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THE PROBLEMS OF SERVICING AND MAINTENANCE AGRICULTURAL MACHINERY IN DEVELOPING COUNTRIES 1/

by

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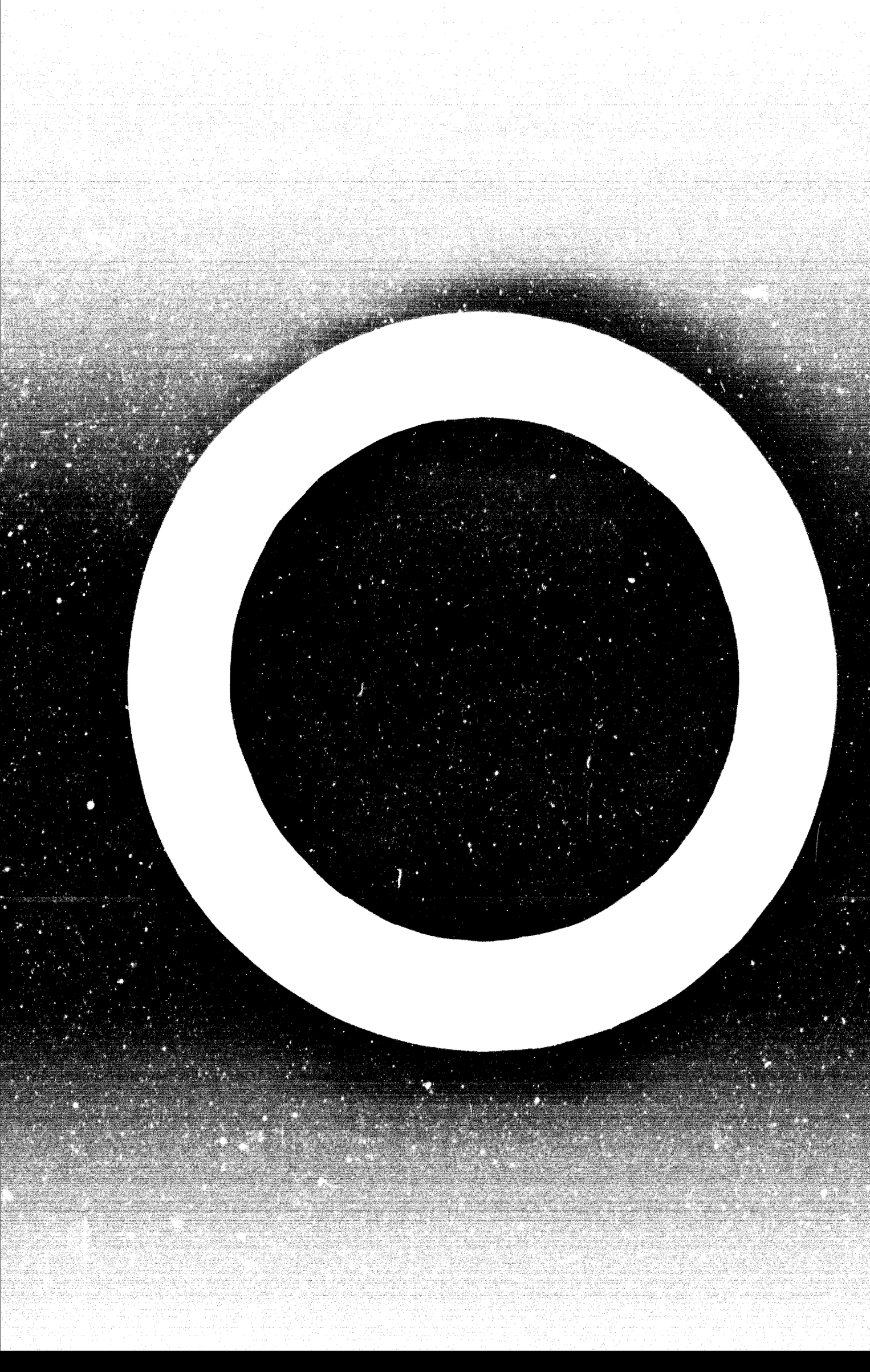

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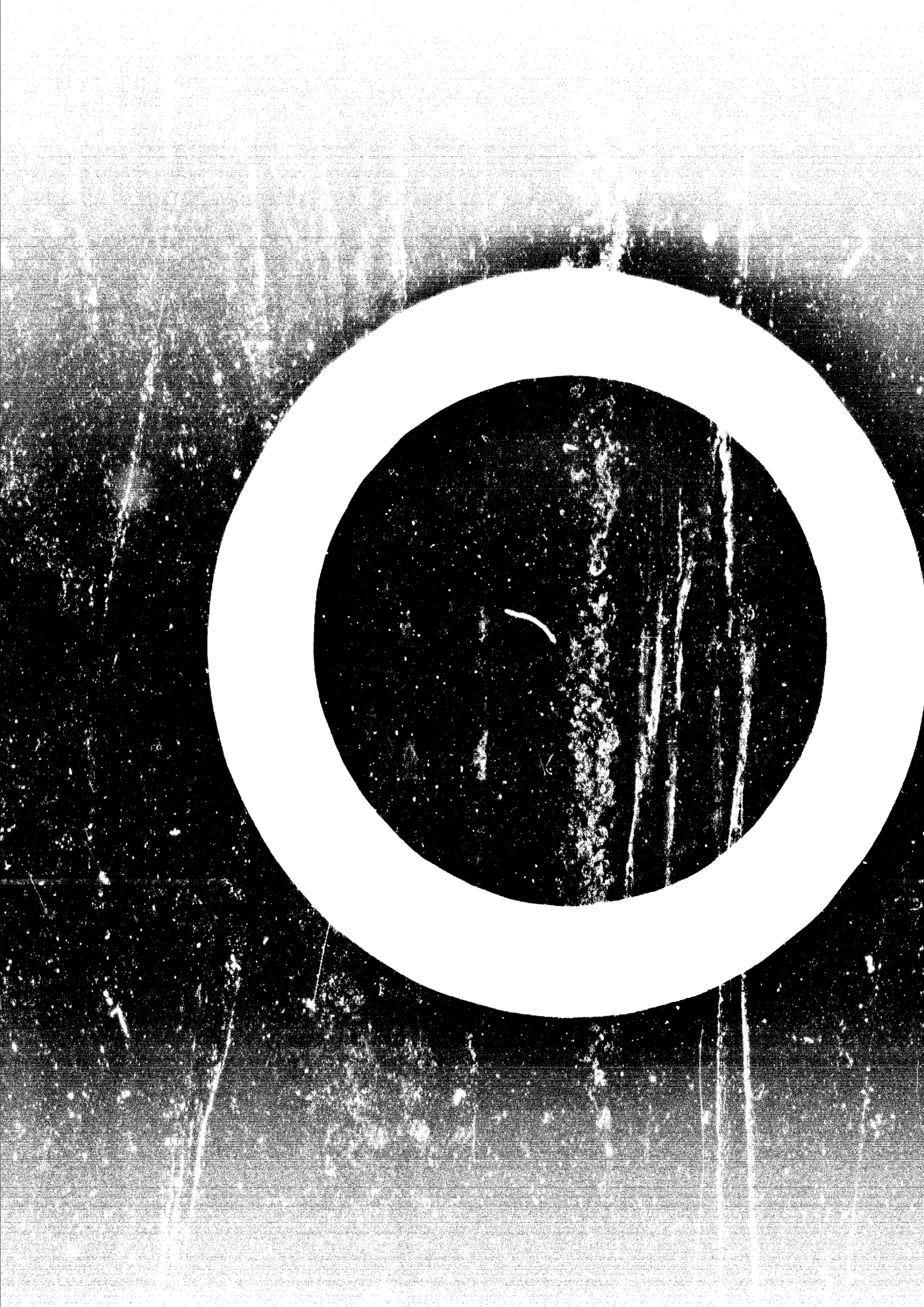


I INTRODUCTION

The main and most obvious problems of servicing and maintaining agricultural machinery at the present time in the countries of Africa, Asia and Latin America are the direct result of their social and economic infrastructure. These basically internal problems are further aggravated by the geographical position of these countries in relation to those where the bulk of agricultural machinery is manufactured.

Agriculture, even in those countries where it was originally developed by Europeans, is extremely fragmented. In most cases the majority of the population is engaged in agriculture with many peasant proprietors producing a wide range of subsistence and cash crops. By its very nature this type of production makes comprehensive mechanisation socially and technically difficult.

Where large scale cash-cropping is practised it is relatively easy to set up fully-integrated mechanisation operations with their own full-time teams of trained operators and workshop repair services. There is also financial justification for setting up a comprehensive spare parts service. In developing countries this type of organisation is almost impossible - at least not without a considerable measure of government involvement.

In most the centres of agricultural production are widely scattered with a very low concentration of machines in any given area. This means that servicing - where commercial concerns are involved (and this means the majority at the moment) - is carried out from one or two main centres in each country. The distances involved in service calls inevitably mean high costs - often so high that the farmers cannot afford them. Machinery frequently stands idle for want of repair.

Because of the distance of most of the countries from the world centres of production, the machinery and its attendant spare parts is relatively expensive. The delay in obtaining parts - 2 to 3 months for the sea journey from Europe is typical - means that slow moving spares have to be stock-piled and this adds further to the cost of maintaining equipment.

The real roots of the problem however, which must be changed in the long run if any improvement is to be made, lie in the developing countries themselves.

Most important is the generally low standard of operation and day to day maintenance of machinery. Apart from the extra hazards of climate and soil type, the machinery is treated unsympathetically by operators who too often lack even the basic knowledge of how a machine should be used.

The generally low standard of education means that any training programme has to start right from very basic principles. Training is therefore a slow and expensive process.

The problem is made worse by the low social standing with which anyone engaged in agriculture is regarded (this, of course, is an attitude common all over the world). Consequently, there is a tendency, once a man has received any sort of technical training, for him to seek employment in some field unconnected with agriculture which is better paid and which has a higher social status.

Because of the low standard of both general and technical education there is inevitably an extreme shortage of good service mechanics. This is a world-wide problem in the agricultural field.

Many of the problems of efficient mechanisation stem from a lack of appreciation by Euro-American manufacturers of the problems of the farmer in developing countries. This is a wider and much more fundamental problem outside the scope of this report, but it does mean that much quite unsuitable machinery is exported to developing countries.

This particular obstacle can only be overcome, according to the majority of experts involved in extension work in developing countries, by setting up machinery testing and product education centres in the territories where the machinery is to be used (this subject is more fully developed later in this report).

Another problem emphasised by the manufacturers, overseas development officers and service engineers interviewed during the preparation of this report, is the irresponsibility of the way in which some manufacturers sell machinery in developing countries.

Too often a batch of machines - which may be completely unsuitable for the territory - are sold to a government official or to a new "dealer" with absolutely no product education. Aim of the salesman is to sell as many machines as possible in a short time. He is not bothered whether the dealer knows anything about the machinery or whether the spares are available to back up his sales.

Machines are often sold over a wide area well out of reach of any repair or spares service and consequently it is not long before the machinery is lying rusting for the want of a few pounds spent on repairs.

The more responsible manufacturers (some examples are given later) take the trouble to ensure that an area is covered by a service depot before extending their sales into a territory. This would appear however, to be a factor which governments could control themselves to a much greater extent than at present.

