on when the volume of work and the variety of activities justifies such reorganization. A reasonable core for creating such institutions may be a faculty of engineering, a polytechnic, a high technical training centre, an industrial laboratory. In general, such institutions have a reasonable number of qualified engineers, technicians, economists, draughtsmen. In general they also have some design, workshops and testing facilities. Starting of such institutions will enable the launching of a project in a very short time, to save on the cost and to utilize in a better way the existing national capabilties. It is not possible to propose an organigramme or a type of management for such institutions; this depends on the specific conditions of each country. As a general guideline it could be said that such institutions should have some kind of autonomy and that the different institutions concerned, government bodies, inter-professinal organizations etc. should be represented in the board of directors or at least participate in the definition of the strategy, the policy and the plan of action of these centres.

THE INSTITUTE

The Kenya Industrial Research and Development Institute (KIRDI) is a parastatal organisation established by the Science and Technology Act Cap. 250 of the Laws of Kenya. KIRDI's predecessor, the East African Industrial Research Organisation (EAIRO) grew from a central laboratory, set up in 1942 for the purpose of initiating and developing industries to relieve shortages brought about by the second world war, and originally administered by a board called Kenya Industrial Management Board (Kimbo). It was later administered by the East African Community, after whose demise, in 1977, EAIRO was incorporated as a department in the then ministry of commerce and industry.

LOCATION

KIRDI is situated in the industrial area of Nairobi (at the junction of Dunga Road and Lusaka Road), opposite the Car & General tyre retreading plant.

FACILITIES

KIRDI consists of laboratories for chemical analysis and research, pilot plant scale facilities, a workshop, an industrial library, stores and offices.
The institute carries on research under the following divisional organisation:-

Analytical and Testing Division

- Provides analytical and testing services to private manufacturing industries, parastatal organisations and government ministries.
- Undertakes research with a view to devising new analytical methods and/or modifying existing methods to suit local conditions.

Design and Engineering Division

- Develops indigenous designs of equipment, machinery and products. Advises on the improvement and development of industrial machines and equipment.
- Conducts laboratory studies aimed at creating products from local materials.
- Designs and operates laboratory pilot plants.

Process and Product Development Division

- Conducts laboratory studies on the improvement and development of industrial processes and products.

Project Studies and Development Division

- Studies market factors (including pricing and distribution) of industrial products. Undertakes economic/statistical analyses of industrial projects.

SERVICES TO MANUFACTURERS AND PROSPECTIVE ENTREPRENEURS

At a nominal fee, the Institute provides industrial entrepreneurs with the following services which can be divided into two categories.

- **(a) Consultancy Services**
  1. Physical and chemical analysis (raw materials, products, effluents, etc).
  2. Technical information.
  3. Economic studies and evaluations (of industrial projects).
  4. Trouble shooting.
- **(b) Research and Development**
  1. Product development and rationalization.
  2. Process development and rationalization.
  3. Materials research and development.
  4. Feasibility studies.
  5. Training.

The contribution of KIRDI has mainly been directed towards the optimal utilization of local resources in industrial development.

Some of the major programmes undertaken by the Institute in the past include:

Vegetable, fruit and oil seed processing; suitability of clays and stones in the manufacture of ceramics and building materials; design of various process equipment; and utilization of industrial wastes.

For further information, contact

The Director,
KIRDI,
P.O. Box 30650, (Phone 557762/557988)
NAIROBI.
Cable Address "REDEV".

The following photographs show a cross-section of the institute's activities:

2. DETAILS OF THE PROJECT

2.1 Program Goal

In order to develop small and medium-scale engineering firms (SMIs) and to activate the linkage between SMIs and large-scale firms, the government of Thailand, through DIP, is planning to establish a governmental organization aiming at re-education and training of firm's veteran engineers, skilled technicians and entrepreneurs, in particular, of small-and medium-scale industries.

The organization will be provisionally named "Engineering Industry Development Institute" (EIDI).

The main goal is to re-structure the engineering industry for higher production efficiency with emphasis on improving and developing technologies for small-and medium-scale engineering industries both in central and regional areas.

2.2 Project Objectives

The objectives of the Engineering industry Development Institute (EIDI) are as follows:

1) In accordance with the National Development Plan, the instutute will support and assist the technological and managerial improvement of small-and medium-scale industries which should support the industrialization of Thailand. For this purpose, the institute will hold seminars and training courses for backbone engineers, veteran technicians and entrepreneurs, and also will execute extension rounding services for small-and medium-scale enterprises.

DIP
Department of Industrial Promoting
Ministry of Industry

2) The institute will be equipped with some production facilities and equipment such as foundry shop, forging and heat treatment shop, sheetmetal and welding shop, plating shop and machining shop. These facilities are used mainly for three purposes, they are ; practical training of machine operation, entrusted jobs from private firms and trial production. The entrusted works will be one of supporting activities for the small and medium-scale enterprises.

3) The institute will also carry out researches and development of appropriate products, production technologies, marketting and managerial technologies etc. And the fruits of studies will be distributed to the privated sectors.

4) The institute will play a role as a technical information center of the country, that is, engineering informations like reports, papers and books will be collected from domestic and foreign countries and some of them will be translated into Thai language and distributed to the private sectors.

5) The institute will be a centre for co-ordination with other organizations both in government and private sectors in relation to the engineering industry development programmes.

2.3 Conditions Expected at Completion of the Project

The institute, when fully operated should be able to:-

1) Facilitate training courses for veteran engineers, skilled technicians and entrepreneurs of small-and medium-scale engineering industry especially in the field of metal-working industry.

2) Conduct 40 workshop/training courses a year for approximately 1200 participants, and to educate interested parties by organizing seminars or by demonstrating/showing some interesting topics on engineering industry field monthly.

3. Provide extension services on a firm-by-firm basis to 12 small-and medium-scale engineering firms annually, and to provide consultancy services to entrepreneurs and interested parties.

4. Provide services on testing, inspecting, designing and experimenting for engineering industrial sectors in the areas which will help increasing production efficiency.

5) Undertake the research work and trial production in accordance with the need of the small-and medium-scale engineering enterprises.

6) Serve as the co-ordinating center to exchange and disseminate the information among institutions and agencies both inside and outside of Thailand and encourage the linkage between SMIs and large scale firms.

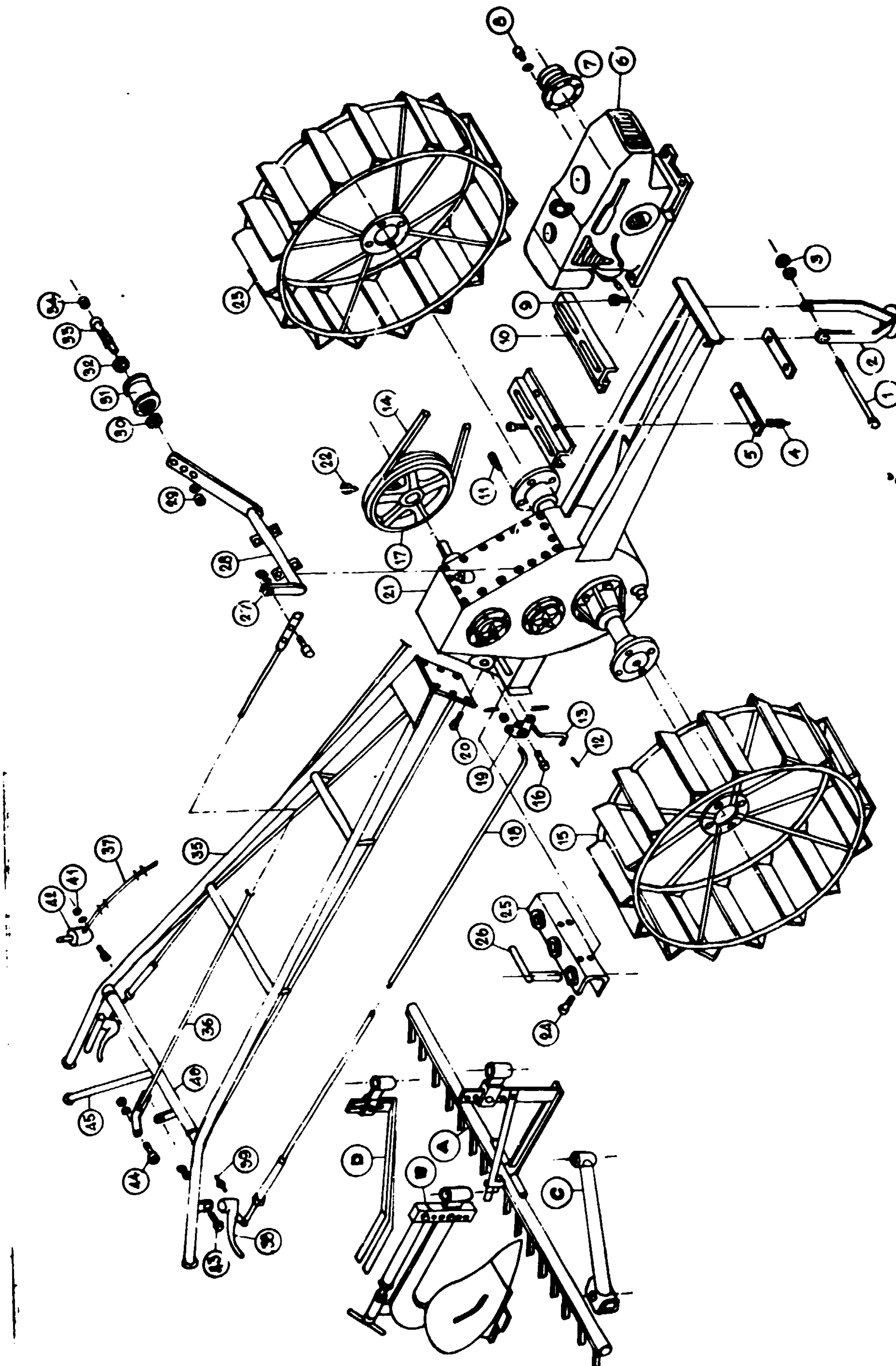

Fig. 1: แสดงส่วนประกอบแยกชิ้น
รถไถเดินตาม รุ่น JPT 4 (TKS 004)