Indeed, it seems inevitable that there will have to be a great deal more government intervention in and direction of agricultural mechanisation schemes if this fundamental obstacle to agricultural development is to be overcome.

"For the commercial companies operating in developing countries it is a problem of what to do first," an FAO farm machinery expert working in East Africa told me.

"Do they establish parts and service depots before the machinery density is sufficient to make it economic or do they merely provide a standard of service which is economically justifiable?"

"I do not believe we can expect the farm machinery trade to provide a very high standard of service in remote areas of developing countries in the initial stages. It is therefore essential that we concentrate on raising the calibre of the farm machinery operators so that they can do more of their own maintenance and repair work. Right now we find the standard of maintenance is appalling."

It is of course dangerous to generalise when discussing this subject. When examining the problems of machinery operation in "developing countries" we are talking about countries in four continents which make up the bulk of the land mass of the world's surface. They are spread through almost every climatic zone and communications involve the use of practically every language spoken in the world.

The geographical types of the countries we are concerned with vary from hot and wet, low-lying equatorial forest regions to the seasonally arid areas on either side of the subtropical desert belts. They vary from densely populated areas to sparsely inhabited desert margins.

Agricultural patterns too, vary from European style mixed husbandry to extensive nomadic grazing - often in the same country.

To avoid the pitfalls of generalisation this report is set out to focus on specific situations in particular areas to show the main problems involved in agricultural mechanisation and the way in which they are being tackled.

Some attempt ie then made to draw conclusions from this experience and to concentrate the knowledge of experts in their particular fields onto these conclusions in order to give some indications of what can be done to solve the basic inadequacies of present approaches to agricultural mechanisation in these countries.

The following section of the report is aimed to give some idea of the difficulties involved in machinery operation in two situations typical of many developing countries: moderately extensive agriculture in Africa with the use of relatively sophisticated equipment and much more intensive peasant farming in Asia where only the simplest machinery is being used.

This is then followed up by a report of an attempt at a comprehensive mechanisation echeme in a developing country.

II THE OPERATOR'S PROBLEM

Case study 1 - the problems of machine operation and service in Uganda:-

The main problems of operating, servicing and maintaining machinery already outlined in the introduction of this report are shown in microcosm by a study of eighteen tractor owners carried out for the Special Development Section of the Uganda Ministry of Agriculture in 1966/67.

The majority of these farmers, situated in the West Acholi region of Uganda, complained of extreme difficulties in getting spares for their machines and in getting them serviced. A delay of two or three months, they said, was not uncommon before the work could be carried out.

Three factors were mainly responsible for this state of affairs:- the supply of agricultural machinery and its servicing was only a sideline of the three firms who handled machinery in the area; only one of these firms employed mechanics who were anything like skilled and lastly - and the possible reason for the first two factors - the farmers concerned did not pay for the service within anything like a reasonable time.

The three dealers are situated in the local town of Gulu. Of the three only one employs mechanics and, the report stated, these were far from proficient. It was fairly obvious that in the case of all three dealers - all agents for well known makes of machinery - farm machinery was regarded as a sideline to their main automobile business.

The dealers only kept fast moving spares such as fan belts, oil filters and electrical parts in stock and the problem of keeping machinery moving was further exacerbated by the fact that major parts had to be obtained from Kampala 200 miles away. Prices for spares 50 to 60 per cent above those in Kampala were commonly charged.

The farmers in this group were operating tractors in the 25 to 45 horse power group and cultivating on average a total of about 250 acres a year. Because of often unskilled operation and the conditions of the area, the total cost of spare parts and service amounted to £200 per annum. Total maintenance costs per acre worked out to 16s - more than 38 per cent of the total running cost.

Running costs were generally high with often excessive fuel charges adding to the already heavy cost of spares and service. An important cause of both these high costs, apart from the actual cost of service and spares, was a generally low standard of tractor operation.

Excessive fuel costs, according to the report, were due to inefficient engine maintenance, mis-setting and maladjustment of implements - which were often used in the wrong conditions - fuel losses and engine damage caused by bad fuel storage and inefficient refuelling methods and waste of man and tractor time by bad planning of tractor operation.

Nevertheless, however much the machinery was mishandled the farmers were paying much more for their spares and service than their equivalent in developed countries.

To demonstrate the difficulties of the farmer it is worth quoting this section of the report in full:

"The farmer has two courses open to him [when he needs spares] - either he deals direct with the main dealers in Kampala or through the three dealers in Gulu.

"If the farmer deals directly with Kampala, he does so either by post, in which case the spare will probably be put on a public transport bus to Gulu (it will then take between one and two weeks to reach the farmer provided it is already in stock in Kampala), or the farmer can journey down to Kampala to pick up the spare himself.

"The latter course is only used if the spare is very urgently needed. If he purchases a spare from Kampala direct he can expect a discount of between 10 and 20 per cent - added to this of course is the cost of transporting the part up to Gulu.

"Thus a spare with a retail price of 100s will, with discount, cost approximately 85s and amount to a total of 95s with the added transport charge by the time it reaches the farmer.

"If the farmer deals with his local dealer in Gulu and the dealer has no spares in stock he will telephone the main dealer in Kampala and order the spare on behalf of the farmer. The part is then usually picked up by one of the dealer's own lorries and transported to Gulu.

"The local dealer will obtain the spare in Kampala with usually 30 per cent dealers discount - this is added on to the spare to cover transport costs - and then the dealer in Gulu will add a further margin of 20 per cent."

The spare with a normal retail price of 100s is therefore purchased in Kampala for 70s and sold to the farmer for 120s - 50s above the dealer's price in Kampala and 25s more than the farmer could have obtained it for himself in Kampala.

The report makes it clear that one of the main reasons for the high prices charged for spares is that the dealers tend to be covering themselves against the endless credit that they are forced to grant to their customers. It is emphasised that it is not because they do not have the money that the farmers do not pay their bills; most of those questioned had adequate funds available to pay their service bills.

"The majority are extremely loath to part with this cash and almost every tractor owner visited had large outstanding bills for repairs and parts for his machines," the report states.

"It is often only when legal action is threatened or a representative of the firm supplying the service visits the farmer and lays down the law that the farmer will pay."

Apart from the general misuse of tractors which merely complicates the service and spares supply problem, the main root of the problem seems to be general lack of confidence between the farmers and the machinery dealers. The farmers are convinced that they are being over-charged for the service and the dealers are offhand about servicing machinery and charge high rates to cover their bad debts.

Two solutions to the problem are suggested in the report: either the commercial concerns at present responsible for maintaining machinery in the area are helped and persuaded to provide a more effective and efficient service or mechanics and workshop facilities should be provided by a government agency.

The main objection to a government operated service is that the farmers would then be at the mercy of changes in government policy. It is suggested however, that this would work if the farmers were given a written, medium-term agreement to say that the service would be provided for four or five years at least.

The agreement would have to be stringent in its terms, the report emphasises. Times and rates for workshop facilities, prooedure for overhauling machines and so forth would have to be stipulated but at the same time leaving some room within the agreement for the farmers and the government administrator concerned to accommodate reasonable variations.

Probably the most workable proposition was that the farmers should get together with the dealers and propose that one agent should be set up as a specialised agricultural machinery agent. He should act for several of the main machinery manufacturers instead of only one, since there is insufficient business to justify a full dealership for any one company. It was also suggested that the agent would be better able to carry the £400 to £800 worth of spares needed in stock at any one time by more favourable dealing terms with his main agent in Kampala.

To gain the confidence of the farmers he must charge a realistic but not excessive price for his services and materials.

On the farmers side it was suggested a cooperative should be formed so that if one farmer defaults on payment the agent would be able to get his payment from the society. To justify the improved type of service that this new style local agent would be providing, the group of farmers must guarantee to buy all their spares from him.

The most difficult suggestion to implement in the report was that this agent should employ trained mechanics - and in sufficient number to allow a regular service visit to tractor owners. As is made clear in other parts of this report, this is the crucial problem.

A further suggestion made in the report was that the central dealers in Kampala should use a travelling mechanic who has a fully equipped service van and a supply of the main spares. Quarterly visits, with the farmers contributing towards hotel expenses and mileage - possibly by a percentage on the cost of the service - would then keep machinery in a much better state of regular repair.

An important factor from the dealer's point of view - and probably the main reason why it would not work, is that the mechanic would have to assure himself that he was going to be paid for any work carried out.

An additional drawback would be the paper work involved and the difficulty of convincing farmers that further faults found during an overhaul need doing and getting him to accept the increased bill.

Another possible answer to the problem suggested was a combination of several of the main features of those already suggested - a joint workshop set up by the dealers and the responsible government department. Main advantage would be that there would be a bigger pool of skilled labour between the private concerns and the government department, which is already operating a tractor hire service.

Case study 2

Operator training and maintenance in Asia - small farm mechanisation in Taiwan, Republic of China:

The previous case study of tractor operators in East Africa demonstrated problems typical of an area where machines are widespread over a large area and the farm units relatively large. Very different problems are found in areas where the population is relatively dense and land is scarce.

This situation is typical of many parts of Asia and a study of machine operation by smallholders in Taiwan, Republic of China, by the Chinese American Joint Commission on Rural Reconstruction emphasised many of its special problems.

In this area the land is divided into many small plots with a farm family dependent on an average area of only 1.2 hectares for their livelihood. The efficient working of this area is further complicated by the holdings being divided up into from 6 to 12 plots.

Large scale mechanisation is not practised for these basic reasons if not for the more obvious reasons of lack of capital and inclination.

It is not surprising therefore, that the most widely used machine is the two wheeled walking tractor; some 6,000 to 7,000 of these machines are in use in the area. And, despite efforts to start cooperatives or contract services, 85 per cent of them are privately owned.

Introduced from America and Japan some fifteen years ago, these tractors - in the $2\frac{1}{2}$ to 10 hp class - are widely used for paddy cultivation.

The results of the introduction of this machinery has been an increase in the output of cash crops and a general all-round improvement in productivity. This came mainly from the reduction in the number of draught animals which not only needed land for fodder growing but also took up a lot of the farm family's working time.

This improvement was not achieved without a considerable amount of operator training and advisory work.

At first, farmers purchasing machines were given individual instruction on their own farms by machinery experts but as the numbers grew this became increasingly difficult. As the operating competence of the first farmers to use the machines grew they were encouraged to act as instructors to train new machine owners. Unfortunately, due to the reluctance of these 'operator instructors' to work on their own initiative, the scheme was not particularly successful.

The third and most successful approach was to set up 'mechanised farming training units' with 15 to 30 members in each village and township. The leader and deputy leader are elected by the group and are given refresher training courses by experts. The groups meet once a month with a comprehensive programme of lectures, discussions and demonstrations.

This type of organisation has been relatively successful, according to the report, and suits this type and stage of basic mechanisation.

As in most areas where this type of training and information dissemination is attempted, a serious obstacle was the shortage of people to do the initial training. This was overcome to a certain extent by giving concentrated and specialised training to groups of young workers on the government experimental stations. They then acted as the peripatetic group instructors.

A problem which has been constantly impressed on the writer by people concerned with mechanisation in developing countries formed one of the more significant comments in this report: the lack of mechanical knowledge of agricultural administrators and advisory workers. Although usually soundly grounded in agricultural science and practice, few of them were able to offer any effective assistance with mechanisation problems.

In Taiwan this was to a certain extent rectified by giving the majority of extension workers concentrated courses in basic farm machinery.