Fig. 7. แผนผังส่วนประกอบแยกชิ้น

รถไถเดินตาม รุ่น JPT 4 (TKS 004)

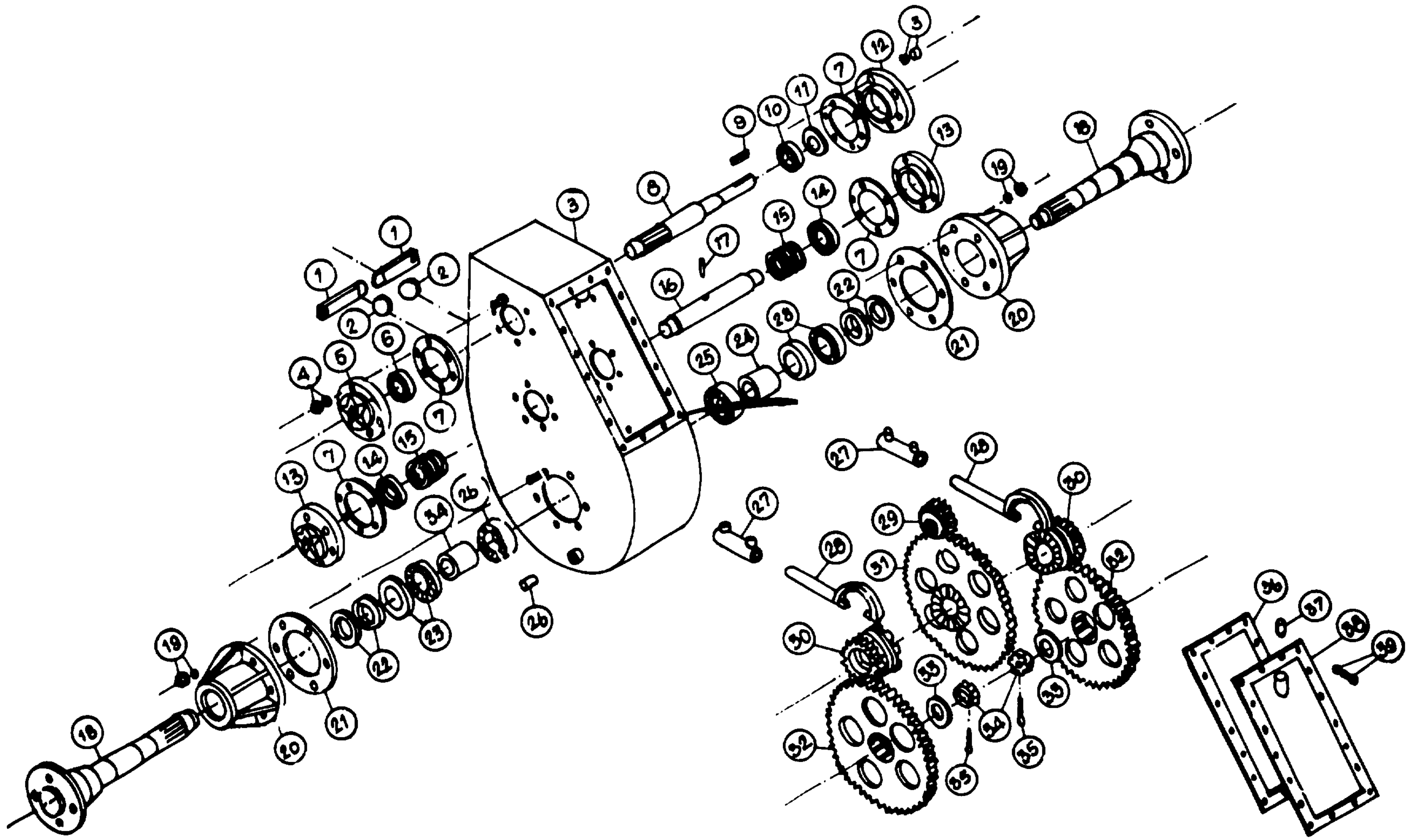

Fig. 2

Table 1: Components and Activities

Component and Description	No. Required	Material & Supplied	Activity
1. Clush shifting lever	2	sheet steel/ import	E
2. Seal	2	local sup.lied	K
3. Gear box	1	sheet steel	A
4. Bolt Nut washer	24	local supplied	K
5. Bearing housing	3	local supplied	D
6. Ball Bearing No. 6206	1	import	K
7. Gasket	4	local supplied	I
8. Input shaft	1	bar steel import	B
9. Key input shaft	1	" do "	F
10. Ball Bearing No. 63)5	1	import	K
11. Seal	1	local supplied	K
12. Bearing housing (Input, left)	1	" do "	D
13. Bearing housing (Intermediate)	2	" do "	D
14. Ball Bearing No. 6306	2	import	K
15. Compression spring	2	import	K
16. Intermediate shaft	1	bar steel import	B
17. Lock bolt	1	local supplied	K
18. Wheel axle	2	bar steel import	B
19. Bearing hub Bolt & Nut	12	local supplied	K
20. Bearing hub	2	" do "	D
21. Gasket	2	" do "	I
22. Seal	4	" do "	K
23. Balls bearing No. 6208	4	import	K
24. Thrust sleeve	2	bar steel import	G
25. Ball bearing No. 6308	2	import	K
26. Drain plug	1	bar steel import	G
27. Fork bushing	2	do "	G

ity	Component and description	No. Required	Material & Supplied	Activity
	28. Fork	2	" do "	H
	29. Input gear	1	special bar steel/import	C
	30. Doc clutch-gear	2	" do "	C
	31. Intermediate gear	1	" do "	C
	32. Axle gear	2	" do "	C
	33. Washer	2	local supplied	E
	34. Axle Nut	2	" do "	K
	35. Cotter Pin	2	bar steel import	G
	36. Gasket	1	local supplied	I
	37. Plug	1	bar steel import	G
	38. Cover plate	1	sheet steel import	J
	39. Bolt/washer	18	local supplied	K

3. Contents of Technology

3.1 Process Description. The Manufacturing process flow chart of the gear-drived transmission set for the two-wheel walking tractor is shown in Fig 3. It can be seen that the main process is assembly process. Components and parts are assembled in the assembly line of the plant. Some components are made in the factory according to the activity shown in the flow process chart. The raw materials and parts used in the process can be grouped as follows:

Raw Materials & Parts	*Specification*	*Activity*
1. Sheet Steel	*1-30 mm. thickness*	*A,E,F,J*
2. Bar Steel	*Special Grade for making shafts & gears*	*B,C,G,H*
3. Semi-finish part	*cast iron*	*D*
4. Gasket	*General Standard*	*I*
5. Bolt, washer, seal & bearing	*----- do -----*	*K*

Most of the jobs in producing components and parts are in cutting, machining, drilling and welding. In the case of gear and shaft, .nere are another two more processes involved. These are hobing and heat treatment processes. Some components and parts which may be difficult to produce and require additional machineries to produce, are ordered from other metal components manufacturing firms in Bangkok. Figures 4-9 illustrate some processes in producing parts while Figure 10 shows the picture of finish gear box.