The report emphasises the importance of laying the sound technical and educational groundwork before embarking upon a mechanisation policy. Closely allied to this was the provision of financial aid to farmers, local repair services and a good fuel supply system.

The service and repair network needed to keep the power tillers working was provided by combined action by government and private enterprise. Blacksmiths and motorcycle repair shops in the centres and market places of town and villages were adopted as 'power tiller repair shops'.

These selected workshops were persuaded to send one or two of their mechanics to short-term government organised machine maintenance courses. This proved to be the most economical way of establishing a workable repair service and produced good results.

Case study - One country's answer to the spares and service problem - machine stations in Ghana

Ghana can be described as having most of the agricultural problems typical of developing countries. More than 60 per cent of the country's 7 million population is engaged in agriculture. A wide range of subsistence and cash crops are grown with 95 per cent of the home food consumption being grown by individual farmers.

As in many similar countries, the agricultural mechanisation problem has been complicated by the wide range of machinery imported into the country from different manufacturers in different parts of western and eastern Europe.

In the last five to ten years some 3,000 prime movers and their attendant ancilliary equipment have been imported. Both wheel and tracklaying machines, worth some £7 to £8 million, from such makers as Massey Ferguson, Ford, Zetor, Caterpillar, International Harvester, Porsche, David Brown, Deutz, Eberhardt and Bratsvo are in use. Understandably, spares and service for such a polyglot collection of equipment is a big problem.

The low standard of general education and the general lack of the "mechanically minded" attitude commonplace in Europe make the successful operation and maintenance of such equipment a much greater problem than they would be in more developed countries.

Fortunately - from a maintenance and personnel training point of view - close on 60 per cent of the tractors at work in Ghana are operated by government machine stations not unlike those used in parts of Russia and Eastern Europe.

These machines are operated from local depots backed up by regional workshops and are used by the Ministry of Agriculture, State farms, Volta River Authority Farms, Workers Brigade farms and hired out to individual private farmers. Although this system does create considerable problems as far as management of individual agricultural

units is concerned, it does have the advantage in the development stage, of creating an organisation more suitable for training potential operators and mechanics and of ensuring that the bulk of the country's farm machinery is kept in running order.

The government farm mechanisation project is directed from a head office in Accra where the central spare parts depot is also situated. There are 33 mechanisation districts covering the main agricultural production areas of the country and large central workshops covering the northern, central, southern and eastern parts of the country.

The mechanisation projects as well as the workshops are under the direct supervision of the regional offices which in turn are controlled from Accra.

The local machine stations, which normally run a team of between 20 and 70 tractors and attendant landclearing, cultivation and planting equipment, are supervised by a government officer. These local depots have simple sheds for the machinery with adjacent workshops, offices and fuel storage.

The tractors and equipment are distributed for work according to the needs of local farmers and charges are made either on an hourly or area worked basis. To facilitate the book keeping and accounting side of the operation the tractor drivers keep log books for the running details of the tractor. These are also obviously used in running the machine maintenance and service side of the operation.

Total charges for work done on any particular farm are worked out at the end of the month and payment is made by the farmer when the work is completed or, alternatively, he pays after harvest when the money is available.

Simple repair work is carried out at these local machine stations. A staff of 2 to 5 mechanics are employed full time to do the simple repairs and maintenance needed to keep the machines running.

The equipment needed to carry out this type of work - greasers, vulcanizers and simple forges - are operated in these workshops. Seasonal maintenance and such jobs as engine overhaul which demand more specialised equipment, is done at the central workshops. A comprehensive range of equipment is installed and they also provide a mobile van service for the more complicated running repairs.

Detailed records are kept of repairs and service and these are entered on the records of individual machines. This information is collected from monthly summaries of mechanic's job cards.

Improving the standard of machine operation and maintenance is tackled by training in two ways: practical training courses for farmers and operators and more detailed factory and college training of mechanics.

Farmers and other young men from the villages who are likely to be operating tractors and other machinery are given operation and simple maintenance training with practical tests and examinations followed up by refresher courses. The mechanics get their basic training in the machine station workshops.

The daily co-operation of teachers and instructors in solving constant practical problems is considered to be the most valuable method of training personnel.

More intense theoretical and practical training is however, not neglected. Particularly promising mechanics are sent on special training courses overseas for six months or so and also on two to four month courses at local training establishments.

The management staff are trained in the normal way through university, college and overseas training courses.

Needless to say training people for all types of jobs is not easy given the basic problems of education the shortage of teachers and general basic educational problems typical of developing countries.

The problem has been succinctly stated by a Ghana University agricultural engineering lecturer:

"Agricultural and technical education is not only a question of short period courses, one to two year training schools or of overseas training, but it is also a long-term process in which background information and knowledge is bui + up."

"Daily work with agricultural and technical staff, as well as with farmers, is the most efficient training method."

A lack of sympathy from manufacturers and others in Euro-American countries with the basic problems of developing countries is also felt.

"Problems that arise from too many different conditions of farm mechanisation between the countries from which the machinery is exported and the country that is importing should be considered", believes this same expert.

"In the developing countries the tractor drivers have not been brought up with mechanical toys, bicycles, motor cycles or cars and consequently do not have the right mechanical background.

"Their first contact with machines is probably when they come onto a training course. This special situation, combined with difficult soil, vegetation and climate conditions should be considered by the designers of the farm machinery and by the teachers and instructers who are to train farmers, drivers, fitters and supervisors."

Although the type of mechanisation detailed above may well be suitable for the early stages of development and is undoubtedly as near ideal as possible in building up a sound structure of trained personnel within a country, it is not regarded as the best long-term approach to farm mechanisation.

"The running and management of farm mechanisation projects under huge organisations or under ministries is usually unprofitable," says the expert already quoted.

"It is very difficult and nearly impossible to control the efficienoy of each tractor, workshop or regional agricultural office from the distance of tens and hundreds of miles.

"Moreover, the most important factors in farming are cost of production and the return per acre. These factors are controlled by the farmers themselves in the easiest and most economical way. Therefore the farmers - either individually or cooperatively - should be encouraged to carry on the mechanisation themselves.

"Farmers should be encouraged through financial aid and extension service to hire or buy their own tractors and implements. Only very expensive tractors and machinery, such as crawlers for land clearing should be operated by government departments or other central organisations.

"The tractors and equipment should be tested under the specific agricultural conditions of the country they are being imported into. It is also very desirable to reduce the types of imported tractors and machines because this complicates and makes more costly the training of manpower, the maintenance and the supply of spare parts."

Ghana has already found to its cost that this is an expensive way of doing the job. Their attitude is now changing towards a combination of the services of the commercial firms with the operation of farmer's cooperatives and the government machine stations.

Fast moving spare parts, as well as fuels and lubricants, it is recommended, should be stored at the machine stations, cooperatives and larger farms with simple repairs carried out in the field.

Most important, it is believed, commercial concerns must be encouraged to set up depots for repairs and service as well as the sale of fuels, lubricants and spare parts to farmers.

III THE DEALER'S POSITION

The experience of an East African service manager

The practical problems of servicing machinery under conditions typical of those of many developing countries were forcefully spelt out to the writer by the manager of a large agricultural machinery business in Nairobi.

His job is complicated and at times made almost impossible by bad communications - both with his sources of supply and his customers - by the weather, by the lack of trained mechanics and by the low standard of machinery operation and mechanical know-how of the farmers themselves. A further important problem is the difficulty of obtaining payment for the services provided by his company.

He handles mainly British manufactured equipment and his source of supply of parts is therefore 3 to 4 months away by sea. This means that he has to carry a much larger stock of parts than his European equivalent; since he is forced to carry a lot of slow-moving spares he must carry a much larger 'dead' stock than he would if he was close to the factory where spares are produced. He therefore has to charge more for parts to cover the interest on this idle money.

Service calls can be from 150 to up to 800 miles over inadequate roads which, in the rainy season, can often be impassable. Typical calls which he quotes are:- Kitale, 250 miles to the north west of Nairobi; Mombasa, 300 miles south east; Mount Kenya, 150 miles to the north; and journies anything from 200 to 800 miles down into Tanzania.

Having made these sorts of journeys, he says, it is not unusual for the service van to reach the end of the farmer's 3 mile driveway and then find it impassable. Cost of these calls is consequently very high.

"The dealer cannot charge the farmer anything like the full cost of these long service calls," he points out. "For this reason we try to make as many calls as possible in a particular area to justify the journey.

"I recently sent two mechanics in a service van to West Kilimanjaro to service equipment on five farms in the immediate area. When they arrived they found that it had rained so hard that even tractors could not travel on the roads. They returned to Nairobi after having both spent two days on the job and having travelled 400 miles with absolutely no return to show for it. This happens often."

Longer trips are often carried out with aircraft where landing strips are likely to be available. Here again the operation is often held up by the weather and time wasted by inadequate weather forecasts and poor communications.

As in most developing countries, good mechanics are in very short supply. In this particular country, Kenya, the problem has been further aggravated by the loss of good Asian mechanics who are unlikely to be replaced until a proper training scheme is set up to train African mechanics.

The low standard of general education and general lack of mechanical aptitude, he believes, is likely to make this a slow process.

The same state of affairs tends to complicate the dealer's relationship with his farmer customers. The farmers' attitude to any commercial concern and their ignorance of the basic principles of machinery makes the provision of an efficient service extremely difficult.

"The African farmer buying and using equipment expects every service to be a free one, every part to be under guarantee and every guarantee to last for ever. He can usually read the parts book just enough to ask you to bring the wrong spare 200 miles to his farm."

"A short time ago I received a telephone call at 11p.m. on a Saturday night from a farmer to say that he urgently needed the cable drive to the cutter bar of his combine replaced.

"I took all the concievable parts for the front cutter bar unit on the Sunday, 170 miles to his farm, to find that in fact a steering ball joint on the rear steering had failed. This sort of thing happens quite often."

In an attempt to reduce the time and money wasted on this type of fool's errand and to make the service more efficient, this particular company tried to set up a local centralised service depot. It failed because of a lack of cooperation from the farmers.

Services were offered to farmers free of labour and mileage charges if they would bring their machinery to the central point. Out of 30 farmers running mechanical equipment in the area, two turned up and even they refused to pay for the parts used in the work.

From the farmer's point of view the main cause of the high cost of machinery maintenance is the shortage of reliable operators who are prepared to treat their machinery with any sort of respect and maintain it properly. Main cause of this is the lack of any training facilities.

Many of his customers attempt to overcome this obstacle by rewarding operators with a bonus scheme for breakdown-free operation. In many cases this works quite well.

But training is a long and repetitive business and often unrewarding. After training men the farmer is seldom rewarded with any loyalty.

IV A MANUFACTURER'S VIEW OF THE PROBLEM:

Some idea of the responsible manufacturer's attitude to the problems of servicing and maintaining machinery in developing countries, and the way in which it tackles them, can be gathered from a brief study of the operations of the world's largest manufacturer of tractors, combines harvesters and diesel engines - Massey-Ferguson.

With its headquarters in Toronto, Canada, but multi-national in its manufacturing and marketing operations, Massey-Ferguson sells a wide range of tractors, harvesting machinery and ancillary equipment, in practically every country in the world.

Last year its sales totalled £358 million, of which about two thirds was farm machinery. Just under 14 per cent of the total - over £48.4 million worth - went to the developing countries of Africa, Asia and Latin America. Although this figure includes sales from the company's two other main product groups, Industrial and Construction Machinery and Engines, the bulk was farm machinery.

Sales to these territories have nearly quadrupled in the last ten years and continue to increase. Massey-Ferguson executives are convinced however, that this performance has only been achieved by a long-term policy of developing comprehensive distributor and dealer networks backed up by a continuous technical support programme.

"When we go into a territory to sell machinery we do everything possible to ensure that the area is adequately covered by a distributor and dealer network, and that buyers know how to use our equipment," a member of Massey-Ferguson (Export) Limited told me.

In most developing countries there are considerable obstacles to such a policy. The most important of these is probably communications: farmers and operators are often spread over large areas, in some cases a matter of more than a hundred miles from their nearest dealer and any sort of workshop.

Social situations also often help to make the dissemination of information to operators more difficult. In particular, the levels of education too frequently make the instruction and training of machinery operators a much more laborious and repetitive process than it would be in more developed countries.

The difficulties stemming from these two main problems are further aggravated by the unique conditions under which most farm machinery is operated in developing countries. Because, as one Massey-Ferguson expert estimated, machines commonly work 1500 to 2000 hours a year (compared to 400 to 800 hours in Europe) the effects of rough handling and rigorous soil and climatic conditions tend to lead to more frequent servicing and maintenance requirements.

The following are some of the ways in which Massey-Ferguson tackle these basic problems.

Service and Product Education

The basis of Massey-Ferguson's marketing in all countries outside those where the company has its own manufacturing facilities is a system of exclusive distributors in each country, each with its own network of exclusive dealers. Exclusivity is considered essential in providing high standards of service and parts supply, ensuring that the distributor has the incentive to provide his own and dealer personnel with sales and technical training and the farm machinery operator with instruction in the use and maintenance of his equipment.

The most important part of a distributor's organisation, apart from his workshops and stores, is considered to be his education facilities. Here, not only are dealers' mechanics trained, but salesmen are also instructed in the main operating features of machines. The aim is that they should be able to help potential buyers choose the right types of machines for their farms as well as show them how the equipment should be operated.

If a farmer, group of farmers or a village community are interested in buying a tractor, arrangements are first made for a comprehensive demonstration so that the potential buyers can study the operating features of the machine.

When a machine is actually sold it is individually installed in its working location by a trained representative of the dealer or distributor. In some cases he will spend at least 48 hours at the farm or village ensuring that the operator is familiar with the main operational points.

Naturally, in many areas he will spend a lot of his time on basic points common to all machines - oil levels, keeping radiators topped up, battery maintenance, tyre pressures and even impressing the importance of keeping the fuel tank filled.

The coverage of these apparently elementary points is essential in many areas because of the lack of 'mechanical mindedness' taken for granted in more developed countries.

The more specific operating points such as correct use of the gear box, hitching implements to the tractor, use of the tractor hydraulics and simple engine maintenance are also explained but it is no easy matter to ensure that the operator achieves an acceptable standard of competence in such a short time.

Further courses of operator training - through government sponsor programmes or the distributor's own training staffs or a combination of both - are relied upon to develop the operator's competence.

In search of new ways to improve the effectiveness of its educational programmes, MF has introduced mobile training units to take its own training expertise to the door-steps of farmers in developing and developed countries alike. This year two units are operating in North Africa and Northern Europe. Last year, the biggest of them toured the Middle East and Southern Europe, reaching as far east as West Pakistan.

These articulated vehicles each with a two-man crew, can be adapted as a cinema, classroom or workshop and they are comprehensively equipped with a wide range of training aids to provide on-the-spot instruction in a variety of aspects of machinery operation and maintenance.

So much of the success of these operations, however, clearly depends on the quality of the service mechanics and the other technicians who carry the training programmes into the field.

Unlike the majority of agricultural engineering companies, Massey-Ferguson itself has shouldered the responsibility of ensuring that the high standards necessary are achieved. For over twenty years they have operated a specialised school at Stoneleigh, England, to train distributor and dealer mechanics, sales and service personnel, independent machinery specialists and instructors from government departments and other training centres, as well as MF company staff.

Some 1500 trainees annually pass through the 500-acre MF school in England each year, and in most years 250-300 will be from developing countries.

Sponsored or recommended by distributors, government departments or international organisations such as FAO, students may be taught specifically about one particular type of machine - or even a single feature of a machine - in short courses lasting a few weeks, or with a combination of courses, they may stay as long as six months to complete the full range of instruction available on the use and operation of tractors, combines and allied equipment.

All tuition at the centre is free - the sponsor is expected to pay only the student's board and lodging while he is in residence at the school.

Unlike many other manufacturer-operated training schemes, emphasis on the Stoneleigh courses is on teaching the student how to operate the machine before he learns how it works and how to service and maintain it. Massey-Ferguson believe that it is impossible for a technician to understand the operator's problems if he cannot use the machine himself. The instruction given is a mixture of maximum practical experience in the field and workshop, balanced with a minimum of theoretical instruction in the classroom.

When these students return to their own countries, it is often to supervisory or advisory capacities in which tney are able to pass on the knowledge gained to mechanics and instructors in their own organisations.

Gradual building up in this way a nucleus of technical expertise is essential, believe Massey-Ferguson, if any improvement is to be made in the standard of servicing, maintenance and operation of agricultural machinery in the developing countries.

There are Massey-Ferguson training centres in several countries doing work similar to that of the Stoneleigh school. Even so, MF believes that solving the problems is beyond the resources of any single organisation; that ultimately the answer lies in governments, the international agencies, manufacturers and other organisations concerned, working together to find the solutions.

Massey-Ferguson itself has already pioneered significant examples of the sort of co-operative effort it feels is required.

Equipment and technical aid was inoluded in a £300,000 contribution by MF towards setting up the South American Farm Mechanisation Centre near Buga, Colombia. Run in conjunction with SENA, the national apprenticeship organisation of Colombia, on behalf of the Colombian government, and FAO, the centre is designed to train farm mechanisation instructors from all parts of Spanish-speaking South America.

MF's experience in training matters and disseminating knowledge has also been lent to the organisation, in conjunction with FAO, of world conferences on rice and sugar, both key world crops.

In 1966, a £200,000 contribution from MF enabled FAO to launch the Young World Food and Development Project. Originally designed as a two-year project to investigate how the enormous potential energy of young people in the world under 25 years old, who constitute some 70 per cent of the population in developing countries, could be more effectively utilised in development programmes, it is now continuing with further support from MF and it is expected to involve up to 50 million young people from developed and developing countries by 1980.

There are others, and in total they reflect the broad front on which MF believes the problems have to be tackled.

The sheer physical distances involved in carrying out such activities are enormous. On the sole question of after-sales servicing of machinery, the problem of the distances that have to be covered remain a main obstacle to efficient provisioning in many territories. Tractor operators are spread over a wide area, and no matter how competent the distributor and dealer mechanics and technicians, there is a limit to what can be done within their resources.

A firm belief of Massey-Ferguson's Export Operations is that more use could be made of mobile service workshops in many such areas.

A prerequisite for their successful operation, however, is that farmers must accustom themselves to the habit of having their machinery serviced regularly; too often the mechanic is never called upon until a machine breaks down. A comprehensive mobile service system could be financially viable only if a majority of farmers in a particular area is prepared to pay for regular servicing of their equipment.

Parts supply

It is Massey-Ferguson's claim that if a part is needed anywhere in the world for an immobilised machine and it is not immediately availabl locally, it will be on its way by air-freight within 24 hours of the request being received at one of MF's Central Parts Operations warehouses.

The main MF distributor in every country is expected to carry 100 per cent spares coverage of all parts, both fast and slow moving.

His branches and dealers must hold all fast moving parts in stock, and, where financially justifiable, they too are required to stock slow moving items. A man selling 50 to 100 tractors a year would have practically as comprehensive a range as the distributor, but it is not likely to be practicable for the smaller dealer to carry such a wide parts range.

The latter, although having a full range of fast moving spares, would normally expect to obtain from the main MF distributor any parts turning over less than four or five times a year.

Massey-Ferguson strongly deny a frequent, but naively based assertion that distributors make excessive profits on parts business.

"It is wrong to think that the agricultural machinery business in developing countries is being carried on in a vacuum. The laws of supply and demand rule there as elsewhere," says Mr. K. A. Graham, Director of the Parts Division of Massey-Ferguson (Export) Limited.

["Indeed, the parts business is one of the most competitive sectors of our industry. If the manufacturer who sold the tractor offers his parts at an uncompetitive price, someone else will soon take the business from him.

"The magnitude of world-wide trade in parts is considerable. Inevitably this has attracted the attention of companies outside our industry who do not make machines of any kind, but produce only parts for equipment made by other manufacturers. Very often, these parts are not genuine units carrying the approval of the makers of the original equipment.

"The most serious aspect of this development is that these parts are usually neither made nor sold by people who have any franchise responsibility.

"At the same time, both the approved and non-approved overseas manufacturers of parts have to contend with the same problems of freight costs, delays on import, interest and insurance charges, all of which help to make spares more costly. Therefore, the only way the non-genuine parts suppliers can undercut the bona fide producers is to manufacture to lower standards."

The results of the use of these non-approved spares, Mr. Graham points out, is too often serious for the machinery user, and, through no fault of his own, the reputation of the maker of the machine involved is adversely affected. A mechanic in Europe is hardly likely to recognise that a particular part has been machined to inadequate tolerances, so it is even less likely that his counterpart in less developed areas will notice the difference.

In the face of this problem, and to protect their reputation for quality, Massey-Ferguson and other reputable manufacturers have often had to supply spare parts at bare manufacturing cost to maintain the good name of their products.

Apart from the reasons mentioned for the higher cost of spares in countries remote from the proper manufacturing source, the distributors and dealers in these countries suffer from another disadvantage which their European or American counterparts do not: they must carry a much higher proportion of spares in relation to their total business. This stock also turns over much more slowly than it does in the more developed countries.

Because he dare not be caught without a particular spare - either slow or fast-moving - the distributor who is two or three months journey from his source of supply must carry about 25 per cent of his total stock-in-trade in the form of spare parts instead of the 8 to 10 per cent commonly held by the average European distributor.

Similarly, the average turnover of these spares will be much lower than those sold by the European machinery distributor. A well organised European distributor would expect to turn over his stocks of spares an average of around 2½ times a year; a competent distributor in a developing country would be lucky if he achieves a spares turnover rate of once a year. In some remoter districts the turnover may be as low as 0.4 or 0.5 times a year.

Before counting any other costs, Mr. Graham points out, the distributor and his dealers will have an on-cost of 8 to 10 per cent for the interest charges on the capital invested in this stock. This figure applies in countries where 'normal' interest rate are being charged - where interest rates are higher this cost will be greater too

In conclusion, it must be emphasised that although Massey-Ferguson feel that the standard of operator competence and service facilities have improved considerably in the last ten years, any rapid improvement in the future must come from even greater co-operation between manufacturers, government departments and local communities.

The improvements needed are more likely to be achieved if mechanisation programmes are carried out as part of an overall economic development plan, Massey-Ferguson believe, rather than if allowed to develop piecemeal. Machines operated incompetently by isolated farmers, to whom it is difficult to get service, information and the training they need to do their job efficiently, result in a waste of scarce resources and do nothing to advance the cause of agricultural progress in developing countries.