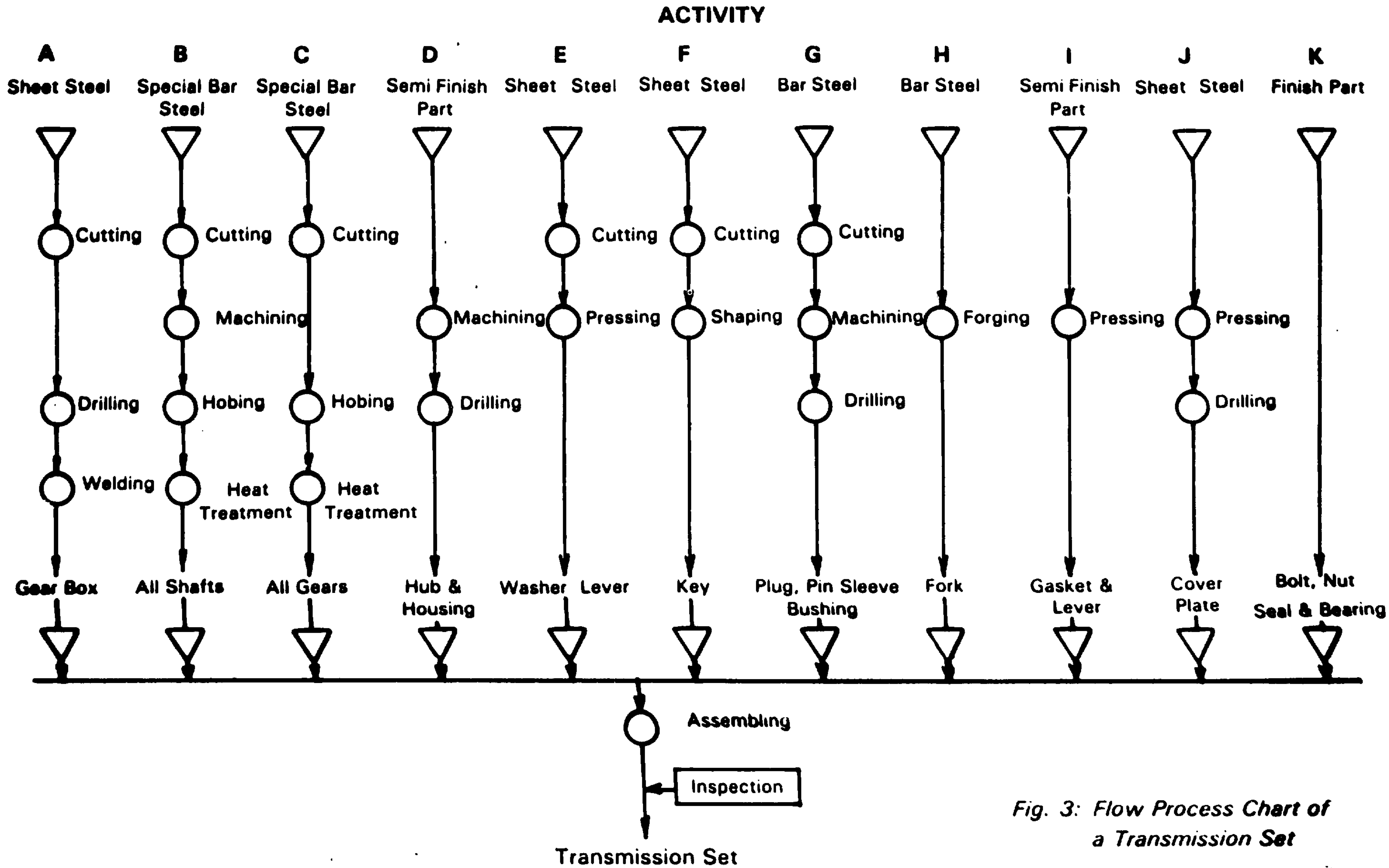

Fig. 3: Flow Process Chart of a Transmission Set

Annex 1

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A. Takla/sw
4 April 1985

Project UC-UD/GLO/84/127
Promotion of the multi-purpose approach to the manufacture
of agricultural machinery and other related capital goods

Preliminary report on the mission from 20 February to 30 March 1985
to Cyprus, Thailand, Indonesia, Kenya, Guinea and Togo

by

Assad TAKLA
UNIDO consultant

1. FINDINGS

Note: This report gives the preliminary observations, findings and recommendations which will be detailed/justified in the final report.

1.1 Cyprus

Agricultural tools and equipment are manufactured in small and medium-scale plants. The quality seems adequate and export for Middle East countries started several years ago.

The most important items manufactured locally are: different types of harrows, ploughs, diggers, planters, seeders, fertilizer distributors, harvesters, sprayers, hammer mills, rolling mills, feed stuff mixers, cereal packaging systems, potato cleaners, sizers, and packers, centrifugal pumps (horizontal and vertical axis: deep wells), irrigation systems, trailers, etc.

As the market is limited, diversifying the production is the solution adopted by several industrial plants. Among the manufactured products the following may be mentioned: silos, belt, screw and chain conveyors, other handling equipment, manure removal systems, luggage transporters, dust removal systems, block making machines, concrete mixers, etc.

In general, the visited medium-scale plants are equipped with general-purpose machine tools and metal forming, they have a variable number of workers according to the volume of work (15-50), they started with copying and slightly adapting imported equipment.

Although the economical situation in general is not very favourable, the manufacturers of agricultural equipment are generally satisfied through the diversification of the production. Scrap is used whenever possible.

The Polytechnic of Nicosia is relatively well equipped and staffed and co-operation with industry is possible. In particular, the Polytechnic has adequate facilities for testing pumps. The organization of a training course on design of water pumps has been discussed and a UNIDO expert will be needed for some weeks.

1.2 Thailand

The number of agricultural equipment manufacturers with more than 30 workers is estimated at 30. The main equipment produced in 1983 may be estimated as follows:

- 50,000 single-axle power tillers, 8-12 HP, generally equipped with mouldboard or disc-ploughed harrow
- 5,000 four-wheel tractors, 18-20 HP
- 300,000 buffalo plough mouldboard and shares
- 3,000 farm trucks
- 4,000 farm trailers
- 5,000 axial flow pump

Several thousands of centrifugal pumps, pedal and mechanical threshers, hullers, shellers, planters, seeders, fertilizer distributors, sprayers, dryers, mills, etc. are locally produced. In addition to the above-mentioned 30 medium-scale plants, there are about 170 other small manufacturers of agricultural tools and implements. The turnover in 1983 is estimated at 35 million US$.

A joint venture of 60% Thailand and 40% Kubota Diesel engines, a Japanese firm, assemble in Bangkok 5-18 HP engines. About 70% of the components is produced locally in different firms located generally in Bangkok. About 40,000 units have been produced in 1984. The local market is estimated at 90,000 engines per year with an annual increase of about 10%. The retail selling price of an 8 HP engine at 1800 RPM is in the range of 17,000 Bath or about US$¿650. Yanmar and Mitsubishi are also assembling Diesel engines.

Power tillers to be equipped with Diesel engines of 5-12 HP for multi-purpose utilization are produced by about 30 manufacturers; Yekpetch Tractor was visited, it is equipped with rather old machines tools and metal forming machines; the casted parts are sub-contracted. This firm produces about 10,000 power tillers per year in its two plants with 100 workers. They produce also disc ploughs and seeders. The quality of the products seems adequate and the selling price of power tillers without the engine is in the range of 8,000 Bath or about US$ 300. Several firms produce different types of centrifugal pumps.

Some of the small-scale industrial units with a small number of workers and generally equipped with lathe machines, shapers, milling machines, radial drills and welding equipment, are building a small number of different types of capital goods machines, in particular excentric and hydraulic presses, plastic and rubber machines, etc.

The firm SEKKE has been building lathe machines and shapers for about 20 years, however, its production is going down due to the rising foreign competition. The production in 1984 was about 100 machines with 50 workers. Except for the casted parts, heat treatment of gears and electric motors, all other parts are manufactured in the plant.

Diversifying the production is the only way of surviving (all the other local machine tools builders have already stopped/changed their activity). Milling machines, slotting machines, sawing machines, drilling machines may be produced by SEKKEE; the very accurate parts may be sub-contracted as in the case of the Diesel engines plant. The layout is not adequate and some reasonable improvement could be expected without high expenses. The firm does not keep records for calculating the production cost. This problem was discussed with the local Industrial Service Institute which may assist in organizing this activity. UNIDO assistance is needed and the possibility of sending an expert in machine tools design and building for 6-8 weeks was discussed. The expert will assist in rearranging the layout, realigning the machines, advising on optimal ways of machining and launching the design production of new prototypes.

A large Japanese-assisted projet (about 17 million US$), "The establishment of Engineering Industry Development Institute (EIDI)" is under approval by the Japanese Government (a copy of the project is available in the Negotiations Branch).

UNIDO assistance to the future Institute was discussed; it will consist in ensuring efficient linkage with the industry.

The Agricultural Engineering Division (AED) of the Ministry of Agriculture was visited. AED redesigned, adapted and tested the following equipment: power tillers, ploughs, seeders, planters, diggers, reapers, rice harvesters, cereal mills, maize shellers, peanut stippers, oil presses, sprayers, farm trucks.

AED, after developing and testing equipments, prepares and supplies detailed drawings to private industrial firms. Short training courses are organized when needed. AED has about 25 agricultural and 3 mechanical engineers; it has a small design office and a reasonable set of machine tools, metal forming machines and testing facilities.

The Industrial Service Institute (ISI) was visited. The ISI has 9 sections, 90 staff members, of which 15 engineers, a relatively well-equipped workshop for training and prototype production, a very poor information section which may eventually be provided with a copy of relevant UNIDO publications. ISI provides training and extension services for the cottage, small and medium-scale industry. A good co-operation is going on with AED.

UNIDO assistance in the field of electronics and package software design (CAD) to be processed in available computers facility is needed.

A meeting with the Department of Industrial Promotion was organized at the end of the mission; the findings of the consultant were discussed, especially regarding a future UNIDO assistance for the SEKKEE machine tools builders, the manufacturers of water pumps, and the future Japanese project.

1.3 Indonesia

Various types of manually-, animal-drawn and mechanically-powered agricultural equipment are produced in Indonesia. However, the production is very small compared with the estimated needs given in the following table extracted from a paper by Sihombing + Al. presented to the Second International Conference on the Development of Agricultural Machinery Industry, January 1984, Amsterdam.

Expected needed additional number of farm machineries in Indonesia

The same authors estimate the number of manufacturers and their production capacity as follows:

Number of farm machinery manufacture and their production capacity

This does not include simple tool and equipment produced by artisans and blacksmiths widely marketed but not formally registered.

According to the discussions with the Ministry of Industry, the Directorate of Food Crops, the Indonesian Agricultural Machinery Association and different managers of industrial plants, the existing production capacity in the country can meet easily the local needs. The acute problem is that the buying power of the farmers is very limited in addition to relatively higher costs of equipment than in similar countries: Thailand and Philippines, for example.

- Diesel engines:

The production capacity of the three Japanese joint ventures Yanmar, Cubota and Mitsubishi is about 82,000 units (3-30 HP) per year and per shift. The production in 1984 is estimated at 50,000. Yanmar which started its production in 1973 is manufacturing locally only about 30 per cent of the components against 70 per cent by Cubota in Thailand. There are three other manufacturers of Diesel engines above 30 HP, Deutz and MWM from West Germany and WIRA from China with an estimated capacity of 2000 units per year and a production in 1984 in the range of 300 units.

The major utilization of the small Diesel engines is in industry and transport and not in agriculture.

- Pumps:

Only the firm EBABA pumps, a joint venture Indonesia-Japan established in 1983, was visited. The information obtained is not reliable, however, it was indicated that the production includes water centrifugal pumps 2-6 inch diameter, 5000 units were produced in 1984 and deep-well and submersible pumps will be produced in the near future.

The plant is well equipped mainly with about 15 lathe machines of different sizes, 4 milling machines, grinding cylindrical machine, multi-broches drilling machine, etc. Modern welding equipment, ferrous and non-ferrous foundry. The plant is trying to find external works for its foundry. The plant seems to have marketing difficulties. Other pump plants exist in the country and there is a movement to create a pump manufacturers association.

- Foundry and metal working

PT BARATA Indonesia, a large industrial group comprises: Engineering Industry Services West, Engineering Industry Services East, Foundry Centres, Machinery and Foundry, self-propelled equipment and project management department. The Djakarta foundry and metal working centre was visited. It is equipped with two induction furnaces: 2 and 5 tons cupolas. mechanical moulding 4 kg, 25 kg and 150 kg pieces, and mechanical sand preparation. Pieces up to 8 tons may be casted. The plant is also equipped with heavy duty machine tools and metal forming. The visited centre produces water tanks, pressure vessels and steel structures.

- Steel structure and agricultural equipment

The firm TUGAS in Pulogandung Industrial Estate was visited; it represents a typical Indonesian small-scale plant.

Tugas has about 50 workers; it is equipped with a reasonable set of machine tools, mainly with 8 lathe machines, one horizontal and one vertical milling machines, 2 shapers, drilling machines, grinding machine, metal forming machines, welding equipment.

No engineers are working in the plant, however, the services of a consultant are hired when needed. In addition to the steel structure works which represent the main activity, the firm is producing prototypes (not yet really commercialized) of power tillers, ploughs, paddlers, rice hullers, mills and dryers. The firm is facing the problem of poor buying power of its eventual customers, for example a co-operative is prepared to buy 300 power tillers if financing facilities could be arranged.

The quality of the developed power tiller seems rather poor.

1.4 Kenya

The mechanization of agriculture in Kenya is characterized by the utilization of high-powered tractors in the large and modern farms and the small mechanization is rather in its beginning.

There is a relatively large number of very small, small- and medium-scale plants which manufacture manually- and animal-drawn tools and implements.

Shovels, hoes, jembs, pangas, axes etc. are produced by artisans and by small- and medium-scale plants.

Multi-purpose plants of medium scale are active in manufacturing various products. Beside the machine tools, the metal forming, forging and welding equipment, small foundries have been developed with locally made cupolas and moulding equipment. Among the visited plants the following are diversifying their production to accommodate their situation with the difficulty of the present market.

- Steel Structure Ltd. is producing:

  sugar cane trailers, tipping trailers, water Bowsers manure spreaders, small prefabricated buildings, hangars, equipment for food industry, equipment for textile industry; the dies and moulds are made by the firm.

- Ideal Casement E.A. Ltd. is producing:

  axes, shovels, hoes, ploughs, cultivators, hand pumps, public telephone cabins. Production of solar water heaters will be started very soon.

- Ndume in Gilgil:

  This firm is equipped with a reasonable set of machine tools, metal forming, forging and heat treatment equipment, a foundry with two locally-made cupolas. The main production is: tractor implements (ploughs, chisels, harrows, rollers, planters, seeders, jungle busters), maize shellers, cereal mills, trailers and ovens. Ndume has developed a rudimentary mini-hydraulic turbine with a small fall combined with a piston pump for a small flow.

However, the efficiency of the system which is already on the market is extremely poor (under 1%). A copy of the technical documents of this turbine was delivered to the Kenya Polytechnic to undertake eventually some research in order to improve the efficiency. The efficiency of the hammer mills developed by Ndume seems also poor. The indicated power needed is much higher than that of similar hammer mills on the international market. The traditional market for Ndume was Kenya, Tanzania and Uganda; however, the Tanzanian and Ugandian markets became very difficult, mainly due to the convertibility of their currencies. Ndume has an oil-fired melting furnace which has never been used.

- Mangal Singh Engineering works:

This plant located in Kisumu is equipped with a reasonable set of machine tools, metal forming and welding equipment. A cupola with a practical production of 1.5 tons/hour has been built locally; its cost is in the range of US$ 1,700 to 2,000. Scrap is utilized extensively for the production of different sizes of sugar cane crushers (14-40 HP and up to 3.5 tons/hour). The production includes also jaggery (sugar juice) equipment: pans, furnaces, also tailor-made equipment for food and chemical industries. The efficiency of the sugar cane crushers seems poor, however, they look very strong. This plant is also active in repair activities and is implementing a project to produce nuts and bolts. Based on the diversification of the products and on the scrap utilization the commercial situation seems sound.

The local manufacturers, particularly of manual tools are suffering of the hard competition of illegally imported similar products and also of paying relatively high taxes. This problem was discussed in the final meeting with the Director of the Industry and it was mentioned that the Ministry of Commerce and Industry is at present discussing this problem with the Ministry of Finance.

Testing power tillers has not yet been given enough importance by the Food Rural Technology Department in Nakuru; however, a Kubota Japanese power tiller is now under testing.

The price of Diesel engines, the heart of any small mechanization, is relatively high and the assembling project under implementation which is scheduled to start the production by the end of 1985 announces also high prices. Co-operation between the different specialized institutions is very weak and a real effort is needed to involve in joint projects the following institutions: the Jomo Kenyata College of Agriculture and Technology, the Kenya Polytechnic, the IRCU, the KIRDI and the Kenya Industrial Training Institute (KITI). The Ministry of Industry is planning the strengthening of KITI to start the design and production of prototypes of different agricultural equipment and UNIDO assistance will be needed.

The Ministry of Industry has prepared a feasibility study for the production of machine tools. During the final meeting with the Director of Industry, the possibility of UNIDO assistance to assess the opportunity of adding other products and introducing some numerical control machines was discussed. In the opinion of the consultant, it will not be feasible to produce only machine tools and the utilization of machining centres may be needed.

Given the importance of scrap to the African countries, the possibility of organizing a sub-regional (English-speaking African countries) 10-day Seminar on collecting, sorting, rentilizing and marketing of different types of metallic scrap was discussed. The Kenyan Polytechnic is prepared to host this Seminar and the Ministry of Industry will discuss and let UNIDO know its position which is, in a preliminary approach, favourable.

1.5 Guinea

The unique plant to produce agricultural equipment, l'Usine d'Outils Agricoles (USOA) at Mamu, about 270 km from Conakry, was visited.

This lant, built and equipped with the assistance of China in 1974, is well equipped with 113 machines (machine tools, metal forming, forging, heat treating, welding, wood working, etc.); the buildings of 7155 m^2 are still in good condition, a reasonable stock of spare parts and some raw materials are still available.

The plant stopped its production in the last trimester of 1984 with the following explanation: no electrical energy, no raw materials and some machines need repair.

The mechanical expert of the UNDP/UNIDO Pilot Centre Project in Conakry accompanied the consultant during the visit. The following remarks may be made:

- Two electrical transformers of 420 and 350 KVA capacity are installed, 85 kW or 106 KVA are utilized to feed the electric dryers for the painted implements produced. it is really a pity to convert a noble energy "the electricity" into heat, the painted implements may be dried in the air and the 85 kW will not be needed.

- Nothing obliges the plant to power, in case of shortage of electricity, all the machines at the same time. the heat treatment operations may be done separately during another shift or another day. A 100 KVA generator instead of 450 KVA may resolve the problem temporarily.