VI SOME SUGGESTED SOLUTIONS

It has been shown that there are three main problems involved in the servicing and maintenance of farm machinery in developing countries: inadequate supplies of spare parts, a lack of efficient maintenance and repair services and, in many countries, a complete absence of facilities for training operators and maintenance technicians.

1. Spare parts supply

The shortage of spares for farm machinery in many developing countries can be divided into two sections: national and local.

National shortages can generally be blamed in the first instance on the manufacturers supplying machinery and secondly a lack of responsible attitude on the part of the government department whose responsibility it should be to ensure that imports of machinery are adequately backed up by the correct quantity of the right type of spares.

Batches of particular types of machines - tractors, cultivating equipment, harvesters - are frequently sold to government officials or directors of agricultural improvement schemes by irresponsible manufacturers who do not inform the purchaser what type and quantity of spares he is likely to need within given stages of the machines' working lives.

Too often the purchase of such a batch of machinery - it may be and often is a complete selection of power units and cultivating and harvesting equipment - is regarded as a 'prestige' operation designed to impress politicians and governments of other countries. The money available for the purchase is usually limited and the aim is to impress by purchasing as many machines as possible; a supply of spares to compliment the machines is seldom considered.

A typical example quoted to me by the export service manager of one of the world's leading farm machinery manufacturers was the case of a government official buying a batch of harvesting machines.

Twenty-four machines were ordered but there was no mention from the buyer of spare parts to service the machines. When the seller investigated this apparent oversight he was told that the country concerned needed this number of machines and that there was no money left for spares.

The manufacturer's advice that they should buy one machine less and spend this money on spares was ignored. In this case the manufacturer refused to supply the machines without spares but in too many cases the purchase would have gone ahead under the buyer's terms.

In addition the machinery is often completely unsuitable for the type of work and conditions it is intended to operate under.

It is also too obvious that an element of bribery and political manipulation is often involved in these machinery deals.

Although most governments object to interfering with private enterprise operations it is inevitable that there will have to be a much closer control of machinery import operations by relevant government departments. This is a job that should be done by a technical expert or expert committee rather than a politician.

The expert or the committee's main task should be to ensure that any import of machinery is accompanied by both adequate spare parts and technical information. Machinery buyers in developing countries have a right to expect manufacturers to ensure that operators will at least receive basic instruction in the main operating points of machines.

Similarly, manufacturers must pay more attention to ensuring that the instruction books and spare parts manuals supplied are easily understood by the people of the country concerned. Too often such essentials to efficient operation are supplied in the wrong language and written in a style and illustrated in such a fashion that they are incomprehensible to unsophisticated operators.

Much more use must be made of instruction manuals which rely more on photographs and diagrams than on words to get their message over. Not only does this make the communication of information easier but it simplifies the translation into less well known languages and dialects.

But the most essential job for anyone in control of imports of farm machinery is to ensure that the right quantity of spare parts are purchased in relation to the number of machines.

Generally expert opinion holds that in remote area where any sort of spares are liable to be delayed for long periods as much as 25 per cent of value of a total consignment should be in the form of spare parts if machines are not to be out of order for uneconomic periods.

The problem of the national supply of spares should be solved by a combination of government and free enterprise action. The local supply of spares in remote regions is a more difficult problem, however. As has already been demonstrated in the case study of machine operation, this is complicated by the financial limitations of servicing machinery widely spread through a remote region and also by the lack of knowledge of their machines on the part of the operators.

This would appear to be a situation that can only be resolved by government assistance in encouraging the setting up of machinery cooperatives which could afford to pay its own mechanic or justify regular trips from a service mechanic. In the former case some financial aid would have to be forthcoming to pay for stockpiling of the main essential spares.

2. Maintenance and operating structure

In most machinery operation situations in developing countries it can be assumed that the distances involved, the wide dispersal of the machines and the lack of operating skill on the part of owners and drivers are the major obstacles to the efficient service and maintenance of machinery.

Economic and communications factors are making the servicing of individually owned machines difficult and it is therefore likely that the only real improvement in the standard of operation and day to day maintenance can only come from government operation of machinery with full cooperation from manufacturers and dealers.

Unfortunately, as existing pilot schemes in several countries have made clear, this is not the type of operation that is likely to aid the smaller peasant farmers to any great extent. The development of extension aid and instruction is likely to be the only effective attack on this problem unless governments are prepared to subsidise the provision of machinery, service and maintenance facilities to remote areas.

Government controlled machinery units should, however, be set up whenever possible because of the effeot they must have on the long-term development of agricultural mechanisation. Unfortunately, because of the difficulties of staffing and obtaining supplies in developing countries they are seldom likely to be run profitably and will inevitably demand subsidies from governments.

However, provided they are properly set up with sufficient emphasis on training operators and mechanics, they must not only produce relatively large numbers of trained personnel but also set a standard by which all other machinery operation can be measured.

The effect of starting even a limited government machinery service are effectively summed up by an FAO adviser in East Africa: "The actual benefits of setting up a government machinery service are difficult to measure but it can set the pace for mechanisation, take the burden of the experimental stage off the farmer, meet requirements where private capital and know-how do not exist, accomplish special tasks which would not be attractive to a private commercial concern and rapidly put new land into production."

Obviously, the main requirement for successful operation of a government machinery operation is having sufficient land to be worked by any particular unit; in many areas where there are already a large number of tractor owners who may well be doing work for their neighbours, this is difficult.

The other main requirements are availability of the right equipment for the area covered and sufficient trained staff and extension workers to ensure that the equipment is properly used.

The most important element in the successful operation of machinery units is the degree of supervision of the operation and general organisation.

An example of the way in which such a machinery unit can be set up and organised is the Tractor Hire Service first set up in 1966 and since modified by the Kenya Government.

The service was established to work for individual farmers and also on government agricultural schemes. The main problem was that many of the areas where work was to be done were 200 miles from the headquarters and there was a lack of trained staff to operate machinery.

The scheme was based on 25 tractor machinery sub-units and the transport obstacle was tackled by equipping each sub-unit with a 5 ton lorry, 6 tanker trailers for fuel and water and a four wheel drive vehicle for the transport of operating and supervisory personnel.

The staffing and training structure was worked out by FAO extension workers and the overseas liaison unit of the National Institute of Agricultural Engineering, UK. The aim was to make maximum use of the trained staff and provide a structure that would ensure that the units could do as much as possible to train their own men.

Implement operation was at a pretty low standard in the country generally and still is. To a certain extent this still applies to the tractor hire service "with men with little more than a driving licence in charge of £2,000 worth of machinery."

Not only has it been difficult to get trained men on the scheme but also to work out a wages structure that would provide both an incentive for high output and a good standard of workmanship.

Originally the operators were paid on the normal wage system ruling in the country but this has resulted in lower output than should have been theoretically possible. This is now being superseded by an overtime and bonus system.

To combat the problem of low standards of operation from a technical point of view a new staffing and training structure has been worked out by FAO and the NIAE Overseas Liaison Unit (Appendix H). A type of organisation that could be applied to government machinery operations in other developing countries where field scale rather than small plot farming is practised, it is designed to provide a high level of supervision as well as a meaningful wages structure.

"The level of supervision is vital to the successful operation of a unit of this type", emphasises Mr. Theo. Willcocks of the Liaison Unit. "This sort of organisation is designed for a 25 tractor unit and the most important part of it is the proportion of workers to foremen and unit supervisors. Any attempt to reduce the amount of supervision will, I believe, result in a very much reduced output and lower standard of work."

As with many other such officially operated mechanisation units, the main problems encountered have been the difficulty of obtaining any sort of economic work rate when operating in the areas of peasant small holdings, getting the operators to feel responsible for their machinery and to understand it thoroughly and, most important to a scheme of this nature, maintaining accurate records.

Most of these obstacles to efficient mechanisation can only be overcome by better training and education. The efficient use of machinery - operating, servicing and repairs - on smaller peasant holdings is altogether a more complex matter which raises the whole question whether it is wise to attempt mechanical cultivations on such farms until a much more advanced stage of economic development is reached.

3. Education

As the foregoing parts of this report have heavily underlined the only long-term solution to the servicing and maintenance problem is education; better trained operators and more skilled mechanics and field staff.

But education in the European context is largely irrelevant - at least as far as operator training is concerned. It is not unreasonable to assume that the majority will be almost illiterate with little mechanical knowledge and training schemes have therefore to be geared to this sort of standard.

Teaching methods will inevitably be largely oral with considerable reliance on visual aids; the emphasis must be on practical demonstration and constant repetition merely to establish the basic principles of machine operation.

Teaching methods and particularly the visual aids used must be carefully graded to the standard of literacy or lack of it of the trainees. Lessons and demonstrations must be put over in the simplest way possible and in sessions of short duration; the instructor must be certain that each stage has been mastered before he moves on to the next.

It is little use an instructor hurrying on with a comprehensive machinery operator's course if the basic principles have not first been mastered. These fundamental principles of instructing people of a low standard of education and unfamiliar with machinery were well understood a decade or two ago; they are nonetheless still true of many areas of developing countries today.

Most educational and extension experts agree that a really effective structure of technical personnel can only be built up from this basis with a gradual selection of the more able men to train as foreman drivers, mechanics, demonstrators and advisory workers.

But before this sort of system can be successfully applied two main problems must be tackled: the general standard of education must be raised and ways must be found of obtaining more of the men who are to do the training.

The first problem can only be solved by developing countries themselves and is likely to be a long-term process. The second problem can be solved more rapidly by more educational aid from developed countries. Aid that is, not so much in the form of direct monetary help to internal education schemes, but more in the form of training sponsored students and seconding trained personnel to these countries.

Having obtained trained men the developing countries must then take steps to ensure that they are able to keep them employed where they are most needed - with their sleeves rolled up, passing on their knowledge to the people who need it.

It should be unnecessary to point out that far too many students trained overseas in practical technical skills return to their own countries to spend the rest of their lives in administrative jobs. Too often most of their expensively won technical knowledge is thus never applied.

Salary scales and other inducements must be provided to keep thes people practically involved in solving the day to day farm mechanisat problems of their countries.

It is a world-wide phenomenon but one particularly noticeable in developing countries that people do not want to work in agriculture. The result therefore of educating or training a man beyond local elementary school standard is to raise him out of his previous social relationship with his neighbours.

Not only is he likely to feel superior to them but, more serious, he is no longer likely to want to soil his hands with practical farming. If he does not actually become some sort of minor administrator, he goes off to the nearest urban centre and becomes a garage mechanic or lorry driver.

Apart from the social situation, this attitude is understandable because of the better pay of these urban occupations. Unless more is done to 'glamourise' the struggle to improve the vital agricultural production in many developing countries and skilled and semi-skilled men are paid more this wastage of educational effort will continue.

The main requirements of most developing countries is for four classes of technicians: skilled tractor and machine operators, farm mechanics, service mechanics and field engineers and service managers. There is also a great need for more extension workers with a more practical knowledge of farm mechanisation.

The structure most likely to produce these various classes of personnel is likely to be simplified but intensive training courses for operators; more detailed - but still simple - intensive training for farm mechanics and foremen drivers; thorough workshop and college training for service mechanics and demonstrators and college and university training for service managers and extension field engineers.

Although in the long-term it cannot be said that any one of these groups of personnel is more important than another, the foregoing section of the report has shown that the most urgent demand is for facilities to train operators.

At present the setting up of such units is hampered by a lack of funds and a shortage of skilled and experienced instructors. Even so it is still possible to make considerable improvements in the standard of machine operation with the bare minimum of equipment and buildings. The availability of dedicated instructors of the right technical calibre is however, vital.

A typical example of this sort of organisation is the Narosurra farm mechanisation training scheme now running in the Baringo district of Kenya.

The scheme utilises the facilities on a 500 acre farm plus machinery and equipment on loan from dealers and manufacturers to provide intensive 12 week courses in operation and maintenance for owners and tractor drivers.

Operating in an area of often marginal rainfall where near famine conditions are semi-endemic, this scheme is seen as part of a plan to increase agricultural productivity through private ownership of tractors. As well as cultivating the owners individual holdings these machines are used for a considerable amount of contract work.

The Narosurra unit can, at the moment, take 35 students on each course and is able to run three courses a year. Aim is to improve the efficiency of machine operation and to teach operators how to do a lot of the maintenance which previously would have been neglected or would have involved expensive service and repair work by commercial organisations.

Ploughing and cultivating, servicing and simple repair work, including gas welding, are the main subjects covered. These are supported by a thorough grounding in farm accounting - particularly essential for the contract operators - and basic animal and crop husbandry.

Apart from money from the Kenya government itself, funds come from several international organisations. The work is nevertheless severely limited by lack of money. Costs of training each student works out at 1,000s. and at the moment half of this has to be contributed by the student himself. Naturally lack of this amount of money bars many men from taking the course.

Despite this obstacle, direct beneficial results of the training scheme has been the raising of the standard of tractor operation to the extent of allowing tractor owners to pay for their own machines in a very short time; one man for example earned a quarter of the capital cost of a tractor in the first three months of operation.

Another beneficial development directly attributable to the training scheme has been the setting up of farmer's cooperative tractor operating groups. Main instigators of these groups have been men trained on the Narosurra course.

As well as being short of money, schemes of this sort are also likely to be short of trained men. Although the Narosurra unit is staffed by experienced men from a number of countries, any expansion of these types of training schemes throughout the developing countries will demand many more locally trained men to carry out the vital task of passing on technical skills.

And, this is what appears to be one of the biggest gaps in the whole structure of technical assistance and educational advice to developing countries: the lack of the appreciation of the fact that the most vital need is for men trained in the practical side of machinery operation and maintenance to train operators and mechanics.

Although most extension workers and advisory men are well aware of this lack, most official bodies - whether individual governments of developing countries, the various sections of the United Nations Organisation, the overseas development ministries of developed countries or the technical aid organisers of international charitable organisations - are obsessed with university degrees.

To too many of these bodies a degree qualification - of whatever type and standard - is considered to be of much greater importance in employing a man to do extension work than deep technical knowledge and the ability to pass on his knowledge to others.

Unfortunately the mechanisation aspect of agricultural improvement and development suffers from this failing more than any other. I would suggest therefore that a man who has undergone a thorough technical apprenticeship, has had an intense two or three year technical college course in agricultural engineering and, ideally, has completed his education by a short course at a teacher or technical teacher training college is far more valuable than any man with an honours degree when dealing with the problem we are concerned with here. Such men are hard to find but the good they can do in attacking this very basic educational problem is bounless.

They must therefore be valued on this basis and rewarded accordingly.

This opinion has not been formed without considerable thought. Throughout the preparation of this report it has been continuously impressed on the writer by advisors, educationalists and commercial machinery experts that unless the technical standard (as opposed to the standard of theoretical knowledge) of the people advising and instructing operators and mechanics can be improved there will be little improvement in the standard of machinery operation and maintenance.

At the moment the educational and industrial structure of developing countries is little fitted to producing such leaders of this educational crusade. Although ideally, men of this type should be trained in the territories where they are to work, a compromise solution will have to suffice for at least the next two decades.

This compromise is likely to consist of developed countries seconding well-trained agricultural engineering specialists to underdeveloped countries and an intensive programme of training - both in their own regions and abroad - of promising technicians coming forward in the developing countries.

An approach favoured by many educationalists is that the service mechanics, demonstrators and instructors should be provided by a combination of men seconded from developed countries and talented technicians from the countries themselves. These latter will often have to be trained abroad. Farm mechanics and operators are in turn trained by these two categories of technicians.

Of course, several countries have already set up their own training establishments but it is likely to be many years yet before the developing countries become self-supporting in their production of training staff.

An educationalist with strong views on the importance of thorough practical grounding for the extension worker is Mr. Frank Turner, Principal of Rycott Wood College, Thame, Oxfordshire, England. Rycott Wood is one of the few colleges in the world to specialise in training agricultural engineers in both practice and theory to just below graduate level.

Many students from underdeveloped countries have been trained at the College and many British students trained there have later worked in mechanisation training and development projects in Africa and Asia.

Establishments like Rycott Wood, Mr. Turner believes, can play an important part in training technicians in the more advanced but essentially practically based categories. British students taking a Rycott course will either be undergoing - on a sandwich course basis - or have completed, a trade apprenticeship with a machinery dealer or distributor.

For overseas students this is not so simple but, Mr. Turner emphasises, they must have had a practical grounding in machinery operation in their own country if they are to gain any benefit from the concentrated type of course they are likely to undergo at Rycott Wood.

"It is nearly always impossible for the student from a developing country to gain, in his own area, the concentrated practical experience that is vital to sound training," he says, "But provided he has a sound knowledge of the machinery used in his own region and its special problems we can help him a lot."

Overseas students of this type inevitably lack the background knowledge of the student who has been undergoing a field and workshop apprenticeship, he point s out. Overseas students cannot be trained to a similar standard without more cooperation from machinery manufacturers and dealers in Britain and other developed countries, he believes.

"What is needed is a sort of concentrated sandwich course to get these students up to the technical standard of their European counterparts. This is impossible unless they can work with a machinery dealer under close supervision and instruction.

"The main obstacle to this is that companies will not take a man on this basis when they know that the time spent on training him will never benefit them since he is never likely to work for them once he is trained."

"I think this problem could be solved however, if the employing firm could be paid a grant to cover this loss. I think a sum of something like £100 would be enough to encourage many more firms to take on an overseas student for a year or so."

There are problems too for the young agricultural engineering technician who is seconded to a developing country. A period spent abroad on such projects tends to reduce a man's career prospects when he returns. He tends to be teaching at a more basic level than at home and is liable to get technically out of date in a short time.

Shorter tours of duty with more refresher courses as well as better pay for this type of work are therefore necessary, Mr. Turner believes, if the right sort of men are to be attracted to this type of work.

Main basis of the teaching at Rycott Wood, as at most other similar agricultural engineering establishments, are the syllabuses set out by the City and Guilds of London Institute. The two most important of these are the Agricultural Machinery Operator's Certificate and the Agricultural Mechanics Certificate.

Tropical versions of these have recently been introduced under the general heading of Agricultural Engineering in Tropical Countries. They cover the same basic subjects as the British versions but there is more emphasis on those subjects most relevant to tropical conditions and there is also scope for altering the syllabus to suit particular regions.

The first of these (no. 816 Agricultural Machinery Operator's Certificate - Appendix B) Mr. Turner believes to be ideal to serve as the basis of training farm mechanics, foremen drivers and machinery demonstrators in developing countries. This particular syllabus covers the basic elements of agricultural practice and machine operation and maintenance and needs a minimum of 500 hours study and practical instruction. At least 160 hours, it is recommended, should be spent on practical work.

Completion of at least six years primary education is necessary, the designers of the course point out, if full benefits are to be obtained. It is designed for full or part time teaching or a combination of both.

Aim of the course is to make the student familiar with the layout, controls and correct and safe operating procedures and also with routine servicing of tractors and machinery.

The second stage of the City and Guilds agricultural engineering teaching programme for technicians in tropical countries is the no. 817 Agricultural Mechanics Certificate (see Appendix C). It is designed for use in improving the technical skills of the man who already has some mechanical experience or ideally someone undergoing an apprenticeship.

For this reason it is only likely to be applied in teaching establishments in developing countries where there are staff of a high enough calibre to instruct to this higher standard. At present therefore it is likely to have most application for the student from these countries being trained abroad in developed countries where he can also gain additional practical experience.

It will also serve, Mr. Turner suggests, as the starting point for training such students who are sufficiently talented, up to the standard of the National Diploma in Agricultural Engineering or the Ordinary National Diploma. Both these qualifications are the equivalent of a pass degree but have a much heavier emphasis on practical work than does the degree qualification.

Training structure

As already made plain, the main problem in training machinery operators and operator mechanics at the moment is lack of enough men with sufficient training in the basic skills to do the training. Several developing countries have at least the beginnings of an agricultural engineering faculty attached to their national universities; very few have the right type of technician training set-up.

This type of training organisation must ultimately be set up within all developing countries if any improvement is to be made in the efficiency of farm mechanisation. At the moment, of course, lack of staff and lack of finance are serious obstacles and both capital and technical aid will have to come from the developed countries.

A particularly important part must be played by agricultural engineers and educationalists from these countries in aiding the setting up of training organisations.

One organisation already playing a significant part in the instigation of such schemes is the Overseas Development Unit of the National Institute of Agricultural Engineering, UK. Financed by the Ministry of Overseas Development, it spends its effort on solving direct individual mechanisation problems and also advising on training and mechanisation organisation.

In the last few years such recommendations have been made for a wide range of territories at the invitation of the governments in many countries of Africa, Asia and Latin America. They are convinced that each plan must be specific to the particular problems of each country.

"There is no fixed formula for setting up an agricultural machinery training scheme," Mr. D. H. Sutton, a member of the Unit staff told me. "Each region has different mechanisation problems, and therefore different training needs. These have to be adjusted to the level of mechanisation and level of general education if any worthwhile results are to be achieved."

Liason unit staff point out however, that generally there is a need for two types of training (ie apart from graduate level and above): intermediate technician level training for mechanics and operator mechanics and very basic teaching of the handling of simple machinery.

A secondary but still most important need is for facilities to give intensive specialised training in machinery operation to extension workers.

"This is specialised training which cannot be carried out on a general agriculture course," emphasises Mr. Theo. Willcocks of the Liaison Unit, "And I feel that this is one of the main problems in machinery training at the moment; ignorant use of machinery is inevitable when general agricultural extension workers are assumed to be competent in machinery operation."

The two types of training organisation referred to above are of course closely linked; once the intermediate level training gets under way trained men from them then become the instructors or assistant instructors in the more basic training scheme.

Two recent activities of the Liaison Unit - a report on training in Ethiopia and advice to a Latin American country on setting up a comprehensive machinery training scheme - illustrate the problems and some solutions.

The Ethiopian problem is a very basic one of many small peasant farmers working below subsistence level who urgently need help and advice in the efficient operation of simple animal drawn equipment. Some four million farm families, it has been estimated, will have to be covered by any training and advisory service.

The Unit's recommendation was for additional training for lower middle grade workers to act as mechanisation assistants to the extension workers. It was emphasised that all the resources available should be concentrated on this project rather than dissipating it on more advanced training which cannot possibly be applied to the country's rudimentary stage of technical development.

This improvement in advisory work was to be complimented by setting up simple small group training schools in each area where farmers could bring their own young oxen and be taught to train and work with them with improved ploughing and cultivating equipment. Once this basic step was completed, the use of simple hand tools and other agricultural equipment such as knapsack sprayers, weeding and harvesting equipment could then be taught.