- There are enough raw materials to produce coupe-coupe tools and the plant may produce these tools pending receiving the other raw materials needed;

- It is very sad to say that metallic ships have been lying on certain machine tools for more than three months. The explanation is that the maintenance team is busy with the maintenance of the pump station!!! Cleaning and greasing of these machines will take only some hours of one worker.

- It was agreed that the Pilot Centre will repair the grilled electri motors, the heat treatment furnace, the gears of a small lathe machine. The machine producing the chains, the weight of which is estimated in the range of 120 kg, will be sent to the Pilot Centre where it will be eventually repaired.

- The general layout and the equipment of the plant are very reasonable and only a reasonable and efficient management is needed to make the plant operational.

- The products are only manual tools and implements: hoes, axes, jembs, coupe-coupe, shovels, ploughs, harrows.

- The production after the end of the Chinese technical assistance in 1979 was only some percent of the production capacity. Comparing with Agritools, a Kenyan private firm, it could be said that the Kenyan firm with 2-3 times less equipment and 77 workers was producing at least 5 times more than the USOA in 1979. The annual installed capacity per shift is estimated at 922,000 units including 6,500 ploughs and 3,000 harrows; the others are manual tools. The production between 1979 and 1983 was as follows:

Year:	1979	1980	1981	1982	1983
Units:	68,791	30,958	30,206	22,638	9,093

- The normal number of workers was 290 and 67 workers are still on the payroll of the plant.

- The USOA could produce, with the available equipment, after adding special tooling, a large number of different agricultural equipment going from soil working to post-harvesting. The Pilot Centre in co-operation with USOA, AGRIMA and the Polytechnic of Conakry may develop rapidly some agricultural prototypes. This supposes providing UNIDO technical assistance under the form of detailed drawings to be obtained mainly from IRRI and a short-term consultant to assist in launching the production. This also supposes that the Guinean authorities will equip the USOA with stand-by electric generators, raw materials, spares and a reasonable management.

- The UNDP/UNIDO Pilot Centre was visited. This Centre which was mainly oriented to repair and maintenance activities operates largely under its installed capacity, the estimated capacity utilization varies between 15 and 40 per cent according to the source of estimation. The Centre is already relatively well equipped and after the implementation of the second phase of the project it will be in a position to play an efficient role in developing agricultural prototypes and to assist USOA in its "rehabilitation".

- It seems important to mention that in all Guinea there is not any foundry, small or large; however, it is fortunate to know that the second phase of the Pilot Centre Project includes the implementation of a 600 tons/year foundry. It is not in the scope of work of the consultant to discuss the feasibility of utilizing electric, oil-fired melting furnaces or cupolas.

1.6 Togo

UPROMA, the UNIDO-assisted project is the only plant manufacturing agricultural equipment. Its commercialized production includes: ploughs, harrows, seeders, fertilizer distributors, maize threshers, semi-trailors, manually-driven water pumps and hand looms.

The strengthening of the project by adding complementary machinery, under implementation, will enable the improvement of the productivity and the production of other types of equipment. One of the main problems of developing the utilization of agricultural equipment, imported and locally made is the high cost of raw materials, components and finished products. From a report of the former CTA of the project dated November 1984, the following extract related to a visit to SISMAR in Senegal is self-explanatory: "La SISMAR nous a proposé de nous fournir des pièces composantes tels que mancherons de charrue à un prix inférieur à celui de la matière première que nous pourrions acheter à Kara. Nous ne pouvons pas accepter cette offre car il nous faut créer des emplois."

The different discussions held with the Génie Rural and during the final meeting with the Ministry of Industry showed a real need to develop particularly the utilization of harvesting and post-harvesting equipment, and to some extent irrigation pumps. It was agreed in this meeting that the Génie Rural will undertake a study to show the maximum acceptable price of a power tiller which may be commercialized in the local market.

According to the Génie Rural adviser: in a preliminary approximation, if the cost of a power tiller with 8 HP Diesel engine is not more than US$ 1,500, a reasonable number of customers will be ready to buy such multi-purpose equipment.

The Ecole Supérieure de Mécanique Industrielle was visited. The director showed his keen interest in participating actively in the development of agricultural prototypes. This college has reasonable production and design facilities.

SOCOMETO is a private firm equipped with large bending press 4000 x 6 mm/2500 x 12 mm, a roller 3000 x 8 mm, a guillotine 4000 x 6 mm and some second-hand machine tools. Its production includes: trailers, tippers, vans, tankers, steel structure. Also it repairs passenger coaches and waggons. Although the equipment and the building are not higher than those available in the public sector, its commercial results seem comfortable.

Railway workshops:

The workshops are equipped with a reasonable set of heavy dut and conventional machine tools, metal forming and welding equipment. Also, they are equipped with old foundry equipment including an oil furnace and oil-heated dryer. The production varied from 24 to 13.5 tons/year between 1973 and 1984. The production cost of the casted products: brake shoes, is more than US$ 10/kg, against 1.5-2.0 US$/kg, the reasonable production cost. The utilized sand comes from a place located about 6 km from Lomé. The Ecole Supérieure de Mécanique Industrielle is testing in its well-equipped soil laboratory the local sands and their suitability for the foundry. If adequate sand is utilized, in addition to reasonable foundry practice, drying the moulds may not be needed to produce brake shoes. The capacity utilization of the workshops is very low.

Centre Régional de Formation pour Entretien Routier:

This centre was visited. It is now under rehabilitation after having been stopped for several years. It is equipped with a reasonable set of machine tools, metal forming and welding equipment, also with training equipment for construction machinery.

Société Nationale de Sidérurgie, Lomé:

This firm is equipped with scrap storing, sorting and balling facilities, a 12 ton arc furnace, ingot making, a preheating furnace and a rolling mill of 40,000 tons/year. This plant was stopped in 1984 and was sold to a private US company. Its main activity now with its 85 workers working in three shifts is the export of the already important stock in addition to the newly bought scrap.

According to the manager of the plant, it is not the intention of the management to operate the arc furnace before several years due to commercial and not to technical problems. Indeed, the Brown Bovery furnace seems in very sound condition.

The firm is planning to import billets to operate the rolling mill. This situation seems difficult to understand, if the interest of Togo has to be saved. It was really difficult for the consultant during his one-hour, not previously planned, visit, and within the framework of his mission, to discuss this problem. However, in the final meeting the consultant drew the attention of the Ministry of Industry to discuss the opportunity of allowing only the export of steel scrap and not cast iron and non-ferrous scrap.

The firm is planning the erection of a foundry and this represents a good project for a country where the only available foundry is the small and old one in the Railway Workshops.

CONCLUSIONS

1. The degree of mechanization in the six visited countries varies largely from one country to the other.

In Thailand, the small mechanization is very popular; power tillers, also called walking or hand tractors, with mouldboards or disc ploughs and equipped with a locally manufactured Diesel engine (6-12 HP, generally 8 HP at 2200 RPM) are very popular. The annual production of power tillers is in the range of 60,000 units. The Diesel engine is manufactured (70%) and assembled locally. The retail price of a tiller is in the range of US$ 300 and of a Diesel engine 8 HP in the range of US$ 650.

In Indonesia, the small mechanization is going on but it is less popular than in Thailand due to the poor buying power of small farmers, less assistance of financing institutions and poor mechanical infrastructure in the rural areas. The price of equipment is about 20-30% higher than in Thailand.

In Kenya there is a relatively large number of tractors (50 HP and over) and the small mechanization is in its beginning. Interest in small mechanization is starting to gain importance. However, high prices will handicap seriously the development of utilization of small-powered equipment. For example, a Diesel engine which costs US$ 650 in Thailand, US$ 850 in Indonesia, is sold in the range of US$ 1400 in Kenya. Industrial plants are very active in the production of agricultural manually- and animal-operated tools and equipment, also in implements and equipment powered by tractors.

In Togo and Guinea, small mechanization is rather inexistant and prices of imported equipment are exaggerated. For example, the price of a Diesel engine in the range of 6-10 HP is about 3 times higher than in Thailand.

2. Focussing on small mechanization seems to be a right approach for developing the agriculture and the local production of agricultural machinery. Well-adapted multi-purpose power tillers (walking tractors) may constitute a reasonable solution for the mechanization of agriculture. The Diesel engines of the tillers (which may also be dismantled and used as a stationary source of power) may power different sorts of equipment: tilling, seeding, fertilizing, harvesting, threshing, milling, irrigating, transporting, etc. This multi-purpose utilization enables small farmers (3-5 hectares) to buy this type of equipment.

3. Multi-purpose plants seem to be the reasonable solution for manufacturing agricultural equipment and capital goods. This has been noticed particularly in several visited plants in Cyprus and Kenya, where the market is limited.

4. High input costs (raw materials, semi-finished product components, sub-contracted services, and depreciation of exaggerated investment in fixed assets), which are generally the case in Africa, and especially in West and Central Africa, in addition to poor productivity and small volume of market results in very high production costs. Transport and shipping costs, and different national taxes cannot justify this unfortunate situation which should be resolved.

5. Efficiency of locally-produced equipment does not always seem satisfactory. This applies, for example, to pumps produced in one plant in Thailand, power tillers in one plant in Indonesia and sugar cane crushers, cereal mills and mini-hydraulic turbines in two industrial plants in Kenya. Improving the efficiency will be discussed in the final report.

6. The taxation system in all the countries visited is often not adequate for the development of production of agricultural machinery.

7. Reasonable production facilities are often available, also some R+D and training facilities. Improving the capacity utilization and interlinkage between the different local institutions concerned will be discussed in the final report.

8. The manpower ...ing local technicians and engineers and sub-contracting works (foundry, machine tools, repair etc.) is rather cheap in Cyprus, Thailand, Indonesia and Kenya.

9. Scrap constitutes a wealthy source for the foundry inputs and for direct utilization (leaves of dumpers, bearing, shafts, nuts and bolts, springs, chains etec.). This scrap may be utilized in a systemized way and particularly export of cast iron and non-ferrous scrap should be discouraged.

10. UNIDO publications which are very relevant in several cases are not available in several visited institutions.

11. UNIDO SIDFAs may participate in collecting information and data which may save on the duration of missions of consultants/experts and sometimes improve extensively the efficiency of such missions.

RECOMMENDATIONS

1. Cyprus

- UNIDO could provide a 6-week expert in the design of water pumps to assist the Ministry of Industry in organizing a training course for the local manufacturers in co-operation with the Polytechnic of Nicosia.

- UNIDO could provide a 4-6 week study tour in developed countries for the agricultural machinery specialist in the Ministry of Agriculture who is in charge of the extension services to the local manufacturers.

2. Thailand

- UNIDO could provide a 6-8 week expert in machine tools design and building to assist the private machine tools firm SEKKEE in Bangkok in improving the lay-out, the accuracy of machining and in diversifying of the production.

- UNIDO could provide a 6-week expert in the design of water pumps to assit, through the Industrial Service Institute, the local manufacturers in improving their technology.

3. Kenya

- UNIDO could provide a 6-week expert to assist the Ministry of Industry in assessing the already prepared feasibility study on production of machine tools and in particular to identify other products to be included in the project and to utilize some numerical control machines. According to our view, this study calls for another review before a damage is made.

- UNIDO could provide complete sets of drawings of agricultural equipment, already prepared by IRRI, to the Ministry of Industry which is trying to promote the production of prototypes in the Kenyan Industrial Training Institute (KITI) in Nakuru. A 6-week expert could be provided by UNIDO to assist in launching the production of several prototypes, in co-operation with the Jomo Kenyatta College of Agriculture and Technololgy, the Kenyan Polytechnic, the IRCU, the KIRDI and the KITI. Eventually, a UNIDO expert for one year and 3 months of consultancy may be provided to strengthen this operation, however the IPF is fully booked till the end of 1986.

4. Guinea

- The UNIDO-assisted project, the Pilot Centre, should play an important role in the rehabilitation of the Usine d'Outils Agricoles at Mamu, also in the development of agricultural equipment prototypes. This should be done in co-operation with USOA, AGRIMA and the Conakry Polytechnic.

- UNIDO could provide a 6-week expert to assist in identifying the most needed equipment which could be produced locally and in launching the production of these prototypes.

5. Togo

- The CTA of the UNIDO-assisted project UPROMA should urge the management of UPROMA to consult suppliers in countries such as Brazil, Argentina, Thailand and India for the supply of raw materials/components in order to reduce the very high cost of production.

- UNIDO, through the SIDFA, may draw the attention of the Ministry of Industry on the economies of exporting the cast iron and non-ferrous scrap.

- UNIDO could provide a 6-week expert to assist, as in the case of Guinea, above.

6. Regional

- Instead of sending different experts in agricultural machinery to Kenya, Guinea and Togo, as mentioned above, a regional project could be formulated as follows:

> A team of two experts could spend 2-3 weeks in IRRI, Philippines, to collect complete sets of drawings and discuss the detailed design of different equipment already developed by this Institute. They will travel to selected African countries and spend 2-4 weeks in each country to explain and discuss the design and the needed adaptation and also to launch the first operations of prototype production.

- A 10-days sub-regional Seminar for English-speaking African countries on collecting, sorting, re-utilizing and marketing metallic scrap will be organized in Kenya. The Kenya Polytechnic in Nairobi is prepared to host this Seminar in co-operation with the Ministry of Industry and other institutions concerned. The budget of this Seminar will be in the range of US$ 50,000.

- UNIDO could prepare, in order to assist the African agricultural machinery manufacturers in their negotiation with their technology suppliers, and in order to promote the South-South co-operation, a detailed study on the sources and prices of different materials, equipment and machinery utilized in building, erecting and equipping different types of multi-purpose plants. The study will give also sources and prices of raw materials and components of different types and sizes of agricultural machinery. A 4 man-month work could be estimated for this study.

- The IRRI has developed an axial flow pump which is now under production, with some adaptation, in Thailand, Indonesia and the Philippines. However, the efficiency of this pump may be improved substantially. The well-known Laboratoire de Mécanique Expérimentale des Fluides, Université Pierre et Maire Curie in Paris, in co-operation with the Ecole Nationale Supérieure des Arts et Métiers de Paris, has soft- and hardware facilities to undertake a systematic R+D work to design and prepare several sizes of prototypes of impellors and diffusers (the main components of the pumping system). It is expected that the cost of such works will be very small compared with the costs to be claimed by private firms. The developed prototypes may be vulgarized in the African and other developing countries which could result in saving thousands of tons of oil per year.

This small project may be extended to develop a series of mini-turbines connected to volumetric pumps, similar to those already manufactured and commercialized in Kenya, which have a catastrophic efficiency - less than one per cent.

The French Government may be approached to finance this project from their special contribution to UNIDO.

Annex 2

RNAM

1
Test Code and Procedure for Ploughs

1. Ploughs are used for primary tillage, the first and important operation for the growing of crops.

In lowland conditions, ploughing is often done after hard soil is softened by water and this operation is usually followed by puddling under submerged conditions for transplanting the seedlings. Soil inversion by the plough is therefore not necessary but the soil surface should be left in an even condition without any marked ridges and furrows.

In upland conditions, on the other hand ploughs are required to give complete soil inversion with some measure of pulverization also.

There may therefore be differences between the tillage of lowland and upland soils, depending upon the emphasis placed on these various factors.

2. This test code prescribes the items to be measured and examined for evaluation of performance, working capacity and adaptability of implement to varied soil conditions, in comparison with the indigenous implement used for the purpose.

SCOPE OF THE TEST

3. The test code and procedure is applicable to various types of animal and tractor-drawn, mouldboard and disc ploughs. (Fig. 1, 2, 3)

It is desirable that in evaluating the suitability of plough, experts from related fields of activity, such as agronomists, soil scientists, economists, be consulted in addition to manufacturers.

4. The following is an outline of the test code and procedure:

(a) Specifications of the implement;
(b) Laboratory test;
(c) Test conditions;
(d) Performance test;
(e) Practical field test;
(f) Criteria for evaluation;
(g) Test report format;

DEFINITION OF TERMS

Vertical suction – the vertical clearance the share makes with the ground when the tip of the share and the heel of landside touch the ground. (Fig. 5).
Horizontal suction – the horizontal clearance at the side the rear of the share makes with the straight line joining the share and heel of the landside.

SPECIFICATIONS OF IMPLEMENT

5. Prior to the test, specifications of implement as well as information on the manufacturer's recommended performance and working capacity have to be confirmed and examined. The implement should be obtained with all the technical information (manual, instruction book, list of spare parts, and other available technical data).

6. The manufacturer's specifications which must be verified and reported are given in the test report format.

LABORATORY TEST

7. The main objectives of the laboratory test are to study and confirm the specifications and essential components comparing them to those given by the manufacturer and to undertake such studies that will assist in modification and improvement of the implement design.

Some of the items to be examined by the laboratory test method are:

(a) Adjustment of working width, depth and level;
(b) Type of coulter available;
(c) Vertical adjustment of the coulter;
(d) Material of plough share, mouldboard or disc;
(e) Safety aspect;
(f) Weight of soil working parts before and after test.

TEST CONDITIONS

8. Performance of plough varies considerably according to type of soil, moisture, content, its distribution in soil, weed growth, crop residue and travelling speed. Therefore, the conditions of the test have to be clearly stated. Test conditions to be defined are as follows:

Conditions of field

(a) Area and shape of test field;
(b) Type and character of soil;
(c) Last crop in the field;
(d) Height of stubble of last crop;
(e) Condition of weed (degree of weed infestation);
(f) Period after draining of water in case of ploughing after rice harvesting;
(g) Irrigation before ploughing;
(h) Soil moisture content (dry basis), bulk density, penetrometer profile and cone index in depth of ploughing.

Condition of implement and operator

(a) Source of draft power;
(b) Adjustment of working parts of implement;
(c) Travel pattern of implement;
(d) Travelling speed;
(e) Skill of operator.

A log sheet for the above testing items must be prepared separately.

PERFORMANCE TEST

9. The main objectives of performance test are to obtain reliable data on the implement such as work capacity, quality, field efficiency and adaptability to varied soil conditions in comparison with indigenous implement as control and to provide basic technical information. It can be described as a controlled field test, and must be carried out under the conditions recommended by the manufacturer but may also include test under other conditions.