The Latin American country had different needs. With an agriculture combining capital intensive cash cropping on the coastal belt and poor, less than subsistence agriculture in the mountainous hinterland, it needed to improve the standard of tractor operators and mechanics and also to provide the backbone of any extension service designed to improve the practice of the peasant farmers.

As in many other developing countries, there were already numbers of graduate engineers being produced by a national university but no training at the intermediate technician level.

Two main objects of the centres, the report recommended, should be to provide firstly practical instruction in the driving, handling, maintenance, adjustment and repair of all makes of machines being used in the country and secondly, the operation and maintenance of cultivating, sowing, crop protection and harvesting equipment should then be taught.

Technical assistance both in the form of money for equipment and instructors to train their own replacements would be needed for a period of four or five years.

The recommended plan most likely to produce as many trained men as possible in a short time was based on a number of short-term basic courses each year with small groups of trainees. When the training unit is under way and has the necessary staff additional specialist courses on particular aspects of individual types of machinery should be run, the report recommended.

Cost of training

Although the provision of operator and mechanic training facilities are not likely to cost as much as they would in a developed country they are still likely to represent a considerable strain on the scarce finances of these countries.

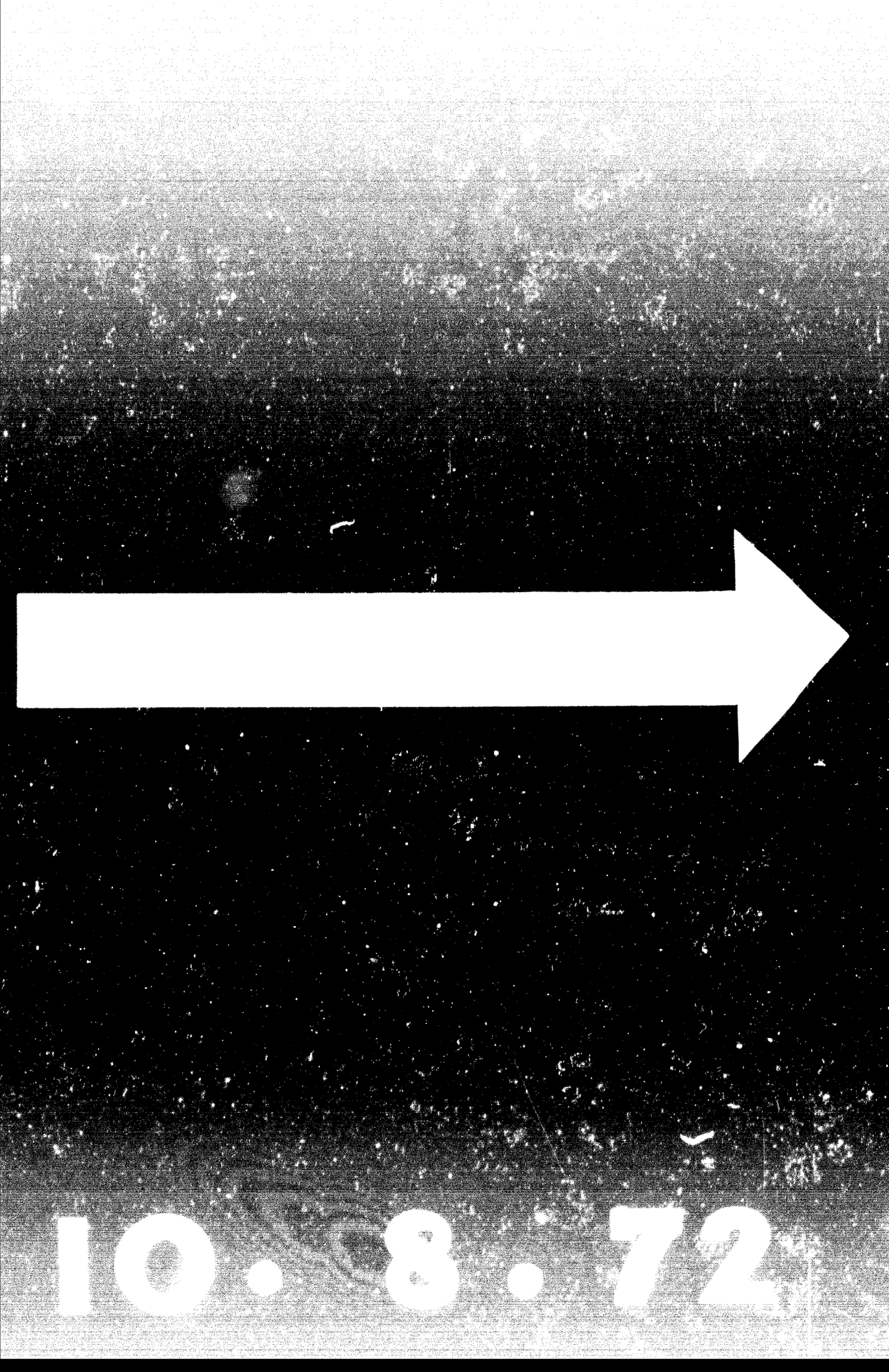
It is inevitable therefore that more money will have to be directed to this basic training need by every organisation involved with improving living standards in developing countries. It demands priority treatment over many much less urgent educational projects on which considerable sums are being spent at the moment.

It is of course impossible to calculate precisely what a particular training set-up is going to cost. Each situation must be solved in a different way. There are nonetheless certain basic costs which provide a guide to estimating the cost of a training programme.

To train a man at the intermediate and more advanced levels abroad will cost someone - his own government, a technical aid organisation or the government of the teaching country - in the region of £1400 for each year of his course.

To equip a training school to handle 20 to 30 students for basic tractor operating and maintenance will cost up to £10,000 depending on the number of tractors used. A workshop training unit will cost from £5000 to £1500. These figures can be considerably reduced by economising on buildings and making use of machinery already being used in the area.

The cost per student of a given course will be much more difficult to estimate because of the variation in staff salaries, length of courses and the other factors already mentioned.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VI CONCLUSIONS

Throughout the writing of this report it has been the aim to focus on the problems of machinery operation as they are in developing countries at the present time. It is however impossible to conclude a work of this nature without making the observation that many of the problems of agricultural mechanisation in these countries are rooted in the attempt by governments and other official bodies to mechanise agriculture before people were ready for it.

As a mechanisation expert working in one developing country put it to me: "What is needed here is not more mechanisation but less. I sometimes think that we should go back to basic principles with farmers exploiting their own working capacity and that of their draught animals to the utmost and then work upwards from there as their technical and economic situation improves."

A great deal of effort and money has been wasted on schemes which went too far too fast; the attempted wholesale application of sophisticated agricultural mechanisation methods originally developed for Euro-American conditions has foundered with monotonous frequency.

It therefore seems obvious that if more money and effort is not to be wasted on attempting to impose European methods on people who are not ready for it, much more effort must be directed towards designing simple machinery for specific jobs and conditions.

This is a view widespread amongst advisory workers deeply involved in the monumental task of improving subsistence agriculture. The views of one such expert working in Ethiopia state the problem and indicate the future line of development in such situations:

"With the present shortage of capital, limited mechanical know-how, short farming season, small and often scattered holdings, lack of workshop facilities, the nearest spare parts supplier 600km away, poor communications, lack of trained mechanics prepared to come down and work here and difficulties in obtaining fuel, even large organisations are finding it difficult to run their mechanised equipment efficiently.

"On the other hand, most of the small farmers in this area already own cattle and some of them have draught animals. The cattle are of good draught type and there is an old tradition of cattle ploughing, forming an excellent basis for building up a comprehensive farming system which is capable of gradual evolution towards complete modernisation."

It has been clearly demonstrated that many of the people in many areas of the majority of developing countries are subsistence farmers with very little involvement in any sort of market economy so that even if they had the inclination to adopt modern machinery they would be unlikely to have the money to pay for it. A complete change has therefore to take place in their social situation before anything like modern methods can be introduced.

However, where the social situation of many small farmers is not so much a problem, where for instance, new land is brought into cultivation by irrigation and bush clearing schemes, comprehensive solutions such as the Volta River and Sudan Gezira schemes can and are going ahead successfully.

Apart from the measurable short term benefits accruing from such projects there must be an additional long term gain in the form of the technical fall-out in the form of development of new methods and the build-up of trained operators and mechanics. This must ultimately benefit the smaller farmers.

In the long term the development of an efficient mechanised agriculture will depend on the formation of larger farm units which allow machines to operate more economically.

In the meantime if the peasant farmers and smallholders who make up the bulk of the agriculturalists, and the bulk of the population, in developing countries are to be helped, much more must be done to aid the improvement and development of methods already in use.

This can only be done by paying much greater attention than in the past to experimenting with and testing machinery in the particular territory where it is to be used. To keep down costs of such operations it will be necessary for much of this simple equipment to be manufactured by the developing countries themselves.

These developments must also be complimented by a concentrated programme of technical education if any worthwhile results are to be achieved.

Indeed, the whole key to improving the efficiency of agricultural machinery operation in developing countries lies in more and better technical education.

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APPENDIX A

Staffing recommended by the Overseas Liaison Unit of the NIAE for a 25 tractor agricultural machinery unit. A staff of 21 operators and 4 foremen operators - plus trainees - should be backed up by 6 mechanics and 2 other machinery technicians, a unit supervisor and a farm machinery manager.

Staff qualifications and a salary scale (for Kenya) are as follows:

1. Farm Machinery Operator Trainee (£90)
   - a. Minimum entry requirements (i) Literate
     (ii) Satisfactory completion of 4 years education
     (iii) Mechanical aptitude
   - b. Minimum 3 week intensive training
   - c. Minimum 90 days 'on the job' training
   - d. Maximum 6 months in grade

2. Farm Machinery Operator (£163 - £250)
   - a. Field qualifications test based on experience gained as a trainee, or in previous employment (minimum 1 year)
   - b. Minimum entry requirements
   - c. Minimum one-week intensive familiarisation training on specified equipment
   - d. To operate a tractor and at least two basic implements under varying field conditions with maximum efficiency and a minimum of supervision
   - e. Driving licence.

3. Senior Farm Machinery Operator (£236 - £320)

a. Must be conversant with all the qualifications of the "Farm Machinery Operator" including serving a minimum of one year in that grade or equivalent

b. Must be proficient in the operation of at least 4 different types of machines

c. Must have experience and knowledge in the keeping of field records

d. Must be able to supervise other operators and carry out required field operations without direct field supervision.

e. As (2) above, but to include organisation and supervision of field work with all applicable equipment.

4. Farm Machinery Technician - (£300 - £440)

a. Must meet all the qualifications for a Senior Farm Machinery Operator including having served a minimum of 2 years in that grade or equivalent

b. Must have completed a minimum of 60 days mechanical training and be able to make routine field repairs and adjustments on all machinery

c. Must be able to supervise the complete sequence of field operations for the specified crops

d. Must be able to operate all applicable tractors and field implements

e. As (3) above.