10. Testing will be carried out at five selected fields. The area of each plot should not be less than 0.2 ha for mounted or trailed plough by large tractor and 0.1 ha for the others. The plot should be a rectangle with the sides in the ratio of 2:1 as far as possible. The items to be measured and observed are:

(a) Width of ploughing*;
(b) Depth of ploughing*;
(c) Actual travelling speed;
(d) Actual operating hours;

---

* See Annex for method of measuring.

(e) Time spent for turning at headland;
(f) Time spent for adjustment of implement;
(g) Time spent for trouble and others;
(h) Fuel consumption;
(i) Degree of inversion;
(j) Degree of pulverization;
(k) Entangling of weed and crop residue to the implement;
(l) Adhesion of soil to the implement;
(m) Evenness of ploughed surface;
(n) Evenness of furrow sole;
(o) Percentage of wheel slip;
(p) Draft.

A log sheet for the above testing items must be prepared separately. Based on the above data, the area covered and the cost of operation may be calculated.

PRACTICAL FIELD TEST

11. The objective of this test is to confirm the adaptability of the plough to practical conditions in the field.

The items to be measured and examined are almost the same as in the performance test. The practical field test shall be conducted in five plots of field, the area of each being the same as in the performance test. The indigenous plough will be tested under identical conditions.

CRITERIA FOR THE EVALUATION OF PLOUGHS

12. The efficiency and suitability of a plough shall be evaluated according to the following criteria:

(a) Field condition;
(b) Soil condition;
(c) Inversion and pulverizing function;
(d) Evenness of ploughed surface;
(e) Power source of draft;
(f) Ease of operation and maintenance of implement;
(g) Working capacity of implement;
(h) Labour requirement;
(i) Operating cost of implement.

TEST REPORT FORMAT

13. The test report must include the following information in the order given:

(a) Test title;
(b) Introduction and background;
(c) Aim and objective of test;
(d) Planning of test and procedure;
(e) Type and main specifications of implement tested;
(f) Principal data of test conditions and results;
(g) Discussion, conclusion and recommendations.

REPORT ON THE TESTING AND EVALUATION OF PLOUGH

PART A
INTRODUCTORY

(1) Background ________________________

(2) Aim and objectives ________________________

(3) Test methods and procedure ________________________

(4) Materials (fuel, instrument, etc.) ________________________

(5) Personnel (names and designations) ________________________

PART B
DATA SHEET

I. Description of plough

A. Photograph of implement

Line diagram and/or photograph on glossy paper of whole view should be attached here. Others suitable for better understanding of test result may be attached at appropriate places in the report.

B. Specifications

Specifications given by the manufacturer should be checked and confirmed.

1. Type of implement

2. i) Make:
   ii) Model:
   iii) Serial No.:
   iv) Manufacturer's address:
   v) Market price US$ (Local currency) Year

3. Overall dimension in cm.

   Length:
   Width:
   Height:

4. Weight in kg.

5. Source of draft power

6. Details of soil working parts

   Type:
   Number of bottom or disc:
   Working width of each bottom or disc:
   Type of mouldboard:
   Disc diameter and concavity:
   Material of share or disc:
   Thickness of share, mouldboard and disc:
   Hardness:
   Horizontal suction:
   Vertical suction:

7. Coulter
   Type:
   Size:
   Adjustment:

8. Details of wheel of implement

9. Details of frame

   Construction:
   Dimension of major member and material:

10. Details of beam

    Construction:
    Dimension of major member and material:

11. Details of handle

    Construction:
    Height of handle from ground:
    Details of adjustment:

12. Details of hitch

    Shape and construction:
    (In case of tractor mounted unit, category of three point linkage)

13. Way and range of adjustment of cutting width, depth and level

14. Safety arrangement

15. Recommended working speed km/hr

16. Working capacity (announced) ha/hr

II. Laboratory test

(a) Study and confirm the specification and essential components given by the the manufacturer under item I above. List items in case of disagreement below and discuss.

(b) Obtain detailed information on various working components which may be helpful in modification and improvement of the design features at appropriate stage. List such case.

(c) The following will need special scrutiny and discussion with illustration.

   i) Soil cutting

ii) Soil inversion
iii) Soil pulverization
iv) Material of soil working parts and their wear in weight after test
v) Safety aspect
vi) Any other items

Name of the investigator ______________________
Designation of the investigator ______________________
Date and venue of test ______________________

III. Performance test/Practical field test (five tests under controlled field condition and five tests under actual field condition).

Particulars	Test Number									
	Performance tests					Practical field tests				
	1	2	3	4	5	1	2	3	4	5
A. Test condition										
a) Condition of field										
1. Location										
2. Kind of field (upland/lowland)										
3. Length m										
4. Width m										
5. Area of field m^2										
6. Type and character of soil										
7. Soil moisture (dry basis) (average of 5 readings at random)										
8. Bulk density gr/cm^3 (average of 5 readings at random)										
9. Cone index (within depth of plouging) (Average of 5 readings at random) Cone apex angle ( ) base dia ( )										
10. Qualitative assessment of field*1										
11. Soil preparation (if any)										
12. Last crop in the field										
13. Height of stubble of last crop cm										
14. Weed infestation										
15. Period after draining of water in case of ploughing after rice harvesting										
b) Condition of draft power and implement										
1. Source and number of draft power										
2. Qualitative assessment of draft animal*2										
3. Make, model, type, and output of tractor										
4. Type of wheel of tractor										
5. Control of hydraulic lift of tractor										

*1 Level, uneven, rough; local depressions, etc.

*2 Light, medium, heavy weight; small, medium, tall, etc.

Particulars	Test Number									
	Performance tests					Practical field tests				
	1	2	3	4	5	1	2	3	4	5
6. Adjustment of implement (if any)										
Depth:										
Width:										
Level:										
7. Gear selected at test										
c) Condition of operator										
1. Skill of operator*										
2. Wage of operator (US$/day) (Local currency/ day)										
d) Ambient conditions										
1. Temperature										
Dry bulb °C										
Wet bulb °C										
2. Wind velocity km/hr										
3. Weather (sunny, cloudy, cold, etc.)										
B. Field Performance										
1. Date of test										
2. Actual operation time hr. min.										
3. Time lost owing to										
i) Turning at headland min										
ii) Adjustment min										
iii) Refuelling min										
iv) Rest of draft animal min										
v) Others (give details) min										

*Excellent, good, satisfactory, unsatisfactory

Particulars	Test Number									
	Performance tests					Practical field tests				
	1	2	3	4	5	1	2	3	4	5
4. Actual area covered m^2										
5. Effective working width (average of 5 readings in one run. This should be repeated three times at least) m										
6. Working depth (-do-) m										
7. Travel speed m/min. (average of 5 readings)										
8. Effective field capacity ha/hr										
9. Field efficiency %										
10. Percentage of wheel slip %										
11. Draft kg										
12. i) Fuel consumption for area tested l										
ii) Fuel consumption per working hour l/hr										
iii) Fuel consumption per hectare l/ha										
13. Machine movement pattern on field										
14. Qualitative assessment of work quality and operation (quantitative assessment may be added if possible)										
i) Inversion of soil										
ii) Pulverization of soil										
iii) Evenness of ploughed sole										
iv) Evenness of ploughed surface										
v) Condition of draft animal										
vi) Condition of tractor										
vii) Others										

Particulars	Test Number									
	Performance tests					Practical field tests				
	1	2	3	4	5	1	2	3	4	5
15. Labour requirement										
(1) Number and total man-hour of operator										
i) at test man-hr										
ii) per ha man-hr/ha										
(2) Number and total man-hour of unskilled labour (specify kind of work)										
i) at test man-hr										
ii) per ha man-hr/ha										
16. Ease of operation										
i) Stability of implement										
ii) Ease of turning										
iii) Safety and others										
17. Breakdown, repair, replacement of part during test										
18. Cost of ploughing (attach a detailed worksheet)										
19. Additional information and remarks, if any										

Name of the investigator ______________________

Designation of the investigator ______________________

IV. Comparative statement of cost of ploughing

Method	Kind of field, type and character of soil, previous land preparation	Depth of ploughing	Labour			Other cost of ploughing per ha		Total cost of ploughing per ha	
			Man-hr per ha	Cost					
				US$	Local currency	US$	Local currency	US$	Local currency
1. Ploughing with indigenous plough									
2. Ploughing with implement tested									

V. Discussion

1. **Machine aspect:** Ease of handling, adjustment, maintenance, defect, safety, breakdown, durability, ease of local repair.

2. **Field operation aspects:** Man-hour requirement per hectare, work capacity (theoretical, actual), field efficiency, fuel consumption/ha.

3. Economics as compared to local practices (fixed cost, variable costs, etc.)

4. Miscellaneous

VI. Summary and conclusion (with tables and graphs as annexures)

VII. Recommendations

Principal Investigator ______________________________

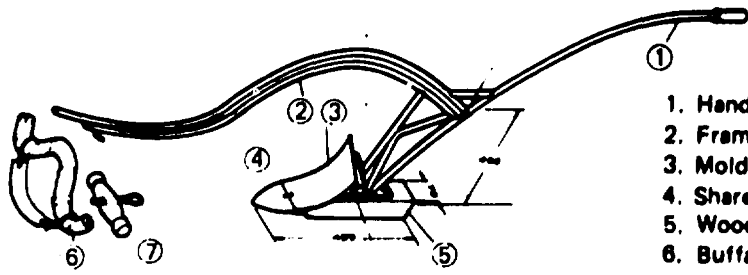
National Institute ______________________________

Place ______________________________

Country ______________________________

Date ______________________________

ANNEX 1. FIGURES AND TERMINOLOGY OF PARTS.



1. Handle
2. Frame or Beam
3. Moldboard
4. Share
5. Wooden block
6. Buffalo Yoke
7. Small Yoke

Fig. 1. INDIGENOUS MOLDBOARD PLOUGH
Source: RNAM Regional Catalogue Agricultural implements)

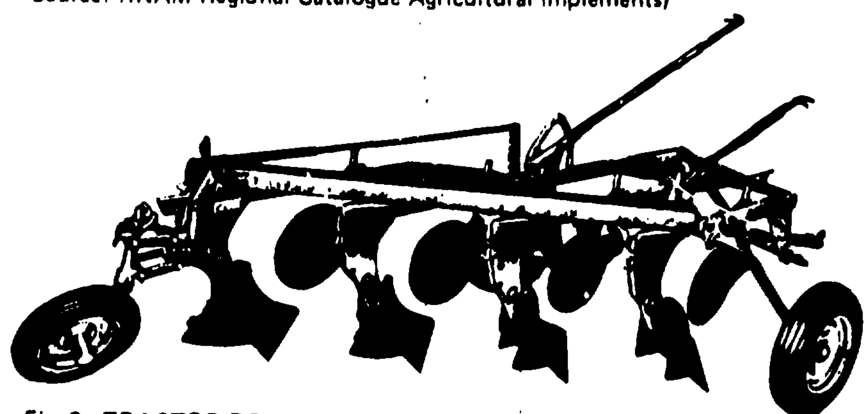


Fig. 2. TRACTOR-DRAWN MOULDBOARD PLOUGH
(Source: FAO Elements of agricultural machinery)

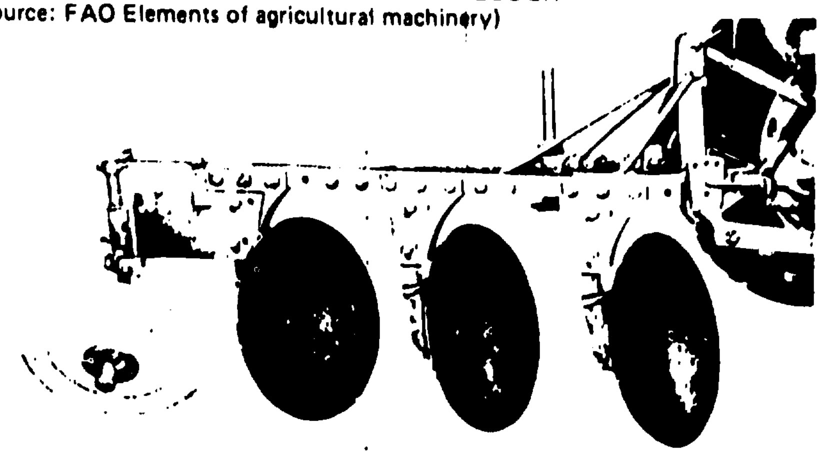


Fig. 3. TRACTOR-MOUNTED DISC PLOUGH
(Source: FAO Elements of agricultural machinery).

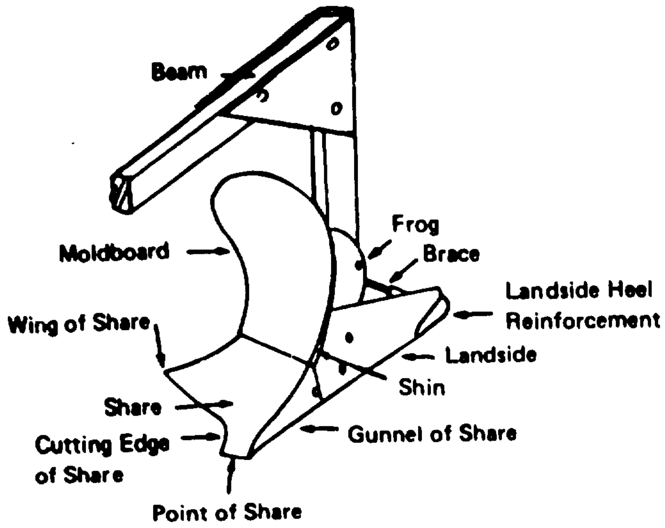


Fig. 4. PARTS OF MOULDBOARD PLOUGH BOTTOM
(Source: FAO Elements of agricultural machinery)

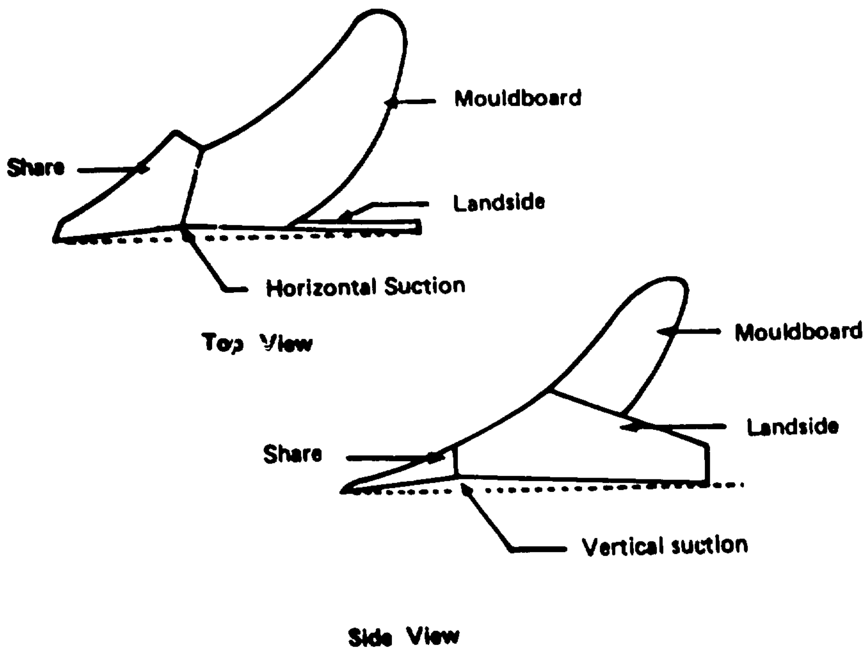


Fig. 5. CLEARANCE (SUCTION) OF MOULDBOARD PLOUGH

2. METHOD OF MEASURING DEPTH AND WIDTH

The depth and width meter shown in Fig. 6 is available for measuring working depth and width simultaneously.

a. Effective working width

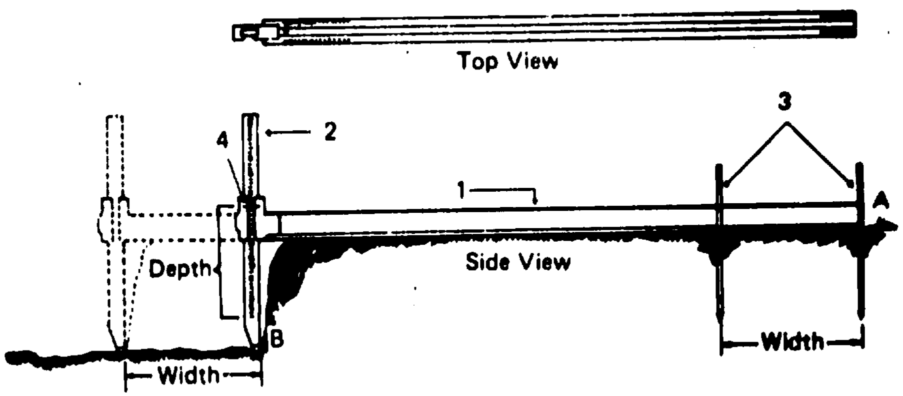
i) This can be simply calculated by dividing the total width of field by the the number of passes. It should be taken into consideration that rate of error becomes big when the width of field is relatively small compared with width of implement, that is, number of passes is few and width of implement cannot be fully utilized at any pass.

ii) Working width can also be directly and successively measured during operation with depth and width meter. The side face of graduated depth scale is placed to face furrow or the tip (B) of it to the definite point of ploughed sole and then the pin is put into soil at the point (A) of a width scale. This procedure is continued and the distance between two pins adjacent each other is the working width. When the ploughed sole has no definite point such as disc plough, accuracy of this method will decrease.

iii) It is advisable to use these two methods and check one with the other.

b. Working depth

The working depth is measured by putting the tip of depth scale on the ploughed sole. However, ploughed sole is not always level depending on the feature of implement. It is therefore desirable to put the tip of depth scale at relatively same point in each pass.



1. Graduated width scale
2. Graduated depth scale
3. Pins for measuring width
4. Base line for reading depth

Fig. 6. DEPTH AND WIDTH METER