5. **Farm Machinery Manager** - (£700 - £1060)

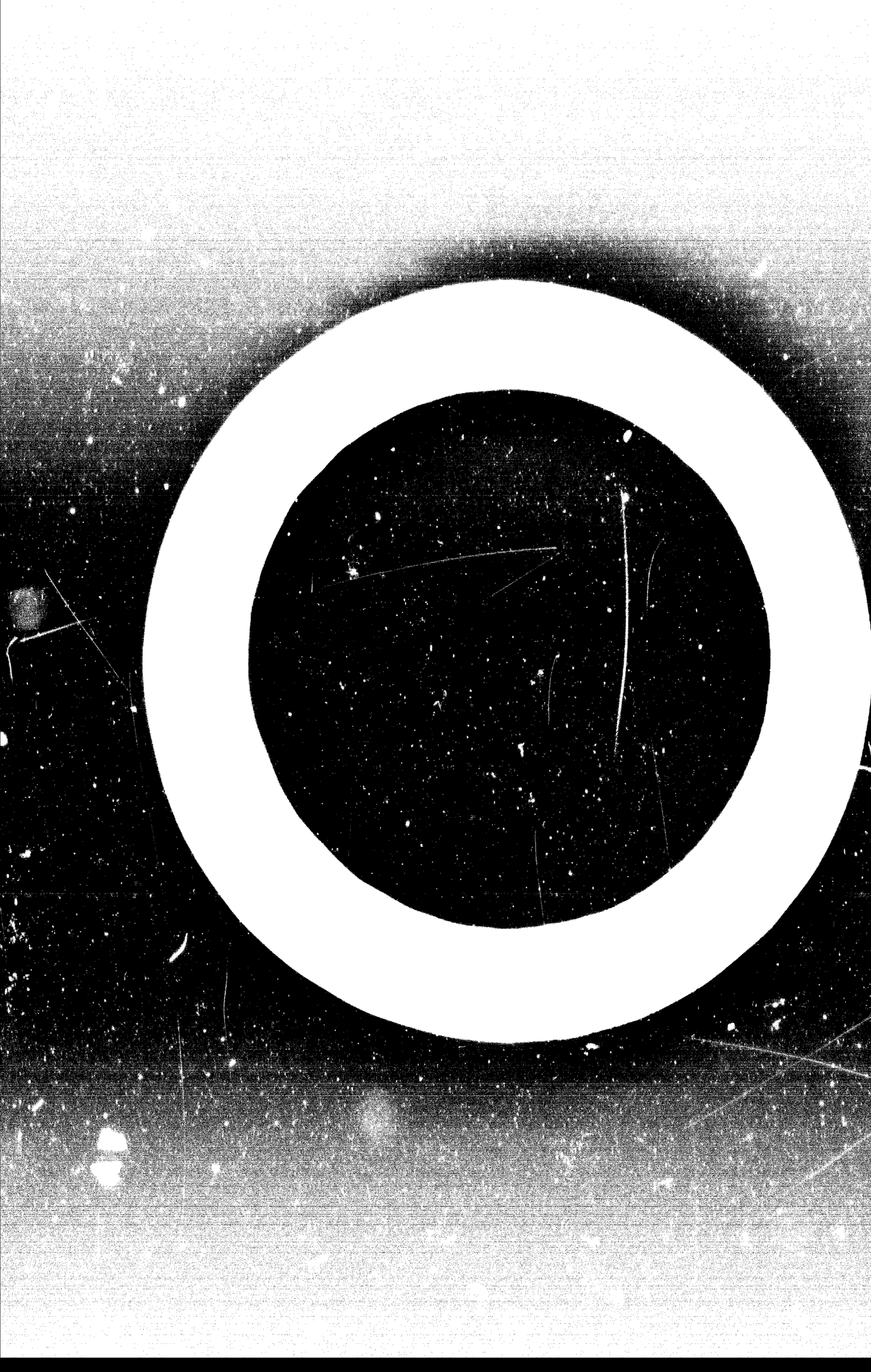
a. Must have a minimum of 3 years experience in mechanised farm management

b. Must be experienced and capable of carrying out administration and accounting for farm tractors and machinery

c. Ability to supervise a staff of farm machinery operators and mechanics; to ensure economic and efficient utilization of equipment.

Wages of the above staff should also include an hourly incentive bonus in addition to a promotion incentive, e.g. Shs. 0.25 per productive tractor hour or such other amount as may be suitable.

This or a similar system permit an organisation such as the Tractor Hire Service to reduce the number of high level supervisors. Senior Farm Machinery Operators and Farm Machinery Technicians would assume most of the day to day field supervision and the Farm Machinery Manager would be responsible primarily for organisation of the work.



APPENDIX B

Outline of course of teaching and practical instruction for devised by the City and Guilds of London Institute for agricultural machinery operators in tropical countries:*

The course is based on a thorough understanding of the basic principles of agriculture. It aims to show why machines are used and how they should be used to obtain optimum benefit. The basic principles of machinery operation form the main part of the course with a considerable reliance on practical instruction in the use of the principal types of equipment. Practical instruction forms one third of the total teaching time of the course.

The syllabus is divided into four parts - elementary principles of crop husbandry and land use, agricultural machinery, related studies and practical work, but it is recommended that all four should be taught concurrently throughout the period of a course. The aim being that student's expanding knowledge of the four main aspects should compliment one another throughout the course.

The sections are divided in the following manner:

1. Elementary principles of crop husbandry and land use:

This section is divided into soils, cultivation and manures; land use and plant growth and reproduction.

The agriculturally important points of soil type, the top and sub-soil relationship and the relationship of soil type and state to plant growth are emphasised.

The cultivation section emphasises the importance of soil structure and tilth, weed control and the reasons for cultivating the soil.

Main subjects dealt with under soil fertility are organic and inorganic manures, green manuring, reasons for rotations and methods of fertiliser application.

* copies of no 816 Agricultural Machinery Operators Certificate syllabus (Agricultural Engineering in Tropical Countries Stage 1 obtainable from City and Guilds of London Institute, 76 Portland Place, London, W.1.)

The Land Use part of the syllabus deals with climate, particularly rainfall, with main emphasis on the student's region. The effects of and reasons for soil erosion are covered and extended into methods of soil conservation with, again, particular emphasis on the student's own area.

Under the heading of Plant Life, Growth and Reproduction the main principles of plant growth and reproduction are explained with particular emphasis on the crops of the region. Differences between different types of plants with particular reference to difference between broad leaved and grass species. Principles learnt under these headings are then brought to bear on the main methods of arable crop production.

2. Agricultural Machinery:

Introduction and materials - power transmission - power units - tractors and implements and machines form the main part of this subdivision of the syllabus.

Man as a power unit for simple machines - hand tools used in the student's region - the draught animal as a power unit - animal drawn machines of the region. The tractor as a power unit replacing animals - torque and lift - reasons why animal drawn machines are often unsuitable for use with tractors.

Identification of materials used in farm machinery - characteristics in relation to use and storage - factors affecting their life - wear and corrosion.

Power transmission - shafts - pulley drives - gears - chains and sprockets - ball and roller bearings - bush and shell-type bearings - sealing elements.

Power units - construction and working principles of 4 and 2-stroke engines - compression and spark ignition - single and multiple cylinder engines.

Lubrication systems - friction - purpose of lubricants - different types of lubricating systems - importance of cleanliness and regular oil changes.

Cooling systems - air and water cooling - layout and function of tractor engine cooling system.

Air cleaners - function - construction and servicing.

Petrol engines - fuel - fuel systems - principles of carburettion - coil ignition and magneto ignition systems.

Diesel engines - fuel - fuel systems - pumps, filters, injection pumps and injectors.

Starting systems - layout of starter circuit - battery and its care - charging systems.

Tractors - layout of four wheeled and track laying tractors. Transmissions - ground drive equipment and brakes - lubrication - hitches - controls and instruments.

Implements and machines - ploughs, chisel, mouldboard and disc plus special reference to local animal drawn types.

Cultivating machinery - disc harrows - seed harrows - chain harrows - rollers and tined cultivators - ridgers and subsoilers.

Planting equipment - principles of the seed drill - the various seed metering devices - types of tuber planter.

Fertiliser distributors - purpose - plate and flicker, spinner and other broadcasting types - maintenance.

Sprayers - fan and cone nozzles - pressure reservoir and continuous pumping knapsack machines - low volume sprayers - manual and powered dusting machines.

Pumps - main principles of reciprocating and centrifugal pumps

Light earth-moving equipment - blade terracers - graders - disc plough as an earth mover - tractor mounted earth box.

Farm transport - wheel barrows and hand trolleys - different types of tractor trailer - trailer weight transfer.

Regional options - grass and light brush-cutting machinery - forage handling machinery - combine harvesters - root harvesting machinery - special harvesting and processing equipment.

3. Related Studies - Calculations - practical calculations using fractions, decimals, formulae, averages, ratios and percentages - measuring and mensuration.

Heat - temperature and quantity of heat - measurement - effects of heat.

Mechanics - the lever - moments - mechanical advantage - pulley and gear ratios. Centre of gravity - stability - safe loading. Hydraulics simplified. Friction.

Electricity - effects of an electric current, heating, chemical, magnetic, circuits, conductors, insulators, resistance colour coding. Earthing and safety. Batteries and fuses.

4. Practical work - this is divided into practical demonstrations and exercises explaining all the foregoing subjects.

APPENDIX C

Syllabus drawn up by the City and Guilds of London Institute for training of agricultural mechanics in tropical countries.*

This syllabus is designed for training school leavers either taking a related course or undergoing an apprenticeship and also for more mature students who may already have mechanical experience. A total of 720 hours of instruction and teaching are involved in which a third will be practical workshop and field work.

The course is divided into four sections: elementary principles of crop husbandry and land use, construction and maintenance of agricultural machinery, workshop processes and materials and related studies.

1. Elementary principles of crop husbandry and land use: this section is divided into soils, cultivation and manures; land use; plant growth and reproduction.

2. Construction and maintenance of machinery: this is sub-divided into five sub-sections - power transmission, power units, tractors, implements and machines and regional options.

Power transmission - shafts and driving devices - pulley drives - gears - chains and sprockets - ball and roller bearings - bush and shell type bearings - sealing elements.

Power units - internal combustion engines - engine construction and materials - engine operation - spark ignition engines - compression ignition engines - cooling systems - electrical equipment - lubrication - air supply - routine engine maintenance and overhaul.

*Syllabus 817 Agricultural Mechanics Certificate - obtainable from City and Guilds of London Institut , 76 Portland Place, London, W.1.

Tractors - general layout of main types - clutches - gearboxes - differential and final drive - ground drive equipment - brakes - steering - hydraulic system - power take off and belt pulley - hitches.
Implements and machines - ploughs - cultivating machinery - planting equipment - fertiliser distributors - harvesting and processing machinery and equipment - sprayers - pumps.
Regional options - grass cutting machinery - forage harvesting and handling machinery - root harvesting machinery - dairy machinery.

3. Workshop processes and materials: this section is sub-divided into materials, processes, metal working and welding and repair work and machining processes.
Materials - general properties - uses - review of metals in relation to repair processes - plastics - corrosion - special steels and other alloys.
Processes - fitting - measurement - identification of materials - hand tools - marking out work - soldering - sheet metal work - machining.
Metal working and welding - bending, twisting, upsetting and drawing down - oxy acetylene and arc welding - bronze welding - building up worn parts.
Repair work - further manipulation of sheet metal and thin plate for repair - integrated exercises involving all processes on repair jobs - manufacture of simple assemblies - electrical wiring.
Machining processes - principles of metal cutting - lathe operation - jigs and templates - portable power hand tools.

4. Related studies: this section provides the theoretical background which should aid the understanding and application of the practical sections of the course. It is divided into calculations, heat, mechanics, electricity and sketching and drawing.